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Facilitation of Enviromental Factors to Reduce Sound Decibels in the Neonatal Intensive Care Unit: A Literature Review

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ENVIROMENTAL FACTORS TO REDUCE SOUND DECIBELS IN THE NEONATAL INTENSIVE CARE UNIT: A LITERATURE REVIEW

By

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Abstract

This literature review investigates nursing interventions to reduce decibel levels in the neonatal intensive care unit (NICU). The secondary purpose of this review was to evaluate if the interventions to reduce noise in the NICU had different outcomes for normal weight premature infants and infants afflicted with neonatal abstinence syndrome. The data bases for completing this review were Google Scholar, the Cumulative Index to Nursing and Allied Health Literature (CINAHL Plus), PubMed, and Elton B. Stephens Co. (EBSCO). The key search words included 'NICU and decibels', 'reducing decibels', 'neonatal abstinence syndrome' 'decibels', 'preterm infants' and 'normal weight preterm infant*'. The inclusion criteria were research articles from 2008 to 2020, articles with a focus on normal weight premature infants and normal weight infants determined to be addicted to a recreational or illicit substance after birth. The results yielded 8 articles meeting inclusion criteria and screened for relevance to the topic. Data indicated there is a need for further research into using multiple interventions. One intervention alone can currently not reduce decibel levels to the recommended level.

Conclusions: Currently the research states private rooms reduce decibel levels the most out of the other intervention listed in the study. Further research with long-term neuro-cognitive data collection over a longer period of time and larger sample sizes is needed to evaluate the use of interventions to reduce high level, decibel noise found in the NICU.

Dedication

This dedication is to all the wonderful NICU nurses who have dedicated themselves to their patients and their patients families.

In hopes this research will help neonates across the country.

And this could not be possible without the help of my wonderful thesis chair Dr. Leslee D'Amato- Kubiet. Thank you for believing in me and I will be a better NICU nurse because of this.

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Introduction

In the US, 48.0% of infants admitted to the Neonatal Intensive Care Unit (NICU) have a normal weight at birth and require support for other reasons (Goodman et. al, 2019). Infants are admitted to the NICU for potentially life-threatening conditions affecting the heart and lungs, as well as other body systems needed to maintain physiologic homeostasis in the first months of life. The NICU environment is important to improving outcomes of infants with normal birth weight and confounding conditions, yet inconsistencies with how the NICU environment is maintained to meet their needs is evident. Understanding which environmental factors contribute to reducing infant length of stay, improving physiologic stability, and reducing critical events is of value to providing cost-effective care and increasing parental satisfaction with the care of the infant in the NICU.

Ambient sound in the NICU consists of monitoring devices, ventilators, infant sounds, and staff activities. Sounds and noises in the NICU are measured in decibels and lower decibels are preferred in the NICU to mimic the muffled sounds of the intrauterine environment. Increased sound decibels can cause overstimulation of the infant's underdeveloped nervous system and negatively affect well-being. Methods to reduce sensory overstimulation include spacing/layout of the unit, infant earmuffs, soft voices, low or no music, and muted monitor and device sound settings. Furthering research involving minimization and consolidation of ambient sound and the effect on infant physiologic and non-tangible variables in the NICU is of value to improving care and outcomes.

Problem

The level of ambient noise in the NICU environment can have a profound effect on physiologic and non-tangible variables associated with normal weight infant's health and well-being. Ambient noise levels in the NICU are recommended not to exceed 45 decibels (American Academy of Pediatrics, 1997). The average range of decibels in the NICU are 49.5 – 89.5 (Matook, Sullivan, Salisbury, Miller & Lester, 2010). Reducing the number of decibels of sounds and noise the infant experiences can further the need for interventions to reduce ambient sound in the NICU.

Existing interventions to reduce ambient noise and sound in the NICU can affect a variety of infant physiologic variables. Physiologic variables affected by ambient NICU noise include growth and weight, recovery from addiction, and oxygenation status. Intangible infant variables affected by ambient noise include increased length of stay in the NICU and escalated cost of care. Examining interventions aimed at reducing the number of elevated sounds decibels associated with ambient sounds and noises in the NICU environment can target specific physiologic and non-tangible variables that affect normal weight infant's health and well-being and ease transition to extrauterine life.

Background

The NICU team cares for neonates with a variety of conditions. Prematurity is a common condition in a neonate and often requires admission to the NICU for further observation. Preterm or premature infant is defined as an infant born before 37 weeks of gestation. Another common condition is neonatal abstinence syndrome (NAS). NAS is described as a constellation of mal-adaptive clinical manifestations in a neonate caused by opioid use during development in the womb. Infants that spent time in the NICU after birth are at a higher risk of neurological disablement (Zhang et al., 2007). Overstimulation from the ambient sound in the NICU environment can increase the risk of neurologic complications.

In utero the structural elements of the auditory sensory system begin developing during the embryonic stage and are fully formed by 20 weeks' gestation. The auditory system becomes functional when a synaptic pathway is formed from the ganglion cells of the cochlea to the brain stem. The pathway is fully developed from 25 to 29 weeks' gestation. From 28 to 30 weeks' gestation the neural connections to the temporal lobe of the cortex become fused and functional. The tonotopic columns of the auditory cortex are paramount for receiving and recognizing outside auditory stimuli and this starts to develop near 30 weeks of gestation. The ambient environment in the NICU plays a role in effecting the cochlea and auditory cortex in the temporal lobe (Graven & Browne, 2008).

In utero the fetus lives and grows in the embryonic sac that is filled with amnionic fluid. Amnionic fluid along with the abdominal wall helps buffer outside stimuli so the neonate can develop properly. For the neonate to be classified as viable for life outside the womb they will

need to be over 23 weeks' gestation and over 500 grams (Seri & Evans, 2008). Given the age of viability preterm infants will be undergoing auditory development outside the womb. Preterm infants must adjust to extrauterine life before the auditory synapses are completely connected. This places the neonate at a higher risk for overstimulation from ambient sound in the NICU. The overstimulation from ambient noise in the NICU and exposer to higher decibels during the neonatal critical period can lead to alterations in the auditory connections and damage to fragile neurologic systems.

Every unit in a hospital has a deafferenting ambient environment that includes monitors, machinery for respiratory support, and an intercom system. The intercom system gives vital information to the hospital staff. Many codes announced over the intercom system throughout the day correlate to specific messages a staff member can be required to respond to in a certain situation. One of the codes necessary for the NICU team is a code red. A code red often means there is a fire in the hospital, and this is important for staff of that hospital to know. The intercom system can have deafferent levels of sound decibels based on how the system was installed and how the person is speaking into the microphone. The jolt of loud noise from the intercom can startle the infants in the NICU. Likewise, monitors will alarm when vital signs are of their parameters or when monitoring devices are triggered. If an infant's oxygenation saturation goes below 95%, an alarm will sound to alert the nurse to check the infant. A nurse in the NICU can lower the parameters of biologic indicators being evaluated but cannot silence the alarm on the monitoring equipment. The alarms on the monitoring equipment in the NICU can have a negative impact on the infant's well-being and nervous system.

The length of stay in the NICU is dependent of the developmental level of the individual infant after birth as determined by The Ballard Scoring Index (Alexander, Caunes, Hulsey, Tompkins & Allen, 1992). In infants born prematurely, the usual time spent in the NICU is estimated based on their due date plus or minus two weeks. The average length of stay in a NICU for infants who are over 28 weeks' gestation or have other issues is 26.4 days with a confidence interval of 95% (DeRienzo, Kohler, Lada, Meanor, & Tanaka, 2016). For infants under 28 weeks' gestation the average length of stay in the NICU is 84.5 days with a 95% confidence level ((DeRienzo, Kohler, Lada, Meanor, & Tanaka, 2016).

Overstimulation in the NICU occurs in several modalities. Tactile overstimulation occurs when the nurse or another health care provider is manually manipulating the infant. Manipulation of the infant includes physical examination, diaper changes, intravenous access placement, orogastric tube placement, temperature checks and any other intervention that involves tactile touch. An intervention to avoid tactile overstimulation is bundling of care. Bundling care is frequently performed during feeding times. Infants need to be fed every two to three hours which provides the nurse an opportunity to plan care activities throughout the shift. Waiting until feedings can reduce tactile overstimulation by introducing a positive experience of food to balance out the negative stimuli of other interventions.

Infants can become overstimulated by bright intense light. The womb acted as a buffered environment for the neonate through muted darkness and muffled ambient sound, combined with the softness of the mother's heartbeat and the sound of blood moving through the circulatory system, also called 'uterine souffle', that lessened harsh sounds. The preterm infants and infants suffering from NAS in the NICU can be exposed to visual overstimulation which can

delay or infringe upon neural connections. Providing dim and dispersed lighting in the NICU can reduce visual overstimulation of the infants. Visual overstimulation of the normal weight infant with complications can be avoided, however auditory overstimulation transpires in the NICU with minimal enforced interventions.

Current interventions for reducing auditory overstimulation from the ambient sounds of the NICU include use of earmuffs or earplugs, muting monitors, placement of infant isolates or bassinets, and speaking softly. Using earmuffs in the NICU to help reduce auditory overstimulation is a cost-effective way to reduce the levels of decibels the infants is subjected to. Earmuffs and properly used earplugs help raise the mean arterial oxygenation saturation, lower pulse and respiration rate of the infant (Abdeyazdan, Ghassemi, & Marofi, 2014). Changing from open bay to single-family rooms for infants is an intervention that requires further research.

Purpose

The purpose of this literature review was to determine interventions to decrease sound decibel levels experienced by the normal weight preterm infant and normal weight preterm neonates with neonatal abstinence syndrome admitted to the NICU. This review will focus on normal weight premature infants and infants that suffer from NAS. The secondary purpose of this review was to examine differences in the level of sound decibels reviewed and recommend interventions that decreased ambient noise for either infant in the NICU.

Method

A comprehensive review of published research articles focusing on interventions to reduce ambient sound in the NICU setting was evaluated. Various databases were used including Google Scholar, the Cumulative Index to Nursing and Allied Health Literature (CINAHL Plus), PubMed, and Elton B. Stephens Co. (EBSCO). Key words included in the search were: 'NICU and decibels', 'reducing decibels', 'neonatal abstinence syndrome' 'decibels', 'preterm infants' and 'normal weight preterm infant*'. The inclusion criteria included articles published from 2008 to 2020, publications written or translated to English, and articles focusing on preterm, normal weight infants in the NICU, with and without NAS. The review evaluated interventions to reduce ambient sound in the NICU and the data was compiled into a table for synthesis. Exclusion criteria extended to publications from outside the listed dates, articles that are not translated to English, and under-weight infants in the NICU.

All research articles were individually critiqued and analyzed. Each selected research article was synthesized and results from the articles meeting criteria were extracted by the researcher. An evidence table was formulated to include articles relevant to the research question and were further analyzed by the researcher. All consistent and inconsistent findings in research articles will be discussed.

Results

Out of fifty-seven articles reviewed eight met inclusion criteria and were relevant to the topic of reducing ambient sound in the NICU. Over the course of the eight articles reviewed, one key intervention to lower decibel levels to an appropriate level was identified. There were three key elemental interventions performed by nurses that were thematic to lowering decibels of ambient noise in the NICU brought forth in the eight studies synthesized: Equipment, voices, and latent environmental factors, such as hand washing, doors opening/closing, and moving objects (rocking/rolling chairs, walking across bare floors, rolling objects). The three key elements mentioned comprised loud decibel ambient noise difficult to control in the NICU, where they are necessary for the functioning of the unit.

Table 1: Equipment, Voices and Environmental Factors

Factor Discussed	**Articles**	**Total Articles**
Equipment	(Best, Hughes, New, & Bogossian, 2020), (Brandon, Ryan, & Barnes, 2008), (Goldstein, Laliberte, & Keszler, 2019), (Newnam, 2017)	4
Voices	(Brandon, Ryan, & Barnes, 2008), (Milette, 2010), (Pineda et al., 2017)	3
Environmental Factors	(Best, Hughes, New, & Bogossian, 2020), (Brandon, Ryan, & Barnes, 2008), (Cassidy, 2009), (Milette, 2010), (Pineda et al., 2017), (Ramm, Mannix, Parry, & Gaffney, 2017)	6

Equipment

There are different types of equipment that is needed in the NICU to help support and care for these infants. Syringe pumps, oxygen, ventilators, bubble CPAP, warmers, monitors, refrigerators, and computers. All of the listed equipment is needed to care for an infant with critical conditions in the NICU and they all have a resting decibel level with higher amplitudes.

In the studies reviewed four articles discussed an equipment focused intervention. All four articles centered around respiratory equipment and one article also mentioned alarms on pumps. All studies in this review did not evaluated reduction of monitor alarms. One study solely gathered data from different types of ventilators to find the one with the lowest decibels. The results stated that the Dräger VN500 in high-frequency mode had the lowest decibel levels (Goldstein, Laliberte, & Keszler, 2019). The Dräger ventilator on its own produced 49.8 dB, this level is already higher than the recommended 45 dB. Another study t focused on non-invasive respiratory therapies and found both respirator therapies had decibel noises over 52 dB (Newnam, 2017). One of the studies included a focus on room type but mentioned a specific type of respiratory therapy and how it could contribute to increased decibel levels, adding to ambient noise the infants were exposed to during their stay in the NICU. In the NICU, regardless of room type, there were increased use of respiratory therapies, leading to a higher decibel level of ambient noise exposure to all infants present (Best, Hughes, New, & Bogossian, 2020). One study took place over a year and found that bubbling water used to humidify respiratory therapies administered to normal weight, preterm infants had a decibel rage of 62 – 87 dB (Brandon, Ryan, & Barnes, 2008). Normal weight preterm infants often receive care in the NICU solely for respiratory support, adding to increased ambient noise exposure.

Voices

Nursing staff and the healthcare team communicate verbally in the NICU setting. Verbal communication is the fastest and most efficient method for expressing information and needs of the infants in the NICU. However, the volume of voices can play a role in high decibel levels heard by the infant. When a stressful period occurs in the NICU there can be more people

gathered in a small area with raised levels of communication, which can increase volume to the surrounding infants. For example, when an infant is admitted to the NICU after a delivery, the team of health professionals will perform many tasks for the infant. The team consists of a delivery nurse, nurse practitioner/ neonatologist, receiving NICU nurse, and charge nurse. Students from various disciplines and new employees learning to provide care across units are also present. If the infant is going into a private room most of the noise will be confined to one room but if the infant is in an open bay style or pod style lay out the voices of the numerous team members can affect infants in the surrounding area. Three out of the eight articles focused on voices used by various individuals in the NICU.

There was one study that centered around different types of voices including: meaningful words and number of adult words. The study also assessed electronic noise and moments of silence. that the research suggested, regardless of room type, meaningful language and words spoken around the infant increased as the neonate aged (Pineda et al., 2017). There was a difference between type of room the infant was in during the stay in the NICU with number of words spoken around the infants who were 40 weeks adjusted gestational age; 4987.2 words per private rooms and 5185.5 words spoken in an open bay style NICU (Pineda et al., 2017). One study conducted over a 12-month period documented a change in communication devices as an item increasing voice decibels in the NICU. The change in devices resulted in a negative outcome due to the increase in decibel levels with the device escalating ambient noise over 100 dB in peak instances (Brandon, Ryan, & Barnes, 2008). The study illuminated the need for further interventions aimed at decreasing ambient noise decibels with communication systems in the NICU.

Education can be the key to reducing voice levels in the NICU and a study done by Milette, incorporated factors involved in communication in the NICU. However, the study had conflicting results due to an increase in nursing staff and infants during the time the study was conducted who did not receive the education offered to participants. The results suggest more studies focusing exclusively on education about ambient noise from communication between health care providers in the NICU would be beneficial to accurately measure adverse outcomes (Milette, 2010). The education provided to the nurses included voice education, harmful effects of high decibel levels and environmental factors.

Environmental Factors

Environmental factors is an umbrella term to include room type, electronic devices not actively used in neonatal care, and music. Electronic devices not actively used in infant care vary from unit to unit. The devices can include but are not limited to family refrigerators, televisions in private rooms, cell phones, electronic soap dispenser and paper towel dispenser, running water from faucets into a sink or collecting basin, footsteps, and clothing Electronics have a resting decibel level emission but others, such as the paper towel dispenser, faucets, and shoe types, have spikes of high decibels. Six out of eight studies examined ambient noise connected with environmental factors with included intervention topics. There was a higher cross over with environmental factors and the other two key factors in all studies reviewed. One of the studies crossed over all three key areas. This study took place over 12 months and was able to gather data in many different areas.

One intervention-based study specifically examined environmental factors related to paper towel dispensers in the NICU. Over the course of the study there was a change made from

manual paper towel dispensers to electronic dispensers. The change suggested a higher decibel level in the infants closer to the electronic paper towel dispenser (Brandon, Ryan, & Barnes, 2008). Also noted in the study was decibel readings from people tapping their fingers on the isolates, which produced a range of 70 – 95 dB (Brandon, Ryan, & Barnes, 2008). Three out of the six studies focused on room type as an intervention to reducing ambient decibel noise in the NICU. There were three layouts that were used to gathered data across the studies. The three layouts include private rooms also known as single family rooms, pod style lay out where each pod has a smaller number of NICU beds, and open bay also known as open plan/open layout. Open bay NICU layout involves a large amount of NICU beds. Across the two studies testing private rooms the NICU, room layout did not reduce ambient decibel sounds as much as expected. In both studies, the average decibel level was well above the recommended level of 45 dB (American Academy of Pediatrics, 1997).

There was a study done that had a focus on electronic noise and moments of silence from ambient noise. The researchers also tested between private rooms and the open bay style NICU. The results found that there were more moments of silence in the private room compared to the open bay style (Pineda et al., 2017). One of the studies focused on music therapy and the decibel levels of the therapy. Another factor that was evaluated was head circumference and physiological response. The results from this study found that there may be more harm from the decibel levels then from the benefit from music therapy for preterm infants (Cassidy, 2009). The decibel level of the music presented to the infants were 65 dB, 70 dB, and 75 dB (Cassidy, 2009). There was no change in head circumference correlated with music therapy but there was a positive correlation between music therapy and reduced heart rate (Cassidy, 2009).

A study done by Milette focused on educating NICU nurses also had an environmental component, but more studies need to conduct to see an accurate outcome. None of the synthesized studies evaluated specific outcomes or infant populations exposed to ambient sounds from a neuro-cognitive perspective over a long period of time, >30 days.

Neonatal Abstinence Syndrome (NAS)

Neonate conditions in the NICU can have a set list of interventions adopted to decrease ambient noise exposure and lessen neuro-cognitive stimulation. One of the issues infants experience is maternal illicit drug use during gestation. When umbilical cord blood is tested and comes back positive for illicit drugs or substances found in neonatal circulation, the health care provider and the NICU nurse begin monitoring for withdrawal symptoms. The withdrawal process is called neonatal abstinence syndrome (NAS). One of the methods of for an infant during withdrawal clinical manifestations is called eat, sleep, console (Grisham et al., 2019). This method includes music therapy as a way of consoling.

The decibel levels are a concern when treating infants afflicted with NAS and for the infants surrounding them. Pharmacologic approaches to managing withdrawal symptoms from NAS are not used with the Eat, Sleep, Console method of NAS therapy, leading to an increase of shrill crying, agitation, and grimacing in the infant with NAS, requiring the need for other interventions to control ambient decibels in the NICU (Grisham et al., 2019). One of the studies reviewed took into account maternal drug use. The study had 44% of their sample size had been exposed to illicit drugs in utero (Pineda et al., 2017). The study found infants exposed to illicit drug use had higher decibel levels and less moments of silence (Pineda et al., 2017). Having one

study meeting criteria about the connection between NAS and decibel levels led to insignificant results for the scope of this review.

Discussion

The reviewed articles suggest one intervention implemented by healthcare staff in the NICU to reduce ambient noise will be beneficial to lowering decibel levels to the recommended level of 45 dB. There is a possibility with combining multiple interventions the decibels from ambient noise in the NICU can be lowered to recommended levels. To evaluate decreased decibels from ambient noise in the NICU interventions aimed at specific outcomes for effectiveness and combining interventions would be of value. All interventions aimed at reducing ambient decibel noise in the NICU, with the exception of music therapy, reduced decibel levels of ambient noise, but further studies exploring a wider range of noises would be beneficial and have potentially improved outcomes related to neuro-cognitive development. Similar results can be concluded about which intervention will work to reduce decibel levels in all infants.

The research for providing interventions to lower decibel levels are integral due to the negative effects high decibel levels can have. High decibel levels can result in disturbed sleep pattern, poor oxygenation and negative neuro-cognitive development in normal weight, preterm infants. In the reviewed articles there was a positive correlation in the listed interventions and lower decibel levels.

Research aimed at developing a list of ambient, noise reduction interventions to lower the decibel levels to the recommended level could be beneficial within the context of the room setting of the NICU. Interventions that can be tested in future studies include monitor and pumps

providing no noise but is sent to the nurses hospital phone as a vibration or tone to their earpiece, new isolates that help buffer outside ambient noise.

The correlation between the shift from pharmacologic treatment to eat, sleep, console methodologies and the increase of decibel levels in the NICU was not found. This is due to a lack of studies focused on this area. Further research can evaluate if there is a positive or negative correlation.

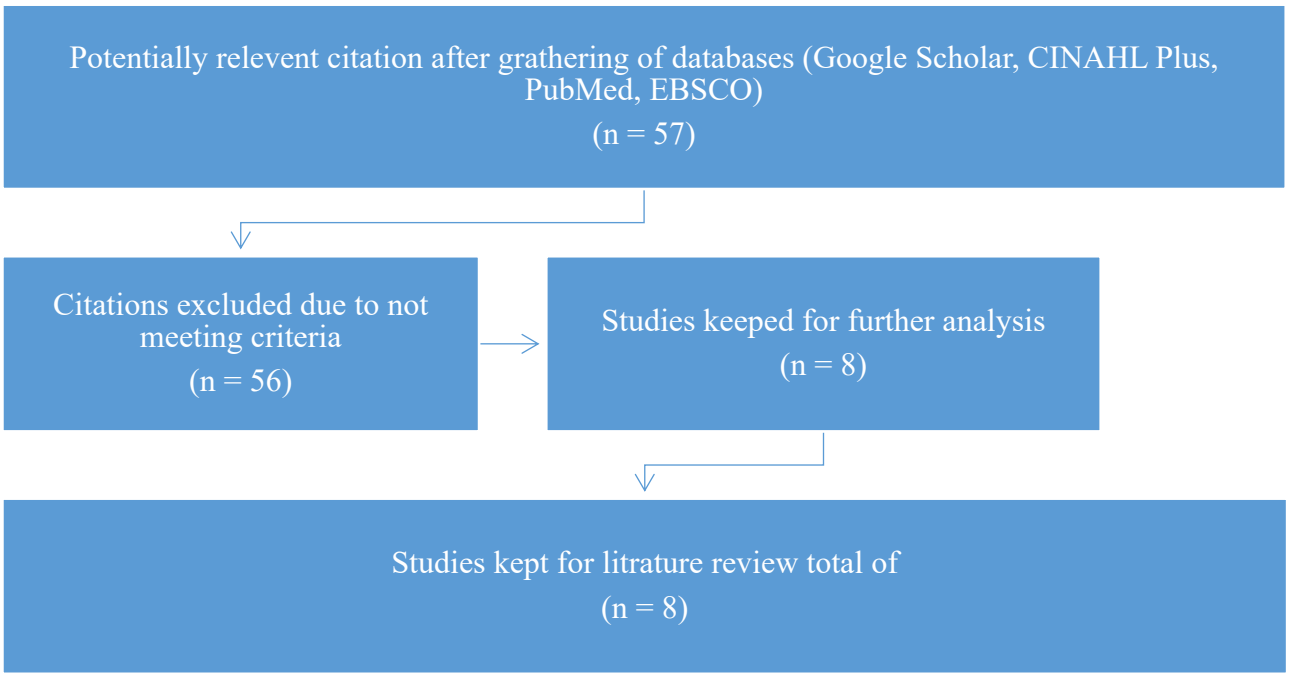
Conclusion

The purpose of this literature review was to list interventions that lowered decibel levels experienced by normal weight neonates in the NICU, some of which had NAS clinical manifestations. Ambient sound in the NICU are made up from multiple components. The three components of the reviewed articles focused on equipment, voices and environmental factors. Some equipment needed to support and care for infants are syringe pumps, oxygen, ventilators, bubble CPAP, warmers, monitors, refrigerators, and computers. The listed equipment all emit a resting decibel levels with alarms peaking decibel levels. Voices from staff and family can have a positive and negative effect on the infants. Meaningful words are found to increase bound but high volume of voices can have prolonged negative effects. Environmental factors is an umbrella term used in this review to combine undirected electronics, music and NICU layout. Private rooms reduced decibel levels more than the other interventions reviewed.

The decibel levels did not reach the recommended level of 45 dB with any intervention studied. Since there was not one intervention alone that can lower the decibel levels to the recommended level it can be tested if combining all positive interventions will lower levels.

Appendix A: Figures

Figure 1: Consort Diagram


Potentially relevent citation after grathering of databases (Google Scholar, CINAHL Plus, PubMed, EBSCO)
(n = 57)
Citations excluded due to not meeting criteria
(n = 56)
Studies keeped for further analysis
(n = 8)
Studies kept for litrature review total of
(n = 8)

Appendix B: Table

Table 2: Table of Evidence

Article	Design/ Purpose	Sample Size	Intervention Used	Key Findings	Does this intervention reduce ambient sound?	Can this intervention benefit infants with Neonatal Abstinence Syndrome?
Ramm, K., Mannix, T., Parry, Y., & Gaffney, M. P. C. (2017). A Comparison of Sound Levels in Open Plan Versus Pods in a Neonatal Intensive Care Unit. HERD, 10(3), 30-39.	The purpose of this study was to see if the decibel levels where lower in a pod set up vs. an open bay NICU layout.	This study focused on NICU lay out and did not have a sample size of neonates but a time frame. The pod set up was 6 NICU beds in each pod and a constant monitor was set up for 4 weeks. The open bay style lay out had 11 NICU beds and this was being constantly monitored for 4 weeks.	The intervention this study focused on is if a pod style lay out reduces decibel level compared to an open bay style layout.	The key finding in this study is that the pods did reduce decibel levels. The decibel levels were still over the recommended level. The average decibel level was 47.29 dBs in the pods and 48.99 dBs in the open bay layout.	Yes, this intervention reduced decibel levels but not enough. The study concluded that more research is needed on other layouts.	This study was not focused on the infants reason for being in the NICU. This question was not answered in this study.
Milette, I. (2010). Decreasing noise level in our NICU: The impact of a noise awareness educational program. *Advances in Neonatal Care : Official Journal of the National Association of*	The purpose of this study was to assess if educating the registered nurses on staff about the decibel levels in the NICU would reduce decibel levels.	This study took hourly mean measurements over the course of 13 days pre-intervention and 13 days post-intervention. This study was conducted in	The intervention used in this study is education. The goal was to answer if educating the staff nurses would have a positive impact on decibel levels.	The key finding is that there was an increase in decibel levels post-intervention. The author states this is due to an increase number of nurses and infants.	According to this study this did not reduce decibel levels in the NICU.	This intervention did not achieve desired results.

Neonatal Nurses, *10*(6), 343–351.		an open bay lay out consenting of 24 NICU beds.	The education given to the nurses was mandatory. This was a class held to explain optimal decibel levels, what high levels of decibels can cause.			
Best, K., Hughes, I., New, K., & Bogossian, F. (2020). An observational study of sound exposure in a single-room configured neonatal unit (SENSE study). *Journal of Neonatal Nursing*, *26*(6), 344–351.	The purpose of this study is to obtain data internally and externally in isolates and bassinets in a single-family room NICU layout. There was a decibel read placed inside each bassinet and isolate and one placed in each room. This study took place from September 15 through October 28.	This study used convenance sampling due to obtaining an informed consent. This study was conducted in 14 single infant rooms and two twin rooms. This study monitored 47 isolates over 47 days. During the time this study took place the NICU did not have infants in bassinets. This study also included the special care nursery as well and that had 25 single infant rooms and 3	The intervention is single-family rooms for the infants. No other noise reduction interventions were used over the course of this study.	The key findings are decibel levels still averaged well above recommended values. However, the study did find that new isolates contributed to lower internal decibel levels. There were higher decibel levels recorded inside bassinets as compared to externally.	This study showed that new isolates can reduce decibel levels, but single-family rooms did not reduce decibel levels.	This study focused on cot type and NICU layout. This study did not answer this question.

		twin rooms. During the course of this study, they collected data from 37 bassinets and 28 isolates over 65 days.				
Goldstein, J., Laliberte, A., & Keszler, M. (2019). Ambient Noise Production by High-Frequency Neonatal Ventilators. *The Journal of Pediatrics*, *204*, 157–161.	This study's purpose is to determine if high frequency ventilators rude decibel levels in the NICU. The study focused on 4 different types of ventilators. The 4 types include the Dräger VN500 in high-frequency mode, Sensormedics 3100A Oscillator and the Bunnell Life Pulse Jet Ventilators Model 203 and Model 204.	There were no infants involved with this study and this was just focused on the four ventilators. This was held in a single-family layout and all other noise producing machinery in the room were turned off. All settings were tested three different types to collect all the data.	The intervention being tested in this study is what ventilator will produce the lowest level of decibel.	The key finding in this study is that the Dräger VN500 in high-frequency mode ventilator was found to have the lowest level of decibels. The average decibel level across all settings was 49.8 dBs.	If the Dräger VN500 in high-frequency mode ventilator is used this can reduce decibel levels.	If an infant affected with NAS needed ventilatory assistance this ventilator can help improve outcomes.
Cassidy JW, & Cassidy, J. W. (2009). The effect of decibel level of music stimuli and gender on head circumference and physiological	The purpose of this study is to see if music therapy had a positive effect on vital signs (heart rate, respirations,	63 preterm infants were studied.	The intervention is music therapy. Group 1 listened to 20 mins of lullaby music (female voice with	Key findings include higher decibel levels during the 20-minute music therapy. The average decibel level during	This intervention did not reduce decibel levels.	This interventio n was not focused on preterm infants with NAS or term infants with NAS.

responses of premature infants in the NICU. *Journal of Music Therapy*, *46*(3), 180–190.	blood pressure and oxygen saturation), and head circumferenc e. This study recorded the decibel levels during music therapy		orchestral background) for two days then listened to 20 mins of classical music (Mozart string music) for another 2 days. Group 2 listened to the same music in opposite order.	therapy is 65 dBs. There was not a correlation with head circumferenc e growth and music therapy. Heart rate was seen to decreases during and after music therapy.		
Newnam, K. M. (2017). Noninvasive Respiratory Therapy and Neonatal Exposure to Sound...12th Annual National Association of Neonatal Nurses (NANN) Research Summit; March 28 - 30, 2017; Scottsdale, Arizona. *Advanc es in Neonatal Care (Lippincott Williams & Wilkins)*, *17*(3), E17–E18.	The purpose of this study was to see the decibel levels when infants were places on noninvasive raspatory therapies. The noninvasive raspatory therapies included in this study were: nasal continuous positive airway pressure, nasal cannula, high-flow nasal cannula, noninvasive positive pressure ventilation, and Vapo-therm (VT), RAM Cannula (RAM).	The sample size included 360 infants that was split into 12 groups of 30	The intervention used in this study is noninvasive raspatory therapies and if they can reduce decibel levels.	Key findings include that higher flow therapies produced higher decibel levels. This study suggests the need to reduce air leaks as a form of reducing decibel levels for the infants needing these therapies.	Yes, using noninvasive raspatory therapies reduces decibel levels but they levels are still over the recommende d amount.	This study was just focused on the therapy itself and did not pertain to this question.
Brandon, D. H., Ryan, D. J., & Barnes, A. H.	This is a quasi-experimental	This took place in a pod style	The NICU where the study took	Key findings include the increase of	Newer isolates did help reduce	This study took place over a year

(2008). Effect of environmental changes on noise in the NICU. *Advances in Neonatal Care: Official Journal of the National Association of Neonatal Nurses*, *8*(5 Suppl), S5–S10.	designed study. The purpose of this study is to determent if environment al changes effected decibel levels. This study took place over one 24-hour period each week for 12 months.	layout. There were eight pods comprised of four NICU beds, one pod of three NICU beds. There was also two isolations rooms and two single family rooms. The day of the week and what pod was studies was picked at random.	place made environmenta l changes that year. The environmenta l changes will be seen as the interventions. Changes that occurred over the year include automatic paper towel dispensers, new communicati on system, and the unit started using newer isolates.	decibel levels after automatic paper towel dispensers were installed. There was also an increase of decibels after the new communicati on system was implemented. The new isolates reduced decibel levels internally.	decibel levels, but the other two intervention s listed in this study increased decibel levels.	and the infants picked to be placed in the study was chosen at random. This study did not answer this question.
Pineda, R., Durant, P., Mathur, A., Inder, T., Wallendorf, M., & Schlaggar, B. L. (2017). Auditory Exposure in the Neonatal Intensive Care Unit: Room Type and Other Predictors. *The Journal of Pediatrics*, *183*, 56–66.	The purpose of this study is to quantify sound exposure. This study also tests to see if private rooms produce less auditory stimuli compared to open bay style NICU. This study was conducted in a NICU that had 38 NICU in an open bay style and 37 Privet rooms. This study obtained sound levels	This study focused on 58 preterm infants over two years.	The interventions tested in this study is open bay versus private rooms.	Key findings include that as postmenstrual age of the mother increased decibel levels decreased. The machine used in this study is able to dececte moments of silence and as postmenstrual age increased there were more moments of silence. Private room were found to have lower decibel levels.	Yes, this intervention seems to be effective in lowering the decibel levels. The average decibel level in the private rooms across gestational age is 58 dB. In an open bay style, the average decibel level across gestational age is 59.58 dB.	This study looked into factors surroundin g NICU stay and one of the factors was maternal illicit drug use. This study comprise of 21(44%) infants that were effected by illicit drug use.

	from inside the NICU beds. Results from the device was over 16 hours.					

References

Abdeyazdan, Z., Ghassemi, S., & Marofi, M. (2014). The effects of earmuff on physiologic and motor responses in premature infants admitted in neonatal intensive care unit. *Iranian Journal Of Nursing And Midwifery Research*, 19(2), 107–112.

Alexander, G. R., de Caunes, F., Hulsey, T. C., Tompkins, M. E., & Allen, M. (1992). Validity of postnatal assessments of gestational age: A comparison of the method of Ballard et al. and early ultrasonography. *American Journal of Obstetrics and Gynecology*, *166*(3), 891–895. https://doi.org/10.1016/0002-9378(92)91357-g

American Academy of Pediatrics. (1997). Noise: A hazard for the fetus and newborn. *Pediatrics, 100*, 724–727.

Best, K., Hughes, I., New, K., & Bogossian, F. (2020). An observational study of sound exposure in a single-room configured neonatal unit (SENSE study). *Journal of Neonatal Nursing*, *26*(6), 344–351.

Brandon, D. H., Ryan, D. J., & Barnes, A. H. (2008). Effect of environmental changes on noise in the NICU. *Advances in Neonatal Care: Official Journal of the National Association of Neonatal Nurses*, *8*(5 Suppl), S5–S10.

Cassidy JW, & Cassidy, J. W. (2009). The effect of decibel level of music stimuli and gender on head circumference and physiological responses of premature infants in the NICU. *Journal of Music Therapy*, *46*(3), 180–190.

DeRienzo, C., Kohler, J., Lada, E. et al. Demonstrating the relationships of length of stay, cost and clinical outcomes in a simulated NICU. *Journal Perinatol 36*, 1128–1131 (2016). https://doi.org/10.1038/jp.2016.128

Goldstein, J., Laliberte, A., & Keszler, M. (2019). Ambient Noise Production by High-Frequency Neonatal Ventilators. *The Journal of Pediatrics*, *204*, 157–161.

Goodman DC, Little GA, Harrison WN, Moen A, Mowitz ME, Ganduglia Cazaban C, Bronner KK and Doherty JR (Eds.). The Dartmouth Atlas of Neonatal Intensive Care. Lebanon, NH: The Dartmouth Institute of Health Policy & Clinical Practice, Geisel School of Medicine at Dartmouth, 2019.

Graven, S. N., & Browne, J. V. (2008). Auditory development in the fetus and infant. *Newborn and Infant Nursing Reviews*, *8*(4), 187–193. https://doi.org/10.1053/j.nainr.2008.10.010

Grisham, L. M., Stephen, M. M., Coykendall, M. R., Kane, M. F., Maurer, J. A., Bader, M. Y. M. (2019). Eat, Sleep, Console Approach, *Advances in Neonatal Care*: April 2019 - Volume 19 - Issue 2 - p 138-144 doi: 10.1097/ANC.0000000000000581

Matook, S., Sullivan, M., Salisbury, A., Miller, R., & Lester, B. (2010). Variations of NICU Sound by Location and Time of Day. *Neonatal Network*, *29*(2), 87–95. https://doi.org/10.1891/0730-0832.29.2.87

Milette, I. (2010). Decreasing noise level in our NICU: The impact of a noise awareness educational program. *Advances in Neonatal Care: Official Journal of the National Association of Neonatal Nurses*, *10*(6), 343–351.

Newnam, K. M. (2017). Noninvasive Respiratory Therapy and Neonatal Exposure to Sound...12th Annual National Association of Neonatal Nurses (NANN) Research Summit; March 28 - 30, 2017; Scottsdale, Arizona. *Advances in Neonatal Care (Lippincott Williams & Wilkins)*, *17*(3), E17–E18.

Pineda, R., Durant, P., Mathur, A., Inder, T., Wallendorf, M., & Schlaggar, B. L. (2017). Auditory Exposure in the Neonatal Intensive Care Unit: Room Type and Other Predictors. *The Journal of Pediatrics*, *183*, 56–66.

Seri, I., Evans, J. Limits of viability: definition of the gray zone. *J Perinatol* 28, S4–S8 (2008). https://doi.org/10.1038/jp.2008.42

Ramm, K., Mannix, T., Parry, Y., & Gaffney, M. P. C. (2017). A Comparison of Sound Levels in Open Plan Versus Pods in a Neonatal Intensive Care Unit. *HERD, 10*(3), 30-39.

Zhang GQ, Shao XM, Lu CM, et al. [Neurodevelopmental outcome of preterm infants discharged from NICU at 1 year of age and the effects of intervention compliance on neurodevelopmental outcome]. Zhongguo Dang dai er ke za zhi. *Chinese Journal of Contemporary Pediatrics*. 2007 Jun;9(3):193-197.