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THE EFFECTS OF MUSIC THERAPY AND ITS IMPACT ON SOUND LEVELS IN THE NEONATAL INTENSIVE CARE UNIT

THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master in Music Therapy in the
College of Fine Arts
at the University of Kentucky

By

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Lexington, Kentucky

Director: Dr. Lori Gooding, Director of Music Therapy

Lexington, Kentucky

2015

ABSTRACT OF THESIS

THE EFFECTS OF MUSIC THERAPY AND ITS IMPACT ON SOUND LEVELS IN THE NEONATAL INTENSIVE CARE UNIT

Sound levels in the neonatal intensive care unit often exceed the recommended level of 45 dBA. Various sounds contribute to the extraneous noise that envelops this fragile environment. Increase in noise and high levels of sound can be detrimental to the health of premature infants, which can cause both short and long-term developmental delays and negative physiologic responses. Music therapy interventions in the NICU have addressed numerous needs of this population, with a positive effect on development, physiologic responses, and hospital stay. The purpose of this study was to investigate the effect of music therapy on decreasing the sound levels in the NICU.

Two different pods in a 66-bed NICU were used to measure sound levels for four consecutive days, alternating between days of baseline and music therapy intervention. A dosimeter was used to collect data, which was later analyzed to determine L_{min}, and L_{max}, and Leq. Results indicated an overall decrease in the sound levels average when music therapy intervention was present. Future studies should use multiple settings and collect data for an extended amount of time to further examine the sound levels of the NICU environment and any additional effects music therapy can have.

KEYWORDS: Music Therapy, Decibel Levels, NICU, Premature Infants, Noise

Sarah Lindsey Timmons

July 10, 2015

THE EFFECTS OF MUSIC THERAPY AND ITS IMPACT ON SOUND LEVELS IN THE NEONATAL INTENSIVE CARE UNIT

By

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_______July 10, 2015_______
Date

To my three wonderful parents

And my dearest friend, Tim,

For the endless love and support you have given me,

I am forever grateful.

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CHAPTER ONE

INTRODUCTION

According to the American Academy of Pediatrics (AAP), sound levels in the Neonatal Intensive Care Unit (NICU) should be lower than 45 dB (Almadhoob & Ohlsson, 2015). Research suggests, however, that infants in neonatal intensive care units are often subjected to disturbing, irregular sounds of high intensity that are louder than most home or office environments. In fact, sound levels in NICUs have been found to be as high as 120 dB (Raoof & Ohlsson, 2013). There are numerous factors that contribute to a noisy NICU; research suggests that (a) monitors/alarms, (b) performing invasive procedures, (c) presence of family, (d) nurses and doctors giving report during rounds, and (e) ringing phones are all contributing factors to NICU noise levels (Darcy, Hancock, & Ware, 2008). Elevated sound levels can lead to numerous health risks that may be detrimental to an infant such as "disrupting normal sleep patterns essential to central nervous system (CNS) development, apnea episodes, bradycardia, sudden fluctuations in blood pressure and oxygen saturation, cochlear damage, and developmental delays" (Krueger, Wall, Parker, & Nealis, 2005, p. 33). Krueger, Wall, Parker, & Nealis (2005) go on to state that "sound maintained higher than 60 dB have been associated with potentiating the ototoxic effects of drugs" (p. 33).

Research has suggested numerous ways to reduce excessive noise in the NICU to increase compliance with the AAP's sound level standards. One of the first steps suggested for improving sound levels has been to implement educational programs that will promote staff awareness (Brandon, Ryan, & Barnes, 2007). Other suggestions have included (a) quicker response time to alarms, (b) moving social calls and patient reporting to an area outside of the unit, (c) using lights rather than ringers on phones, and (d) getting rid of speakers to make announcements (Brandon, Ryan, and Barnes, 2007; Krueger, Wall, Parker, & Nealis, 2005).

Music has also been used in the NICU setting to positively impact the sound environment. For example, recorded music has been used to decrease exposure to unpleasant auditory stimuli (Keith, Russell, & Weaver, 2009). Likewise, live music therapy has also been employed to minimize environmental stress in the NICU (Hodges & Wilson, 2010.) Music therapy in the NICU has been shown to produce many positive and beneficial effects for premature infants such as parental bonding, shorter hospital stays, weight gain, reducing stress, increasing oxygen levels, and enhancing developmental growth (Standley, 2012). Research has even shown that music can be beneficial for very low birthweight infants (Cassidy & Standley, 1995). While much is known about the effects of recorded music and live music therapy on infant states, little evidence exists about the impact of music interventions on sound levels themselves.

Operational Definitions

The following operational definitions are provided to define for the reader concepts addressed in this study:

Apnea: is a temporary suspension of breathing.

Bradycardia: is a slower than normal heart rate.

Decibel: or dB, is the unit used to measure the intensity of sound.

dBA: is A-weighted sound levels adjusted to attempt to take into account the sensitivity of the human ear to different frequencies of sound.

Dosimeter: is an instrument that is able to measure the decibel levels of auditory stimulation in the environment.

Environmental Noise: is all ambient noise that is uncontrolled and in the background of the NICU environment.

L_{10}: is the sound level exceeded 10 percent of the time.

Leq: is the equivalent continuous sound level achieved during that period.

L_{max}: is maximum decibel level achieved.

L_{min}: is minimum decibel level achieved.

Purpose

The purpose of this study was to determine the effect of music therapy interventions on sound levels in a NICU. More specifically, the following research questions were addressed:

1. What are the NICU sound levels with and without music therapy present?
2. Does live music therapy intervention decrease sound levels in the NICU?

CHAPTER TWO:

LITERATURE REVIEW

NICU Environment

Although every NICU may differ in design and physical aesthetics, standards and guidelines have been put in place to ensure each patient's safety and care. The American Academy of Pediatrics (AAP) and American College of Obstetricians and Gynecologists have provided standards in their edition of *Guidelines of Perinatal Care* (AAP Committee on Fetus and Newborn and ACOG Committee on Obstetric Practice, 2012). The American Institute of Architects has also published guidelines for hospital construction and design, including neonatal intensive care units (NICU) (White, Smith, & Shepley, 2013). In regards to NICU design, White, Smith, & Shepley (2013) stated that design should be:

> driven by systematically developed program goals and objectives that define the purpose of the unit, service provision, space utilization, projected bed space demand, staff requirements, and other basic information related to the mission of the unit. Design strategies shall address the medical, developmental, educational, emotional, and social needs of infants, families, and staff. This allows flexibility and creativity to achieve the stated goals. (p. S6)

Though each NICU environment is unique, they all require various equipment as well as adequate staffing to properly care for patients. There are different NICU levels (I-III) that indicate the level of medical care each particular NICU is equipped to handle. Darcy, Hancock, and Ware (2008) stated that, "sound levels have been found to be higher in level III NICUs in comparison to level II NICUs, implying the excess noise is associated with increased acuity, level of care, and equipment utilized within this environment" (p. 166).

Several NICUs have taken the previously mentioned standards for NICU design and implemented them in new state of the art facilities. Even with alterations in design, it hasn't always been enough to adequately adhere to current sound level recommendations. For example, Byers, Waugh, and Lowman (2006) discovered that even after a NICU renovation was completed and additional staff training occurred, sound measurements still exceeded recommended levels.

Contributions to Sound Levels

The materials used to construct a NICU and the overall physical layout contribute significantly to the sound levels in the NICU environment. Walls, ceilings, and floors all act as a reverberating soundboard when environmental acoustics aren't considered. Hard, stiff surfaces like glass, tile over concrete, plastic, and plaster walls reflect and bounce sound waves throughout the room (Philbin, 2004). In contrast, soft, thick surfaces absorb the sound and subdue it from reverberating throughout the room. (Evans & Philbin, 2000; Philbin, 2004). Philbin (2004) stated that wall barriers, even partial barriers, between infant beds can also reduce sound travel throughout the room, thus decreasing the level of sound.

The recommended standards for the NICU environment call for infant beds to be within 20 feet of sinks (no closer than three feet), and a require a minimum of eight feet between infant beds to help minimize traffic flow and consequential noise that occurs (White, Smith, & Shepley, 2013). In regards to traffic flow, White, Smith, & Shepley also concluded that NICU environments needed to be separate from the rest of the hospital. In other words, the authors suggested that staff and visitors should not pass through the NICU to get to other services, thereby lowering the amount of personnel allowed in this environment. Traffic flow and extraneous noise in hallways within the NICU can also affect the sound levels, even if they are away from the room in question. A study by Brandon, Ryan & Barnes (2007), found that sound levels were greatest in the NICU during the day versus at night, due to an increase in staff and caregiver activity in the unit and increased use in automatic paper towel dispensers and the communication system (p. S9). It has been suggested that the best solution is closed doors to isolate the sound being produced (Philbin, 2004). If the environmental space is open, even adding sound absorbing materials can help reduce additional noise.

To keep sound levels near the infant lower, Philbin (2004) suggested, "alarm sources, phone ringers, heating, ventilation, and air conditioning (HVAC) registers, staff congregation areas, sinks, and storage should be located as far from the infant's head as possible" (p. 338). These factors all affect background noise, and when they are installed without consideration for the acoustics of the room they can reach sound levels beyond what is recommended. Installation of sound absorptive materials and acoustically reflective surfaces can also cut back on excessive noise, in some cases at levels greater than 25% (Philbin, 2004; White, Smith & Shepley, 2013). In fact, Philbin and Gray (2003) conducted a study showing sound absorbing materials were more effective in lowering sound levels than staff awareness in an open, multiple-bed NICU.

Medical care equipment for infants, though necessary, can also contribute to high sound levels in the NICU environment. IV pumps, incubators, and cardio-respiratory alarms can measure anywhere from 59-86dBA when engaged (Brandon, Ryan, & Barnes, 2007; Thomas & Uran, 2007). Those levels far exceeds the hourly maximum of 45dBA established by the AAP (Wachman & Lahav, 2011) and the overall nighttime limit of 35dB set forth by the EPA and American Academy of Pediatrics Committee on Environmental Health (Bremmer, Byers, & Kiehl, 2003; Johnson, 2003). Incubators and ventilators can even increase sound levels, with the incubator maintaining an internal sound level of 45dB as a result of the motor (Bremmer, Byers, & Kiehl, 2003; Byers, Waugh & Lowman, 2006). However, it should be noted that depending on the noise source, incubators can either dampen or intensify the sound exposed to the infant.

Staff and caregivers have also been found to be major contributors to the sound levels in the NICU. While it is the job of the nursing staff to provide care for their patients and execute medical procedures, unintended extraneous noise can occur. Staff conversation and activity can add 10-20 dB to the sound level alone (Bremmer, Byers &Kiehl, 2003). For instance, "running water, closing incubator portholes, and placing formula bottles on a bedside table can produce sounds up to 75dB" (Brown, 2009, p. 165-166). A study conducted by Brandon, Ryan, and Barnes (2007), looked at sound levels in the NICU before and after automatic paper towel dispensers and a new communication system was installed. Results found that all three sound level variables (Leq, L_{10}, L_{max}) were significantly higher after the installation of both equipments (Brandon, Ryan & Barnes, 2007). Use of automatic sinks, intercoms, and telephones can further contribute to higher levels in the NICU (Evans & Philbin, 2000). Staff and caregiver conversation and rounding on patients can also lead to excessive sound levels ranging anywhere from 50 to >100 dB (Brandon, Ryan & Barnes, 2007; Thomas & Uran, 2007). Byers, Waugh, and Lowman (2006) noted that staff conversation increased sound levels even more than NICU equipment (p. 28).

Impact on Premature Infants

The majority of auditory development occurs in utero, with hearing and cochlear function beginning around 22-24 weeks (Brandon, Ryan & Barnes, 2007). The uterine environment is a dark and warm place that is significantly different than the NICU, a bright and noisy atmosphere (Bremmer, Byers, & Kiehl, 2003). While in utero, the infant is protected by fluid, shielding exposure to low, mid, and high frequencies of sound (Brandon, Ryan & Barnes, 2007). By 26-28 weeks gestational age, the auditory system is mature enough for loud noise to produce physiological changes in heart rate, blood pressure, respiration, and oxygen saturation (Wachman & Lahav, 2011). According to Brandon, Ryan and Barnes (2007) , once the infant is in the NICU environment, it is exposed to harsh ranges of sound that are "continuous, unpredictable, and strong, even by adult standards" (p. S6).

The Central Nervous System (CNS) is one of the final systems to develop in an infant, and when infants are born earlier than anticipated, "normal cortical development of the brain is dependent on specific environmental input" (Bremmer, Byers & Kiehl, 2003, p. 448). Bremmer, Byers, and Kiehl (2003) stated that the immaturity of a premature infant's CNS development can be detrimental to their health, causing "decreased autonomic and self-regulatory abilities to deal with stress because the infant cannot selectively limit or inhibit incoming stimuli and the impact of noxious stimuli on physiological balance" (p. 448). Once infants reach 32 to 34 weeks gestational age, they are more equipped to differentiate between tactile and environmental stimuli and respond appropriately (Bremmer, Byers & Kiehl, 2007).

The NICU environment exposes premature infants to exaggerated auditory stimulation and decreased vestibular stimulation during a time in development when they should be protected in utero with filtered sound and regular vestibular stimulation felt from the mother's movements (Brown, 2009). All aspects of the NICU environment emit sound, contributing to the overall sound levels which can have a negative impact on premature infants. Extraneous noise in the NICU environment is a "major source of stressful stimulation that can agitate the neonate and further complicate medical management" (Johnson, 2003, p. 280). Due to their immaturity, vulnerability and need for intensive care, premature infants respond differently than full term infants to the NICU environment and are more susceptible to noise exposure and the negative effects and potential health risks that accompany it (Bremmer, Byers, & Kiehl, 2003; VandenBerg, 2007). Premature infants also have a harder time coming to a quiet alert state than full term infants and are challenged by the intense and chaotic stimuli in the environment. This results in a limited capability for infants to self-regulate and makes distinctions between different types of sounds and patterns difficult, especially if the background noise is too high. Premature infants are also not as equipped as full term infants to block out environmental stimuli (Brandon, Ryan & Barnes, 2007; Darcy, Hancock, & Ware, 2008; Wachman & Lahav, 2011). For example, loud bursts of sound can cause an exaggerated startle reflex in premature infants than that of full term infants (Bremmer, Byers, & Kiehl, 2003). Due to the adverse effects of excessive noise and loud bursts of sound in the NICU environment, premature infants are susceptible to numerous health risks. Krueger, Wall, Parker, and Nealis (2005) described how extraneous noise disrupts normal sleep patterns and can even mock the ototoxic effects of drugs when sound levels are maintained at >60 dB. Increased sound levels can also mask positive sounds, such as the parent's voice, disrupting opportunities for parent-child bonding (Krueger, Wall, Parker & Nealis, 2005). High levels of sound exposure can be associated with hearing loss, delays in language development, and altered brain development (Brown, 2009; Committee on Environmental Health, 1997; Krueger, Wall, Parker, & Nealis, 2005; VandenBerg, 2007). Physiological responses may also occur when premature infants are experiencing stress from intense sound exposure, further complicating medical management (Johnson, 2003). Physiologic changes in premature infants as a result from high levels of sound include apnea; bradycardia; hypoxia; hypoxemia; and abrupt fluctuations in heart rate, respiratory rate, blood pressure, perfusion, and oxygen saturation (Brandon, Ryan & Barnes, 2007; Bremmer, Byers, Kiehl, 2003; Brown, 2009; Byers, Waugh, Lowman, 2006; Committee on Environmental Health, 1997; Krueger, Wall, Parker, & Nealis, 2005; Wachman & Lahav, 2011).

Hearing Loss. With duration and high levels of sound exposure, long-term effects have been correlated with not only hearing impairments, but also hearing loss from prolonged, uninterrupted exposure to levels higher than 90 dB (Brown, 2009). Premature infants have the highest rate of hearing loss compared to full term infants due to their high level of medical needs and length of stay in the hospital, exposing them to high levels of sound for a long, continuous amount of time. (Wachman & Lahav, 2011).

Sleep Patterns. Sleep plays an integral role in neurological development, and exposure to extraneous sound disrupts this process. Bremmer, Byers, and Kiehl (2003) conducted a study that looked at changes in premature infant's behavioral state. Seventy-eight percent changed their behavioral state in response to noise and care-giving intervention, most of which were from normal sleep to fussy and crying states. Forty-three percent changed their behavior from sleep state to fussy and crying states in response to noise alone (p. 449).

Heart Rate. Fluctuations in heart rate have been noted when premature infants are exposed to abrupt, loud spikes of sound. If stressful noise exposure remains continuous, the initial increase in heart rate (and subsequently respiration rate) will stop, causing the premature infant to become bradycardic and apneic (Bremmer, Byers, & Kiehl, 2003). Comparatively, premature infants have a more limited ability to self-regulate and make distinctions between noises than full term infants, leading to potential health risks.

Blood Pressure. Though neither study was statistically significant, Wachman and Lahav (2011) conducted studies that looked at the correlation between noise exposure and blood pressure levels. The first study exposed infants to thirty seconds of continuous noise, resulting in an increase in both systolic and diastolic blood pressure (p. F306-F307). The second study exposed infants to the then proposed baseline of 50-60dBA over a two hour period. Heavier infants showed a bi-phasic (decrease, than an increase) blood pressure response to sound exposure, while lower birth-weight infants showed a decrease (p. F307).

Respiratory Rate. Auditory stimuli have been described by Wachman and Lahav (2011) as triggering a decreased respiratory rate in all infants. The louder the noise stimuli became, the lower the respiratory rate of the infant. They also discussed another study that measured oxygen saturation and sound levels between infants in an incubator, and infants in an incubator with sound absorbing foam. The group with foam had an average decrease in noise of 3.27 dBA, with oxygenation improving by more than one percent for all infants, and was sustained for ten minutes after foam was removed (Wachman & Lahav, 2011, p. F307). Finally, another study exposed premature infants to abrupt noises measured between 70-75 dBA resulting in an increase in respiratory rate and a decrease in oxygen saturation (Wachman & Lahav, 2011).

Brain Perfusion. Abrupt loud noises (approximately 80dB) in the NICU have been shown to result in hypoxia, hypoxemia, agitation, crying, sensorineural disorganization, decrease of critical brain tissue, and an increase in intracranial pressure (Brown, 2009; Committee on Environmental Health, 1997; Wachman & Lahav, 2011).

High levels of sound exposure, both brief and extended stimulation, can put premature infant's health at risk and experience a negative physiological response. While adults have been determined to have a maximum noise threshold of 80dB without causing damage regardless of duration, the level in neonates has not yet been determined (Milette, 2010). Again, with accordance to AAP, the hourly Leq should be below 45dB, L_{10} not exceeding 50 dB, and peaks of noise should not exceed a 1-second maximum of 65 dB at all times (Almadhoob & Ohlsson, 2015; Milette, 2010). Bremmer, Byers, & Kiehl (2003) state a "3dB decrease in sound levels equates to a decrease in noise of approximately 50% as experienced by infants" (p. 449). Reducing excessive sound in the NICU environment will greatly affect premature infants' outcome.

Reducing Noise Impact in NICU

Johnson (2003) provided five steps to successfully adapt a noise-reducing intervention into the NICU environment:

> 1. Complete an environmental assessment including sources of noise and measures of noise.
> 2. Use the findings of the assessment to guide the development of your protocol.
> 3. The educational component engages the staff in assuring success of the protocol.
> 4. Implement the protocol at the completion of the in-service component.
> 5. Continued intermittent sound level monitoring is the best evaluation progress. (p. 281)

Modifying the environment to reduce extraneous noise requires time, patience, and teamwork (Bremmer, Byers & Kiehl, 2003). It has been stated that attitudes and related behaviors are the greatest challenge to change and accept new program protocol. Initial assessment for baseline and continued assessment after intervention is key to insure success rate and make any modifications to continue to help reduce additional noise in the NICU environment (Johnson, 2003).

Following the guidelines for appropriate sound levels in the NICU environment will "promote sleep, support parent-infant bonding, support neonatal physiologic stability, and reduce potential adverse effects on auditory development of premature infants" (Johnson, 2003, p. 280). Several approaches and studies have been conducted to reduce the sound levels in the NICU environment including… **Physical Alterations.** Changes to the physical design and materials used in the NICU environment can drastically affect the acoustic environment. In most NICUs, White, Smith, and Shepley (2013) describe that the ceiling provides the largest available area for sound absorption (p. S10). Using sound absorptive materials that are thick, soft surfaces will help dampen the decibel levels (Philbin, 2004) on walls, ceilings, and floors and "reduce reverberation" (White, Smith, & Shepley, 2013, p. S13). VandenBerg (2007) stated, "the most successful reduction in sound levels in the NICU takes place when sound absorbing materials are integrated into architectural unit design" (p. 436). White, Smith, and Shepley (2013) suggested placing the airflow at a "low velocity to minimize drafts", which can impact noise levels (p. S8). One study looked at the effects of noise levels on different environmental conditions. They collected data in two different rooms: a room with sound absorbing materials, and a standard control room. The intervention room was 4-6 dB lower than the control room. Incubators in the intervention room were also found to be Leq 4dB in comparison to the standard control room (Byers, Waugh, & Lowman, 2006).

Altering the physical design can be expensive and in some instances, unrealistic. Cheaper modifications can be implemented to help reduce sound levels in the NICU. Covering an incubator with a blanket or quilt that is one-fourth of an inch or greater in thickness can reduce the impact of sound levels by an average of 4.8 dB (Bremmer, Byers & Kiehl, 2003; Brown, 2009; Philbin, 2004). Other possible changes to reduce sound levels in the NICU include: install curtains over windows; place weather stripping along doors and drawer edges; use open shelving; and move nursing stations, telephones, staff congregation areas, and rounds away from patient beds (Bremmer, Byers & Kiehl, 2003; Brown, 2009; Krueger, Wall, Parker, & Nealis, 2005).

Silent Alarms. Many alarms are set to make audible noise to alert nursing staff, which in turn contributes to the overall sound levels in the NICU. Using pagers that vibrate or overhead soft lights (visual alarms) that are connected to equipment and will turn on or flash to gain staff's attention are ways to help reduce the sound impact on the environment (Bremmer, Byers, & Kiehl, 2003; Brown, 2009; Philbin, 2004; White, Smith & Shepley, 2013). The same process can be used for telephone calls, and abolishing loud speakers/intercoms will lower sound levels (Krueger, Wall, Parker & Nealis, 2005). Visible alarms can even be set to produce an audible alarm in 30-60 seconds if no intervention was applied (Bremmer, Byers & Kiehl, 2003). More cost efficient options are: adjust the volume to alarms and telephones; turn off unneeded equipment; respond quickly to alarms and crying infants; and suspend alarms when providing infant care that will cause the equipment to activate (Bremmer, Byers & Kiehl, 2003; Brown, 2009; Byers, Waugh & Lowman, 2006; Philbin, 2004; White, Smith & Shepley, 2013).

Educational Training and Awareness. Educational training, such as workshops, in-service training, and discussions, should be seen as the first step toward promoting awareness and significantly decreasing the sound levels in the NICU (Brandon, Ryan, & Barnes, 2007; Bremmer, Byers, & Kiehl, 2003; Krueger, Wall, Parker, & Nealis, 2005). Educational programs can provide staff with awareness, encourage cooperation, and be more sensitive to their own care giving behaviors (Brown, 2009; Johnson, 2003). Providing literature for family and visitors and placing informational posters can also help provide awareness and reduce excess noise (Brown, 2009; Evans & Philbin, 2000). Brown (2009) described installing a light in the NICU that signals when sound levels are above 60dB, which allows staff to make any modifications needed to the environment. One study described by Krueger, Wall, Parker, and Nealis (2005) found a 5dB decrease in overall sound levels in the NICU after educational programs were put in place. Johnson (2003) saw a 9.26 dB decrease in sound levels one week after implementation of educational training, cutting the perceived loudness in half (Brown, 2009). Another study saw a 10 dB decrease after the implementation of educational programs, where just a decrease of 3 dB equates to a decrease in noise by 50% as experienced by infants (Bremmer, Byers & Kiehl, 2003). Before educational programs were in place, conversation occurred during 62% of the recorded periods. After the intervention, the number of conversations decreased to 14% (Bremmer, Byers & Kiehl, 2003).

Quiet Hour. Implementing a quiet hour into the NICU environment can also help reduce sound levels in the NICU. One study used the last hour of each shift as the quiet hour; restricting all noise produced by visitors, tests, large equipment, and doctor rounds (Bremmer, Byers, & Kiehl, 2003; Brown, 2009; Johnson, 2003). Results showed a significant decrease in sound levels with the control group (no quiet hour) having a Leq of 58.3 dB with a range of 50 to 78 dB, and the quiet hour with a Leq of 52.2 dB and a range of 40-65 dB (Johnson, 2003). Infants also showed less crying and a deeper sleep during the quiet hour implementation, with 84.5% of infants in light or deep sleep compared to 33.9% in the control (Bremmer, Byers &Kiehl, 2003; Brown, 2009). Other suggestions made have included using low lighting in the NICU environment and posting signs that say, “Quiet, Please” or “I am sleeping” to encourage quieter conversation (Brandon, Ryan & Barnes, 2007; Bremmer, Byers & Kiehl, 2003; Johnson, 2003).

Uninterrupted quiet time not only reduced sound levels in the NICU but it can also decrease apnea and bradycardia in premature infants (Bremmer, Byers & Kiehl, 2003).

Music. An early development of music versus environmental sound occurs in utero, where the fetus can begin to make the distinction between the two (Standley, 2012). While the fetus is in the intrauterine environment, it is exposed to "rhythmic, structured, patterned cardiovascular, intestinal, and placental sounds" (Neal, Lindeke, 2008, p. 320), which is similar to music. Schwartz and Ritchie (2004) discuss that the fetus hears their mother's rhythmic heartbeat approximately 26 million times, creating a sense of comfort and security associated with the musical aspects.

The main auditory stimulation infants receive out of utero is environmental noise (Neal & Lindeke, 2008). This is unpredictable, irregular and can at times be overwhelming to the premature infant. Music is organized, rhythmic, and intentional with the ability to soothe and decrease stress in the NICU environment, which can be brought on by excess noise (Schwartz & Ritchie, 2004). Both recorded music and live music therapy have been used to decrease exposure to unpleasant auditory stimuli and minimize environmental stress in the NICU (Hodges & Wilson, 2010; Keith, Russell & Weaver, 2009). Music therapy is an inexpensive, non-invasive approach to help combat sound levels in the NICU. Used by a trained music therapist, music can be applied and used in an evidence-based and therapeutic way. As music and noise differ, music can be used to mask excessive sounds that may be detrimental to sound levels in the NICU environment.

Music Therapy in NICU

Use of music and music therapy in the NICU has shown positive effects in premature infants on: pacification; parent bonding; weight gain; stimulation; shortened hospital stay; sleep; reducing stress; development; and physiological states (Standley, 2012). Another benefit music can provide is in its relationship with noise. Though music is sound, music and noise act very different from each other and are processed differently in the brain (Gooding, 2010, p. 212). As Gooding (2010) described it, “noise is irregular and unanticipated, which creates stress. Music is organized and predictable, functioning to soothe” (p.212).

Music therapy in the NICU environment uses music to “enhance developmental care and promote maturation” (Standley, 2012, p. 311) in premature infants. Music used in the NICU should be simple in nature, with slow and easy rhythms, fluid and lyrical melodies, simple harmonies, and soft dynamics (Schwartz & Ritchie, 2004). Music volume should adhere to AAP standards. Cassidy and Ditty (1998) stated in order for music to mask extraneous, stressful sounds from the NICU environment, music should be played at slightly higher decibel levels. Music therapy intervention is provided in short intervals, with sessions lasting from approximately 10-20 minutes. Signs for overstimulation are continuously monitored and include: hiccoughs, tongue protrusion, arched back, red face, grimace, hand halt, and finger splay (Standley, 1998). Music therapy intervention is chosen depending on the premature infant’s gestational age, level of medical care needed, and developmental milestone achieved. There are three different levels of development that premature infants are categorized in: Survival/Pacification, Cautious Stimulation, and Interactive Learning (Standley, 2010).

Survival/Pacification. The age infants are in Survival/Pacification range anywhere from 23-30 weeks gestational age. These infants are very medically fragile, and stimuli are reduced as much as possible with: low lighting; decreased sound levels; and very limited, if any, tactile stimulation (Standley, 2010). Music therapy interventions include live music listening without touch, recorded lullabies, and the mother's voice (Gooding, 2010). Music listening can be live or recorded, but research suggests that live music is more effective because it allows the music therapist to continuously monitor the premature infant for any signs of overstimulation and behavioral or physiological change, and adjust interventions when needed (Arnon et al., 2006; Keith, Russell, & Weaver, 2009). Research reported that increased oxygen saturation, decreased heart rate, and increased quiet alert states occurred as a result of premature infant's exposure to recorded music (Hodges & Wilson, 2010). Caine (1991) also noted an increase in non-stress behaviors, lower initial weight loss, increased caloric intake, weight gain, and shortened hospital stay when infants were exposed to recorded music. Other research noted premature infants went home, on average, two days sooner when they listened to a recording of their mother's singing than the control group (Cevasco, 2008).

Cautious Stimulation. The premature infant moves to Cautious Stimulation once they weigh approximately 2.5 pounds and also show signs of neurological development (Standley, 2010). The objectives at this stage are to increase their tolerance to stimulation (Gooding, 2010). Monitoring the premature infant for signs of overstimulation is essential. Once a sign of overstimulation occurs, all stimuli must stop for approximately 15 seconds before beginning again (Standley, 2010). Music therapy interventions include music combined with kangaroo care (skin-to-skin contact with parent) and multimodal stimulation. Though it increases stimulation, kangaroo care also provides the opportunity for parental bonding. Research also suggests it can improve physiological and behavioral states, as well as decreasing maternal anxiety (Hodges & Wilson, 2010).

Multimodal stimulation is an expansion on auditory, tactile, visual, and vestibular (ATVV) stimulation. All five stimuli are layered together, slowly introducing one stimulus at a time. Signs for overstimulation are again carefully monitored, with intervention ceasing when overstimulation occurs. Standley (1998) conducted a study in which multimodal stimulation increased tolerance to stimulation for both genders, but more so in females (Standley, 1998). It also shortened hospital stay, with male infants leaving 1.5 days sooner (than the control) and female infants 11.9 days sooner (Standley, 1998).

These music therapy interventions not only help with increasing tolerance to stimulation, but also negative effects of extended hospitalization and neurological development.

Interactive Learning. Premature infants are usually at least 32 weeks gestation age during this stage (Standley, 2010). Many premature infants have had prolonged exposure to the NICU environment with additional medical needs, potentially leading to adverse effects in development (Standley, 2010). With music therapy interventions, inconsolable crying and feeding can be addressed (Gooding, 2010). Keith, Russell, and Weaver (2009), conducted a study looking at the effects of developmentally appropriate music therapy interventions on inconsolable crying. Results indicated that music therapy intervention significantly reduced inconsolable crying with crying lasting approximately

5.5 minutes compared to a little over 23 minutes in the control group (Keith, Russell & Weaver, 2009). Before infants can go home, they must be able to successfully nipple feed (Gooding, 2010). Contingent music has been shown to increase feeding with non-nutritive sucking teaching premature infants the sensations of sucking and feeding (Standley, 2010).

With numerous benefits listed, NICU professionals should be weary of other uses of music not supported in the research including live instrumental performances in the NICU and musical radios (Standley, 2012). Trained music therapists adhere to evidence-based research and stay current with appropriate interventions.

Music Therapy and Sound Levels

As stated above, there are numerous benefits in introducing music therapy to premature infants in the NICU. As Standley (2012) described, "music is an intentional, preferred auditory stimulus with the potential for soothing" (p. 312). Music is different than all other sound and can mask extraneous noise in the NICU environment, alleviating the negative impacts of extraneous noise such as: stress, lack of sleep, poor behavior and physiological states, and startle reflex (Standley, 2012).

Though there is little evidence about music therapy and sound levels in the NICU, research suggests music listening is a beneficial intervention in positively impacting physiological responses and reducing stress resulted from excessive noise by masking aversive auditory stimuli in the NICU environment (Standley, Swedberg, 2011). With the numerous positive impacts of music on the NICU, it's the purpose of this study to examine how music therapy intervention impacts the sound levels in the NICU environment.

CHAPTER THREE

METHODOLOGY

Prior to conducting this research, the University of Kentucky Office of Research Integrity was contacted for IRB (Institutional Review Board) approval. Since this study focused on the acoustic environment and not interaction or intervention with human subjects, IRB review was not needed (See Appendix A). Approval was obtained from NICU staff prior to the onset of the study.

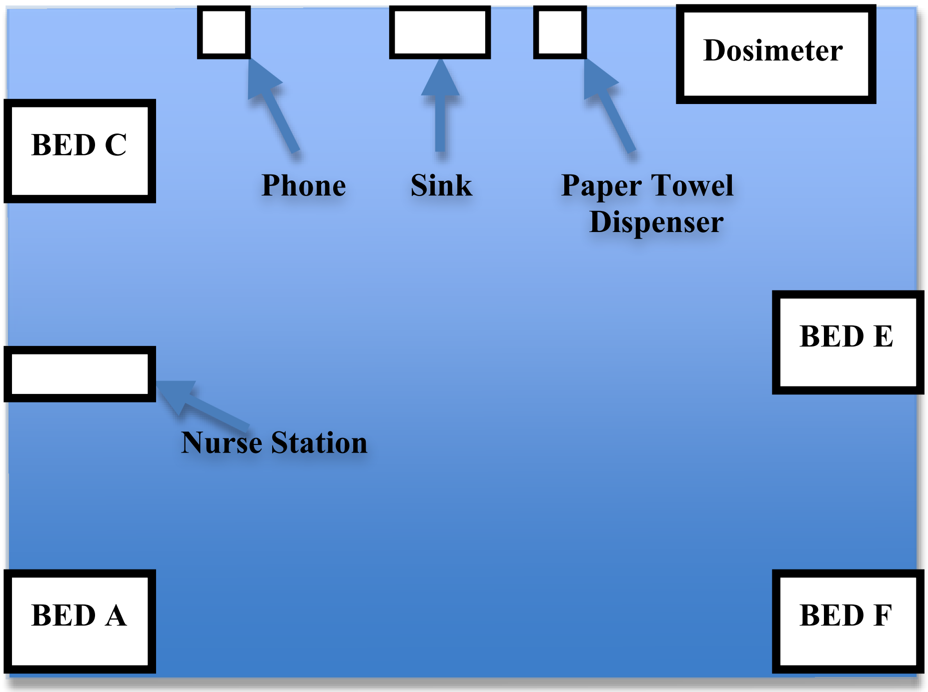
Selecting Locations

Data collection occurred at Kentucky Children's Hospital in a 66-bed neonatal intensive care unit that provides Level III and intermediate care for newborns. The unit is divided into different pods, with 2-6 beds per pod. The principle investigator collaborated with NICU staff to identify specific pods that could be included in data collection without interfering with medical care. Two pods were identified, both of which contained patients who were actively receiving music therapy services from hospital staff. All data collection occurred in those two pods.

Pod A. The first location, "Pod A" was smaller in comparison to other NICU rooms. It had a square layout and space for six patients, though there were only three patients, one nurse, and a nursing station present in this location during the study. Due to the low number of patients and staff, this room required less medical equipment and fewer traffic volume occurrences. Pod A also contained a phone, paper towel dispenser, and a sink. The equipment noted in this room all contributed to the sound levels in this environment and included: heart rate and respiration alarms; incubators; feeding alarms;

oscillating swing; an audible HVAC unit constantly running; and a bottle warmer. The dosimeter was consistently set-up in the same area, as close to the center of the room as possible, without impeding on medical staff's ability to care for patients. Please refer to Figure 3.1 for a diagram of Pod A.

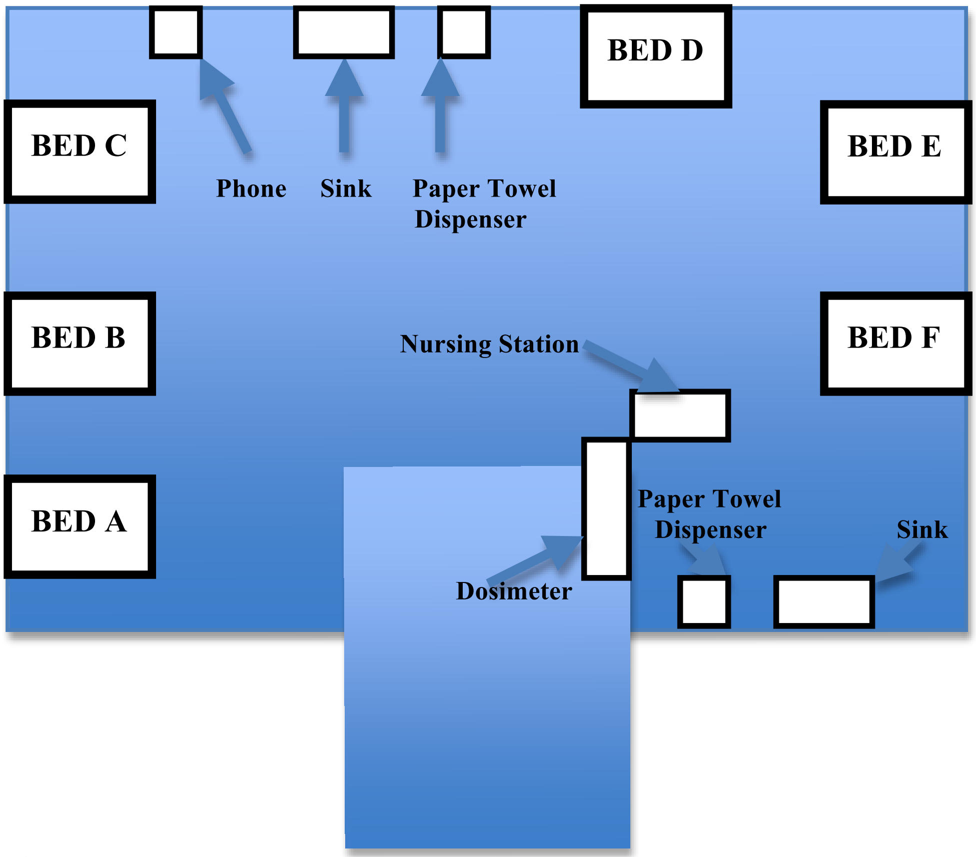
Figure 3.1
Layout of Pod A



**Note: On day one, there was a patient in Bed F and Bed E was Empty. On days two-four, Bed F was empty and there was a patient in Bed E.*

Pod B. The second location, "Pod B", was larger and consisted of an L-shape layout. This room had space for six patients, and at times had up to three nursing stations and three nursing staff. It had a phone, two sinks, an intercom, and two paper towel dispensers. This room was comprised of patients who had a high medical need, and required a lot of care. This increased the amount of staff, nursing stations, and equipment. The following equipment all contributed to the sound levels in this environment and included: x-ray machines; ultrasound machines; heart rate and respiration alarms; feeding alarms; oscillating swing; bottle warmer; and incubators. Since this room had patients with a higher medical need, traffic flow increased in the room with doctors, visitors, and specialists. Due to the high volume of staff and patients, the dosimeter was set up in two different locations during data collection, both centralized in the environment. Please refer to Figure 3.2 for a diagram of Pod B.

Figure 3.2
Layout of Pod B



**Note: On day one, there were two additional nurses and nursing stations in Pod B, where the dosimeter is set-up in the diagram. The dosimeter was then placed in front of the sink by the telephone to best accommodate staff. One day two, Bed C was empty and a nurse and nursing station was added in the space. On days three and four, both nurses and nursing station were in the location of Bed C. All beds (with the exception of Bed C on days two-four) were occupied with patients.*

Materials

A Wensn model WS1361 Digital Sound Level Meter was used to collect data. The instrument was plugged into a computer, allowing the dosimeter to record the decibel levels in the environment. The dosimeter was placed on a tripod on the edge of a table, closest to the center of the room. The measuring range was 30~130dBA or 35~130dBC, with an accuracy of ± 1.5 dB and time weighting of fast or slow. For the purposes of this study, A-weighting was used for general sound level measurements with time weight on slow to record the average level of fluctuating noise.

Procedure

This study used a single subject reversal design (ABAB), with data collection alternating between baseline (A) and music therapy intervention (B). One female music therapist and one male music therapy intern provided services during this study. They sang culturally and developmentally appropriate songs with various music therapy intervention used such as infant-directed singing, singing A cappella while doing multimodal stimulation, and singing with light finger picking guitar accompaniment. Data collection occurred in two separate pods, with decibel levels measured in each location for four consecutive days for a total of 8 days (4 in Pod A and 4 in Pod B). All measurements occurred in the mornings from 9 to 11am. This time slot was chosen because it worked well with staff and the collaboration with music therapy, while it accommodated cluster care/care times of the patients who received music therapy services. This time was also chosen because rounds occurred during this period, which made this time slot one of the louder and busier parts of the day. The researcher sat with the dosimeter for the full duration to monitor the sound levels. When high levels of sound were measured by the dosimeter, the researcher recorded what was occurring in the environment. The researcher also noted the times that music therapy intervention took place to later compare to baseline data. Data on specific music therapy interventions used were also collected. The dosimeter automatically recorded the average decibel level (dBA) per second in the environment. After the recording was complete, the data was automatically put into a graph, showing: a) average, b) minimum, and c) maximum level achieved.

CHAPTER FOUR

RESULTS

This study occurred in two different pods, Pod A and Pod B, at the Kentucky Children's Hospital neonatal intensive care unit. Each pod varied in size and amount of staff stationed in pod, dependent on patient's level of care needed. Both pods had 3-6 beds, and contained patients that were actively receiving music therapy services from hospital music therapy staff. Data collection was taken over the course of four consecutive days occurring at the same time, alternating between baseline and music therapy intervention.

Pod A

Data collected each morning for two hours from 9am-11am, was put into Excel to determine the specific mean, minimum, and maximum decibel level that also corresponded to the time in which it occurred. The dosimeter that collected the data measured dBA every second. Table 4.1 shows the decibel readings taken during the data collection period in Pod A. When comparing baseline to music therapy intervention, the days in which music therapy occurred had a consistently lower mean, minimum, and maximum decibel reading.

Table 4.1
Pod A Decibel Readings

	M	Max.	Min.
Day 1 (Baseline)	59.92dBA	79.4dBA	55.9dBA
Day 2 (Music Therapy)	59.05dBA	77.8dBA	55.3dBA
Day 3 (Baseline)	57.3dBA	77.2dBA	53.3dBA
Day 4 (Music Therapy)	56.2dBA	69dBA	53dBA

Figure 4.1 shows the overall sound level averages within Pod A, comparing baseline to music therapy intervention day.

Figure 4.1
Pod A Daily dBA Mean

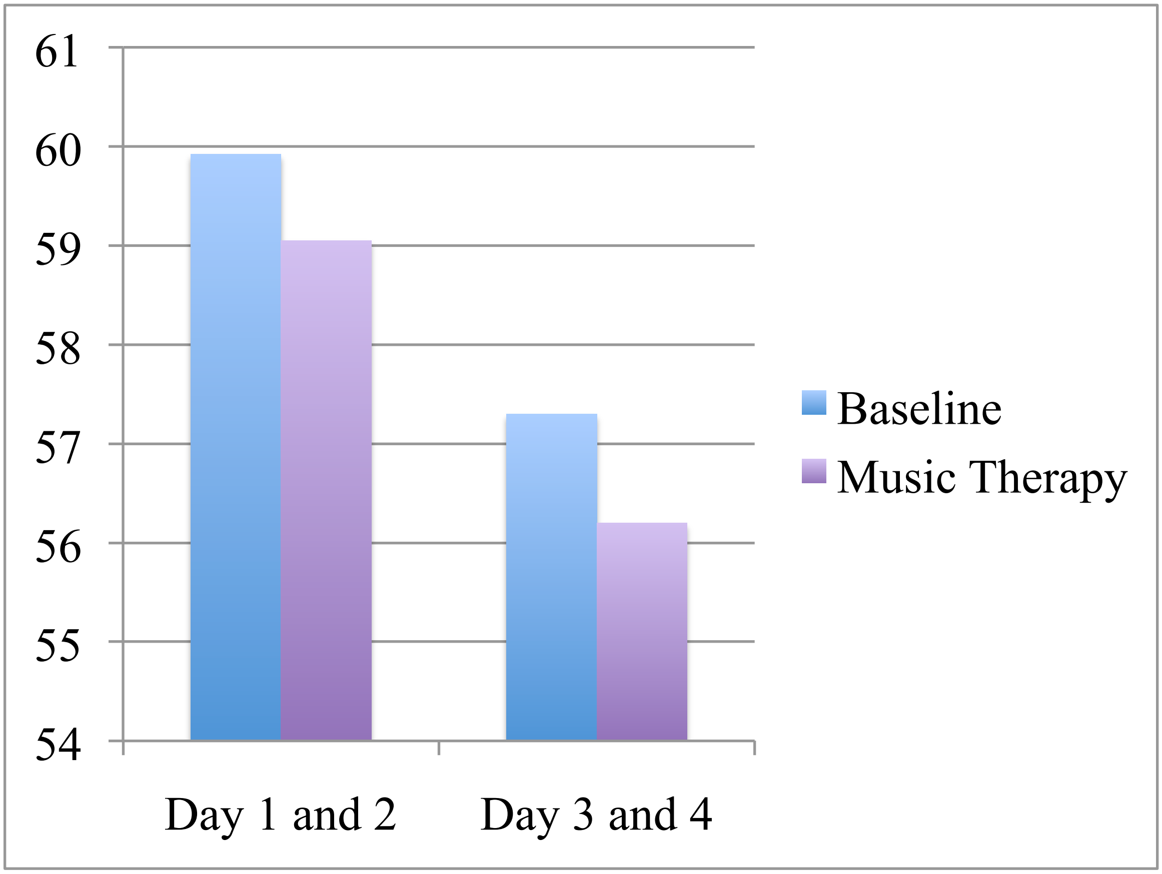
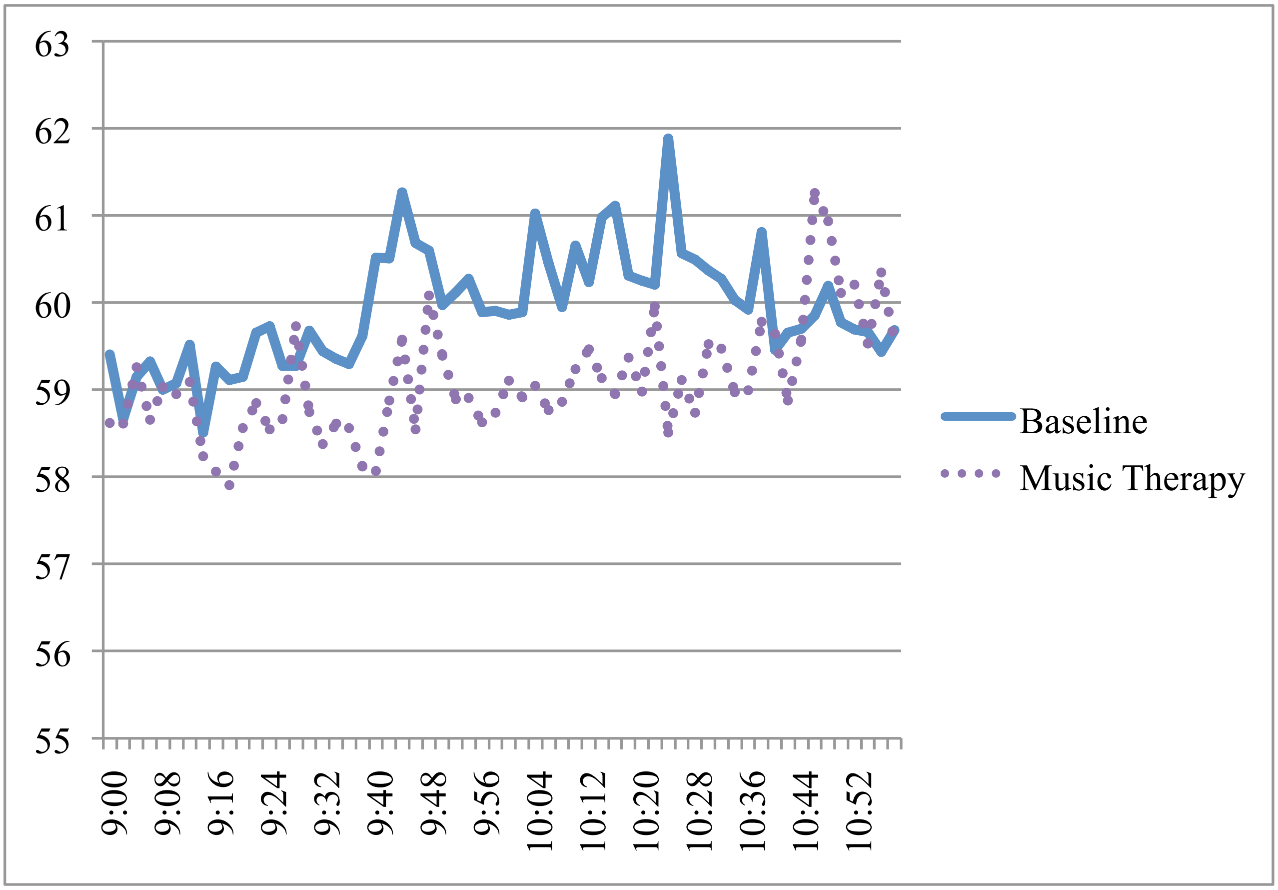


Figure 4.2 and 4.3 illustrate the average sound levels measured in two-minute increments from 9-11AM that occurred in Pod A, comparing baseline to intervention day.

Figure 4.2

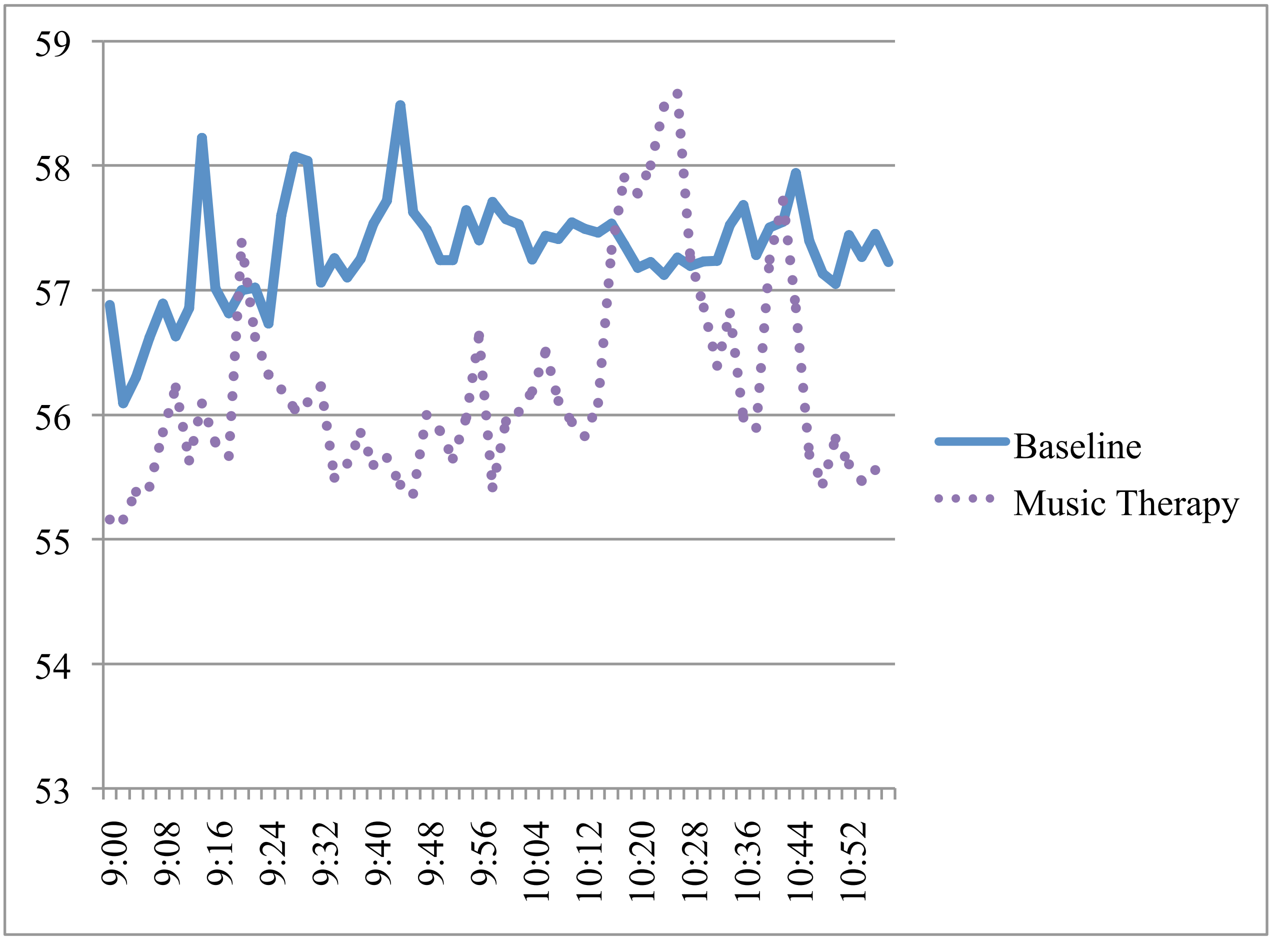
Comparative Graph of dBA Pod A Baseline Day 1 and Intervention Day 2.



Note. Due to space constraints, the x-axis shows times in increments of eight, though data reflects averages of every two minutes.

Figure 4.3

Comparative Graph of dBA Pod A Baseline Day 3 and Intervention Day 4.



Note. Due to space constraints, the x-axis shows times in increments of eight, though data reflects averages of every two minutes.

Data were also tracked in relation to music therapy services. The time range of intervention services were compared to the same time frame on baseline days to see the impact that occurred. Mean, minimum, and maximum decibel readings were taken and consistently both the mean and the minimum during music therapy services were lower than the baseline. Each music therapy service and the correlated times for the baseline are found in Table 4.2.

Table 4.2

Pod A Intervention Readings and Comparative Findings

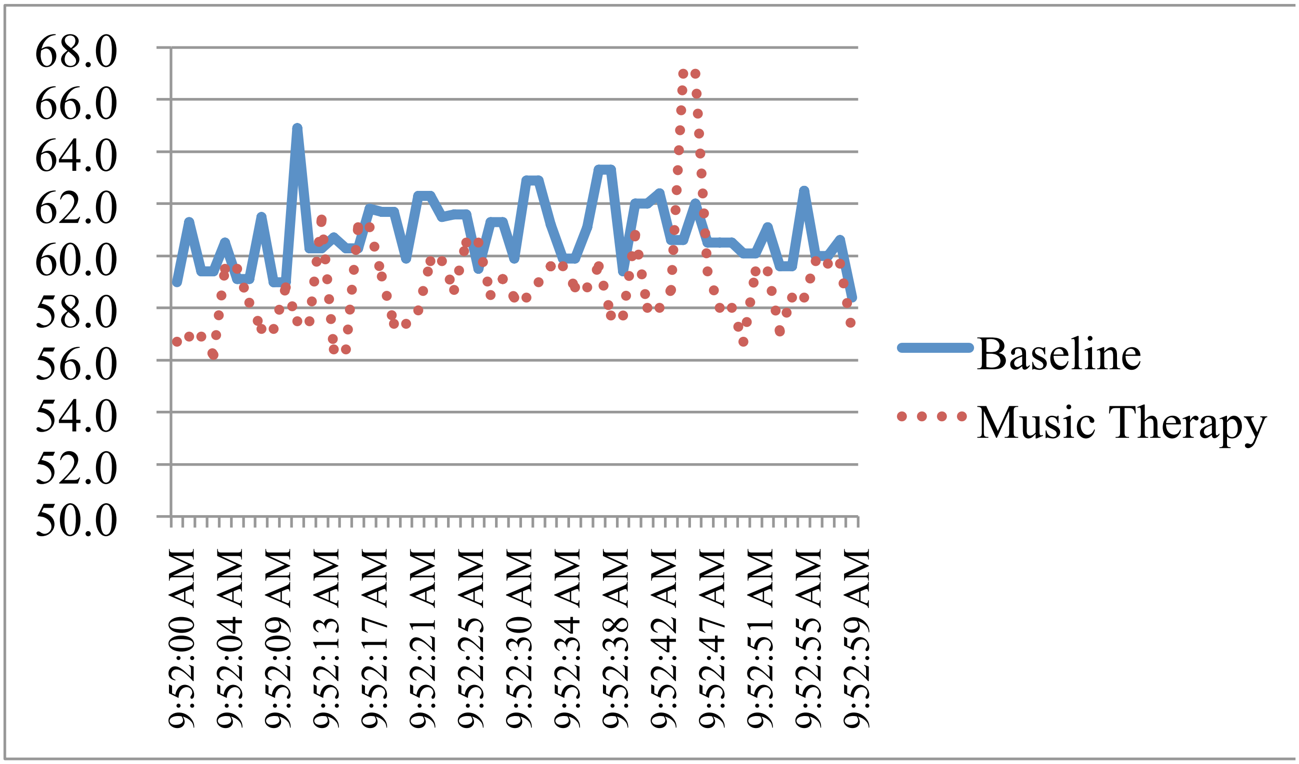
	Time	Intervention Duration	M	Max.	Min.	Number of Staff Present	Number of Patients Present	Did Ext. Noise occur?**
Day 1 (Baseline)						2	3	Yes
Session 1*	9:52	1 minute	60.8dBA	64.9dBA	58.3dBA			
Session 2	10:04	20 minutes	60.4dBA	73.4dBA	56.8dBA			
Session 3	10:34	9 minutes	60.2dBA	64.5dBA	57.6dBA			
Day 2 (Music Therapy)						2	3	Yes
Session 1*	9:52	1 minute	58.87dBA	67dBA	56.2dBA			
Session 2	10:04	20 minutes	59.08dBA	65.5dBA	56.1dBA			
Session 3	10:34	9 minutes	59.15dBA	65.6dBA	56dBA			
Day 3 (Baseline)						2	3	Yes
Session 4	9:25	10 minutes	57.42dBA	66.4dBA	54.7dBA			
Session 5	9:38	6 minutes	57.17dBA	59.8dBA	54.9dBA			
Day 4 (Music Therapy)						2	3	Yes
Session 4	9:25	10 minutes	56.45dBA	62.1dBA	53.7dBA			
Session 5	9:38	6 minutes	55.78dBA	61.2dBA	53dBA			

Note. Investigator was present during all sessions and was included in staff numbers.
**It should be noted that Session 1 on Day 1 and 2 only lasted for one minute. This may not be sufficient time to obtain an accurate reading.*
***Extraneous noise includes spikes of sound and anything that contributes to the noise in the environment. A more descriptive explanation can be found after Figure 4.14.*

In total, Pod A received five music therapy sessions over the course of the study. Each session were graphed for comparison between music therapy services and control and can be found in Figure 4.4-4.8.

Figure 4.4

Pod A Session 1 dBA from 9:52



Note. Due to space constraints, the x-axis shows times in increments of 4 seconds, though data reflects every second.

Figure 4.5

Pod A Session 2 dBA from 10:04-10:24

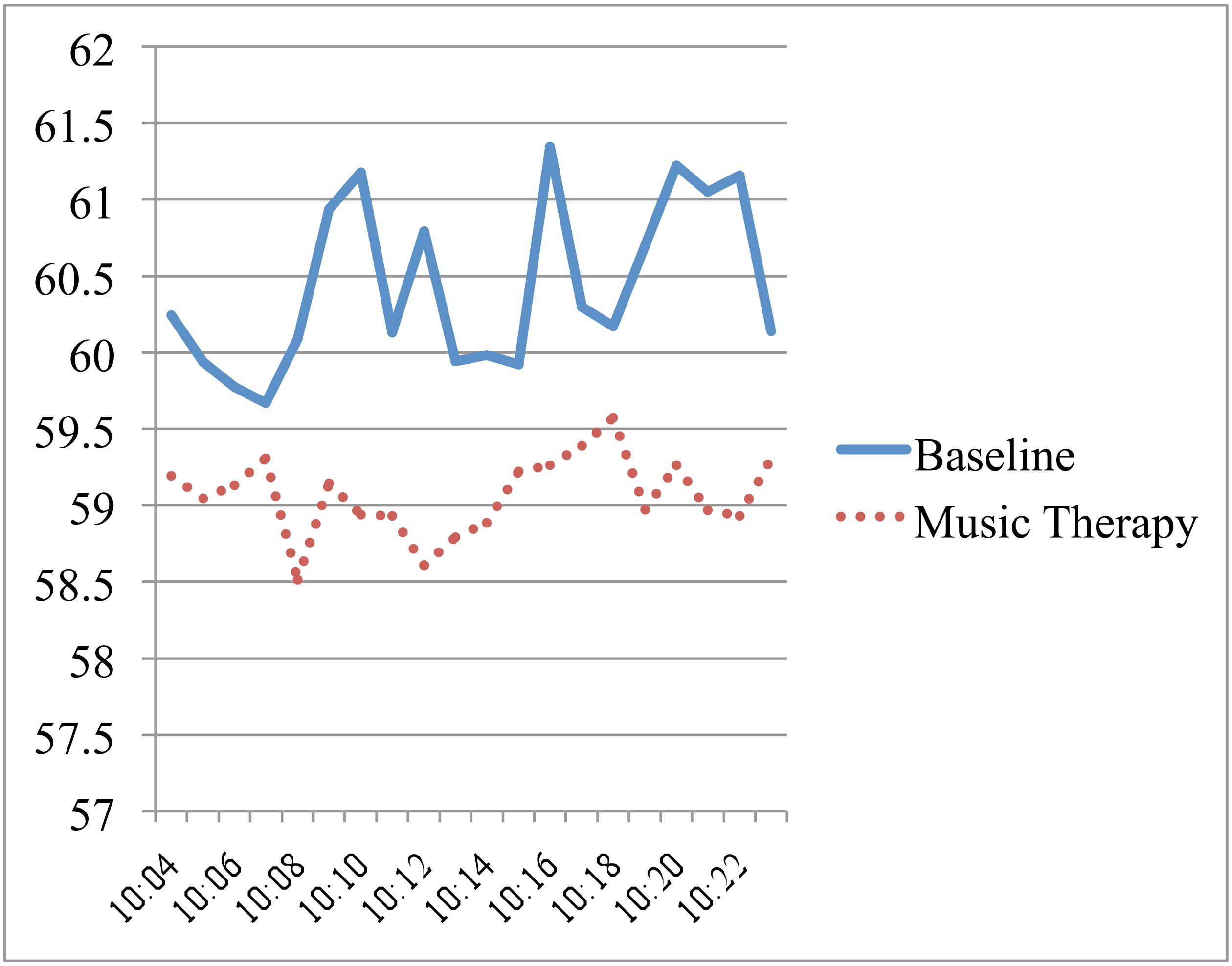


Figure 4.6

Pod A Session 3 dBA from 10:34-10:43

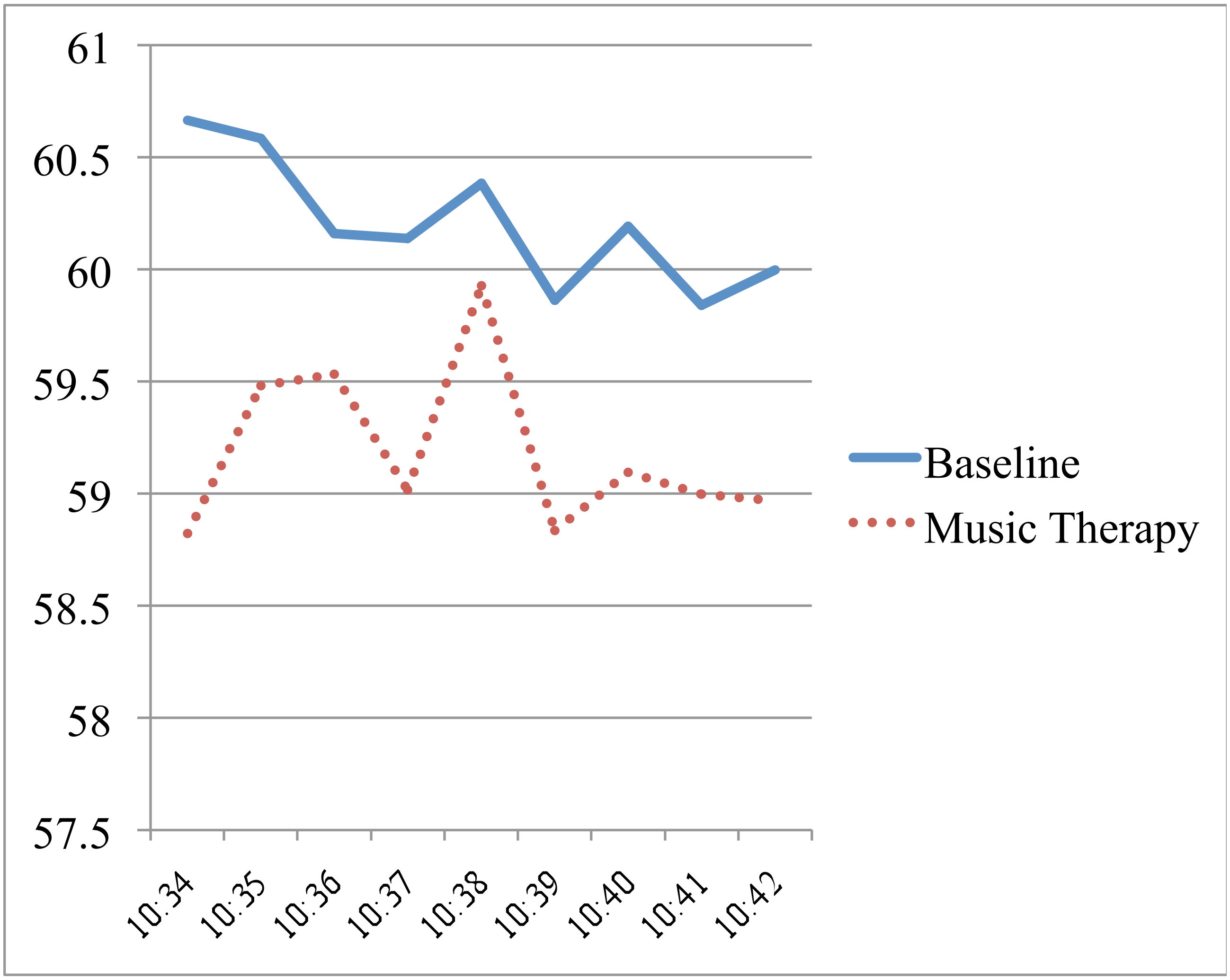


Figure 4.7

Pod A Session 4 dBA from 9:25-9:35

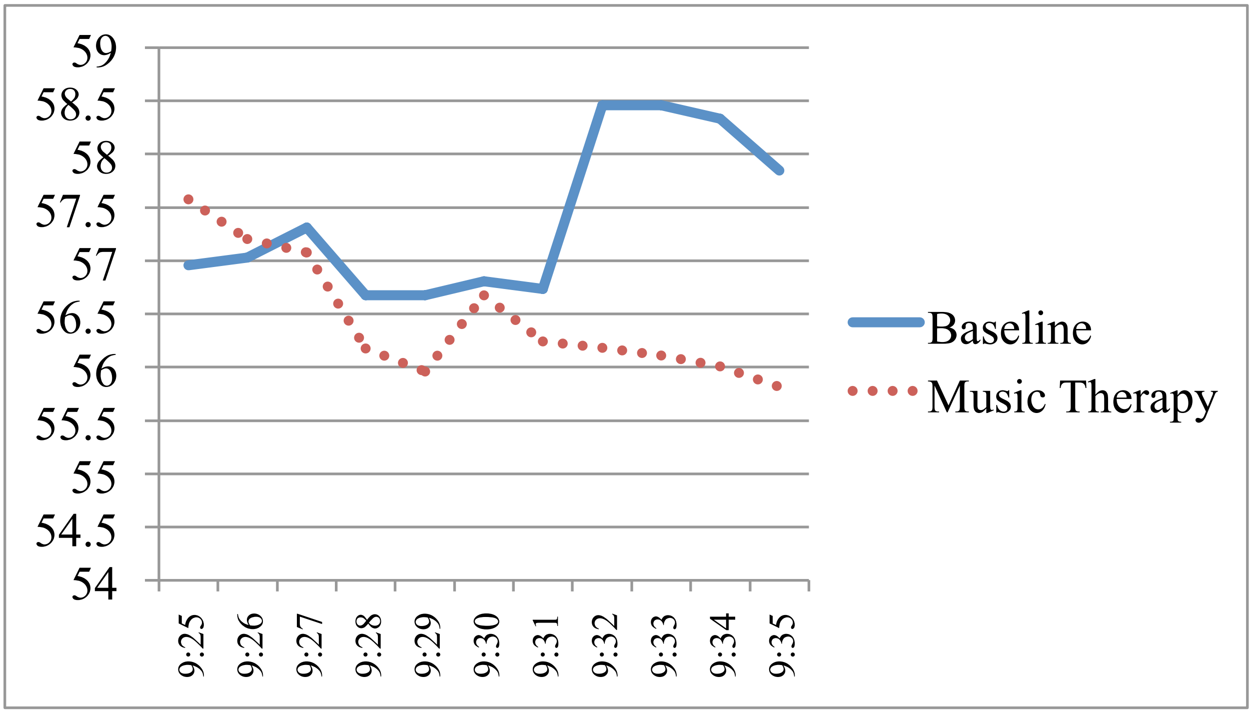
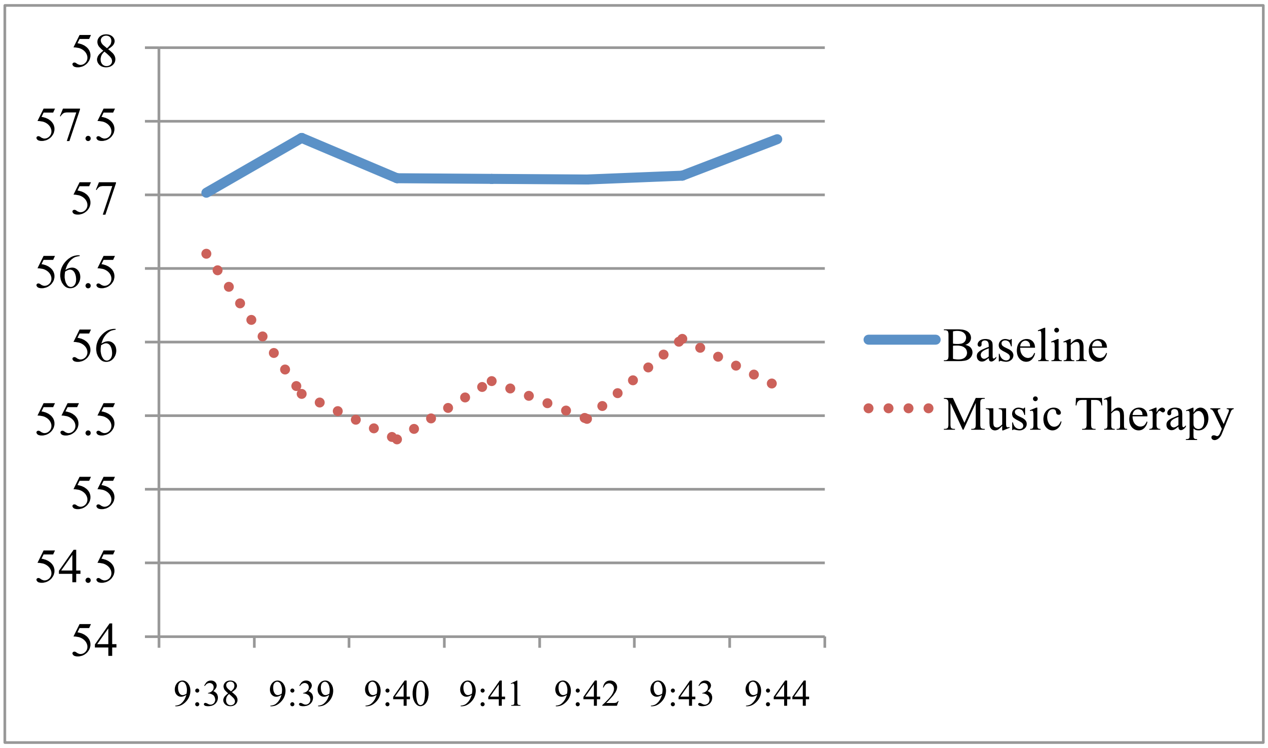


Figure 4.8
Pod A Session 5 dBA from 9:38-9:44



Pod B

Like Pod A, data collection occurred for two hours every morning from 9am-11am. Unlike the first Pod [A], the results varied in comparing maximum and minimum decibel levels between baseline and intervention. The daily mean, maximum, and minimum decibel readings for pod B can be found in Table 4.3.

The mean was consistently lower on intervention days in comparison to baseline.

Table 4.3
Pod B Decibel Readings

	M	Max.	Min.
Day 1 (Baseline)	56.64dBA	77.6dBA	48.9dBA
Day 2 (Music Therapy)	55.56dBA	78.3dBA	50.2dBA
Day 3 (Baseline)	55.15dBA	70.1dBA	49.9dBA
Day 4 (Music Therapy)	54.99dBA	77dBA	49.5dBA

Figure 4.9 shows the overall sound level averages within Pod B, comparing baseline to music therapy intervention day.

Figure 4.9
Pod B Daily dBA Mean

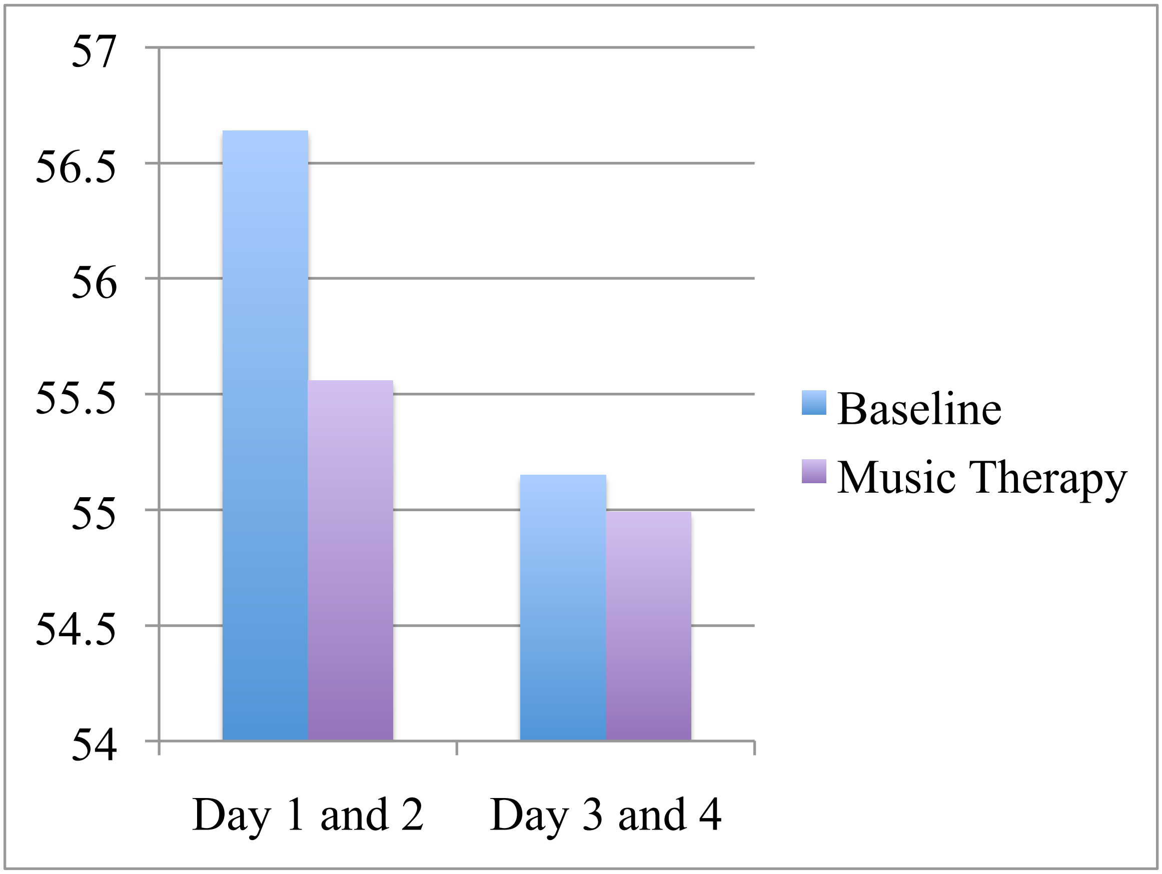
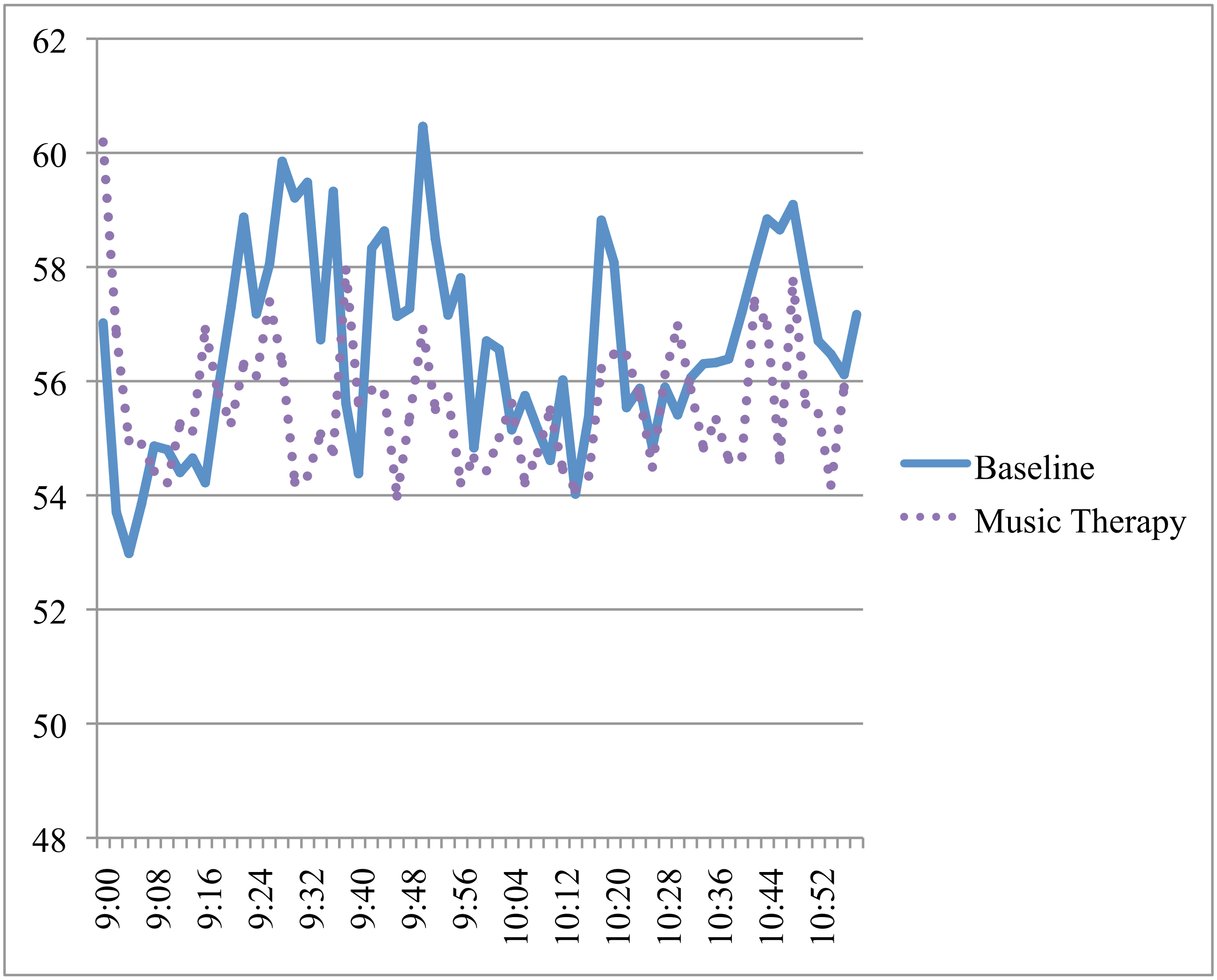


Figure 4.10 and 4.11 illustrate the average sound levels measured in two-minute increments from 9-11AM that occurred in Pod B, comparing baseline to intervention day.

Figure 4.10

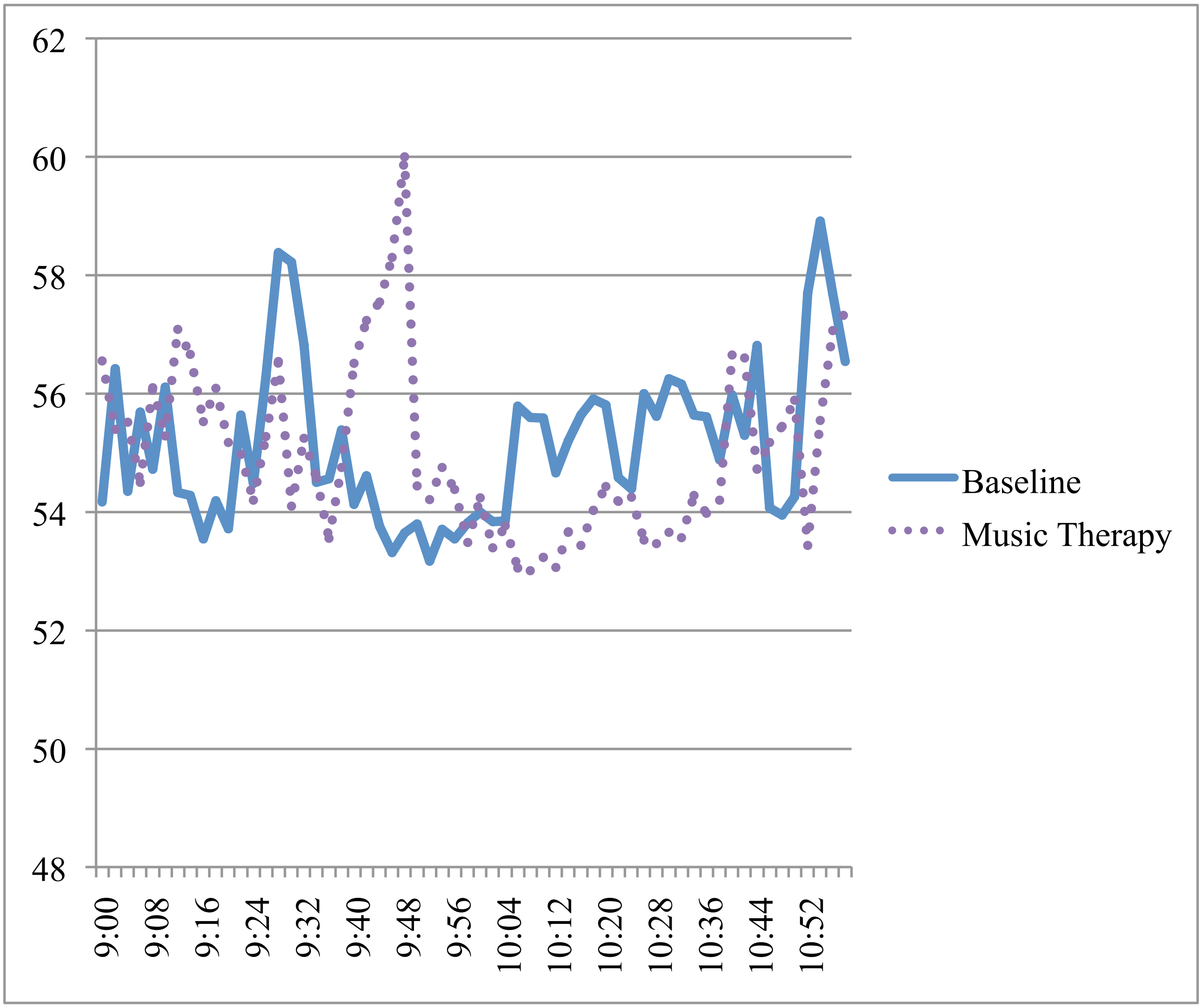
Comparative Graph of dBA Pod B Baseline Day 1 and Intervention Day 2.



Note. Due to space constraints, the x-axis shows times in increments of eight, though data reflects averages of every two minutes.

Figure 4.11

Comparative Graph of dBA Pod B Baseline Day 3 and Intervention Day 4.



Note. Due to space constraints, the x-axis shows times in increments of eight, though data reflects averages of every two minutes.

Music therapy services also varied depending on staff and patient needs, similar to pod A. The mean taken during music therapy services was consistently lower than the same time during baseline. Results from music therapy sessions and baseline comparative are found in Table 4.4.

Table 4.4
Pod B Intervention Readings and Comparative Findings

	Time	Intervention Duration	M	Max.	Min.	Number of Staff Present	Number of Patients Present	Did Ext. Noise Occur?*
Day 1 (Baseline)						4	6	Yes
Session 1	10:19	18 minutes	56.2dBA	72.5dBA	49.5dBA			
Session 2	10:46	16 minutes	57.58dBA	65.9dBA	50.6dBA			
Day 2 (Music Therapy)						3	5	Yes
Session 1	10:19	18 minutes	55.8dBA	68.2dBA	51dBA			
Session 2	10:46	16 minutes	55.73dBA	78.3dBA	50.2dBA			
Day 3 (Baseline)						3	5	Yes
Session 3	10:21	14 minutes	55.55dBA	62.3dBA	51dBA			
Day 4 (Music Therapy)						3	5	Yes
Session 3	10:21	14 minutes	53.88dBA	59.3dBA	50.6dBA			

Note. Investigator was present during all sessions and was included in staff numbers.
**Extraneous noise includes spikes of sound and anything that contributes to the noise in the environment. A more descriptive explanation can be found after Figure 4.14.*

Overall, Pod B received three music therapy services during the course of the study. Each session were graphed for comparison between music therapy services and control and can be found in Figure 4.12-4.14.

Figure 4.12

Pod B Session 1 dBA from 10:19-10:37

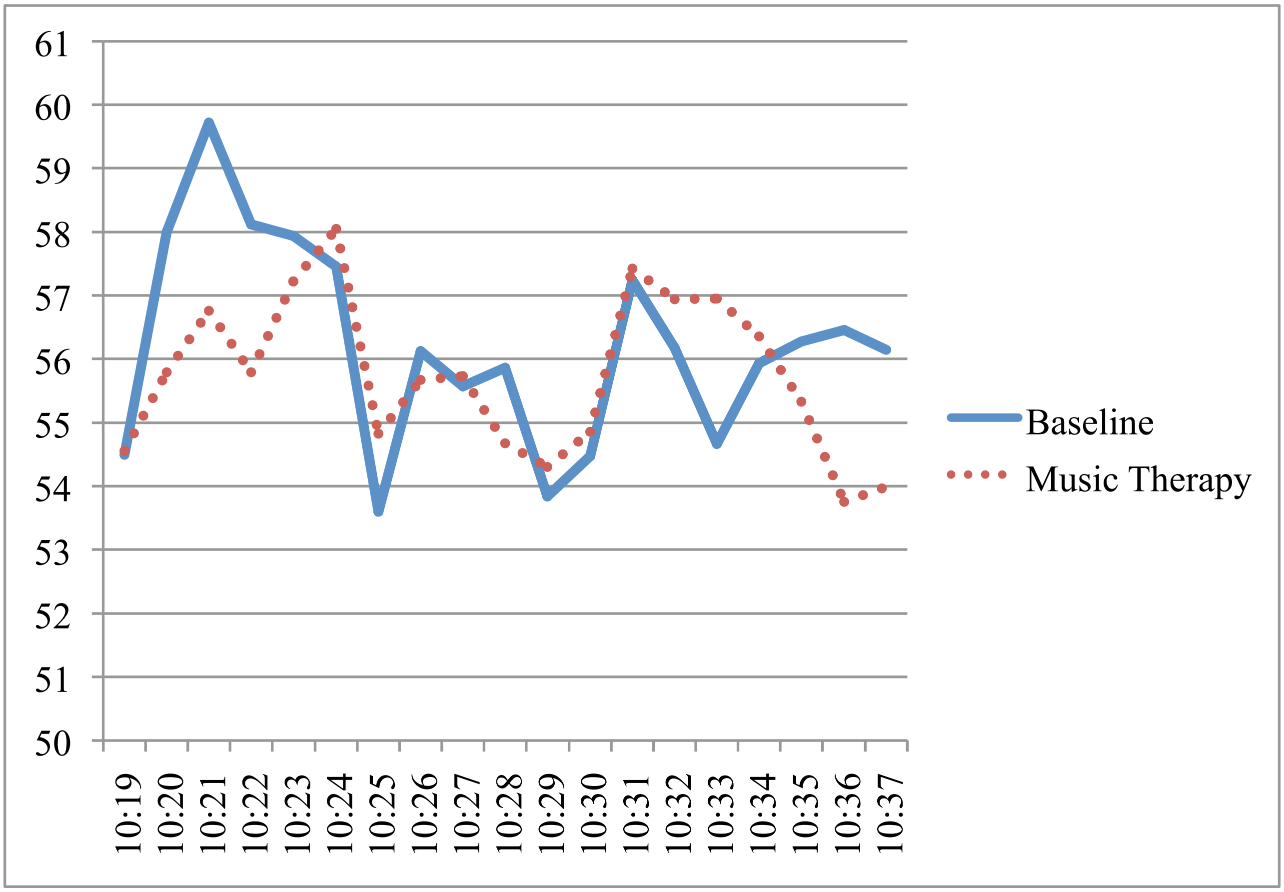


Figure 4.13

Pod B Session 2 dBA from 10:46-11:02

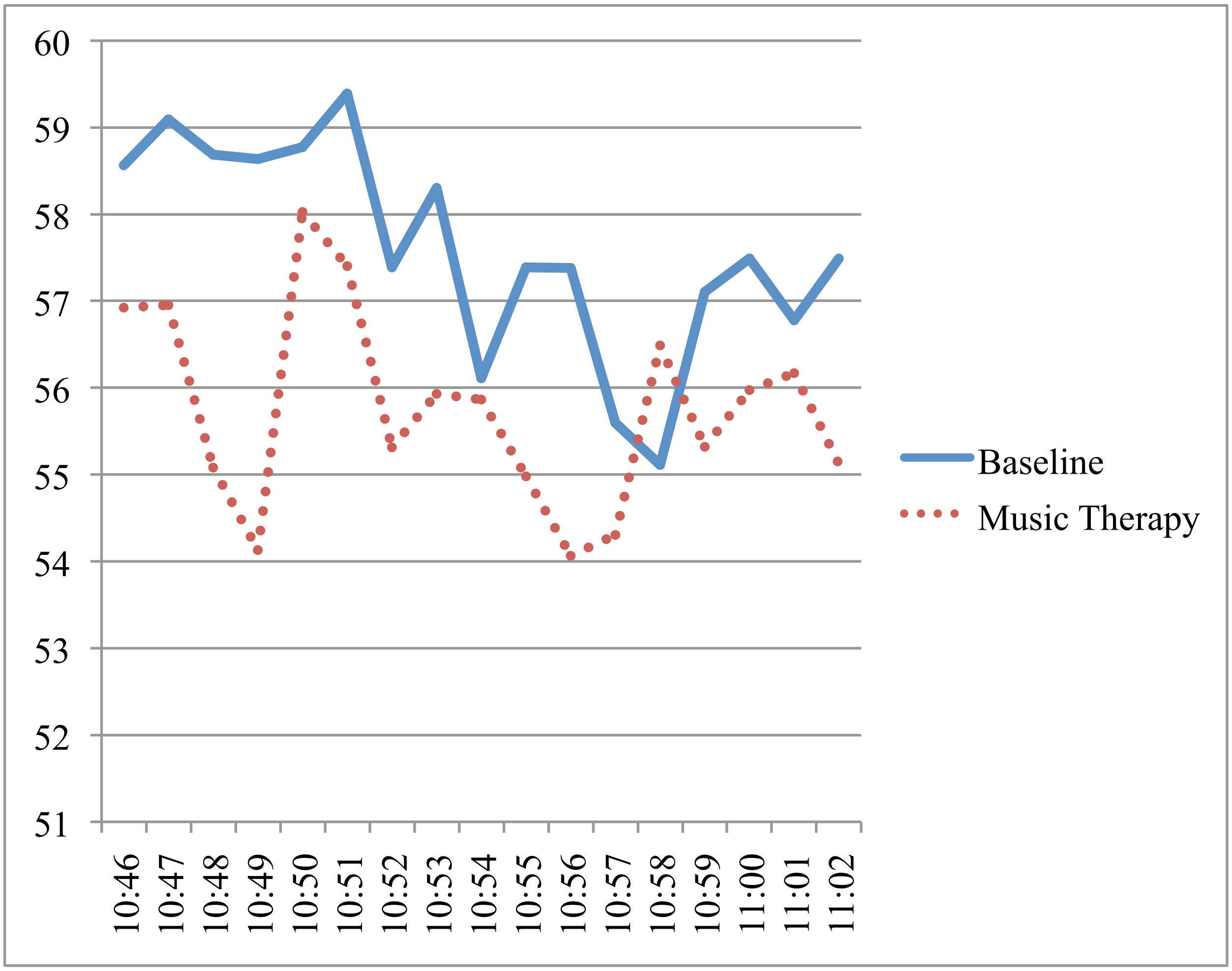
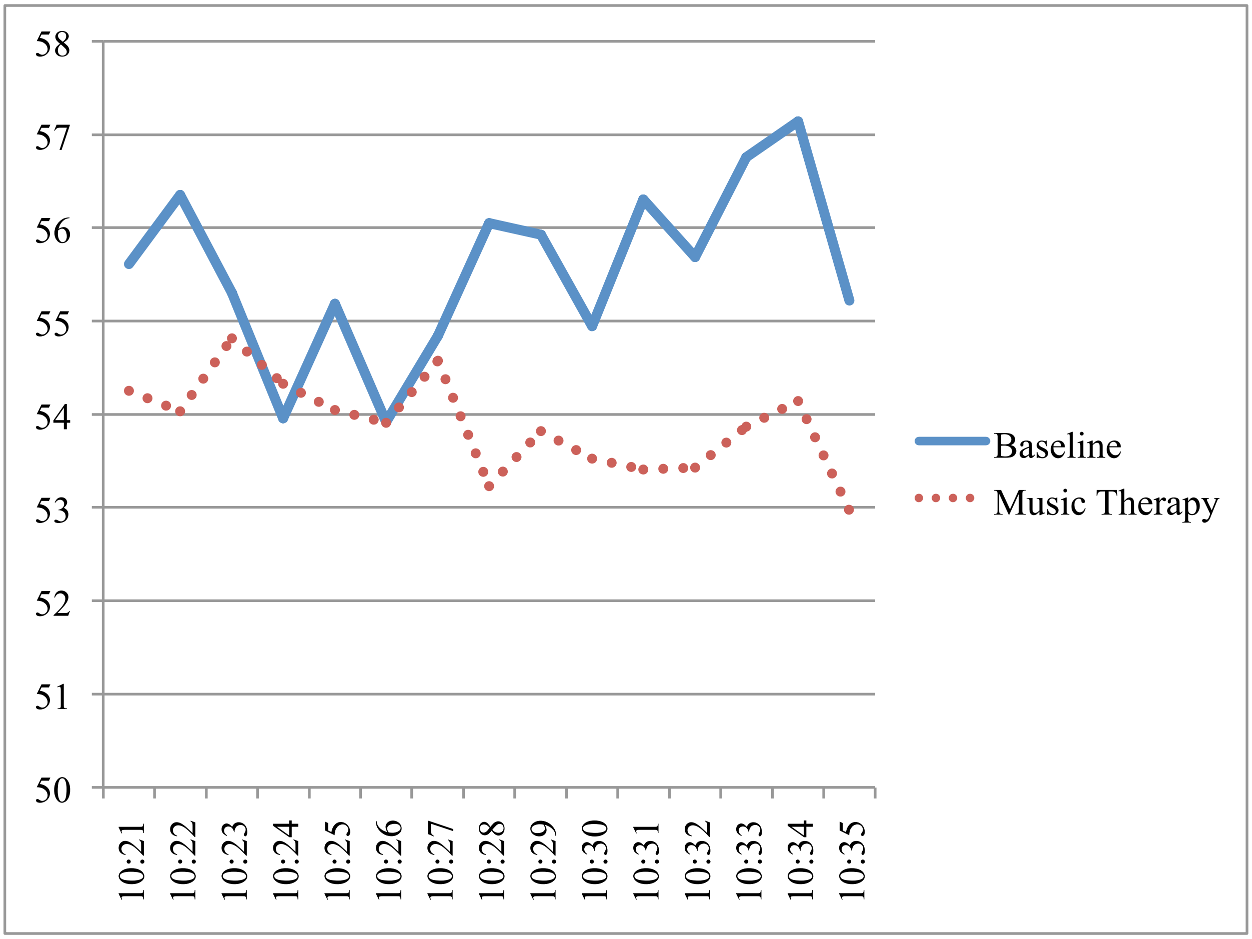


Figure 4.14

Pod B Session 3 dBA from 10:21-10:35



Again, levels varied due to extraneous noise that occurred in the environment in concurrent to music therapy intervention. Extraneous noise is anything that contributes to the noise in the environment. This can include sudden spikes or bursts of noise, or loud, elongated sounds. Some of the extraneous noises observed in both pods include: alarm from equipment; doctor's rounds; normal-loud volume conversation, and multiple conversations at once in room and/or hallway; laughter; telephone; intercom speaker; paper towel dispenser; sink; baby crying and/or screaming; coughing/sneezing; moving chairs, tables, equipment around room; x-ray and ultrasound machine; removal of trash; closing drawers; and dropping objects onto the ground.

CHAPTER FIVE:

DISCUSSION

This study reiterates what is described in numerous other studies and articles; the sound levels in the NICU are too high, far exceeding Leq 45dBA, the recommendation set forth by AAP. Music therapy intervention was introduced in this study to investigate its overall effect on the sound levels in the NICU environment. Two different locations were measured to provide reliability and also compare differences in sound levels based on individual environmental characteristics. Each NICU area that was investigated was different in size, staffing, patient volume, and extraneous noise, all of which appeared to impact the outcome. Results showed that decibel levels were reduced during music therapy intervention as compared to the baseline of no music therapy intervention. These data suggest that music therapy intervention can have a positive impact on sound levels in the NICU setting. A number of variables in the NICU environment were outside the control of this study, and these variables may have negatively impacted sound levels in the environments studied. However, the findings still provide evidence that music therapy has the potential to improve the sound environment for such a fragile population.

Research Questions

1. What are the NICU sound levels with and without music therapy present?

Numerous factors contributed to the sound levels in the NICU environment during this study. Loud, sudden bursts of noise and a variety of extraneous noises throughout the study were present which include: alarms beeping; moving equipment; x-ray machines; intercom announcements; telephone ringing; laughter; coughing; doctor rounds, conversation in room and hallway, and multiple conversations at once; babies crying extended amounts of time, and babies screaming for a short amount of time; traffic in hallway and in room; closing drawers; and dropping an object on the floor.

Though there was a decrease in sound levels when music therapy was present, they are still too high and far exceed the AAP's standard of 45dB. NICU sound levels in these locations were fairly consistent with previous research where Liao and colleagues (2013) found NICU sound levels to range from 54.4 to 67.8dBA, though the maximum decibel level found during this study far exceeded Liao and colleagues (2013) research. During this study the decibel levels on baseline days were 53.3dBA-79.4dBA in Pod A and 48.9dBA-77.6dBA in Pod B. On intervention days, the decibel levels were 53dBA-77.8dBA in Pod A and 49.5dBA-78.3dBA in Pod B. During music therapy intervention session times on baseline days, decibel levels were 54.7dBA-73.4dBA in Pod A and 49.5dBA-72.5dBA in Pod B. On intervention days, decibel levels were 53dBA-67dBA in Pod A and 50.2dBA-78.3dBA in Pod B. During session times, the presence of music therapy intervention decreased the overall sound levels up to 1.93dBA in Pod A, and 1.85dBA in Pod B. While results show music therapy to be beneficial on the sound levels it was often hindered by extraneous noise overpowering the music, which resulted in high minimum and maximum decibel levels during music therapy interventions.

A collaborative effort with use of multiple interventions must be made in an attempt to decrease the sound levels to a more appropriate level. Combining different techniques and protocols will create awareness and further the reduction of sound levels.

2. Does live music therapy intervention decrease sound levels in the NICU?

There is numerous evidence of the positive impact recorded music and live music therapy have on premature infants. Research suggests music can mask aversive auditory stimuli in the environment but little, if any, research has been done examining the impact of music therapy on the sound levels in the NICU environment.

The results from this study showed that music therapy intervention had a positive impact on sound levels, contributing to decreased overall average decibel levels of up to 1.1dBA in Pod A and up to 1.08dBA in Pod B. During the actual session times music therapy intervention was present, the average decibel levels were decreased up to 1.93dBA in Pod A and 1.85dBA in Pod B in comparison to the baseline. Though music therapy resulted in lower decibel levels, it was not enough to mask all extraneous noise; especially in relation to sudden bursts of sound. When music therapy intervention was present, other factors and sources of noise were also occurring; this included staff rounding on patients and/or engaging in conversation, alarms sounding, equipment being moved, and sinks and automatic paper towel dispensers being dispersed. These factors contributed to the overall sound level, resulting in higher decibel readings during this time.

Each pod differed greatly from one another in size, amount of equipment, staff, and degree of patient's medical care. As suggested by Darcy, Hancock, and Ware (2008), this could have led to different results. Pod A was the most consistent environment throughout the study. Pod A appeared more stable because it had a decreased amount of traffic entering the room, less conversation, and a lowered amount of sudden bursts of extraneous noise due to: lowered amount of staff in the room; less patients who had a lower level of medical care; and less equipment making excess noise with alarms. Results indicated that sound levels (Leq, L_{max}, L_{min}) were consistently lower throughout the study on days where music therapy intervention occurred. When looking at individual music therapy sessions, the average sound level and minimum achieved was lower than the same timeframe during the baseline with a 2dBA difference.

Pod B was quite the opposite. Pod B was significantly larger in size and experienced much more traffic, conversation, and more frequent bursts of extraneous noise throughout the study due to: increased amount of staff and nursing stations; more patients who had a high need for medical attention; and a higher volume of medical equipment that emitted various sounds and alarms. Throughout the study, Pod B experienced lower sound levels during intervention days than the control. Sound levels were also lower on average during the actual intervention than its counterpart on the baseline with a 1.85dBA decrease.

Pod B contained patients that were medically fragile and needed additional care from doctors and nurses, which resulted in significantly more traffic and noise in this environment. This pod was also attached to a high traffic hallway, which contributed to excess noise. Again, as suggested by Darcy, Hancock, and Ware (2008), patient acuity and the associated needs can greatly impact the sound levels in the NICU environment.

In both pods, sudden bursts of high levels of sound also impacted the results of this study. While music therapy intervention can act as a masking tool to aversive auditory stimuli, it can be overpowered by loud bursts of noise. These loud bursts of noise could originate from: laughter; loud conversation; doctor's rounds; alarms; intercom announcements; and dropping or moving an object or piece of equipment.

Though music therapy intervention appeared to impact overall sound levels, more collaborative interventions must occur to decrease sound levels in the NICU environment. It should be noted that even though music therapy appeared to reduce sound levels, levels still were above the range suggested in the recommendations set forth by AAP. Though both pods had lower sound levels with the presence of music therapy it is beyond the scope to determine why, but it could be due to: other staff modeling quiet behaviors during music therapy sessions; less spikes of extraneous noise; or the Hawthorne Effect (Darcy, Hancock, & Ware, 2008 discuss the unintentional but beneficial effect of others changing their actions due to the awareness of this particular study). However, even with music therapy present, spikes in sound still occurred. This suggests that music therapy, though helpful in reducing decibel levels, may not be enough alone to combat the noise problems common to the NICU environment. Previous research has shown that a collaboration and combination of noise reducing interventions including bed design, individual alarm noise, and staff education should all be considered when trying to improve sound exposure levels in the NICU setting (Liao et al., 2013). As has been suggested before, educational programs and awareness for staff and caregivers should be the first steps in combating high sound levels (Brandon, Ryan, & Barnes, 2007).

Limitations

Like any study, limitations occurred that require further exploration into the effects of live music therapy intervention on the sound levels in the NICU environment.

The first limitation to this study was the small sample size. More NICU environments need to be included to further investigate the severity of extraneous noise on different layouts and environments.

Another limitation was the amount of time spent measuring and collecting data. To gain more of an understanding, data collection needs to occur over a longer period of time. The study was designed shorter due to time constraints and to best accommodate staff and patients. It was also a challenge to align appropriate times (i.e. cluster care, and not interfering with sleep and surgeries) for music therapy sessions to occur while maintaining consecutive days for data collection.

In regards to environment, the room itself was at times a limitation due to its size and amount of staff, patients, and equipment. It was important to set-up the dosimeter in an area where it wouldn't impede on the staff or their ability to care for patients, while also attempting to be as close to the center of the room as possible. Patient care necessitated some changes in study set up which may have had the potential to impact results. Previous data have also shown that the construction of the NICU itself (i.e., open-bay verses single-family-rooms) can impact sound levels (Stevens, Helseth, Thompson, Pottala, & Khan, 2012). Given that this study did not control for such variables, it is hard to determine the true impact of music therapy on sound levels.

A lack of statistical analysis is also a limitation of this study. Because the data collected were descriptive in nature, no significant comparisons could be made. There was also no way to control for other variables that may have impacted results. So while the current study does show positive results those results should be viewed with caution.

Suggestions for Future Research

While research about music therapy intervention and its effect on decibel levels is in its infancy, further studies should lengthen the amount of time data is collected, and increase the amount of NICU environments recorded and measured for decibel levels. Recording data longer than two hours will give more accurate results on the sound levels over an extended amount of time. Lengthening the time will also allow the opportunity to examine lasting effects live music therapy may have on the decibel levels in the NICU environment. Different music therapy interventions may also be investigated to see if one is more beneficial than the other at reducing decibel levels in the NICU environment.

Further research should increase the amount of equipment used to record and measure decibel levels. Having additional dosimeters placed throughout the room, especially one near infants receiving the music therapy intervention would be beneficial in examining results.

Due to treatment and time constraints, an accurate reading of how music therapy intervention impacts the environment after intervention has occurred was not possible. Further studies should look at how music therapy effects the NICU environment after intervention.

Conclusions

With a continued rise in births of premature infants and future neonatal intensive care units, more and more infants are likely to be impacted by exposure to sounds found in the neonatal intensive care unit. Though many improvements have been implemented to reduce the impact, decibel levels continue to exceed recommended levels of 45dBA. While the findings from this study appear to indicate that live music therapy interventions can lower sound levels in the NICU environment, other variables continue to impact sound levels. Lowering sound levels in the NICU environment must be a collaborative effort amongst staff and caregivers, with additional sound reducing interventions implemented to reduce the impact of exorbitant noise and ensure the health of this vulnerable population.

APPENDIX

Appendix A: E-mail Stating UK IRB Review Not Needed

Sarah-

I forwarded you email below to the IRB Chairman for review. He determined that since you were only recording information about the acoustic environment, and not about any individual person, your project did not meet the definition of human subject research as defined by the Department of Health and Human Services:

> Research (DHHS): "A systematic investigation designed to develop or contribute to generalizable knowledge" [45 CFR 46.102(d)]
> Human Subjects (DHHS): "A living individual about whom an investigator conducting research obtains (1) data through intervention or interaction with the individual, or (2) identifiable private information" [45 CFR 46.102(f)]

Although your investigation may be considered research, it does not meet the definition of including human subjects as defined above. No IRB review will be needed at this time. If anything about your project changes in such a way that information may be collected from or about individual human subjects, please notify our office before those change are implemented. The IRB's determination may have to be reassessed.

Good luck,
Andrew

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