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The Association Between Noise and The Neonatal Physiological and Behavioral Status in Neonatal Intensive Care Unit at AL -Makassed Hospital, Jerusalem

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Thesis Approval

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Declaration

I declare that this thesis was composed by myself and that the work contained herein is my own, except where it states otherwise by references or acknowledgment, the work presented is entirely my own.

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Dedication

I dedicate this thesis to my precious parents and all my family members. Also dedicate this work to Dr. Mohammed Jallad and Dr. Ahmad Al – Ayed for their support and help to me all the time and everyone who taught me in my life and also to all nurses and doctors in Al Makassed hospital.

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First, I give all the glory to Allah, the source of our strength, for blessing me with both the mental and physical endurance and tolerance to complete this monumental task.

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Abstract

Background: The Neonatal Intensive Care Unit is a vital space for newborns needing specific medical care. Here, the amount of noise present can greatly affect the physiological and behavioral condition of the newborns, possibly resulting in negative consequences. Recognizing how noise exposure relates to the well-being of neonates is essential for improving care methods in the Neonatal Intensive care unit.

Objectives: The research aimed to explore the association between noise levels and the physiological and behavioral condition of neonates in the Neonatal Intensive Care Unit at Al-Makassed Hospital in Jerusalem. The specific goals were to identify the sources of noise, analyze its effects on physiological indicators such as heart rate, respiratory rate, and oxygen saturation, and assess its impact on neonatal behavioral patterns, including sleep habits.

Methodology: The study employed a cross-sectional correlational, a non-experimental observational design to gather data from neonates admitted to the Neonatal Intensive Care Unit, particularly focusing on those who born at gestational age 28 week to 39 weeks or during these first 28 days of life. The estimated sample size, determined using the G-power 3.1 program, was 120 observations. Noise levels were measured during specified noisy and quiet periods using a Digital Environmental Meter (EM5) device. Physiological parameters such as heart rate, respiratory rate, and oxygen saturation were monitored. Neonatal behavioral states were evaluated using the Anderson Behavioral State Scale. Statistical analysis, including independent samples t-tests, was conducted to compare outcomes between noisy and quiet periods.

Results: The investigation into noise exposure within the Neonatal Intensive Care Unit uncovered significant effects on both the physiological and behavioral aspects of neonates. Physiologically, noise exposure led to a notable increase in heart rate (Mean HR: 164.07 bpm during noise time vs. 137.87 bpm during quiet time), respiratory rate (Mean RR: 52.93 bpm during noise time vs. 42.88 bpm during quiet time), and a decrease in oxygen saturation levels (Mean saturation: 83.48% during noise time vs. 95.85% during quiet time) during noisy hours compared to quiet times. Behaviorally, neonates exhibited higher levels of activity and decreased instances of sleep during noisy periods. Moreover, heart rate ($r = 0.458$, $p<0.05$) this positive correlation with the Anderson Behavioral State Scale, O_2 saturation ($r = -0.667$, $p <0.05$) this negative correlation with Anderson Behavioral State Scale and Respiratory rate ($r = 0.242$, $p <0.05$) this positive correlation with the Anderson Behavioral State Scale. Statistical analysis confirmed these differences, highlighting the detrimental effects of noise on neonatal well-being in the Neonatal Intensive Care Unit environment.

Conclusions: The findings underscore the detrimental effects of noise on neonatal health and well-being in the Neonatal Intensive Care Unit. Elevated noise levels were associated with physiological stress and disrupted behavioral states among neonates. Therefore, interventions to mitigate noise exposure in the Neonatal Intensive Care Unit are essential to promote optimal developmental outcomes and improve neonatal care practices.

Keywords: neonate, noise, quiet, physiological status, behavioral status.

Table of Contents

List of Tables

List of Figures

List of Appendices

List of Abbreviations

NICU	Neonate Intensive Care Units
AAP	American Academy of Pediatric
Db	Decibels
ICP	Intra Cranial Pressure
ANOVA	One - Way Analysis of Variance
HR	Heart Rate
RR	Respiratory Rate
Bpm	Beat per minute
Mm hg	Millimeter of Mercury
Map	Mean arterial pressure
Bp	Blood pressure
NIDCAP	The Newborn Individualized Developmental Care and Assessment Program

Chapter One

1.1 Introduction

Infants who require postpartum care are frequently admitted to the neonatal intensive care unit for a variety of reasons, including maternal factors, medical conditions, delivery complications, and prematurity, which prevents them from being exposed to the outside world (Choudry & Dunckley, 2018).

According to Smith et al. (2018), the neonatal intensive care unit, also known as the NICU is a specialized care facility that offers the appropriate care to newborns and neonates who were born prematurely and with medical fragility. Numerous researchers worked hard to give and develop a more perfect environment for the neonates and medical professionals due to the rising number of newborns and neonates admitted to NICUs.

A NICU is a place with excessive sound and noise. In order to optimize the neurologic and behavioral development of newborns, especially premature ones, it is crucial that the NICU be designed with as few stressors as possible. Loud noise is one of the main sources of stress in the NICU, and it can have severe effects on the health of the infants (Chouery & Dunckley, 2018).

A special focus was placed on the difference between sound and noise. A sound is something that you can hear. A noise is an unpleasant or unexpected sound. You say that machinery makes a noise. People and animals can also make noises. Sound, is the general term for what you hear as a result of vibrations travelling through the air, water, etc. (Fink, 2019).

In NICU, infants are commonly placed in incubators, acting as a substitute for the mother's womb. These incubators serve to maintain warmth, regulate temperature, supply essential moisture, and shield against infection and noise. The NICU setting substantially influences the physiological and neurobehavioral condition of newborns, emphasizing the critical need to maintain an optimal environment by reducing excessive noise levels (Cardoso et al., 2015).

Many factors, including prolonged ventilation, nursing techniques, and surrounding conditions like noise, exacerbate newborn suffering in the NICU. Infants in this environment expend energy just to manage, potentially hindering their developmental progress and growth and disrupting physiological functions and central nervous system development (Zeraati et al., 2019).

While the equipment utilized in the NICU supports the growth and development of infants, it also exposes them to loud noises, which can trigger adverse physiological reactions, particularly in preterm infants. These reactions may manifest as increased heart and respiratory rates as well as fluctuations in oxygen saturation levels. Additionally, the cacophony generated by machinery operations, parental conversations, nursing hand-off reports, and ringing telephones can excessively stimulate infants jeopardizing their physiological well-being. In severe instances, this overstimulation may lead to hearing impairment and disturbances in sleep patterns among premature infants (Gramajo, 2023). Noise is directly linked to sleep, as it was defined as an inhibitory element to healthy sleep patterns since it impairs comprehension, generates stress, and disturbs sleep (Colombo and De Bon, 2011).

Noise was also linked to deafness. The noises produced by equipment in the NICU can profoundly affect newborns, resulting in heightened heart and respiratory rates, reduced oxygen saturation, changes in motor activity, and the possibility of long-term hearing impairment (Cardoso et al., 2015). The Joint Committee on Infant Hearing has claimed that noise is "one of the most polluting physical agents in neonatal intensive care, such that hospitalization in intensive care can be considered itself a risk factor for pre-verbal deafness" (Trapanotto et al., 2004).

The American Academy of Pediatrics recommends sound levels not exceeding 45 dB during the day and 35 dB at night. However, within the NICU, noises generated by incubator fans, equipment alarms, infant crying, and telephones often surpass these recommendations, reaching levels as high as 80–90 dB, even within the confines of an incubator. Elevated noise levels beyond recommended thresholds can induce detrimental effects, including changes in oxygen saturation, increased heart and respiratory rates, and heightened intracranial pressure, and indirectly impact cerebral perfusion and oxygenation. This can culminate in agitation, crying, and behavioral alterations in premature infants (Zeraati et al., 2019).

The Newborn Individualized Developmental Care and Assessment Program (NIDCAP) is a model designed to create a supportive environment for premature infants and their families, aiming to balance the infant's physiological, motor, and state subsystems. It employs two key strategies: providing individualized care and adapting NICU settings to reduce stressors, such as incorporating quiet periods for uninterrupted sleep. NIDCAP targets five subsystems of infant functioning: autonomic, motor, state regulatory/organizational, attention/interactional, and self-regulatory systems. Its focus is on assessing and enhancing the smoothness, modulation, regulation, and differentiation of these subsystems. Research findings indicate that infants receiving care through the NIDCAP approach experience benefits such as reduced hospital stays, improved brain development, increased weight gain, fewer episodes of sepsis, decreased need for ventilator assistance, and enhanced growth and development post-discharge. Moreover, the NIDCAP approach influences organizational structures, care delivery philosophies, and relationships between families and medical professionals. It fosters parental bonding, reduces parental stress, aids NICU staff in assessing infant well-being, and enhances staff satisfaction. (Charafeddine et al.,2020).

1.2 Problem Statement

The noise was described as a harmful external environmental stimulus because of its reversible effects in the short term and irreversible effects in the long term (Zeraati et al., 2019). The prolonged exposure to noise in the NICU causes changes in the behavioral and physiological status of the newborn (Freedman et al., 2001).

Despite the guidelines set by the American Academy of Pediatrics to prevent the irreversible effects of noise on infants and newborns, noise still constitutes a dangerous factor that causes severe acoustic pollution in the NICU (Benini et al., 1996).

Several studies indicate a pressing need to identify interventions aimed at reducing noise levels within the NICU. Despite this, there has been a notable scarcity of research dedicated to identifying specific interventions for noise reduction in NICU settings (Manske, 2017).

In addition, many studies have discussed the effect of music on infant behavior, while limited articles have discussed the effect of noise. And there is no study in Palestine about it. So, the present study was conducted to identify the association between noise and the physiological and behavioral status of neonate.

1.3 Significance of the study

This research is the first to look into the relationship between noise and the physiological and behavioral status of newborns in NICUs in Palestine. Therefore, this study provides literature framework as reference for future studies. Moreover, the results of this study intend to support hospitals to evaluate and develop their own strategies and guidelines to prevent the occurrence of the reversible and irreversible effects of noise on infants and newborns in the NICU.

1.4 Aim of study

The aim of the study is to investigate the association between noise and the neonatal physiological and behavioral Status in NICU at AL -Makassed Hospital, Jerusalem.

1.5 Sub- Objectives of the study

- To determine the major sources of noise in the NICU.
- To determine the association between noise and neonate's sleep patterns in the NICU at Al-Makassed Hospital.

1.6 Research Question

This study sought to answer the following question

- What is the correlation between noise and the neonatal physiological and behavioral status in neonatal intensive care unit at Al-Makassed hospital in Jerusalem?
- Is there difference in the mean scores of the Anderson Behavioral State Scale between noise time and quiet time in the NICU?
- Is there difference in the mean heart rate between noise time and quiet time in the NICU?
- Is there difference in the mean respiratory rate between noise time and quiet time in the NICU?
- Is there difference in the mean of O2 saturation between noise time and quiet time in the NICU?

1.7 Research Hypotheses

This study sought to the following questions:

- There is no significant difference in the mean scores of the Anderson Behavioral State Scale between noise time and quiet time in the NICU at $\alpha \leq 0.05$.
- There is no significant difference in the mean heart rate between noise time and quiet time in the Neonatal Intensive Care Unit (NICU) at $\alpha \leq 0.05$.
- There is no significant difference in the mean respiratory rate between noise time and quiet time in the Neonatal Intensive Care Unit (NICU) at $\alpha \leq 0.05$.
- There is no significant difference in the mean of O2 saturation between noise time and quiet time in the Neonatal Intensive Care Unit (NICU) at $\alpha \leq 0.05$.

1.8 Conceptual Definition

- Heart rate: frequency of heartbeats occurring within a minute (bpm). (Mandal,2023).
- Respiratory rate:" the number of breaths per minute, (breath /min), or more formally, the number of movements indicative of inspiration and expiration per unit time.” (Stöppler,2021).
- O2 saturation:" measures the percentage of ox hemoglobin (oxygen-bound hemoglobin) in the blood, and it is represented as arterial oxygen saturation (SaO2) and venous oxygen saturation (SvO2). Oxygen saturation is a vital parameter to define blood oxygen content and oxygen delivery”. (Dutta,2021).
- Sleep pattern: "is the natural state of rest in which your eyes are closed, your body is inactive, and your mind does not think". https://www.collinsdictionary.com/dictionary/english/sleep.
- Behavior: something that a person does that can be observed, measured, and repeated (Bicard and Bicard, 2012). And other definition: how someone behaves or carries themselves, particularly in relation to others. https://www2.education.vic.gov.au/pal/behaviour students/guidance/11-definitions .2023.
- Noise: "is an unpleasant or unexpected sound”. (Fink, 2019).

1.9 Operational Definition

The following operational definitions were utilized for the aim of this study:

Noise levels were measured during specified noisy and quiet periods using a Digital Environmental Meter (EM5) device. Per American Academy of Pediatrics (AAP) guidelines, normal heart rate (HR) will be between 100 and 170 beats per minute, as well as tachycardia over 170 and bradycardia under 100, both of which are abnormal. Normal RR between 30 and 60 breaths per minute, bradypnea under 30 breaths per minute and tachypnea over 60 breaths per minute, both of abnormal, and additional normal O2 saturation between 90% and 99%, if saturation below 90%, abnormal. In regards to behavior, and sleep were measured by Anderson behavioral state scale. Per American Academy of Pediatrics (AAP) normal vs abnormal behaviors guidelines are listed below:

Normal findings

- Normal skin color
- Arms and legs flexed or tucked
- Hand touching his face
- Hand to mouth or in-mouth
- Sucking
- Looking at you
- Smiling and looking relaxed

Signs of stress (abnormal findings)

- Restless
- Excessive hiccupping
- Excessive yawning
- Excessive sneezing

- Frowning
- Looking away
- Squirming
- Frantic, disorganized activity
- Arms and legs pushing away
- Arms and legs limp and floppy
- Skin color changes

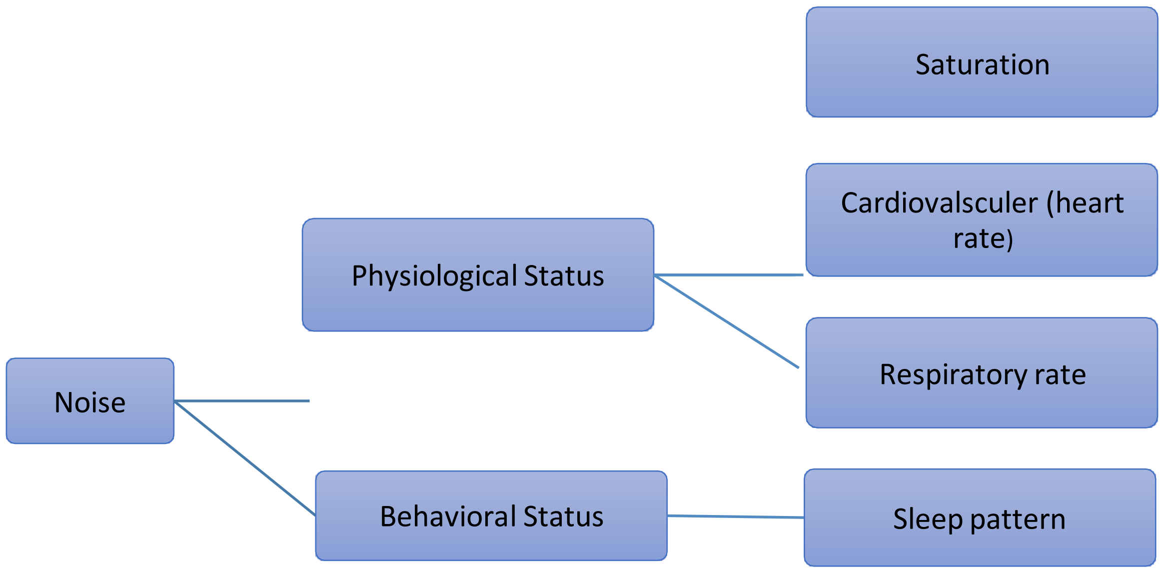
In regards to sleep. Per American Academy of sleep medicine guidelines, generally newborns sleep about 8 to 9 hours in the daytime and about 8 hours at night. But they may not sleep more than 1 to 2 hours at a time. Most babies don't start sleeping through the night (6 to 8 hours) without waking until they are about 3 months old or until they weigh 12 to 13 pounds. About two-thirds of babies can sleep through the night regularly by age 6 months.

Babies also have different sleep cycles than adults. Babies spend much less time in rapid eye movement (REM) sleep (dream time sleep). And the cycles are shorter. The following are the usual nighttime and daytime sleep needs for newborns through 2 years old:

Table (1): The usual nighttime and daytime sleep needs for newborns through 2 years' old

Age	Total sleep hours	Total hours of nighttime sleep	Total hours of daytime sleep
Newborn	16 hours	8 to 9	8
1 month	15.5 hours	8 to 9	7
3 months	15 hours	9 to 10	4 to 5
6 months	14 hours	10	4
9 months	14 hours	11	3
1 year	14 hours	11	3

1.10 Conceptual Framework



Chapter Two

Literature Review

The Neonatal Intensive Care Unit offers essential care for premature and newborn infants, serving as their initial encounter with the outside world. Despite the committed medical attention provided, the NICU atmosphere presents difficulties, including intense lighting, noise from medical equipment, and limited maternal contact, all of which can affect infant adjustment (O'Callaghan & Philip, 2019). In this chapter, literature was classified according to themes of the study

Previous Studies

2.1 Impact of NICU Environment on Brain Development

The Neonatal Intensive Care Unit (NICU) plays a pivotal role in the early development of preterm and newborn infants, who are exceptionally susceptible during this crucial phase of development and maturation. The design of the NICU, with its multitude of sensory inputs, holds significant importance in this developmental journey, where noise levels stand out as a particularly influential element. Noise, frequently an unavoidable element of the NICU surroundings, has gained growing acknowledgment as a notable influencer of the developmental paths of neonates. Research has shown that prolonged exposure to elevated noise levels in the NICU can disturb the delicate equilibrium of neuronal activity and synaptic connectivity within the developing brain (O'Callaghan & Philip, 2019).

The underdeveloped nervous systems of preterm and newborn infants exhibit heightened sensitivity to external stimuli, rendering them especially vulnerable to the negative impacts of environmental factors like noise. Studies have demonstrated that excessive noise levels in the NICU can evoke stress responses in neonates, prompting physiological reactions that may interfere with essential neural processes crucial for brain development (Lejeune et al., 2016).

Additionally, disturbances caused by noise during critical stages of neurodevelopment could hinder the formation of neural circuits accountable for diverse cognitive functions, sensory processing, and emotional regulation. These disruptions have been associated with a heightened likelihood of neurodevelopmental disorders, such as attention deficits, learning disabilities, and behavioral issues, which might emerge later in childhood or endure into adulthood (O'Callaghan & Philip, 2019).

Moreover, the NICU environment, known for its continual activity, intense lighting, and medical procedures, can exacerbate the neurobiological susceptibilities of preterm and newborn infants. The combined effect of these environmental stressors, including noise, on the evolving brain emphasizes the significance of adopting measures to alleviate their negative impacts and enhance optimal neurodevelopmental outcomes in this fragile population (Lejeune et al., 2016).

2.2 Guidelines for Noise Levels in NICU

The American Academy of Pediatrics (AAP) has set forth rigorous standards concerning noise levels within the Neonatal Intensive Care Unit, stressing the vital significance of fostering an environment conducive to neonatal development and welfare.

As outlined by Khalesi et al. (2017), the AAP advises that noise levels in NICUs should not surpass 45 decibels (dB).

These guidelines stem from extensive research indicating that excessive noise exposure can profoundly affect neonatal health and development. The fragile physiology of premature and newborn infants renders them especially susceptible to the harmful effects of environmental stimuli, including noise pollution. Elevated noise levels in the NICU have been associated with various adverse outcomes, including heightened stress levels, disturbed sleep patterns, impaired neurodevelopment, and compromised physiological stability.

Surpassing the recommended noise threshold of 45 dB can worsen these risks, presenting significant obstacles to the care and recuperation of infants in the NICU. Hence, adhering to AAP guidelines is crucial for maximizing the developmental outcomes and overall welfare of neonates receiving intensive care.

2.3 Sources of Noise Pollution in NICUs

Noise pollution in NICUs is a multifaceted problem arising from various sources within the healthcare environment. Primarily, medical equipment plays a substantial role in generating noise. Devices like mechanical ventilators, radiant heaters, infusion pumps, and incubators produce differing levels of sound during their operation (Cardoso et al., 2015). Although these machines are crucial for monitoring and maintaining the health of premature infants, their noise emissions can surpass recommended levels, thereby adding to the overall ambient noise within the NICU.

Furthermore, human activity within the NICU significantly adds to noise pollution. Healthcare professionals, comprising nurses, doctors, and support staff, carry out crucial duties like patient care, medical assessments, and equipment adjustments around the clock. These tasks frequently entail conversations, movements, and interactions with medical devices, all contributing to noise generation. Additionally, the presence of visitors, including parents and family members, further elevates ambient noise levels as they engage in conversations or move within the unit. (Jordão et al., 2017).

Operational activities within the NICU intensify noise pollution. Handling equipment, like opening and closing incubators or adjusting settings on medical devices, generates brief bursts of noise. Similarly, tasks such as restocking supplies, cleaning procedures, and administrative duties entail movements and actions that add to the overall noise level within the unit (Jordão et al., 2017).

Collectively, these sources of noise pollution pose challenges for neonates in the NICU. While medical equipment and human activity are indispensable for neonatal care, initiatives to reduce their noise emissions and control operational noise are vital for fostering a quieter and more conducive environment for neonatal development and well-being.

2.4 Importance of Improving NICU Environment

The Neonatal Intensive Care Unit serves as a vital setting for the care of preterm and newborn infants, many of whom are fragile and medically complex. The environment in which these infants receive care plays a crucial role not only in their immediate health outcomes but also in their long-term developmental trajectory. Therefore, enhancing the NICU environment is paramount for several reasons

First and foremost, the NICU environment directly influences the survival and well-being of newborns. Studies indicate that factors like noise levels, lighting, and overall environmental stressors can impact infants' physiological stability, neurodevelopmental outcomes, and susceptibility to infections (Lejeune et al., 2016). By optimizing the NICU environment to offer a quieter, more soothing atmosphere, healthcare providers can reduce the risks linked with prematurity and enhance infants' prospects of thriving outside the womb.

Furthermore, a supportive NICU environment aids in decreasing mortality and morbidity rates among newborns. Infants admitted to NICUs are frequently born prematurely or with intricate medical conditions necessitating specialized care. Within these high-risk populations, environmental factors can heighten existing health complexities and weaken infants' resilience to physiological stressors (Edwards & Austin, 2016). Hence, by employing approaches to improve the NICU environment, healthcare facilities can mitigate adverse outcomes, lower the occurrence of complications, and ultimately preserve lives.

Additionally, the quality of the NICU environment not only affects infants but also shapes the experiences of their families and the healthcare providers tending to them. Families of newborns in the NICU endure considerable emotional stress and anxiety, compounded by the clinical setting and uncertainties regarding their infants' health (O'Callaghan & Philip, 2019). A well-planned and supportive NICU environment can alleviate some of these stressors, nurturing a feeling of comfort, empowerment, and involvement among families as active participants in their infants' care.

Additionally, healthcare providers working in the NICU endure prolonged exposure to environmental stressors, including noise, fluctuations in lighting, and high workload demands. These factors can contribute to provider burnout, fatigue, and compromised decision-making, ultimately impacting the quality of care provided to infants (Lejeune et al.,2016). By prioritizing enhancements in the NICU environment, healthcare organizations showcase their dedication to staff well-being and professional satisfaction, thereby boosting retention rates and fostering a culture of excellence in neonatal care.

2.5 Need for Noise Reduction in NICU

The NICU environment is inherently noisy, filled with a cacophony of sounds originating from diverse sources like medical equipment, human activity, and operational tasks (Cardoso et al., 2015; Jordão et al., 2017). This continuous onslaught of noise can profoundly impact the delicate physiology of premature and newborn infants.

Continuous exposure to heightened noise levels in NICUs can disturb the natural sleep patterns of infants, which are pivotal for their growth and development (Edwards & Austin, 2016). Sleep isn't just crucial for rest; it also plays a vital role in brain maturation, memory consolidation, and overall neurodevelopment. Disrupted sleep in neonates has been associated with a range of adverse outcomes, including impaired cognitive function, behavioral issues, and delayed growth (Graven & Browne, 2008).

Furthermore, the physiological functions of infants, including heart rate, respiratory rate, and oxygenation, are highly sensitive to environmental stimuli such as noise (Lejeune et al., 2016). Increased noise levels in the NICU can evoke stress responses in infants, resulting in fluctuations in vital signs and potentially jeopardizing their overall well-being.

Furthermore, the effects of noise pollution extend beyond the infants themselves to encompass the entire NICU ecosystem. Healthcare providers working in noisy environments encounter difficulties in communication, concentration, and stress management, all of which can ultimately impact the quality of care provided to neonates (Lasky et al., 1996).

Additionally, parents and family members, already grappling with the emotional strain of having a baby in the NICU, may find that noise exacerbates their stress and anxiety, hindering bonding and involvement in their child's care (Pineda et al., 2014).

During the transition from the womb to the outside world, newborns must undergo physiological and behavioral adjustments crucial for their survival. However, premature infants face unique challenges in this process. Variations in physiology and caregiving practices profoundly influence how premature neonates engage with their environment (Sabagh et al., 2022).

Physiological characteristics of premature neonates serve as early indicators of their health status. Changes in physiological states, such as heart rate, respiratory rate, temperature, skin color, and oxygen saturation levels, are significant signals of health alterations. Factors such as pain, stress, separation from parents, environmental stimuli, and multiple caregivers can trigger fluctuations in these parameters, potentially leading to fluctuations in blood pressure and heightened restlessness in the infant (Sabagh et al., 2022).

Since stress is "the non-specific response of the body to any demand for change", as defined by Hans Selye, the nature of the NICU is thought to be a stressful environment for babies .These stresses can be caused by internal or external factors, and determining these factors in a newborn is very challenging, However, these stresses can also be approached and measured through physiological status, such as heart rate, blood pressure, etc., and behavioral changes, such as facial expressions, limb movements, crying, sweating, etc. (Bautista et al., 2019).

The healthy physical environment of the NICU can consistently ensure a normal development of premature neonates, even though various factors can impact the normal development and growth of neonates. In some NICUs, there are gaps in the protocols for controlling light and noise, when patients are exposed to excessive noise, their vital signs—including heart rate, respiratory rate, blood pressure, body temperature, oxygen saturation, and sleep pattern—change (Abdel Hamid et al., 2021).

A study conducted by Morris et al. (2000) emphasized the common occurrence of excessive noise in Neonatal Intensive Care Units (NICUs), specifically highlighting its effects on the cardiovascular and respiratory systems. The response patterns of these systems are influenced by various factors such as sound intensity, infant behavioral state, maturity, postnatal age, and perinatal history.

Using the Assessment of Preterm Infant Behavior scale, Cardoso et al. (2015) conducted a prospective observational study to evaluate the behavior, neurobehavioral, and physiological status of premature newborns in NICUs. Their findings revealed that NICU noise can have detrimental effects on newborns, resulting in changes in physiological parameters such as heart rate (HR), respiratory rate, blood pressure, and oxygen saturation levels, as well as alterations in behavior. Adequate auditory rest is crucial for newborn development and growth, helping to alleviate stress responses induced by noise. Prolonged exposure to a noisy environment, exceeding 48 hours, is considered a risk factor for hearing loss and may delay weight gain and discharge of newborns.

A non-randomized controlled trial study by Gholami et al. (2023) unveiled that noise serves as the primary stressor for neonates in the NICU. This stress triggers alterations in their physiological status, such as bradycardia, apnea, elevated blood pressure, decreased oxygen levels (desaturation), and behavioral changes like hyperactivity, crying, and behavioral problems such as attention deficits.

In a study conducted by Wachman and Lahav (2010), it was discovered that noise levels within the neonatal intensive care unit (NICU) can negatively impact infant physiological stability and subsequent neurodevelopment. Loud transient noises were observed to trigger immediate physiological changes, including increased heart rate, blood pressure, respiratory rate, and decreased oxygen saturation. These alterations heighten the risk of subsequent apnea and bradycardia episodes, which pose short-term detrimental effects and have long-term implications on neurological development. These long-term effects encompass increased intracranial pressure (ICP), neurological impairments, language difficulties, as well as the potential for hearing impairment and disruptions to sleep patterns.

In a study on the brain's response to sound (Volpe et al., 2017), which examined how intracranial pressure (ICP) is affected by sound, it was demonstrated that infants' persistent crying led to an increase in ICP, respiratory rate, heart rate, and caused hypoxemia by reducing transcutaneous oxygen tension, alongside background noise levels of sixty to sixty-five decibels and abrupt increases to seventy and seventy-five decibels. Another study (Jordão et al., 2017) corroborates these findings regarding physiological and neurological alterations, including elevated blood pressure, increased heart rate, dilated pupils, disrupted sleep patterns, agitation, fatigue, and irritability.

Studies by Brown (2009) and a comprehensive review by Almadhoob and Ohlsson (2020) underscore the frequent exposure of infants in the neonatal intensive care unit (NICU) to continuous loud noise, which can have detrimental effects on their development. Adverse physiological reactions, such as apnea, changes in heart rate, blood pressure, and oxygen saturation, are commonly observed in response to excessive auditory stimulation. By reducing noise levels in the NICU, the physiological stability of sick neonates can be enhanced, thereby fostering optimal brain development in infants. Prolonged exposure to excessive noise also increases the risk of hearing loss and may lead to abnormalities in brain development, sensory functions, as well as speech and language skills.

Numerous studies have shown that excessive noise is highly bad for newborns, especially premature babies who are more likely to experience physiological and neurological problems .As the acceptable normal range level of noise is 45dB, many of the hundreds of incubator alarms were the source of this noise ,as was observed, when the noise level increased and became extremely loud, there were numerous changes in physiological parameters, including an increase in heart rate and respiration rate (HR), a decrease in oxygenation, and a mean blood pressure reading, These changes had an impact on the behavior of the premature, and because newborns require an average of 15 hours of sleep per day, the disruption in their sleep patterns caused by the loud noise was severe (Zacarías et al., 2022).

Morris et al. (2000) conducted a randomized control trial study to examine the physiological effects of sound on newborns. The trial involved two groups of newborns, each of which was exposed to a different level of sound for one to one and a half minutes, The results revealed changes in the newborns' physiological status, including elevated blood pressure, heart rate, and respiratory rate, as well as occasionally apnea or irregular breathing and decreased oxygen levels, which had an adverse.

A study by (McMahon et al., 2012) found a link between noise and neonatal growth, as the noise in the NICU disrupts the development of the newborns and increases their risk of developing cognitive, language, and hearing problems. The study also argued that the positive auditory experience is necessary for the maturity of the brain and could be an effective factor in maintaining the neonates in a healthy neurodevelopmental process, preterm neonates were known to be more sensitive to excess noise because of their immaturity in the auditory system.

A study conducted by Balsan et al. (2021) investigated the tolerance of infants in the Neonatal Intensive Care Unit (NICU) and nurses' use of a novel frequency-selective hearing protection device called DREAMIES (NEATCap Medical, LLC). The study involved 50 newborns receiving care in a Level 3 NICU in a two-phase prospective study. The tolerance of newborns was assessed based on device-related skin irritation, behavioral status, and vital signs. The findings revealed that there were no instances of skin breakdown in any of the newborns during either phase of the study. Only transient skin erythema was observed. Additionally, there were periods when infants experienced deceleration in heart and respiratory rates and increased sleepiness while using the DREAMIES device .

According to a study by Freedman et al. (2001), environmental noise in NICUs emerged as a significant factor in disrupting newborns' sleep patterns. Many newborns in NICUs experienced this issue due to loud noise, leading to irregular sleep patterns, weight loss, and potential neurological problems in the future.

According to a study conducted by Almadhoob and Ohlsson (2020), stressors present in the neonatal intensive care unit (NICU) can have adverse effects on infants, leading to physiological changes such as bradycardia, tachycardia, increased blood pressure, apnea, hypoxemia, alterations in oxygen saturation, heightened oxygen consumption, and elevated intracranial pressure. Therefore, it is imperative to mitigate noise levels within the NICU. This can be achieved through educational initiatives targeting parents and caregivers to modify their behaviors, alongside the utilization of noise level meters equipped with computing and data storage capabilities to continuously monitor and electronically record noise levels over extended periods, both inside and outside the incubator.

Elevated noise levels have been linked to a higher incidence of mistakes and accidents, resulting in a negative impact on staff performance. Lowering noise levels could therefore enhance staff performance, increase parental satisfaction with care, and reduce medical errors, consequently improving patient safety (Almadhoob and Ohlsson, 2020).

Currently, there are few scales available to assess neonatal behavior, including Brazelton's system primarily designed for term neonates, and the Anderson Behavioral State Scoring System specifically tailored for preterm neonates. As the respiratory and neurological systems of premature infants are still developing, behavioral assessment serves as a valuable tool for healthcare providers to gauge the neurological development of neonates. This enables the design of individualized developmental care plans for hospitalized infants (Manske, 2017).

According to a study, the noise level in the NICU environment before and after quiet time (hours) was 70 dB, after the intervention to reduce the level of noise, which included turning off all alarms on equipment, telephones, and monitors, stopping family visits during this time, and measuring the noise in the side of incubators, the noise level was reduced to 20dB . The quiet time show a positive impact on a neonate's behavioral and physiological status, making it important to identify the factors and intensity of noise in NICUs that affect neonate development, especially in premature infants, and loud noise also affects healthcare providers' performance (Hernández et al., 2020).

To offer a calm environment for both staff and patients and to keep the ward as quiet as possible, quiet time was suggested, the concept of quiet time has evolved over time because of the desire of a restorative ward environment. Currently, quiet time refers to minimizing infant handling and reducing the ward's light and noise over a period, which the quiet time give more rest time for the premature infants and better growth and development will be (Zhang et al., 2022).

According to (Ryherd, 2019) cohort study, they created their own rules, which included limited discussions, dimmer lights, and coordinating scheduled cleaning services at specified times every afternoon and evening and worked with the nursing staff to establish a quiet period in the NICU, they observed that the quiet period had a favorable impact on neonates and their health.

An intervention referred to as the "quiet hour protocol" entails implementing eight-hour shifts during which light and sound levels are deliberately reduced, and disruptions at the patient's bedside are minimized. This protocol aims to enhance the environment by primarily focusing on reducing sound levels. It includes measures such as providing private rooms, educating staff about the adverse effects of noise, maintaining silence among staff, minimizing patient handling, lowering alarm volume, utilizing visual warning systems, promptly responding to alarms, and locating toilets away from the baby's bed. The quiet hour approach emphasizes recognizing patient stress as an environmental stimulus, preventing environmental stressors, and facilitating environmental adaptation (Zauche et al., 2020).

The Advantages of Quiet Time is reduces stress in infants, assisting them in maintaining good blood pressure, respiration, oxygen levels, heart rate, and other critical signs, enables better, longer sleep, which aids in the development of all infants and the speedy recovery of sick infants, encourages self-quietness and healthy sleeping habits, and it may also assist to lessen chronic concentration problems , promotes proper brain and sensory development and safeguards the delicate hearing of premature infants. Therefore, quiet time is advised for lowering stress in preterm babies since it lowers heart rate and improves breathing pattern by limiting external stimuli (noise, light, and handling) (Choudhury, 2020).

Summary of Literature Review

Literature review has revealed that the noise levels in NICUs frequently surpass the thresholds advised for these environments, impacting the physiological and behavior condition of neonate. There is a growing concern that such noise puts preterm infants at high-risk for adverse health effects. Research also demonstrates that noise has a number of negative health consequences on infants and how the medical staff feels about it, and every research is in agreement over the need for intervention and measures to reduce noise levels in the NICU to avoid help minimize the risk of exposure to loud noises.

Chapter Three

Methodology

3.1 Introduction

This chapter described the methodology, including research design, setting, Population, sample and sampling, data collection, and data analysis processes are Outlined.

3.2 Study Design

The cross-sectional correlational study, a non-experimental observational approach.

3.3 Study Setting

The study was conducted in the Neonatal Intensive Care Unit (NICU) at Almakassed hospital in Jerusalem.

Al-Makassed Hospital is a Palestinian hospital located in the neighborhood of Al-Tur in East Jerusalem. It was founded in 1968 as a non-profit, charitable institution and became one of the largest hospitals in the region. The hospital has multi-specialties and offers a lot of medical services, including cardiology, neurology, oncology, orthopedics, pediatrics, and surgery. Al-Makassed Hospital has a capacity of over 300 beds and is equipped with modern medical equipment, including MRI and CT scanners, digital radiography, and ultrasound machines. The hospital is staffed by a team of qualified medical professionals, including doctors, nurses, and support staff, who work together to provide quality healthcare to patients. The hospital is committed to medical education and research and offers residency programs in several medical specialties. In addition to inpatient and outpatient services, Al-Makassed Hospital also has an emergency department that provides 24/7 care to patients with acute medical conditions. Also, the hospital offers other support services, involving laboratory and radiology services, pharmacy, and physiotherapy. Al-Makassed Hospital is known for its commitment to serving the local community, regardless of their ability to pay. The hospital provides free or heavily subsidized medical care to those in need and is a vital healthcare provider for many people in the region. The hospital has 50 critical care nurses. The hospital has accreditation by the Joint Commission International (JCI). (Al-Makassed Hospital, 2023).

Additionally, the neonate intensive care unit in the hospital contained two ICUS rooms: the first one ICU-ONE (seven patients in incubators with two to three nurses) and the second one ICU TWO (seven patients in incubators with two to three nurses), one isolation room (four patients in incubators with one nurse), two intermediate rooms (six patients in cots or incubators with one nurse or two nurses), and two equipment rooms.

3.4 Study Population (Human Subjects)

The study population includes neonates, who born at gestational age 28 week to 39 week or during these first 28 days of life.

3.5 Study Criteria

a. Inclusion Criteria

- neonates, who born at gestational age 28 week to 39week or during these first 28days of life.
- Neonates who don’t suffer from cardiovascular problems like arrhythmias such as v-tach, A-fib, and others.
- Neonates with no disruptions in sleep patterns.

- Neonates who passed the hearing test.
- Neonates are in incubators.

b. Exclusion Criteria

- babies after 39 weeks and after 28day (infants).
- Neonates who suffer from cardiovascular problems like arrhythmias such as v-tach, A-fib, and others.
- Neonates who have disruptions in sleep patterns.
- A Neonate who failed a hearing test.
- Neonates are not in incubators.

3.6 Study Sample and Sampling

The estimated number of subjects using the G-power 3.1 program will be 120 observational sample.

3.7 Study Variables

- *Independent Variables*

  The independent variable is noise.
- *Dependent Variables*

  The dependent variables are physiological status: including cardiovascular, respiratory, oxygen saturation, and behavior status of the neonates including sleep patterns.

3.8 Data Collection Tool and Process

The purpose of the study was explained to the administration and the NICU manager. Permission was granted from the IRB at the Arab American university, and the hospital administration to conduct the study and collect the data daily for about two hours for each observation, in two periods. on shift A (7 AM – 2:30 PM) and shift B (2:30 PM – 10 PM). According to previous researches, the time from (07:00 to 11:00 AM.), there are more staff members present, and the evening shift, from (14:00 to 18:00 PM.), when medical residents rotate shifts, nurses change shifts, family visits occur, and morning medical visits occur, is when noise levels in NICUs are highest (Hernández and Hernández, 2020). We attempted to keep things as quiet as possible by limiting major source of noise in the NICU in both time periods which include:

- Monitors alarms in NICU.
- Mechanical ventilator alarms in NICU.
- Syringe pumps alarms.
- Incubators alarms
- Suction sound.
- Visitors' sounds.
- Opening and closing one or two doors of incubators.
- Speaking the voice of health care providers in NICU during the caring and handoff between shifts.

The noise level was measured in the two-time period: between 8 -10 am, the noise level ranged from 60 to 80 decibels, while from 4-6 pm, it ranged from 50 to 60 decibels. After noise level control in both times (stopping visitors during this time, lowering the volume of the monitors alarms, stopping care, and speaking, and turning off the phones), both periods recorded noise levels ranged between 40 to 49.2 decibels. The noise level was measured by Digital Environmental Meter (EM5) code device (NEDA16046F22006P), the device was calibrated and valid, from Al- Makassed Hospital.

Measured noise effect on physiological changes and behavioral on neonates on One group (same neonate), at the two time periods (8am -10 am) and (4pm -6pm) and then compared it to neonate' physiological and behavioral changes with more quiet time (with noise level control at the same two time periods). Anderson Behavioral State Scale, international scale was used to collect the information about the infant's behavior and sleep status. (Yang et al.,2014: Alkhawaldeh et al.,2023).

3.9 Data Collection Tool

(Anderson Behavioral State Scale) was used to collect information regarding infant's behavior and sleep status. The noise level was use measures using Digital Environmental Meter (EM5) device to measure the level of noise in NICU. This scale was used to assess the sleep-wake status of preterm newborns using 12 specific behavioral sleep characteristics. Each state is assessed based on the regularity of breathing, the opening or closure of the eyes, the movement of the limbs and trunk, and the intensity of crying. The behavioral state is depicted in what its characteristics indicate:

State	Characteristic
Deep sleep	No eye movements, No activity, Regular breathing.
Light sleep	Low levels of activity, Rapid eye movement possible.
Drowsiness	Variable activity levels, heavy-lidded eyes that open and close.
Quiet alert	Wide, bright eyes, Attention focused on stimulus.
Active alert	Increased motor activity Periods of fussiness Irregular respirations.
Crying	Increased motor activity, Color changes.

The Anderson behavioral states were assessed as follows:

Anderson state scoring scale:

Regular Quiet Sleep: score {1}, Irregular Quiet Sleep: score {2}, Active Sleep: score {3}, Very Active Sleep: score {4}, Drowsy: score {5}, Alert Inactivity: score {6}, Quite Awake: score {7}, Active: score {8}, Very Active: score {9}, Fussing: score {10}, Crying: score {11}, Hard Crying: score {12}.

The scoring will be: (state 1–5) indicate that infant sleep, and (6–8) indicate that the infant is awake and calm and (9 to 12) indicate that the infant is in a state of restless activity or fussiness.

3.10 Statistical Analysis

The analysis was conducted using various data analysis software, including Microsoft Excel, STATA 14, and Statistical Package for Social Sciences version. The analysis initiated by providing descriptive statistics for both physiological and behavioral parameters observed in the Neonatal Intensive Care Unit (NICU). This included metrics such as heart rate, respiratory rate, oxygen saturation, and neonatal behavioral states during designated quiet and noise times.

Subsequently, comparisons were made between physiological parameters during quiet and noise times. Utilizing mean values, standard deviations, and ranges, the researcher visually depicted these comparisons through graphs and tables.

Similarly, the distribution of neonatal behavioral states during quiet and noise times was compared using frequency counts and percentages. This comparison was summarized in tabular form, providing insights into the impact of environmental factors on neonatal behavior.

Hypothesis testing was then conducted to ascertain significant differences in mean scores of the Anderson Behavioral State Scale, heart rate, respiratory rate, and oxygen saturation between noise and quiet times. Independent samples t-tests were employed for this purpose, with results presented alongside t-values, degrees of freedom, p-values, and confidence intervals.

Interpretation of the results followed, where in each hypothesis was assessed in terms of its statistical significance and implications. The researcher discussed how observed differences in physiological parameters and behavioral states between noise and quiet times underscored the potential impact of environmental noise on neonatal well-being.

3.11 Ethical Considerations

The study presented in this thesis conducted by the Institutional Review Board (IRB) at AAUP. To respect the rights, dignity, and safety of the research participants, the researcher explained to the family of the participants the purpose and content of the study, the duration, the research procedure, the confidentiality, the benefits, and the accompanying risk. Data collection conducted only for persons who agreed to participate in the study through voluntary participation of the study subjects. Be read to each legal guardian and participant orally, and the consent form emphasizes that the data collected by an anonymous method, data will be used for research goals only, and the participant or the legal guardian (mothers or fathers of the babies) has the right to withdraw from the study at any time.

3.12 Limitations

- Small sample size.
- The study conducted in limited time.
- The study was in one place.
- Limited articles and mostly was about music effect.

Chapter Four

Results

4.1 Introduction

The Neonatal Intensive Care Unit (NICU) serves as a critical environment for the care and treatment of newborns requiring specialized medical attention. Within this setting, various factors can significantly impact the delicate physiological and behavioral status of neonates. Among these factors, noise levels emerge as a crucial consideration due to their potential to disrupt the stability and development of neonatal health. This paper examines the correlation between noise exposure and its adverse effects on the physiological well-being of neonates in NICU, particularly focusing on cardiovascular function, respiratory health, and oxygen saturation levels. Furthermore, it explores the influence of noise on the behavioral status of neonates, encompassing sleep patterns and overall behavioral responses within the NICU environment.

4.2 Overview of Sample Characteristics

The sample characteristics in this study encompass various aspects of neonatal health and behavior in the Neonatal Intensive Care Unit (NICU). These include physiological parameters such as cardiovascular indicators (e.g., heart rate), respiratory measures (e.g., respiratory rate), and oxygen saturation levels. Additionally, the behavioral status of neonates is assessed, particularly focusing on sleep patterns, utilizing the Anderson Behavioral State Scale (ABSS).

4.2.1 Neonatal Behavioral State Distribution in the NICU (Anderson Behavioral State Scale)

The figure (1) represents the distribution of scores on the Anderson Behavioral State Scale (ABSS) for a sample of neonates in the Neonatal Intensive Care Unit (NICU).

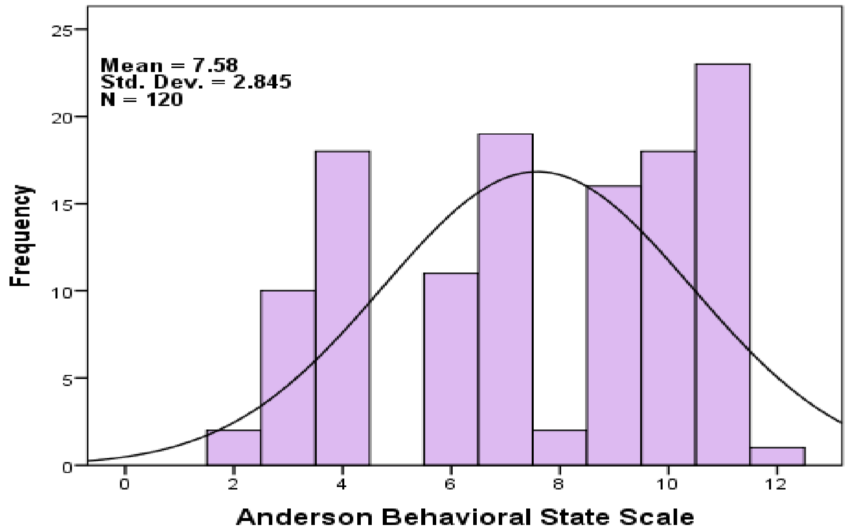


Figure (1): Neonatal Behavioral State Distribution in the NICU (Anderson Behavioral State Scale)

The total number of valid observations in the sample is 120. The average score on the ABSS across all neonates in the sample is 7.58, the range is 10, indicating that the scores vary from a minimum of 2 to a maximum of 12 as shown in figure (1).

Categories of Behavioral States: The scale categorizes neonatal behavioral states into three groups based on their ABSS scores:

- "The infant sleep (1-5)": This category includes neonates exhibiting sleep patterns corresponding to scores ranging from 1 to 5 on the ABSS. There are 30 cases, accounting for 25% of the total sample.

- "The infant is awake and calm (6-8)": This category encompasses neonates who are awake and in a calm state, with ABSS scores falling within the range of 6 to 8. There are 32 cases, constituting 26.7% of the sample.
- "The infant is in a state of restless activity or fussiness (9-12)": This category comprises neonates displaying restless activity or fussiness, characterized by ABSS scores ranging from 9 to 12. It is the most frequent category, with 58 cases, representing 48.3% of the sample.

4.2.2 Neonatal Physiological State Distribution in the NICU (Heart Rate)

The figure (2) provides a summary of heart rate (HR) measurements for neonates in the Neonatal Intensive Care Unit (NICU).

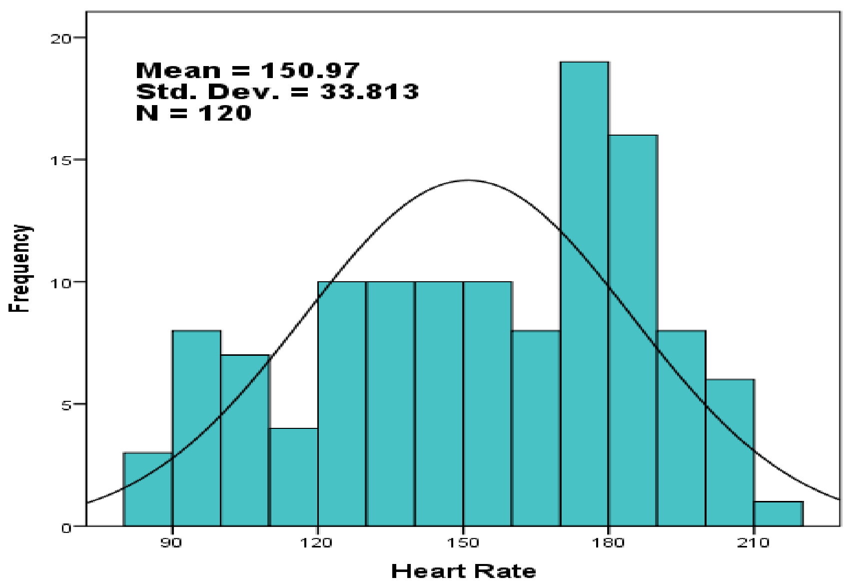


Figure (2): Neonatal Physiological State Distribution in the NICU (Heart Rate)

The analysis includes data from 120 neonates, the mean heart rate for the neonatal sample is 150.97 beats per minute (bpm) and standard deviation of heart rate measurements is 33.813 bpm, that suggests greater variability in heart rates among the neonates in the NICU. The range of heart rate measurements spans from a minimum of 80 bpm to a maximum of 218 bpm as shown in figure (2).

4.2.3 Neonatal Physiological State Distribution in the NICU (Respirator Rate)

The figure (3) summarizes respiratory rate (RR) measurements for neonates in the Neonatal Intensive Care Unit (NICU).

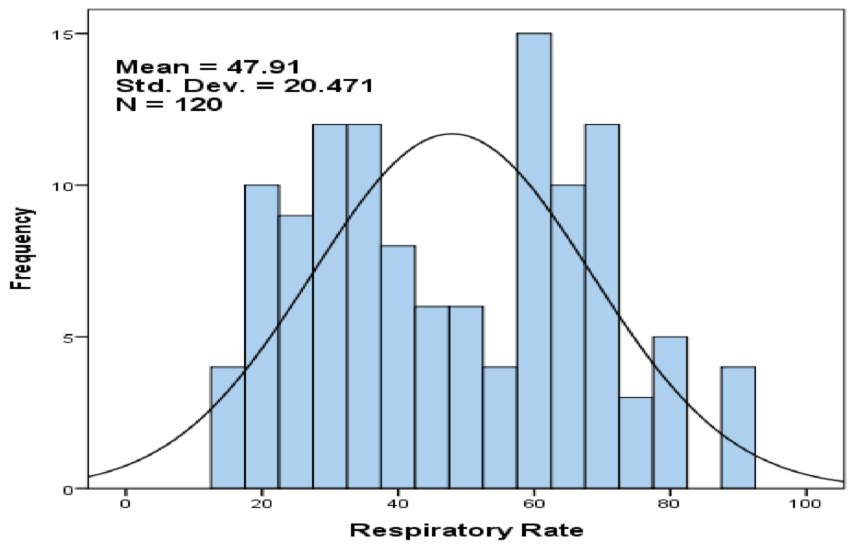


Figure (3): Neonatal Physiological State Distribution in the NICU (Respirator Rate)

The analysis includes data from 120 neonates. The mean respiratory rate for the neonatal sample is 47.91 breaths per minute (bpm), and the standard deviation of respiratory rate measurements is 20.471 bpm. This indicates greater variability in respiratory rates among the neonates in the NICU. The range of respiratory rate measurements spans from a minimum of 15 bpm to a maximum of 90 bpm, as shown in Figure (3).

4.2.4 Neonatal Physiological State Distribution in the NICU (Saturation)

The figure (4) presents a summary of oxygen saturation levels among neonates in the Neonatal Intensive Care Unit (NICU).

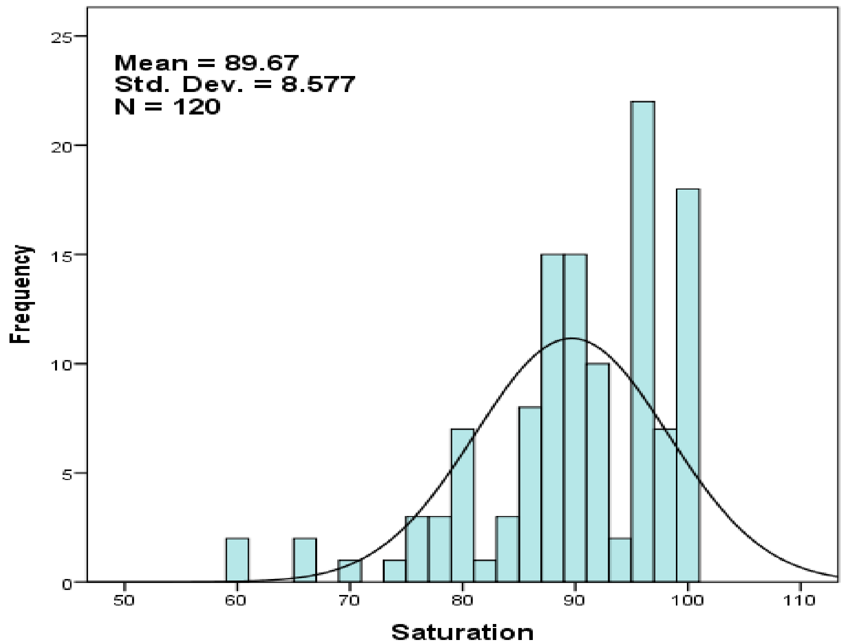


Figure (4): Neonatal Physiological State Distribution in the NICU (Saturation)

The analysis includes data from 120 neonates, the mean oxygen saturation level for the neonatal sample is 89.67% and standard deviation of oxygen saturation measurements is 8.57. The range of oxygen saturation measurements spans from a minimum of 60% to a maximum of 100%, as depicted in Figure 4.

4.3 Neonatal Physiological State Distribution in the NICU: Comparing Noise and Quiet Times

The table (2) provides detailed insights into the physiological status of neonates in the Neonatal Intensive Care Unit (NICU), focusing on heart rate (HR), oxygen saturation levels, and respiratory rate (RR) during both quiet and noise times. Understanding the impact of environmental factors, particularly noise, on the physiological well-being of neonates in the NICU is essential for optimizing care practices and improving outcomes.

Table (2): Neonatal Physiological State Distribution in the NICU: Comparing Noise and Quiet Times

The Physiological Status	Mean	Standard	Minimum	Maximum
Quiet Time (8-10 Am)				
HR	138	22.37	100	170
Saturation	96	3.38	90	100
RR	42	12.3	24	60
Quiet Time (4-6 Pm)				
HR	138	19.51	100	170
Saturation	96	3.14	90	100
RR	44	11.55	25	60
Noise Time (8-10 Am)				
HR	157	45.49	80	218
Saturation	85	6.64	70	95
RR	52	27.72	15	90
Noise Time (4-6 Pm)				
HR	171	30.66	90	201
Saturation	82	8.61	60	92
RR	54	23.63	15	80

The table (2) shows the following results:

1. Quiet Time (8-10 AM)

   - Heart Rate (HR): The mean HR during quiet time in the morning is 138 beats per minute (bpm), with a standard deviation of 22.37. The HR ranges from 100 to 170 bpm during this period.

- Oxygen Saturation: The mean saturation level is 96%, with a standard deviation of 3.38. Saturation levels range from 90% to 100%.
- Respiratory Rate (RR): The mean RR is 42 breaths per minute, with a standard deviation of 12.3. RR ranges from 24 to 60 breaths per minute during this time.

2. Quiet Time (4-6 PM)

- HR: The mean HR remains the same at 138 bpm during the afternoon quiet time, with a slightly lower standard deviation of 19.51. HR ranges from 100 to 170 bpm.
- Saturation: Similarly, the mean saturation level remains consistent at 96%, with a standard deviation of 3.14. Saturation levels range from 90% to 100%.
- RR: The mean RR slightly increases to 44 breaths per minute during the afternoon quiet time, with a standard deviation of 11.55. RR ranges from 25 to 60 breaths per minute.

3. Noise Time (8-10 AM)

- HR: During noisy hours in the morning, the mean HR significantly increases to 157 bpm, with a much higher standard deviation of 45.49. HR ranges from 80 to 218 bpm.

- Saturation: The mean saturation level decreases to 85% during noisy hours, with a standard deviation of 6.64. Saturation levels range from 70% to 95%.

- RR: The mean RR also increases to 52 breaths per minute during noise time in the morning, with a substantially higher standard deviation of 27.72. RR ranges from 15 to 90 breaths per minute.

4. Noise Time (4-6 PM)

- HR: Like the morning noise time, the mean HR significantly increases to 171 bpm during the afternoon noise time, with a standard deviation of 30.66. HR ranges from 90 to 201 bpm.

- Saturation: The mean saturation level decreases further to 82% during noisy hours in the afternoon, with a higher standard deviation of 8.61. Saturation levels range from 60% to 92%.

- RR: The mean RR increases to 54 breaths per minute during noise time in the afternoon, with a standard deviation of 23.63. RR ranges from 15 to 80 breaths per minute.

5. Significance Differences

- Significant differences are observed in all physiological parameters (HR, saturation, RR) between quiet and noise times.

- During noise time, there is a notable increase in HR and RR, accompanied by a decrease in oxygen saturation levels compared to quiet time.

- These differences highlight the impact of noise on the physiological status of neonates, indicating potential stress and discomfort during noisy hours in the NICU.

4.4 Neonatal Behavioral State Distribution in the NICU: Comparing Noise and Quiet Times.

The table (3) presents data on the behavioral states of neonates admitted to the Neonatal Intensive Care Unit (NICU) during noise and quiet times, categorized according to the Anderson Behavioral State Scale. This scale assesses the infants' behavioral responses, particularly focusing on sleep patterns, calmness, and restless activity or fussiness. By examining the frequency and percentage distribution of each behavioral state during noise and quiet times, we can gain insights into the potential impact of environmental factors, such as noise levels, on neonatal behavior in the NICU.

Table (3): Neonatal Behavioral State Distribution in the NICU: Comparing Noise and Quiet Times

Anderson Behavioral State Scale	Noise Time		Quiet Time	
	Frequency	Percentage	Frequency	Percentage
The infant sleep (1-5)				
4-6 pm	0	0.0%	17	28.3%
8-10 am	0	0.0%	13	21.7%
The infant is awake and calm (6-8)				
4-6 pm	0	0.0%	13	21.7%
8-10 am	2	3.3%	17	28.3%
The infant is in a state of restless activity or fussiness (9-12)				
4-6 pm	30	50%	0	0.0%
8-10 am	28	46.7%	0	0.0%
Total	60	100%	60	100%

To analyze the impact of noise on the behavioral status of neonates admitted to the NICU using the Anderson Behavioral State Scale, we can examine the distribution of behavioral states during noise time compared to quiet time as shown in table (2).

1. *Comparison between Noise and Quiet Times:*

    - The infant sleep (1-5): No neonates were observed sleeping during noise time, whereas during quiet time, 17 neonates (28.3%) were sleeping from 4-6 pm, and 13 neonates (21.7%) were sleeping from 8-10 am.

    - The infant is awake and calm (6-8): No neonates were observed to be awake and calm during noise time, while during quiet time, 2 neonates (3.3%) were awake and calm from 8-10 am, and 17 neonates (28.3%) were awake and calm from 4-6 pm.

    - The infant is in a state of restless activity or fussiness (9-12): A significant difference is observed between noise and quiet times. During noise time, 30 neonates (50%) were in a state of restless activity or fussiness from 4-6 pm, and 28 neonates (46.7%) were in this state from 8-10 am. However, during quiet time, no neonates exhibited this behavior.

2. *Significance*: The table highlights significant differences in neonatal behavioral states between noise and quiet times in the NICU, particularly regarding sleep, calmness, and restlessness. These differences underscore the impact of environmental factors, such as noise levels, on neonatal behavior and well-being.

4.5 Hypothesis Testing

In the Neonatal Intensive Care Unit (NICU), providing a conducive environment for neonatal development is paramount. Among the critical factors affecting neonatal well-being are noise levels, heart rate, respiratory rate, and oxygen saturation. Understanding how these variables are influenced by environmental factors, such as noise, is essential for optimizing neonatal care. Therefore, this study aims to investigate the impact of noise exposure on neonatal physiological parameters and behavioral state in the NICU. Specifically, the study that there is no significant difference in the mean scores of the Anderson Behavioral State Scale, heart rate, respiratory rate, and oxygen saturation between noise time and quiet time in the NICU at $\alpha \leq 0.05$.

First hypothesis: There is no significant difference in the mean scores of the Anderson Behavioral State Scale between noise time and quiet time in the NICU at $\alpha \leq 0.05$.

The results of the independent samples t-test on the Anderson Behavioral State Scale indicate a statistically significant difference in mean scores between noise time and quiet time in the NICU as shown in table (4).

Table (4): The significant difference in the mean scores of the Anderson Behavioral State Scale between noise time and quiet time in the NICU

<table>
<tr><th></th><th>Type</th><th>N</th><th>Mean</th><th>Std. Dev.</th><th>Df</th><th>t-value</th><th>p-value</th><th colspan="2">Confidence interval</th></tr>
<tr><td rowspan="2">Anderson Behavioral State Scale</td><td>Noise Time</td><td>60</td><td>10.08</td><td>0.926</td><td rowspan="2">118</td><td rowspan="2">20.37</td><td rowspan="2">0.000</td><td>Lower</td><td>Upper</td></tr>
<tr><td>Quiet Time</td><td>60</td><td>5.08</td><td>1.660</td><td>4.514</td><td>5.486</td></tr>
</table>

The t- test shows the following points:

Mean Scores**:** During noise time, the mean score on the Anderson Behavioral State Scale was 10.08, whereas during quiet time, it was 5.08. This suggests that neonates exhibited a higher level of behavioral state during noise time compared to quiet time.

T-test Results**:** The t-test shows a significant t-value of 20.376 (p value = 0.000 less than $\alpha \leq 0.05$), indicating a significant difference in mean scores between noise time and quiet time.

The results indicating that there is a significant difference in the mean scores of the Anderson Behavioral State Scale between noise time and quiet time. These findings suggest that noise time in the NICU is associated with a higher level of behavioral activity among neonates compared to quiet time. High levels of noise may disrupt the neonates' behavioral state, potentially affecting their overall well-being and development.

Second hypothesis: There is no significant difference in the mean heart rate between noise time and quiet time in the Neonatal Intensive Care Unit (NICU) at $\alpha \leq 0.05$.

The results of the independent samples t-test comparing the mean heart rate (HR) between noise time and quiet time in the Neonatal Intensive Care Unit (NICU) indicate a statistically significant difference as shown in the table (5).

Table (5): The significant difference in the mean heart rate between noise time and quiet time in the Neonatal Intensive Care Unit (NICU)

	Type	N	Mean	Std. Dev.	Df	t-value	p-value	Confidence interval	
Heart Rate	Noise Time	60	164.07	39.034	118	4.588	0.000	Lower	Upper
	Quiet Time	60	137.87	20.818				14.89	37.51

The t- test shows the following points:

Mean Heart Rate**:** During noise time, the mean heart rate was 164.07 beats per minute (bpm), while during quiet time, it was 137.87 bpm. This suggests that neonates exhibited a higher mean heart rate during noise time compared to quiet time.

T-test Results**:** The t-test shows a significant t-value of 4.588 with 118 degrees of freedom, indicating a statistically significant difference in mean heart rate between noise time and quiet time since (p value = 0.000 less than $\alpha \leq 0.05$). The 95% confidence interval for the difference in mean heart rate ranged from 14.890 to 37.510 bpm, this interval does not include zero, further supporting the conclusion of a significant difference in mean heart rate.

These results provide evidence that there is a significant difference in mean heart rate between noise time and quiet time in the NICU. The higher mean heart rate during noise time suggests that environmental noise may contribute to increased physiological stress or arousal in neonates.

Third hypothesis: There is no significant difference in the mean respiratory rate between noise time and quiet time in the Neonatal Intensive Care Unit (NICU) at $\alpha \leq 0.05$.

The results of the independent samples t-test comparing the mean respiratory rate (RR) between noise time and quiet time in the Neonatal Intensive Care Unit (NICU) indicate a statistically significant difference as shown in table (6).

Table (6): The significant difference in the mean respiratory rate between noise time and quiet time in the Neonatal Intensive Care Unit (NICU)

	Type	N	Mean	Std. Dev.	Df	t-value	p-value	Confidence interval	
Respiratory rate	Noise Time	60	52.93	25.556	118	2.763	0.007	Lower	Upper
	Quiet Time	60	42.88	11.862				2.847	17.253

The t- test shows the following points:

<u>Mean Respiratory Rate</u>**:** During noise time, the mean respiratory rate was 52.93 breaths per minute (bpm), while during quiet time, it was 42.88 bpm. This suggests that neonates exhibited a higher mean respiratory rate during noise time compared to quiet time.

<u>T-test Results</u>**:** The t-test shows a significant t-value of 2.763 with 118 degrees of freedom, indicating a statistically significant difference in mean respiratory rate between noise time and quiet time (p value = 0.007). The 95% confidence interval for the difference in mean respiratory rate ranged from 2.847 to 17.253 bpm, this interval does not include zero, further supporting the conclusion of a significant difference in mean respiratory rate.

These results provide evidence that there is a significant difference in mean respiratory rate between noise time and quiet time in the NICU. The higher mean respiratory rate during noise time suggests that environmental noise may contribute to increased physiological stress or arousal in neonates.

Fourth hypothesis: There is no significant difference in the mean of saturation between noise time and quiet time in the Neonatal Intensive Care Unit (NICU) at $\alpha \leq 0.05$.

The results of the independent samples t-test comparing the mean saturation levels between noise time and quiet time in the Neonatal Intensive Care Unit (NICU) indicate a statistically significant difference as shown in table (7).

Table (7): The significant difference in the mean of saturation between noise time and quiet time in the Neonatal Intensive Care Unit (NICU)

	Type	N	Mean	Std. Dev.	Df	t-value	p-value	Confidence interval	
Saturation	Noise Time	60	83.48	7.751	118	-11.399	0.000	Lower	Upper
	Quiet Time	60	95.85	3.246				-14.515	-10.218

The t- test shows the following points:

<u>Mean Saturation Levels</u>**:** During noise time, the mean saturation level was 83.48%, while during quiet time, it was 95.85%. This suggests that neonates exhibited lower mean saturation levels during noise time compared to quiet time.

<u>T-test Results</u>**:** The t-test shows a significant t-value of -11.399 with 118 degrees of freedom, indicating a statistically significant difference in mean saturation levels between noise time and quiet time (p value = 0.000). The 95% confidence interval for the difference in mean saturation levels ranged from -14.51 to -10.218, this interval does not include zero, further supporting the conclusion of a significant difference in mean saturation levels.

These results provide evidence that there is a significant difference in mean saturation levels between noise time and quiet time in the NICU. The lower mean saturation levels during noise time suggest that environmental noise may adversely affect oxygen saturation levels in neonates.

The results of the correlations between the Anderson Behavioral State Scale and the physiological status indicators (Heart Rate [HR], Saturation, and Respiratory Rate [RR]) are presented in the table below.

4.6 Reliability of the Tool

The significant p-values across all three physiological measures (all below 0.05) suggest that the Anderson Behavioral State Scale reliably correlates with physiological indicators of the individual's status. The scale appears to capture aspects of physiological arousal and distress, as reflected in heart rate, saturation, and respiratory rate.

However, the varying strengths of the correlations indicate that while the tool is reliable, its sensitivity may differ across different physiological measures. For instance, it is more strongly associated with saturation and heart rate than with respiratory rate.

Table (8): The Anderson Behavioral State Scale reliably correlates with physiological indicators of the individual's status

Correlations		The Physiological status		
		HR	Saturation	RR
Anderson Behavioral State Scale	Pearson Correlation	0.458**	-0.667-**	0.242**
	Sig. (2-tailed)	0.000	0.000	0.008
	N	120	120	120

1. Heart Rate (HR) and Anderson Behavioral State Scale.

• Correlation coefficient (r = 0.458): This positive correlation suggests a moderate relationship between the Anderson Behavioral State Scale and heart rate. As the behavioral state scale score increases, the heart rate tends to increase as well.

• Significance (p = 0.000): The p-value is less than 0.05, indicating that the correlation is statistically significant. Thus, the observed relationship is unlikely to be due to chance.

2. O2 Saturation and Anderson Behavioral State Scale.

• Correlation coefficient (r = -0.667): This negative correlation indicates a strong inverse relationship between the behavioral state scale score and oxygen saturation. As the score on the behavioral state scale increases, the saturation levels tend to decrease.

• Significance (p = 0.000): The p-value is less than 0.05, indicating that the correlation is statistically significant. This means the negative relationship between the behavioral state scale and saturation is reliable and not due to random variation.

3. Respiratory Rate (RR) and Anderson Behavioral State Scale.

• Correlation coefficient (r = 0.242): This positive correlation suggests a weak relationship between the behavioral state scale and respiratory rate. As the behavioral state score increases, there is a slight increase in respiratory rate.

• Significance (p = 0.008): The p-value is less than 0.05, indicating that the correlation is statistically significant. Despite the weak correlation, the relationship is statistically reliable.

Chapter Five

Discussion

The outcomes of the present study illuminate the substantial influence of noise levels on both neonatal physiological parameters and behavioral states within the NICU. Upon juxtaposing these findings with prior research, notable parallels and distinctions surface, underscoring the critical significance of addressing noise exposure within neonatal care environments.

5.1 Physiological Parameters and Behavioral States

The recent investigation unveiled a clear connection between noise exposure and detrimental impacts on neonatal well-being. Specifically, heightened noise levels correlated with elevated heart and respiratory rates and decreased oxygen saturation levels. Additionally, alterations in neonatal behavioral states, characterized by restlessness and disrupted sleep patterns, were observed in response to increased noise levels.

These findings are consistent with prior research indicating that excessive noise in the NICU triggers physiological stress responses in neonates (Gholami et al., 2023; Morris et al., 2000). Numerous studies have consistently shown that elevated noise levels lead to changes in cardiovascular and respiratory parameters, including increased heart rate, blood pressure, and respiratory rate, as well as decreased oxygen saturation levels (Cardoso et al., 2015; Wachman and Lahav, 2010). Likewise, disruptions in neonatal behavioral states, such as heightened agitation and reduced sleep duration, have been linked to noise exposure in the NICU (Zacarías et al., 2022; Freedman et al., 2001).

5.2 Impact on Neurodevelopment and Long-term Outcomes

Moreover, the harmful impact of noise on neonatal neurodevelopment and long-term prospects is well-documented. Studies have established a connection between excessive noise exposure in the NICU and adverse neurological consequences, such as heightened intracranial pressure, disturbed sleep patterns, and hindered brain development (Volpe et al., 2017; Jordão et al., 2017). These findings emphasize the critical need for creating a tranquil and nurturing environment conducive to optimal neurodevelopmental outcomes in neonates.

Interventions and Recommendations

Given these discoveries, it's imperative to implement interventions aimed at reducing noise levels in the NICU to support the well-being and development of neonates. Prior research suggests several strategies to achieve this goal, including the adoption of quiet time protocols, the reduction of equipment alarms, and educational initiatives targeting staff and caregivers about the harmful effects of noise (Almadhoob and Ohlsson, 2020; Ryherd, 2019). Moreover, innovative solutions such as frequency-selective hearing protection devices have demonstrated efficacy in alleviating noise-related stress among neonates (Balsan et al., 2021). These interventions collectively contribute to creating a quieter and more conducive environment for neonatal care, thereby optimizing outcomes for vulnerable infants in the NICU.

5.3 Overview of Sample Characteristics

The findings depicted in Figures (2), (3), and (4) offer significant insights into the distribution of physiological states among neonates in the Neonatal Intensive Care Unit

(NICU), particularly concerning heart rate, respiratory rate, and oxygen saturation levels, respectively. To elucidate their implications and significance, it is pertinent to contextualize these results within the framework of previous studies. By comparing these findings with existing literature, we can discern patterns, correlations, and potential causal relationships, thus enriching our understanding of neonatal health in the NICU setting.

Commencing with heart rate (HR), the average HR of 150.97 bpm with a standard deviation of 33.813 bpm indicates significant variability among neonates in the NICU. This variability may be influenced by diverse factors such as stress, pain, environmental stimuli, and developmental stage, as highlighted in prior research (Sabagh et al., 2022; Bautista et al., 2019). Studies have demonstrated that excessive noise levels in the NICU can induce physiological changes in neonates, including alterations in heart rate (Wachman and Lahav, 2010; Zacarías et al., 2022). Moreover, interventions targeting noise reduction, such as quiet time protocols, have shown favorable impacts on neonatal physiological status, particularly in regulating heart rate (Hernández et al., 2020; Zauche et al., 2020).

Transitioning to respiratory rate (RR), the average RR of 47.91 breaths per minute (bpm) with a standard deviation of 20.471 bpm also underscores notable variability among neonates in the NICU. Analogous to heart rate, respiratory rate can be influenced by external stressors, noise levels, and overall environmental conditions (Morris et al., 2000; Gholami et al., 2023). Excessive noise exposure has been associated with alterations in respiratory patterns among neonates, underscoring the significance of interventions aimed at noise reduction to enhance respiratory stability (Cardoso et al., 2015; McMahon et al., 2012).

Finally, oxygen saturation levels serve as critical indicators of neonatal health, with the mean saturation level of 89.67% and a standard deviation of 8.57 highlighting variability in oxygenation among NICU neonates. Past studies have stressed the adverse effects of elevated noise levels on oxygen saturation, potentially leading to decreased oxygen levels and hypoxemia (Volpe et al., 2017; Jordão et al.,2017). Efforts to mitigate noise in the NICU have positively affected oxygen saturation levels and overall physiological stability (Zacarías et al., 2022; Almadhoob and Ohlsson, 2020).

In brief, the results regarding heart rate, respiratory rate, and oxygen saturation levels in NICU infants emphasize the considerable influence of environmental factors, especially noise, on neonatal physiological stability. Interventions like implementing quiet time protocols have proven effective in improving physiological outcomes for NICU neonates by reducing noise levels. Understanding and addressing these environmental stressors enable healthcare providers to enhance the care environment, thereby better supporting neonatal health and development.

5.4 Neonatal Physiological State Distribution in the NICU: Comparing Noise and Quiet Times.

The data depicted in Table (2) elucidates the notable influence of noise on the physiological condition of neonates in the NICU, specifically about heart rate (HR), oxygen saturation levels, and respiratory rate (RR). Let's delve into a discussion of these findings in light of previous studies:

1. Physiological Responses to Noise:

- Heart Rate (HR): Our findings regarding the increased heart rate (HR) during noise times (8-10 AM and 4-6 PM) align with studies conducted by Bautista et al. (2019) and Gholami et al. (2023). Their research supports the notion that noise in the NICU contributes to elevated HR among neonates.
- Oxygen Saturation: Our findings are consistent with studies conducted by Cardoso et al. (2015) and Wachman and Lahav (2010), which have also reported decreased oxygen saturation levels in response to noise. Neonates in our study exhibited a decline in saturation levels during noise times, suggesting potential stress-induced changes.
- Respiratory Rate (RR): Our observations the results of studies conducted by Cardoso et al. (2015) and Morris et al. (2000), revealing an increase in RR during noise times. This suggests heightened respiratory effort among neonates in response to environmental stressors.

2. Impact on Neurodevelopment:

- Long-Term Effects: Research conducted by Wachman and Lahav (2010) and McMahon et al. (2012) indicates that noise-induced physiological alterations may have enduring impacts on neurodevelopment. Elevated HR, RR, and diminished oxygen saturation levels could potentially contribute to cognitive, language, and hearing difficulties in neonates over the long term.
- Behavioral Changes: Studies by Zacarías et al. (2022) and Morris et al. (2000) have documented behavioral shifts in reaction to noise, including heightened activity levels and increased crying, which may amplify physiological stress responses.

3. Importance of Quiet Time:

    - Encouraging Rest and Recovery: Quieting protocols, advocated by Hernández et al. (2020) and Ryherd (2019), offer a solution to counteract the negative impact of noise on neonatal physiology. These measures aim to minimize environmental disturbances, enabling neonates to rest and promoting improved physiological balance.
    - Enhancing Neurodevelopment: Choudhury (2020) highlighted the significance of quiet periods in nurturing optimal brain and sensory growth. Through reducing external disturbances like noise and handling, quiet periods facilitate the development of healthy sleeping patterns and safeguard the delicate hearing of premature infants.

3. Clinical Implications:

    - Staff Efficiency and Patient Well-being: Almadhoob and Ohlsson (2020) emphasized how noise affects staff efficiency and patient well-being. Decreasing noise in the NICU not only enhances physiological stability in neonates but also diminishes medical errors and boosts parental contentment with care

In conclusion, the outcomes extracted from Table (2) resonate with prior research, highlighting the adverse impacts of noise on neonatal physiology and neurodevelopment in the NICU. Adopting measures like quiet time protocols is a potential solution to alleviate these consequences, thereby fostering improved outcomes for premature infants.

5.3 Neonatal Behavioral State Distribution in the NICU: Comparing Noise and Quiet Times.

The findings presented in this study regarding the influence of noise on neonatal physiological parameters and behavioral states in the NICU resonate with previous research outcomes while also introducing some novel insights. Here's how these findings relate to and extend upon prior studies:

1. Physiological Responses to Noise: have been extensively studied in previous research by Sabagh et al. (2022), Bautista et al. (2019), and Cardoso et al. (2015). These studies have consistently highlighted alterations in parameters like heart rate, respiratory rate, blood pressure, and oxygen saturation levels in response to noise exposure. Similarly, our study demonstrates a notable variance in mean heart rate between noise and quiet periods, with elevated heart rates observed during noisy conditions. This correlation with previous findings underscores the notion that noise within the NICU can induce physiological stress responses in neonates.
2. Behavioral Responses to Noise: The study's assessment of neonatal behavior using the Anderson Behavioral State Scale revealed noteworthy distinctions between noise and quiet periods. Our findings indicate a significant association between noise exposure and heightened behavioral activity among neonates. This aligns with previous research by Gholami et al. (2023) and Cardoso et al. (2015), which similarly observed behavioral alterations, including hyperactivity and crying, in response to noise. Moreover, the absence of neonates exhibiting restlessness or

fussiness during quiet periods further underscores the impact of noise levels on neonatal behavior.

3. Impact of Noise Reduction Interventions: Numerous prior studies have investigated interventions geared towards reducing noise levels within the NICU and their potential advantages. For instance, strategies like quiet time protocols (Hernández et al., 2020; Ryherd, 2019; Zauche et al., 2020) and frequency-selective hearing protection devices (Balsan et al., 2021) have been suggested to alleviate the negative impacts of noise on neonatal well-being and growth. The current study indirectly underscores the significance of such interventions by illustrating the variances in neonatal physiological and behavioral reactions between periods of noise and quietness.
4. Long-Term Developmental Implications: Research conducted by Almadhoob and Ohlsson (2020) and Freedman et al. (2001) has emphasized the potential long-term developmental ramifications of prolonged exposure to excessive noise in the NICU. These repercussions encompass disruptions in sleep patterns, cognitive deficiencies, and language challenges. Although the present study concentrates on the immediate physiological and behavioral reactions to noise, its results underscore the necessity of tackling noise levels in the NICU to foster favorable long-term developmental trajectories for neonates.

In summary, the current study's findings add to the growing body of research by offering additional insights into the influence of noise on neonatal physiological indicators and behavioral patterns in the NICU. By corroborating and extending prior research, this study emphasizes the significance of interventions designed to lower noise levels, thus enhancing neonatal care and promoting optimal development.

5.4 Independent Samples t-tests.

The outcomes of the independent samples t-tests, which examined the mean respiratory rate and saturation levels during noise time versus quiet time in the Neonatal Intensive Care Unit (NICU), offer significant insights into how environmental elements, notably noise, affect neonatal well-being.

Respiratory Rate:

- The research demonstrates a statistically notable variance in mean respiratory rate between noise time and quiet time in the NICU. Neonates displayed a higher average respiratory rate during periods of noise compared to quiet intervals.
- This discovery aligns with prior studies suggesting that heightened noise levels in NICUs can induce physiological stress in neonates, resulting in alterations in respiratory rate (Sabagh et al., 2022; Bautista et al., 2019).
- Research indicates that noise-induced stress can lead to elevated respiratory rates, possibly stemming from the body's generalized reaction to challenging stimuli, as described by Selye (Bautista et al., 2019).
- Moreover, the observed rise in respiratory rate during noise exposure corresponds with prior research indicating that noise in NICUs can induce changes in physiological parameters, such as heart rate and oxygen saturation levels (Cardoso et al., 2015; Gholami et al., 2023).

O2 Saturation Levels:

- Likewise, the research highlights a notable contrast in mean saturation levels between periods of noise and quiet in the NICU. Neonates displayed reduced mean saturation levels during noise exposure compared to quieter periods.
- This discovery aligns with prior studies illustrating the detrimental impact of environmental noise on neonatal oxygen saturation levels (Wachman and Lahav, 2010; Almadhoob and Ohlsson, 2020).
- The excessive noise prevalent in NICUs has been associated with immediate physiological alterations, notably decreased oxygen saturation, which can adversely affect neonatal health and development in both the short and long term (Volpe et al., 2017; Zacarías et al., 2022).
- The decreased mean saturation levels observed during noise exposure underscore the critical role of maintaining a tranquil NICU environment to promote optimal physiological stability and neurodevelopment in neonates (Zacarías et al., 2022; Almadhoob and Ohlsson, 2020).

Comparison with Previous Studies:

- The results of this study support earlier research suggesting that noise in NICUs can have adverse effects on neonatal physiological parameters such as respiratory rate and oxygen saturation levels (Morris et al., 2000; Cardoso et al., 2015).
- In line with prior research, the present study underscores the significance of reducing noise levels in NICUs to enhance neonatal health outcomes and support neurodevelopment (McMahon et al., 2012; Freedman et al., 2001).

- Quiet time protocols have emerged as effective interventions for noise reduction and enhancing neonatal health within NICUs, a finding reinforced by the current study and consistent with prior research (Zhang et al., 2022; Zauche et al., 2020).
- The findings of the current study resonate with existing evidence, highlighting the adverse impact of noise on neonatal health and underscoring the necessity of adopting interventions to cultivate a quieter NICU setting for enhanced neonatal care (Choudhury, 2020; Ryherd, 2019).

5.5 Conclusions

The study's findings illuminate the substantial influence of environmental noise on neonatal health outcomes, notably within the NICU. It unveils a correlation between noise exposure during NICU care and adverse physiological effects, such as heightened respiratory rate, heart rate and diminished oxygen saturation levels in neonates. These results align with previous research, emphasizing the harmful impacts of excessive noise on neonatal development and overall well-being.

Furthermore, the study highlights the critical need for interventions to reduce noise levels within the NICU setting. Implementing strategies like quiet time protocols, reducing equipment alarms, and educating healthcare staff and caregivers about the detrimental effects of noise are vital measures to establish a more favorable environment for neonatal care. These interventions are crucial steps in promoting optimal neonatal health and well-being. Also its useful for all NICU hospital in Palestine because its consider as a first study in Palestine.

5.6 Recommendations

Based on the findings of this study and the existing literature, several recommendations can be made to improve neonatal care in the NICU:

- Implement Quiet Time Protocols: Hospitals should establish structured periods of reduced noise and activity in the NICU, allowing neonates to rest and promoting better physiological stability.
- Developing training programs to educate NICU staff and caregivers about the harmful effects of noise on neonatal health is essential: These programs should focus on raising awareness about the significance of maintaining a quiet environment and minimizing activities that generate unnecessary noise in the NICU. By providing education and training, healthcare professionals and caregivers can better understand the impact of noise on neonates and learn strategies to create a quieter and more supportive care environment. This proactive approach helps to ensure that all members of the NICU team are equipped with the knowledge and skills needed to prioritize the well-being of neonates and optimize their care.
- Use Technology to Monitor Noise Levels: Utilize noise level monitoring devices within the NICU to continuously assess ambient noise levels and identify sources of excessive noise. This data can inform interventions aimed at reducing noise pollution in the care environment.
- Optimizing the layout and design of NICUs to reduce noise propagation is essential for creating a conducive environment for neonatal care. Architectural and design modifications can be implemented to minimize noise levels within the NICU. This

may involve incorporating sound-absorbing materials into the construction of the unit, strategically placing equipment to minimize noise generation and transmission, and creating designated quiet zones for sensitive procedures and infant care activities. By designing NICU layouts with noise reduction in mind, healthcare facilities can mitigate the impact of environmental noise on neonatal health and promote better outcomes for their patients.

- Support Research and Innovation: Invest in research initiatives aimed at developing novel technologies and interventions to reduce noise exposure and improve neonatal outcomes in the NICU. Collaborative efforts between researchers, healthcare providers, and industry partners can drive innovation in this field.

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Appendices

Appendix 1: IRB Approval

Arab American University
Institutional Review Board - Ramallah

الجامعـــة العربيـــة الأمريكيـــة
مجلس اخلاقيات البحث العلمي – رام الله

IRB Approval Letter

Study Title: "The Association between Noise and the Neonatal Physiological and Behavioral Status in NICU at AL -Makassed Hospital, Jerusalem"

Submitted by: Ayat Zuhear Abayat

Date received: 8th December 2023

Date reviewed: 2nd January 2024

Date approved: 1st February 2024

Your Study titled **"The Association between Noise and the Neonatal Physiological and Behavioral Status in NICU at AL -Makassed Hospital, Jerusalem"** with the code number **"R-2024/A/2/N"** was reviewed by the Arab American University Institutional Review Board - Ramallah and it was approved on the 1st of February 2024.

Sajed Ghawadra, PhD
IRB-R Chairman
Arab American University of Palestine

الجامعة العربية الأمريكية - فلسطين
مجلس اخلاقيات البحث العلمي - رام الله
IRB-R
ARAB AMERICAN UNIVERSITY-PALESTINE
INSTITUTIONAL REVIEW BOARD - RAMALLAH

General Conditions:

1. Valid for 6 months from the date of approval.
2. It is important to inform the IRB-R with any modification of the approved study protocol.
3. The Bord appreciates a copy of the research when accomplished.

رام الله – فلسطين

Tel: 02-294-1999 **E-Email:** IRB-R@aaup.edu **Website:** www.aaup.edu

Appendix 2: Consent form:

INFORMED CONSENT

AAUP-IRB Code No.: ………………………….
AAUP-IRB Date: ……………………………….

I, ...(Name of Participant / optional) hereby agree to take part in the clinical research (clinical study/questionnaire study/drug trial) specified below:

Title of Study:

The Association between Noise and the Neonatal Physiological and Behavioral Status in NICU at AL -Makassed Hospital, Jerusalem". Fulfillment of master degree, in neonatal nursing program, in AAUP.
(Name of program)

The nature and purpose of which has been explained to me by ……Ayat Abayat …………………..……., and interpreted by …researches .... to the best of his/her ability in English.

I have been told about the nature of the research in terms of methodology, possible adverse effects and complications (as per Participant Information Sheet).
After knowing and understanding all the possible advantages and disadvantages of this research, I voluntarily consent of my own free will to participate in the clinical research specified above.
I understand that I can withdraw from this research at any time without assigning any reason whatsoever.

Date: … ……………….…………………………… Signature: …………
(Participant)

IN THE PRESENCE OF:

Name: … …………………………………...……

Designation:.. Signature: … …………………………………….

(Witness for Signature of Participant)

I confirm that I have explained to the patient the nature and purpose of the above-mentioned research.

Date: Signature:

(Attending investigator)

الملخص

الخلفية: تعتبر وحدة العناية المركزة لحديثي الولادة مكانًا حيويًا للذين يحتاجون إلى رعاية طبية .يمكن أن تؤثر كمية الضوضاء الموجودة بشكل كبير على الحالة الفسيولوجية والسلوكية لحديثي الولادة، مما قد يؤدي إلى عواقب سلبية. يعد التعرف على كيفية ارتباط التعرض للضوضاء برفاهية أطفال حديثي الولادة أمرًا ضروريًا لتحسين طرق الرعاية في وحدة العناية المركزة.

الأهداف: استكشاف العلاقة بين مستويات الضوضاء والحالة الفسيولوجية والسلوكية لحديثي الولادة في وحدة العناية المركزة لحديثي الولادة في مستشفى المقاصد في القدس. وكانت الأهداف هي تحديد مصادر الضوضاء، وتحليل آثارها على المؤشرات الفسيولوجية مثل معدل ضربات القلب، ومعدل التنفس، وتشبع الأكسجين، وتقييم تأثيرها على الأنماط السلوكية لحديثي الولادة، بما في ذلك عادات النوم.

المنهجية: تم اعتماد تصميم ارتباطي وصفي مستعرض غير تجريبي . تم مشاركة عينة متاحة مكونة من 120 طفل في عمر الحمل من 28 إلى 39 أسبوعًا أو خلال هذه الأيام الـ 28 الأولى. تم قياس مستويات الضوضاء خلال فترات محددة من الضوضاء والهدوء باستخدام جهاز قياس البيئة الرقمي .(EM5) و تقييم الحالات السلوكية لحديثي الولادة باستخدام مقياس أندرسون للحالة السلوكية. تم إجراء التحليل الإحصائي، بما في ذلك اختبارات t– test للعينات المستقلة، لمقارنة النتائج بين الفترات الصاخبة والهادئة.

النتائج: أظهرت النتائج تأثيرات كبيرة على الجوانب الفسيولوجية والسلوكية لحديثي الولادة . من الناحية الفسيولوجية، أدى التعرض للضوضاء إلى زيادة في معدل ضربات القلب (متوسط معدل ضربات القلب: 164.07 نبضة في الدقيقة أثناء وقت الضوضاء مقابل 137.87 نبضة في الدقيقة أثناء وقت الهدوء)، ومعدل التنفس (متوسط معدل التنفس : 52.93 نفس في الدقيقة أثناء وقت الضوضاء مقابل 42.88 نفس في الدقيقة أثناء وقت الهدوء). وانخفاض مستويات تشبع الأكسجين (متوسط التشبع: 83.48% أثناء وقت الضوضاء مقابل 95.85% أثناء وقت الهدوء) خلال ساعات الضوضاء مقارنة بأوقات الهدوء. من الناحية السلوكية، أظهر الأطفال حديثي الولادة مستويات أعلى من النشاط وانخفاضًا في حالات النوم أثناء الفترات الصاخبة. علاوة على ذلك، معدل ضربات القلب (معامل الارتباط =

0.458 ، القيمة الاحتمالية > 0.05) هذا الارتباط الإيجابي مع مقياس أندرسون للحالة السلوكية، وتشبع الاكسجين (معامل الارتباط -0.667 = ، القيمة الاحتمالية > 0.05) هذا الارتباط السلبي مع مقياس أندرسون للحالة السلوكية ومعدل التنفس (معامل الارتباط = 0.242 ، القيمة الاحتمالية > 0.05) هذا الارتباط الإيجابي مع مقياس أندرسون للحالة السلوكية. وأكد التحليل الإحصائي هذه الاختلافات، وسلط الضوء على الآثار الضارة للضوضاء على صحة الأطفال حديثي الولادة في بيئة وحدة العناية المركزة لحديثي الولادة.

الاستنتاجات: تؤكد النتائج على الآثار السلبية للضوضاء على صحة الأطفال حديثي الولادة في وحدة العناية المركزة. وارتبطت مستويات الضوضاء المرتفعة بالإجهاد الفسيولوجي والحالات السلوكية المضطربة بين الاطفال . ولذلك، فإن التدخلات الرامية إلى التخفيف من التعرض للضوضاء في وحدة العناية المركزة ضرورية لتعزيز النتائج التنموية وتحسين ممارسات رعاية الأطفال حديثي الولادة.

الكلمات المفتاحية: اطفال حديثي الولادة ، الضوضاء ، الهدوء ، الحالة السلوكية ، الحالة الفسيولوجية.