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The Effect of Utilizing a Smart Phone Decibel Reader Application by Unit Staff to Alert and Reduce Noise Levels in an Open-Design Neonatal Intensive Care Unit

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Abstract

Sound levels in the neonatal intensive care unit (NICU) consistently exceed the 45-decibel limit recommended by the American Academy of Pediatrics (AAP). Excessive noise has been shown to cause detrimental short- and long-term effects on premature infants. The cost of a NICU stay in 2008 averaged $3500/ day with some exceeding $1 million at discharge (Muraskas & Parsi, 2008). Post-discharge, the cost of care for these children can be 7 times more than a term infant in the first year (Boss & Hobbs, 2013). Reducing the length of stay and long-term detrimental effects of a NICU stay will benefit organizations and the overall cost to society. This project tested the effectiveness on noise levels by using a free decibel phone application provided to staff within an open design NICU. Conclusion: Overall, mean decibel levels decreased after intervention, but more research is needed to prove if the decrease is not only significant, but also substantive.

Keywords: noise, sound, neonatal intensive care unit, NICU, neurodevelopment, IVH, premature infants, intraventricular hemorrhage

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The intrauterine environment provides the fetus protection from harmful stimuli, such as sound, light, and touch, yet allows positive sensory experiences that are crucial to neurodevelopment (Altimier, 2015). The neonatal intensive care unit (NICU) is a specialty area where infants born prematurely, defined as less than 37 and as young as 22 weeks gestation, can receive the care and attention needed to survive outside the womb until they are able to successfully transition to a home environment (Silva, Linhares, & Gaspardo, 2018). Although these units provide the life-saving interventions required to “grow” these infants, it comes with the price of exposure to noxious sounds, bright lights, and painful procedures (Altimier, 2015).

With the improved survival rate of preterm infants in the United States, it is becoming apparent those infants are exhibiting increased incidence of neurodevelopmental problems (Wachman & Lahav, 2010). There is growing concern this may be in part because of the environmental noise within the NICU (Wachman & Lahav, 2010). Premature infant brains are still developing at the time of birth and are very sensitive to the stimulating environment of the NICU (Altimier, 2015). While elimination of every potentially negative experience is impossible at this time, researchers and clinicians are focusing on areas that can be improved, especially the environment within the NICU (Silva et al., 2018).

Problem Statement

One intervention NICUs are attempting to control is noise exposure (Wachman & Lahav, 2010). In 1997, the American Academy of Pediatrics (AAP) recommended sound levels remain at or below 45dB in the NICU environment (American Academy of Pediatrics, 1997). In NICUs, studies have shown noise levels consistently above these levels, and at times, are above 85dB (Chow & Shellhaas, 2016).

Purpose of the Project

The American Association of Colleges of Nursing (AACN) recognizes the need for nurses to understand and use technology to improve patient outcomes (AACN, 2006). After monitoring ambient noise levels within an open-concept NICU, this writer intends to utilize a free application installed on staff phones to alert when noise levels exceed a set decibel level. Ambient noise will be measured after training staff on the use of the application and for a set period after training is complete. Training staff to become aware of the amount of noise present in the NICU at any given time should reduce the overall environmental noise within the unit (Calikusu Incekar & Balci, 2017).

Clinical Question

Will the utilization of a smart phone decibel reader application by unit staff alert and reduce noise levels in an open-design neonatal intensive care unit?

Significance

The aim of this project is to understand the current sound levels within this NICU compared to recommended standards set by the AAP, to educate staff, and to facilitate ambient sound reduction.

Review of the Literature

The literature search utilized the following databases: Cinahl Plus, PubMed, Cochrane Library, and MedlinePlus. Additional searches were completed by reviewing references, search suggestions of selected articles, and search engines of Google and Google Scholar. Search terms included: noise/sound in the neonatal intensive care unit/NICU and noise/sound. Parameters were limited to research studies between the years of 2013-2018. Exclusion criteria include noise studies from equipment, sound exposure prior to birth, music therapy, sound therapy, kangaroo care, and ototoxic medications. This writer found 367 trials and/or reviews, with 14 accepted. Most of the studies found were duplicates listed across databases and search engines.

The AAP, World Health Organization (WHO), and the Environmental Protection Agency (EPA) recommend hospital sound levels no greater than 45dB during the day and 35dB at night (Garindo Galindo, Caicedo, & Velez-Pereira, 2017; Halm, 2016; Kargar et al., 2017).

Excessive noise in the NICU environment can cause physiological changes in the neonate resulting in decreased oxygen perfusion to the brain as evidenced by bradycardia, apnea, and blood pressure fluctuations (Disher et al, 2017; Kargar et al., 2017; Romeu, Cotrina, Perapoch, & Lines, 2016).

Fluctuations in hemodynamic stability can lead to decreased oxygen perfusion, possibly resulting in intraventricular hemorrhages (Blackburn, 2016; Bolisetty, et al., 2014; Noori, McCoy, Anderson, Ramji, & Seri, 2014; Poryo, et al., 2018; Riquito Marques, et al., 2019; Zhang, et al., 2013).

Early exposure to noise by premature infants can alter structural and functional changes in the auditory system resulting in hearing damage or loss (Bures, Popelar, & Syka, 2017).

Infants less than 29 weeks gestation have and increased stress response as compared term or near-term infants. (Gorzilio, Garrido, Gaspardo, Martinez, & Linhares, 2015). Premature infants are at an increased risk of long-term neurodevelopmental impairment and disabilities, such as cerebral palsy, deafness, and blindness at both 2-3 years and at 5 years of age (Bolisetty, et al., 2014; Di Rosa, et al., 2016; Jarjour, 2015; Kobayashi, et al., 2015; Leppanen, et al., 2014; Philpott-Robinson, Lane, Korostenski, & Lane, 2017).

With formal training and reinforcement of that training, NICU staff can reduce the sound levels within their units, thereby reducing physiological fluctuations in premature infants (Biabanakigoortani, Namnabati, Abdeyazdan, & Badii, 2016; Calikusu Incekar & Balci, 2017; Kargar et al, 2017).

Conceptual and Theoretical Framework

Previous sound measurements within the unit reached levels greater than 85dB during peak times of activity and remained greater than 65dB much of the time. Management has attempted to reduce noise levels using a "stop light" system, whereby a green, yellow, or red light would flash depending on the decibel readings. Initially, staff remained aware of the noise within the unit, but eventually stopped paying attention to the lights. Physicians and managers continue to look for ways to alert staff, parents, and families to the increased sound in the unit and the possible long-term complications of overstimulation.

This writer used Roger Lippitt's theory of change within the NICU to encourage and support the staff during this project period. Lippitt's change theory is composed of the following seven phases:

1. Aware of the need for change
2. Develop a relationship between the system and change agent
3. Define a change problem

4. Set change goals and action plan for achievement

5. Implement the change

6. Staff accept the change; stabilization

7. Redefine the relationship of the change agent with the system (Barrow & Toney-Butler, 2018)

This NICU is already aware of the need for change, as evidenced by the previous effort to reduce the noise levels within the unit. This writer has spoken with numerous staff members regarding the reasons the previous attempt has failed. Among the reasons cited were: staff became too complacent with the stop light system and no longer noticed it; staff became agitated with each other for reminding them to keep the volume down (i.e. “I got tired of telling everyone to hush” or “I got tired of hearing my coworkers telling me to hush”).

The literature supports the relationship between excessive noise and detrimental short term and long-term outcomes in premature infants. This writer conducted an informal education to the NICU staff to highlight the research findings regarding long- and short-term noise exposure on premature infants. This was completed to not only introduce staff to why the project was necessary, but also an attempt to increase recruitment within the unit.

This writer chose to begin with ambient noise in the NICU to identify and reduce that noise, set goals and a plan to achieve those goals. Informal education was completed prior to project initiation and continued through recruitment as to why noise is a problem in this population.

The American Association of Colleges of Nursing (AACN) recognizes the need for nurses to understand and use technology to improve patient outcomes. (AACN, 2006) After monitoring ambient noise levels within an open-concept NICU, this writer utilized a free application installed on staff phones to alert when noise levels exceed a set decibel level. Ambient noise was measured after training staff on the use of the application and for a set period after training was completed. Training staff to become aware of the amount of noise present in the NICU at any given time should reduce the overall environmental noise within the unit (Calikusu Incekar & Balci, 2017).

The AACN (2016) also recommends collaboration among team members. By involving the entire NICU staff, including physicians and ancillary personnel, family-centered care and accountability are shared by all.

This project was the implementation of the change and with time and training, the staff will adopt the change permanently. The data does show a statistical decrease in the ambient decibel levels post-intervention, but it is not possible to determine if this was due to the intervention. Staff was more aware of the noise levels during the intervention and immediately post-intervention, but more studies will need to be conducted to determine if it has become permanent.

Methodology

Project Design

This writer utilized a digital sound meter (decimeter) to record ambient noise within the NICU at 3 second interval divided among two areas of the unit. This writer spent approximately 20 hours each week during day and night shift collecting data. This continued through the entire project time. This writer placed the decimeter in the unit periodically prior to the project start so staff will ignore the equipment. This was an attempt to avoid the Hawthorne Effect (Shuttleworth, 2009).

Participants

Volunteers were recruited from the 125-adult staff over 18 years of age within the NICU. This included nurses, patient care technicians, secretaries, physicians, nurse practitioners, physician assistants, physical/ speech therapists, respiratory therapists, social workers, and environmental services personnel. Occasional staff to the unit, such as students, volunteers, radiology or consulting physicians were excluded (see Appendix A). Information regarding project was posted on unit news bulletin boards, announced during pre-shift huddle, during staff meetings, and through email invitations (See Appendix D). This writer was responsible for consenting all participants.

Setting

This project was conducted in a single, level III NICU in a not-for-profit community hospital in Georgia. The NICU is a 42-bed unit and cared for over 650 infants in 2018. The patient population includes 22-week gestational age to well past term infants. The unit is an open concept design and uses centralized monitoring. There are central nursing stations surrounded by several open bays containing 1-2 patient bed spaces or a central nursing station with patient bed spaces aligned along the walls. This unit has three distinct areas that were monitored, based on patient census (see Appendix B).

Tools

This writer utilized a TeckoPlus SLM25TK Data Logging Function Sound Level Decibel Meter (with CD software) to record decibel levels within the unit (see Appendix C). The standard applied is IEC651 type 2, ANSI SI .4 type 2. Calibration sound source is 94dB @ 1kHz (See Appendix C). The device measures a range of 30~130dBA with an accuracy of +1.5dB. The recording interval is 1~60 sec / 1~60 min / 1~24 hours with a frequency response of 31.5~8.5KHz (TekcoPlus, 2019)

The staff used a student created, for iOS, or a commercially available, for Android, smart phone application to run in the background on their personal cell phones. The applications consisted of a mobile decibel reader to run in the background on staff personal cell phones. This application was set to give a vibratory alert when decibel levels exceed 55dB.

The Intervention and Data Collection

Staff was asked to download a specific, free smartphone application into their personal cell phone. While at work in the NICU, they allowed this application to run in the background on their phone. When alerted to an excessive noise notification by cell phone vibration, staff was expected to modify their personal behavior until notification ceases. The project took four weeks from time of installation to completion of project. One week of decibel monitoring was conducted prior to initiation of intervention to gain baseline data. The settings on the application were adjusted for each staff for ease in recognition of the alert. One week was allotted to consent staff and to install and calibrate application. One week for implementation. Following this, there was one week of noise monitoring within the NICU.

The data is stored as date/time reading only. No identifying information or sounds are recorded. This data is stored in a secured personal computer. Digital copies of consents are stored in a secured personal computer until completion of project and participants were given the original consent.

Data Analysis

The sampling method was convenience and based on the number of consented participants working in the NICU during the project implementation. The independent variable is use of a smart phone application which is a continuous variable and the level of measurement is ratio. The dependent variable is the ambient noise level in the NICU, it is a continuous variable and the level of measurement is ratio. The null and alternative hypothesis are: H_0: There will be no difference in mean decibel levels before and after the intervention. H_A: There will be a decrease in the mean decibel levels after the intervention. The level of significance (α) is set at 0.05. All data analyses were completed using Statistical Package for Social Sciences (SPSS) software. Due to the high number of datum points, there is a high likelihood of significance, but the focus should be on substantive findings.

A paired samples t-test was conducted to compare the mean decibel levels of A-side pre- and post-intervention (see Appendix E, Table 1). There was a significant difference in mean decibel levels pre-intervention ($M=53.24$, $SD=4.38$) and post-intervention ($M=51.17$, $SD=4.16$; $t\ (53{,}039) = 77.59$, $\alpha = -0.03$, two-tailed). The average noise level decreased after the intervention on the A-side, supporting the alternative hypothesis presented.

A paired samples t-test was conducted to compare the mean decibel levels of B-side pre- and post-intervention (see Appendix E, Table 1). There was a significant difference in mean decibel levels pre-intervention ($M=50.78$, $SD=5.08$) and post-intervention ($M=51.98$, $SD=6.27$; t

(37,934) = -29.67, α=0.06, two-tailed). On the B-side, the average decibel level increased after the intervention, supporting the null hypothesis.

A paired samples t-test was conducted to compare the mean decibel levels of the entire unit pre- and post-intervention (see Appendix E, Table 1). There was a significant difference in mean decibel levels pre-intervention (M=52.97, SD=4.36) and post-intervention (M=51.17, SD=4.16; t (53,039) =68.04, α= -0.02, two-tailed). There was a decrease in mean decibel levels in the entire unit post-intervention supporting the alternative hypothesis.

The relationship between the pre- and post-intervention was investigated using Pearson's correlation coefficient (see Appendix E, Table 2). Preliminary analysis was performed to ensure no violation of the assumptions. There was a weak, negative correlation between the two variables, r = -0.05, n = 53.040, p< .01, with decibel levels decreasing due to the use of the smart phone application by staff in the NICU.

This writer was able to separate data by day or night shift, and although it was not part of the original study information, a paired samples T-test was conducted. There was a significant difference in mean decibel levels between day (M=51.91, SD=4.96 and night shift (M=51.51, SD=5.16; t (90,974) =17.13, p=0.00, two-tailed) (see Appendix E, Table 3). The data did show a difference between day and night shift noise levels, with night shift having lower mean decibel levels than day shift.

Discussion

After completing all data analysis, this writer must reject the null hypothesis and accept the alternate hypothesis that there will be a decrease in the mean decibel levels after the intervention. The data shows a slight decrease in decibel levels pre- and post-intervention, but this may not be due to the intervention. This project involved using staff's personal smart phones to complete and this writer attempted to enroll 80% of NICU staff into the project, but only consented 16%. The common reasons for not participating were the concern the participants were being recorded or the application had access to personal data within the phone.

The census in the NICU was low during the project. The A-side had only three infants and the B-side had 10 infants admitted. This may have accounted for the decrease in decibel levels on the A-side as well as the increase in decibel levels on the B-side. The iOS application was being tested specifically for this project. Although calibration was completed between the phones and the decimeter, fluctuations still occurred, and the application would not stop alerting until the levels dropped below the set limit. This caused frustration for the participants and the developer is aware and improvements to the application would have to be made prior to implementing on a larger scale.

Practice Implications

Although this project did not definitively decrease the ambient noise levels within the NICU, it did give the opportunity for staff to become aware of the issue and now have true baseline data on noise in the unit. Although this project focused on noise in the NICU, excess noise is an issue in all parts of the hospital. Future studies could involve the use of company supplied smart phones with the application installed for staff to use in various units. This would also allow consistency across phone applications to eliminate discrepancies between applications and 100% participation.

Further development and testing of the iOS application are warranted, both to correct for fluctuations and to insert stop alert commands to allow time for the staff to remedy the source of the noise before alerts begin again.

Another opportunity for investigation could be to compare monitor alarm frequency during periods of high decibel levels to those during quieter times within the unit. This could confirm the physiologic instability of the infants during periods of increased noise (Disher et al, 2017; Kargar et al., 2017; Romeu, Cotrina, Perapoch, & Lines, 2016).

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Appendix A

Georgia State University

Informed Consent

Title: The Effect of Utilizing a Smart Phone Decibel Reader Application by Unit Staff to Alert and Reduce Noise Levels in an Open-Design Neonatal Intensive Care Unit
Principal Investigator: Dr. Susan Breslin
Student Principal Investigator: Kelly Schnellinger, RN

Introduction and Key Information

You are invited to take part in a quality improvement project. It is up to you to decide if you would like to take part in the project.
The purpose of this project is to monitor the effects of a smart phone decibel reader on noise within the neonatal intensive care unit (NICU).
Your role will last your scheduled shifts within the NICU over 3 weeks. You will be asked to download a free smartphone app onto your personal cell phone. While at work, you will allow this app to run on your phone. The app will not collect or have access to any information or data from your phone. The app will not interfere with phone service or any other installed apps on your phone. The app will have access to the speaker on the phone both to monitor decibel levels and to alert the decibel level. When alerted, change your personal behavior until alert stops. This project will take three (3) weeks to complete. One (1) week will be to install, train, and calibrate phone app (30 -60 minutes). Week two (2), you will be asked to run the app while working in the unit. The final week will be unit monitoring by a portable decibel reader. There is no need for you to document alerts, actions, or activities occurring during the project. No personal information will be collected at any time during this project. The only data to be stored is ambient decibel levels within the NICU from a portable decibel meter in the unit. Consents will be stored in a locked filing cabinet until completion of project.

Participating in this project will not expose you to any more risks than you would experience in a typical day.
This project is not designed to benefit you. Overall, we hope to gain information about the use of technology to reduce noise within the NICU.

Purpose

The purpose of the project is to monitor noise levels within the NICU before, during, and after installing a smart phone app for staff phones. You are invited to take part in this QI project because you are staff working within the NICU. A total of 125 people will be invited.

Procedures

If you decide to take part, you will be asked to download a free smartphone app onto your personal cell phone. While at work in the NICU, you will allow this app to run on your phone. When alerted, change your personal behavior until alert stops. This project will take three (3) weeks to complete. One (1) week will be used to install, train, and calibrate phone app (30-60 minutes). Week two (2) will be the phase where you are asked to run the app while at work in the unit. Following this, there will be one (1) week of noise monitoring within the NICU. There is no need for you to document alerts, actions, or activities occurring during the monitoring phase. No personal information will be collected at any time during this project. The only data to be stored is ambient decibel levels within the NICU.

Future Research

Researchers will have no information that may identify you.

Risks

In this project, you will not have any more risks than you would in a normal day of life. No injury is expected from this project, but if you believe you have been harmed, contact the project team as soon as possible. Georgia State University and the project team have not set aside funds to compensate for any injury.

Benefits

This project is not designed to benefit you personally. Overall, we hope to gain information about the use of technology to reduce noise within the NICU.

Voluntary Participation and Withdrawal

You do not have to be in this project. If you decide to be in the project and change your mind, you have the right to drop out at any time.

Confidentiality

No personal information will be collected at any time during this project. The only data to be stored is ambient decibel levels within the NICU. The following people and entities will have access to the data collected:

- Dr. Susan Breslin, Kelly Schnellinger, RN
- GSU Institutional Review Board
- Office for Human Research Protection (OHRP)

We will not use your name on project records. Consents will be stored in a locked filing cabinet until completion of project. This project will take three (3) weeks to complete. One (1) week will be to install, train, and calibrate phone app (30-60 minutes). Week two (2) will be the phase where you will be asked to run the application while at work. The final week will be unit monitoring by a portable decibel reader. There is no need for you to document alerts, actions, or activities occurring during the monitoring phase. No personal information will be collected at any time during this project. The only data to be stored is ambient decibel levels within the NICU.

When we present or publish the results of this project, we will not use your name or other information that may identify you.

Contact Information

Contact Dr. Susan Breslin and Kelly Schnellinger at sbreslin@gsu.edu (404-413-1160) and kmcdowell@gsu.edu (404-909-5547)

- If you have questions about the project or your part in it
- If you have questions, concerns, or complaints about the project

The IRB at Georgia State University reviews all projects that involves human participants. You can contact the IRB if you would like to speak to someone who is not involved directly with the project. You can contact the IRB for questions, concerns, problems, information, input, or questions about your rights as a project participant. Contact the IRB at 404-413-3500 or irb@gsu.edu.

Consent

We will give you a copy of this consent form to keep.

If you are willing to volunteer for this project, please sign below.

____

Printed Name of Participant

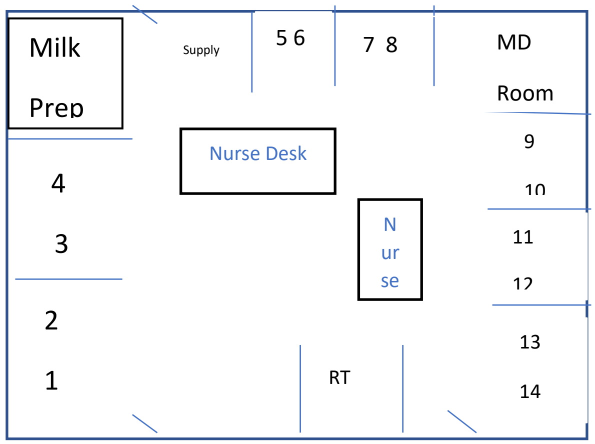
____ ________________

Signature of Participant Date

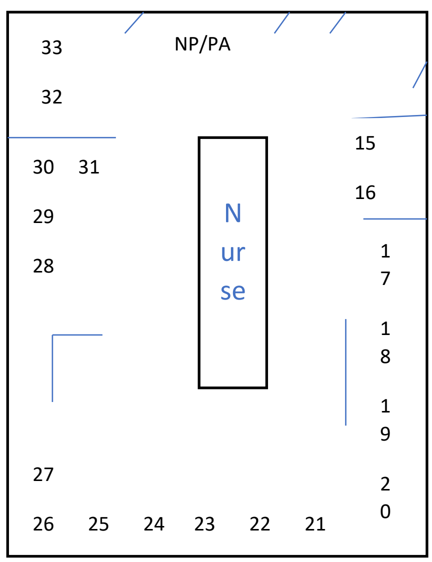
____ ________________

Principal Investigator or Researcher Obtaining Consent Date

Appendix B



Area A



Area B

Appendix C


TEKCOPLUS
FAST
92.8
AUTO
dBA
A/C
MAX
REC
F/S
TEKCOPLUS
Sound Level Meter
TEKCOPLUS
PROFESSIONAL
SOUND LEVEL METER
TEKCOPLUS

Calibration for professional sound level meter SLM-25 SN 201816892

Tested level (dBSPL)	250Hz	500Hz	1000Hz	2000Hz	3000Hz	4000Hz	6000Hz	8000Hz
30	30.5	28.9	31.6	31.9	30.1	31.1	30.6	30.5
40	40.1	40.2	38.6	40.3	41.1	40.1	40.1	41.2
60	61.1	60.4	60.5	60.3	61.1	59.8	59.9	59.9
80	81.2	80	79.2	79.8	79.2	79.1	80.4	81
95	95.1	96	95.1	95.3	96.1	95.1	94.8	94.1

All measurements in dBSPL as recording using a GSI-61, audiometer last professionally calibrated by E3 Medacoustics 9/15/2018, using insert earphones and coupler.

Measurements taken by Lisa Osborne, AuD Clinical audiologist GA license # AUD003866 on 03/07/2019

Lisa Osborne, AuD

Appendix D

Seeking Volunteers for DNP Project

Reduce noise

Help our infants

Improve outcomes

For details:

Kelly Schnellinger

Kelly.schnellinger@emoryhealthcare.org

kmcdowell@gsu.edu

Recruitment Script

You are invited to take part in a quality improvement project. The purpose of this project is to monitor the effects of a smart phone decibel reader on noise within our NICU.

Your role in the project will last your scheduled shifts within the NICU over 3 weeks. You will be asked to download a specific, free smartphone application into your personal cell phone. While at work in the NICU, you are asked to allow this application to run in the background on your phone. When alerted to an excessive noise notification, you are to modify your personal behavior until notification ceases.

This project will take three (3) weeks from time of installation to completion of project. The first week will be allotted to install and calibrate phone application, provide training and make individual adjustments to maximize use of the application. This will take 30 minutes to an hour. The second week will be the implementation week. The final week will be unit monitoring by a portable decibel reader. There is no need for you to document alerts, actions, or activities occurring during the project. No personal information will be collected at any time during this project. The only data to be stored is ambient decibel levels within the NICU.

Overall, we hope to gain information about the use of technology to reduce noise within the NICU.

Appendix E

Table 1

	Pre-Intervention			Post-Intervention		
	Number	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**	**t-test**
A-Side	**53040**	**53.24**	**4.38**	**51.17**	**4.16**	**77.59**
B-Side	**37934**	**50.78**	**5.08**	**51.98**	**6.27**	**-29.67**
Unit	**53030**	**52.97**	**4.36**	**51.17**	**4.16**	**68.04**

Table 2

Correlations

		Pre dB	Post dB
Pre dB	Pearson Correlation	1	-.022**
	Sig. (2-tailed)		.000
	N	59286	53040
Post dB	Pearson Correlation	-.022**	1
	Sig. (2-tailed)	.000	
	N	53040	53040

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3

	Number	**Mean**	**Standard Deviation**	**t-test**
Day Shift	**93464**	**51.91**	**4.96**	**17.13**
Night Shift	**90974**	**51.51**	**5.16**	