DETERMINING NOISE LEVEL AND ITS SOURCES IN NEONATAL INTENSIVE CARE UNITS OF SELECTED PUBLIC HOSPITALS IN KIGALI CITY

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By

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DECLARATION

I DUSABE Ruth declare that this research report is my own original work. It is being submitted in partial fulfillment for the Degree of Masters in Nursing Science in Neonatology track. This research report was not submitted for any academic grading, and was not published elsewhere.

Date 12th June 2019

Signature ………………

DUSABE Ruth

DEDICATION

I sincere dedicate my work:

To my family especially; my husband MULISA Tom

To my children; MULISA Miguel and MULISA TETA Grace

To all my classmates for the moments shared together,

Finally to my sister and friends

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ABSTRACT

Background: Environmental noise in the neonatal intensive care unit (NICU) has an impact on developmental progress of neonates especially preterm. Technology advancement has improved the life of preterm neonates but also changed NICU into a noisy place. Exposure to noise in NICU has the potential to affect neonatal auditory development, sleep patterns and physiological stability. It is necessary to determine the noise levels and its sources in overcrowded and busy urban hospitals of Kigali city.

Aim: To measure the noise levels and its sources in NICU in selected public hospitals in Kigali city.

Methodology: A quantitative cross-section descriptive study. A sound level meter was used in recording Sound level in six different locations of the NICUs at five different times of the day over the course of seven days at each hospital. Observational checklist was used to identify possible sources of noise. Data were analysed using descriptive and inferential statistics (ANOVA). Ethical Clearance Letter was granted by the College of Medicine and Health Science, Institution Review Board.

Results: Sound levels recorded in all the NICUs were high ranging from 61.8 dB to 77.0 dB, when the recommendation from American Association of Pediatrics (AAP) is 45 dB. Maximum noise level of hospital 1, 2, 3 and 4 were 72.3dB, 72.6dB, 76.5dB and 77.0dB; respectively, which were statically significant ($p < 0.001$). Ward rounds had the maximum noise levels compared to other times. The lowest noise level was lunch time in all hospitals. Noise levels were also high in all NICUs' rooms at the station near the entrance and the station which was located near nurses/midwifery station.

Conclusion: In all NICUs the noise level generated was greater than the standard limits established by WHO and AAP. More research is needed on noise level in neonatal units of different health settings. Advocacy is also needed for the health of neonates towards noise free environment. Excess noise has a negative effect on neonates.

Key words: NICU, Noise level, Neonates, Sound

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LIST OF ACRONYMS AND ABBREVIATIONS

AAP	**:** American Academy of Pediatrics
CPAP	**:** Continuous Positive Airway Pressure
CHUK	**:** Centre Hospitalier Universitaire de Kigali
CI	**:** Confidence Interval
DALYs	**:** Disability Adjusted Life Years lost
dB	**:**Decibel
EPA	**:** Environmental Protection Agency
HCP	**:** Health Care Providers
KMC	**:** Kangaroo Mother Care
IRB	**:** Institution Review Board
NCU	**:** Neonatal Care Unit
NICU	**:** Neonatal Intensive Care Unit
NUs	**:** Neonatal Units
RMH	**:** Rwanda Military Hospital
SD	**:** Standard Deviation
SLM	**:** Sound Level Meter
SPSS	**:** Statistical Package for Social Sciences
UTHK	**:** University Teaching Hospital of Kigali
WHO	**:** World Health Organisation
VLBW	**:** Very Low Birth Weight

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CHAPTER ONE: INTRODUCTION

1.1. INTRODUCTION

High level of noise in the neonatal intensive care unit (NICU) leads to damage and disruption of preterm growth. Most preterm neonates spend their time in NICU or neonatology care unit (NCU) receiving special care and this time is special for them. Most hospitals in Rwanda do not have NICU rather they have NCU which consists of a ward that acts as NICU. According to World Health Organization (WHO) recommendation, noise level in health settings should not exceed 35 decibel (dB) as mean sound level whereas, the American Academy of Pediatrics (AAP) recommends noise level not to exceed mean value of 45 dB (Schokry, 2016). Previous studies have stated numerous adverse effects of noise mostly to preterm neonates. Those effects of noise to preterm neonates are; hearing loss, stimulation of cardiovascular disease, gastric secretion increased and decreased immune response from infections (Blourchian and Sharafi, 2015 p. 22). NICU consists of different noise produced both by human activity and various biomedical materials (Raboshchuk et al., 2018 p. 391). Recognizing the noise level in NICU will help in reduction and maintenance of recommended sound in the NICU, to improved neonatal outcome.

1.2. BACKGROUND

Despite the recommendations from WHO and AAP, existing analyses of the acoustic environment in the NICU have indicated that noise standards are being exceeded regularly. Studies done in different NICU environments have demonstrated that average noise levels range from 48 to 55 dB (Knutson, 2012). Another study found that sound levels exceeded the recommended standard and noise level was 84dB (Smith, 2018). Noise level in NICU is produced by various sources, that may exert undesirable physiological effects on the neonates (Blourchian and Sharafi, 2015 p. 23). The noise level in NICU are from extremely diverse which; heated cribs, incubators, mechanical ventilators, monitors alarms, infusion pumps, opening and closing of doors and draws, circulation of people and conversations (Jordão et al., 2017).

WHO reported that; "western Europeans every year 45,000 DALYs (Disability Adjusted Life Years lost) are lost due to noise induces cognitive in children, 61,000 cardiovascular disease, 903,000 sleep disturbance due to noise (Thomas and Mette, 2017). In the study conducted by

Aly and Ahmed found out that “the vital signs of preterm were affected by noise more than full term (Aly and Ahmed, 2016 p. 4). Different study show that preterm neonates are affected by noise more compared to term neonates. Preterm neonates may spent time in NICU hospitalized needing special care.

NICU noise standard limits were developed long time have not been changed. Environmental Protection Agency (EPA) was developed in 1974 with average sound level of 45 dB and AAP in 1997 applied this recommendation to the NICU environment, stating that average sound levels not to exceed 45 dB (Santos et al, 2018 p. 121). NICU is full of advanced medical technology, that impact the life of the neonates and leads to high incidence of disability and neurodevelopmental disorders among survivors of NICU remains high and problematic (Santos et al 2018 p. 121).

Worldwide every year 15 million neonates are born preterm, and those that survive may suffer from disability throughout their lives, especially related to auditory problems, visual and learning difficulties (WHO, 2017), mostly caused by high noise in NICU. More than one million die because of complications (US Agency, 2015). South Asia and Sub-Saharan Africa accounts for over 60% of preterm births worldwide (US Agency, 2015). In Rwanda, 35,000 neonates are born preterm each year and 2,600 neonates die due to preterm complications they may face during hospitalization (US Agency, 2015). Disabling hearing loss in children was thirty four million (7.3%) of the 466 million people and the highest numbers was in South Asia, Asia Pacific and Sub-Saharan Africa (Neumann et al, 2019 p. 7).

According to Schokry, (2016), earlier neonate exposed to repeated loud noise in the NICU are more at risk of having sensor neural with hearing loss and developmental delay. Exposing preterm neonates to noise will have a big impact to their lives, as most part of their bodies is not yet developed well. Exposure of noise to preterm has the potential effect on neonatal auditory development, sleep patterns and physiological stability, thus impacting developmental progress (Neille et al., 2014 p. 7). The measurement of noise level in a neonatal unit is necessary determine if what is there is recommended. This location is very different from the protective intrauterine environment where the neonate was living. The neonate comes out of a calm, quiet, dark and cushioned environment, to an environment with excessive light and noise, constant movement of people and interruptions of sleep and wakefulness, often with discomfort and pain (Jordão et al., 2017).

The physiological effects of excess noise include: changes in heart rhythm, increased blood pressure, peripheral vasoconstriction, and dilation of the pupils with increased secretions of adrenaline (D'Souza et al., 2015 p. 60). These changes, affect the physiological and neurobehavioral states of the neonate (Cardoso et al., 2014 p. 585). High noise also causes disturbances in sleep patterns, agitation, irritability, crying, increased oxygen consumption fatigue, and increased heart rate (Jordão et al., 2017). In study done by Almadhoob and Ohlsson, (2015) demonstrated that 52% of preterm neonates treated in NICU had abnormal audiograms due to noise leading to impaired hearing. Improved technology for caring for preterm infants have been accompanied by concerns about the impact of NICU noise to these neonates (Schokry, 2016 p. 2).

1.3. PROBLEM STATEMENT

Various studies were published on the issue of high noise levels in NICU. Whereas NICU is an area with various sources of noise, that contribute to high noise levels (Caicedo, 2017 p. 119). Conversation had the most value ranging between 80 dB to 95 dB and door closure 80 dB to 90 dB (Joshi et al, 2016 p. 4). Conversation is a major contributor of high noise level in neonatal ward (Neumann et al, 2019 p. 7). A neonate that is admitted in NICU comes from the uterus which provides protection of external noise up to 40 dB (Jordão et al., 2017). Worldwide different published studies have report high noise levels in NICU which range between 49 - 92 dB (Caicedo, 2017 p. 122). WHO recommends that noise in hospital facilities should not exceed mean sound of 35dB (WHO, 2000) and AAP 45 dB (AAP,1997). Worldwide each year 15 million of preterm neonates are prone to have hearing complications due to their immature organs and system (WHO, 2017). The noise occurring in NICU affect the growth and neurodevelopment of preterm infants (Raboshchuk et al., 2018 p. 392).

Worldwide prevalence estimates for all hearing loss in neonates is caused by noise level greater or equal to 20 dB which increased from 14.3% in 1990 to 18.1% in 2015 (Neumann et al, 2019 p. 7). The estimation for hearing loss disabling increased also from 5.7% in 2005 to 6.4% in 2015 (Neumann et al, 2019 p. 7). In study done by Almadhoob and Ohlsson, (2015) demonstrated that 52% of preterm infants treated in NICU had abnormal audiograms due to noise leading to impaired hearing. It is important to identify and measure the noise level in NICU, in order to protect neonates from harmful environment. Moreover, in Rwanda there appear to be no published study, done on determining noise level in different NICUs. Noise levels have to be measured & identified in NICU and this will help in reduction and maintaining the recommended level.

1.4. THE AIM OF THE STUDY

The aim of the study is to measure the noise level and identify possible sources of noise in NICU of selected public hospitals in Kigali

1.5. RESEARCH OBJECTIVES

Main Objective

1. To determine noise levels and possible sources of noise level in selected NICUs of public hospitals of Kigali city

Specific objectives

1. To measure sound levels in NICU of selected public hospitals of Kigali city
2. To compare sound levels at the NICU to that recommended by the AAP
3. To identify possible sources of noise levels in NICU of selected public hospitals of Kigali city

1.6. RESEARCH QUESTIONS

1. What is the sound level in NICU of selected public hospitals in Kigali city?
2. What is the sound level of selected NICUs compared to the recommended level by the AAP?
3. What are the possible sources of noise levels in NICUs of selected public hospitals in Kigali city?

1.7. SIGNIFICANCE OF THE STUDY

Noise levels in NICUs have an adverse impact on preterm neonates like growth and neurological development, there is a need to know sound level in these area mostly in busy and overcrowded urban hospitals (Joshi and Tada, 2016 p. 1359). Because of the potential risk that noise can cause to preterm infant, it is necessary to identify the noise levels prevailing in NICU, in order to implement change, that can help in controlling and reducing the noise level (Jordão et al., 2017). Results will be used in policy making and developing NICU guidelines, where preterm neonate stays for a long time needing care. It will inform health policy makers as key actors in achievement of the third sustainable development goals that state that; good health and wellbeing, aiming to reduce global neonatal morbidity ratio (World health statistics, 2018), through informing the decision makers on the apropriate noise level as recommended.

In research the study will provide baseline information for other researchers for the noise level found in selected hospitals. In education and practice the study will help the teaching instututions to bridge the gap in component of neontal practice in reduction of noise level as it is harmful to neonates. It will help in developing a course work for students during their pre-service training on maintaining the apropriate noise level recommended. The hospitals where research were conducted will benefit from this study by receiving current sound levels within the NICU and will be provided with recommendations as to how to reduce the sound levels within the NICU so as to reduce possible harmful effects on neonates.

1.8. DEFINITION OF CONCEPTS

Noise is defined as sound that is loud or unpleasant or that causes disturbance (Oxford Dictionary, 2019). In this study noise defined as an unwanted sounds that is greater than the recommended.

Sound is the vibration that travels through the air or another medium and can be heard when they reach a person's or animal's ear (Oxford Dictionary, 2019). In this study it is unpleasant **sounds** which are referred to as **noise**.

Decibel: A unit used to measure the intensity of a sound or the power level of an electrical signal by comparing it with a given level on a logarithmic scale (Oxford Dictionary, 2019). In this study it is a unit that expresses the relative magnitude of a sound.

Sound level meter: Is a device measuring the intensity of any given sound with a standard sound that is just perceptible to the normal human ear at a frequency in the range that is most sensitive to the ear (Valizadeh, 2013). In this study is a device for measuring the intensity of noise

NICU: Is a unit that combines advanced technology and trained HCP to provide specialized care of ill or premature newborn infants (Medical dictionary, 2019). In this study it means advanced care neonatal care unit with critical ill neonates, and severe premature neonates who demand intensive care.

Preterm neonates: Is defined as neonate born alive between 24 to 37 weeks of pregnancy (WHO, 2017). Here it means neonates born before time between 26 to 37weeks and most of their organs are not yet developed well and are vulnerable.

1.9. STRUCTURE/ORGANIZATION OF THE STUDY

There are six main chapters; introduction, literature review, methodology, results, and discussion, and the sixth chapter is conclusion and recommendations. Following chapters are references sited in the text and appendices.

1.10. CONCLUSION TO CHAPTER ONE

In this chapter, an overview of the research was given, including the background of the study, the problem statement illustrated how high noise affect neonates, aim was to measure noise level in NICU and objectives, research questions, significance of the study; is that it will assist policy development, future research, education and practice as well as the structure of the study. In addition, definitions of the concepts were defined.

CHAPTER TWO: LITERATURE REVIEW

2.1. INTRODUCTION

This chapter discusses on how different authors identified this problem of noise in NICU. Below we will discuss on the theory supporting this research. This chapter consists of five topics; theoretical literature, empirical literature, critical review and research gap identification as well as a conceptual framework. Different database has been used during literature search such as"google scholar" "pubmed" "hinari" "Cochrane" etc Many studies have been done on how high level noise is dangerous to human being; preterm neonates are affected more compared to adults. This study measured sound level and observed possible noise level in NICU of chosen hospital in Kigali city.

2.2. THEORETICAL LITERATURE

Theoretical literature discussed on theory behind the study; which is environmental theory. Also different researchers' views; how an appropriate NICU environment should be, physiological effect on neonates and impact of noise to preterm neonates.

2.2.1. Environmental theory (Florence Nightingale 1859)

Florence Nightingale theory stated that; placing the client in the best condition for nature to act upon him (Baly, 1986 p. 37). In her book "Notes on Nursing" she mentioned that: "*Unnecessary noise, or noise that creates an expectation in the mind, is that which hurts a patient. It is rarely the loudness of the noise, the effect upon the organ of the ear itself, which appears to affect the sick. Unnecessary noise, then, is the most cruel absence of care which can be inflicted either on sick or well* (Nightingale, 1946). Nightingale cited that; the environment has to be controlled when caring for the individual by providing ventilation, light, warm, **noise absence or reduction**, cleanliness and diet (Nightingale, 1946).

2.2.2. NICU environment

NICUs are often designed as open units with cribs, radiant warmer or incubators in one open room. For better survival of preterm infants depend in NICU environment and they experience enormous stress in it (D'Souza et al., 2015 p. 59). Neonatal units is like most hospital environments which is congested with beds often close to each other, visitors talking loudly and staff working quickly and moving equipment around (Schokry, 2016 p. 3). NICU is also an environment that supports neonatal physiologic stability, facilitates and promotes sleep, and reduces potential adverse effects on the auditory development of preterm infants (Aly and Ahmed, 2016 p. 4)**.** NICU environment which is full of noisy sound is thought to affect the growth and neuro development of preterm infant (Raboshchuk et al., 2018 p. 392). The use of technology that facilitates caring for preterm has improved survival but has also transformed NICU into very noisy places (Schokry, 2016 p. 4).

The uterus where the infant lives before birth is a calm place, quiet, dark and convenient environment (Jordão et al., 2017). After birth infant comes to an environment with excessive noise and light, movement of people and interruptions of sleep and wakefulness, often with discomfort and pain (Jordão et al., 2017). The uterus provides protection of the fetus when it is still in the womb of up to 40 dB from external noise (Jordão et al., 2017). The fetus inside the womb is exposed to a basal level of sound of 28 dB (Pugliesi et al., 2018 p. 394). Which is ideally, to promote healthy auditory development, sound levels in the NICU should be consistent with intrauterine environment.

Many studies show that average sound levels in a NICU range between 70 to 80 dB, whereas the American Academy of Pediatrics recommends a maximum noise level of 45 dB (Schokry, 2016 p. 4). The NICU environment has to be like the uterus environment where the neonate comes from, in order to support the proper growth and development of the preterm infant. This environment has to be calm without excessive light and noise that harm the life of preterm neonates. Due to the fact that the newborn is exposed to noise leads to developmental problems, great changes have to be put in place to protect them. The impact of noise observed in newborn has encouraged the implementation of new approaches in care delivery that include rebuilding the physical environment of NICUs that controls noise levels (Schokry, 2016 p. 4)

2.2.3. Physiological effect on infants

Auditory system starts developing by 3-6 weeks of gestation after 20 weeks' gestational age the structural aspects required for audition are well developed, and become functional at around 29 weeks' gestation (Thakur, Batra and Gupta, 2016 p. 112). The fetus is able to hear as indicated by observations of blink startle responses to vibro acoustic stimulation during antenatal ultrasonography around 24 weeks of gestation (Zimmerman and Lahav, 2013 p. 3). The cochlea of the middle ear and the auditory cortex in the temporal lobe are most important in the development of the auditory system, which are both easily affected by noisy environment and care practices in the new born in NICU (Thakur, Batra and Gupta, 2016 p. 111). Overexposure to constant noise while the auditory system is still developing can alter the natural development of the auditory pathways, making them overly sensitive to noise (Lahav and Skoe, 2014 p. 381).

In NCU, different sound intensities and frequencies are produced from different sources which may exert undesirable effect to the infant. Alto of auditory stimulation leads to negative physiological effects like; changes in heart rhythm, peripheral vasoconstriction, apnea, increased blood pressure, and oxygen saturation (Schokry, 2016 p. 5). Preterm infants are prone to high noise due to central nervous system immaturity which lead to decreased autonomic and self-regularity abilities to manage stress (Almadhoob and Ohlsson, 2015). High noise causes stress characterised by increased levels of stress hormones such as cortisol and catecholamine, which lead to a number of pathophysiological adaptations, like increased blood pressure, heart rate and cardiac output (Münzel and Sørensen 2017 p. 26).

Noise may cause apnea, hypoxemia, alternation in oxygen saturation and increased oxygen consumption secondary to elevated heart and respiratory rates and may, therefore, decrease the number of calories available for growth (Almadhoob and Ohlsson, 2015). The electrical activity of the central nervous system changes in response to acoustic stimulation in the range between 40 dB and 90 dB leading to increased intracranial pressure, electromyography and behavioral changes due to sudden noise (Almadhoob and Ohlsson, 2015) . Noise can lead to hearing loss during childhood, exposed to a range of 85 to 95 dB during intrauterine period (Thakur, Batra and Gupta, 2016 p. 112). Higher sound level dameges the neuroendocrine system and this may affect the immunity system (Morris 2000; Wachman 2011 in Almadhoob and Ohlsson, 2015).

2.2.4. Impact of noise to preterm

Premature infants in the NICU are exposed to high level of noise and this have a big impact on their life. According to the previous studies on neonates, excessive exposure to noise can affect cardiovascular system (e.g., blood pressure and heart rate), newborn sleep pattern, respiratory system and cerebral circulation (Ramm et al., 2017 p. 31). Due to repeated exposure to high noise in the NICU early newborns are more at risk of sensor neural hearing loss and future developmental delay (Schokry, 2016 p. 2). It can also have long-term effects on brain development processes such as language development, growth and hearing (Lahav &

Skoe, 2014). There is an increase rate of very low birth weight (VLBW) and those who grow are diagnosed with neurodevelopmental disorders when they reach school-age (Blourchian and Sharafi, 2015). Some of this problem may be due to secondary noisy acoustic environment of the NICU and neonatal wards (Blourchian and Sharafi, 2015 p. 22).

In preterm infants, high sound leads to an increase of 10mmHg in systolic and diastolic blood pressure above baseline (Almadhoob and Ohlsson, 2015). Preterm infants who are exposed to prolonged excessive noise are also at high risk of hearing loss, brain damage and abnormal sensory development (Schokry, 2016 p. 2). Noise causes stress response like increased blood pressure, increased intracranial pressure bradycardia and tachycardia (Almadhoob and Ohlsson, 2015). Excessive noise also can cause disturbances in sleep patterns, agitation, fatigue, irritability, crying, increased heart rate and increased oxygen consumption (Jordão et al., 2017). It leads also to alteration in oxygen and increased oxygen consumptions could lead to high risk like; poor growth, abnormal sleep patterns, hearing impairment, bronchopulmonary dysplasia, retinopathy of prematurity, intraventricular hemorrhage, periventricular leukomalacia and developmental delay (Almadhoob and Ohlsson, 2015).

In the study done by Shimizu and Matsuo, (2016) reported that noise levels affect neonates' ability to self-regulate, which may result in increased intracranial pressure tachycardia, bradycardia and hypoxia. If there is reduction in the noise levels, that reach to preterm infant while in the NICU, this will lead to reduction of these adverse effect that preterm infant suffer (Almadhoob and Ohlsson, 2015). Preterm neonates who reach school age may have difficulties in academic skill or impaired language due to consequence of noise in NICU environment exceeding the capacity of the central nervous system of preterm infant's to cope with it (Aly and Ahmed, 2016 p. 5).

2.3. EMPIRICAL LITERATURE

There are many studies that were conducted on sources of noise in NICU or noise level in NICU, or both. In empirical literature we will discuss on the sources of noise and levels of noise in NICU environment.

2.3.1. Level of noise in NICU

High level of noise leads to stimuli that produces adverse effects on neonates, especially among premature, like somatic effects, sleep disturbances, auditory damage and emotional development problems (Caicedo, 2017 p. 120). In the research by Aly and Ahmed, (2016) there was significant increase of respiratory rate, heart rate, systolic and diastolic blood pressure due to noise exposure. There was also decreased oxygen saturation and only temperature did not show any significant change with noise exposure. The vital signs of preterm were affected by noise more than full term infant (Aly and Ahmed, 2016 p. 3).

A study done by Schokry, (2016) on measuring the NICU noise level in public hospitals in Gaza City, found a noise level from 56 to 81 dB (Schokry, 2016 p. 5). Also a study conducted India in NICU of a tertiary hospital in an urban city identified noise level of 60 - 90 dB (Joshi and Tada, 2016 p. 1360). Another study done in Adelaide, South Australia found out that noise level in NICU average range was 74.5 dBs (Ramm et al., 2017).

Noise levels were increased during day shifts as compared with those during night shifts, and also peaked during ward rounds and shift changing (Matook et al., 2010; Ramm et al., 2017). Noise level was high during ward round with 52.4 dB according to Ramm et al., 2017. Blourchian and Sharafi (2015) found out that mean noise levels during morning, afternoon and night shifts were 61.67±4.5, 61.32±4.32 and 60.71±4.56 dB and statistically significant ($p = 0.002$). another research found that levels of noise were also statistically significant and the levels decreased from morning shift (77.89 dB) to night shift (69.09 dB) in NICU (Joshi and Tada, 2016).

2.3.2. Comparison of sound levels to the recommended

Previous researchers have reported noise level which is greater than the recommended by AAP. A study done in South Australia by Ramm et al., 2017 found out that noise levels in both areas of the NCU exceeded the recommended range by AAP. In a study done in Portugal, the result showed that; all the evaluated areas of the NICUs, noise levels exceeded international guidelines, with levels ranging between 48.7 dB to 71.7 dB (Santos et al., 2018 p. 126). Another study done in Canada reported that was higher than recommendation where 58.15 dB vs 45 dB and ($p = 0.001$) (Milette, 2010 p. 350). A study done in Northern Portugal by Sá, et al (2018) stated that the sound level recorded in NICU was higher that the recommended by AAP.

2.3.3. Sources of noise level in NICU

There are different sources of noise and most of them can be prevented. Various researchers have mentioned different sources of noise that are generated in NICU. Source of noise in NICU can be; circulation of people and conversations, incubators, heated cribs, mechanical ventilators, infusion pumps, monitors, alarms, air conditioning, opening and closing of doors and draws (Jordão et al., 2017; Thakur, Batra, and Gupta, 2016). Excessive noise in NUs is due to numerous sources, such as life support equipment, voices/talking, alarms, medical and family visits, careless handling when locking cabinets (Cardoso et al., 2015). Many premature infants are admitted for special medical care in NICU but it is an environment full of noisy produced by both human activities and multiple biomedical equipment (Raboshchuk et al., 2018). The source of noise may be medical equipment, telephones, conversations among personnel, closing and opening of doors, and things falling within the unit (Caicedo, 2017).

The ambient noise that is generated by the incubator fan, respiratory equipment and environmental noise like conversations, opening and closing doors may contribute to the total sound pressure levels which mostly affect preterm infant (Aly and Ahmed, 2016). Noise can also be generated by incubators being opened and close and dropping items accidentally, affect the wellbeing of the baby (Schokry, 2016). If the newborn is born too early they leave a silent environment of the uterus and come to a noisy place of the NICU (Schokry, 2016). A study done by Nathan, Tuomi and Muller found that; staff conversations were the highest contributor to the sources of noise and the monitor alarm (Nathan et al., 2008).

A study done also by Neille, George and Khoza-Shangase in three NICUs of Johannesburg in South Africa, found that the majority of noise sources identified were human generated (Neille *et al.*, 2014). Noise was not only produced by the equipment but also the impact of persons and increased activity including; staff's conversation, presence of students, rings of personal cell phone and many others (Aljawadi et.al. 2017 p2742). Another study report phone ring tones and neonatal crying had the highest result (Blourchian and Sharafi, 2015).

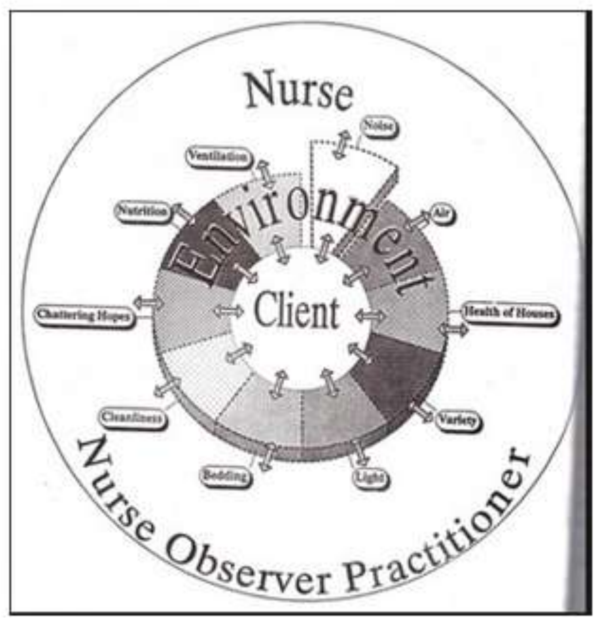
2.4. CRITICAL REVIEW AND RESEARCH GAP IDENTIFICATION

NICU environment is essential in determining the health of preterm infant, NICU Noise should be evaluated routinely and reduced as much as possible (Schokry, 2016). Different researchers faced some limitation while measuring sound level in NICU. In the study done by Aly and Ahmed, (2016), they had limitation about staff and visitors, who possibly adapted their behavior during the study period. Whereas the study done by Schokry, (2016); had limitation of taking measurements for two days only in short period of time and no measurements were taken during the night. This study will try to overcome these limitations by measuring the whole week for long time and the measurement will be taken at night shift.

2.5. CONCEPTUAL FRAMEWORK

2.5.1. Florence Nightingale's environmental theory (Conceptual framework)

This theory of Florence nightingale assisted in conceptualization of this study. If preterm neonates are put in an environment which is calm as the uterus they come from, it will help the neonate to develop well. Nursing practice focus on the client's response to noise and nursing intervention is to reduce the noise level. Putting preterm neonate in proper position without noise and this will encourage healing. Nature, Hospital and NICU environment may be sources of noise; proper control over them determines the safety of the preterm neonate. Time (day and night) may lead to low, moderate or high noise. If the noise is moderate as recommended by WHO (30 dB) or AAP (45 dB) there would be no harm to the development of the neonate. But if noise is high more than the recommended, the neonate will face some complications like; hearing loss, brain damage and abnormal sensory development**.**



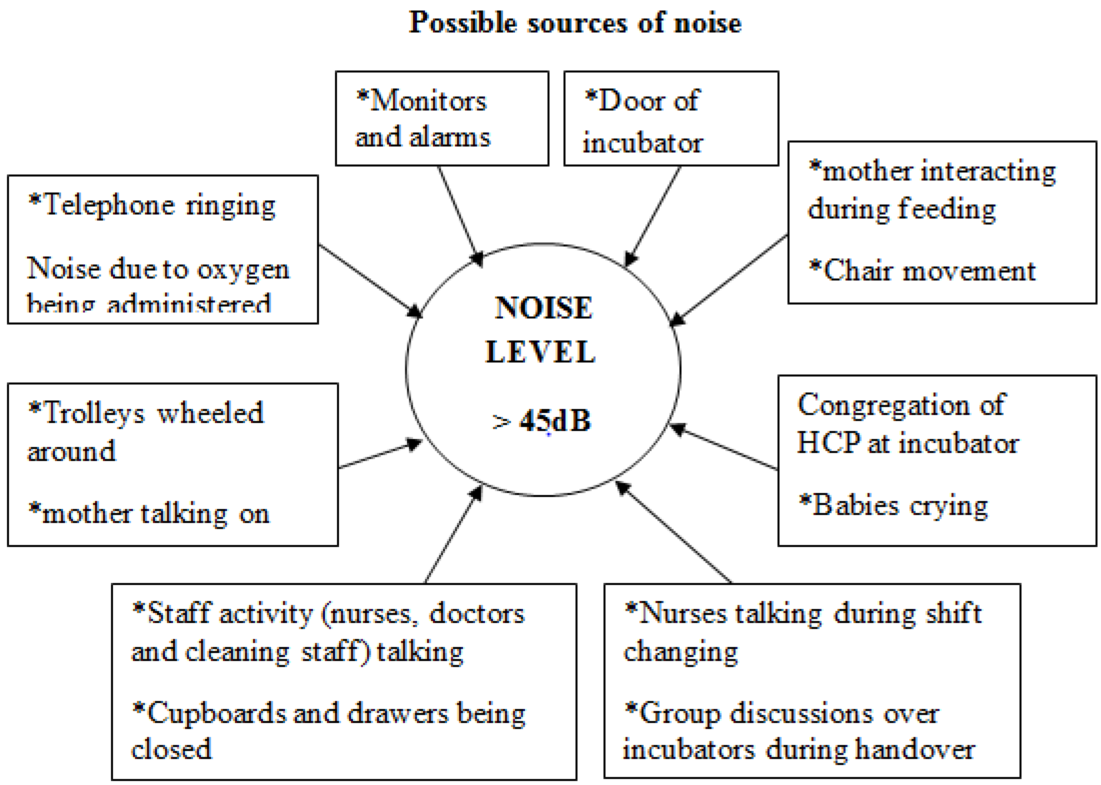


Figure 2.1. Modifide conceptual framework from Florence Nightingale

(Nightingale, 1869)

Independent variables are possible sources of noise, which are the following; Nurses talking loudly, Monitors and alarms, telephone ringing, oxygen being administered, staff activity, Group discussions over incubators during handover, Metal trolleys wheeled around, Metal drawers and cupboards being closed, Door of incubator (closing and opening), Infusion pumps, Mother interactions during feeding, Mother talking on phones, Chairs being moved around, neonates crying.

Dependent variable or outcome is noise level.

Possible source of noise will impact the noise level. Noise level will increase due to different sources of noise.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. INTRODUCTION

Research methodology outlines how the steps, strategies, and procedures a researcher used to collect data and analyze them. This chapter describes the research design, study area, population of the study, sampling, data collection instruments and procedures, data analysis, ethical consideration and limitation of the study. It also discussed on data management and dissemination.

3.2. RESEARCH DESIGN

This study used non experimental simple descriptive cross sectional study design. Study design helps to decide how generated data can be analysed. Cross sectional is the way data is collected at one point of time (Setia, 2018). The research design that was used for this study can be described as quantitative descriptive study, since it provided a description of the variables studied as they exist within the specific group (Tobi and Kampen, 2018). The variables mentioned here were the mean sound level readings taken in each NICU that was part of selected public hospital group. The study then set out to describe these mean sound level readings that were taken at each NICU. The researcher also conducted an observation on possible sources of noise.

3.3. RESEARCH APPROACH

Research approach is quantitative approach. Quantitative is the approach that use numbers as its basis for making generalizations about a phenomenon and the result of it are based on careful observation, correct measurement and interpretation of measured data (Denscombe, 2014). In this study sound level was measured at different hospitals.

3.4. RESEARCH SETTING

The study was conducted in four selected public hospitals in Kigali city with NICU. Data were collected in NICU rooms (with critically ill neonates and preterm). The hospitals selected are two referral hospitals in Kigali; University Teaching Hospital of Kigali and Rwanda Military Hospital. Two district hospitals were; Muhima District Hospital and Kibagabaga District Hospital.

University Teaching Hospital of Kigali which is a teaching and tertiary referral hospital. It is commonly known as CHUK a French acronym of "Centre Hospitalier Universitaire de Kigali. This is among the hospitals with NCU that receives big number of neonate from different district hospitals of Northern Province and some in Kigali city. It admits an average of 45 neonates per month. Neonatology unit in this hospital is located near the entry of the hospital and main public road. Staff working in NCU are; 12 Nurses A_1, 1 Midwife A_1, 1 Nurse A_0, and 1 pediatric doctor. UTHK is built in Kigali city, Nyarugenge District, Nyarugenge sector, situated in few meter from Serena Hotel. This hospital was considered as hospital one in order to keep anonymity.

Rwanda Military Hospital is also a tertiary referral hospital and receives big number of neonate from different district hospitals from Eastern Province and some in Kigali city. It also admits an average of 20 neonates per month only in NICU. Neonatology unit in this hospital is located in the middle of the hospital. The total number of neonatology staff is 42, 7 doctors (2 pediatricians and 5 pediatrician residents) and 35 nurses and midwives (means 1 holding masters in neonatology, 14 with A_O and 20 with A_1 in nursing and midwifery). RMH is located in Kigali City, Kicukiro District, Nyarugunga sector, 3km from Kigali International Airport. This hospital was considered as hospital two in order to keep anonymity.

Kibagabaga District Hospital receives an average of 80 neonates per month. Neonatology unit in this hospital is located in the middle of the hospital. This room is a mixture of critically ill neonates, preterm and recovering neonates. It has 6 Nurses A_1, 2 Midwife A_1 and 2 Nurse A_2. It is located in Kigali City, Gasabo District, Kimironko sector. This hospital was considered as hospital four in order to keep anonymity

Muhima District Hospital receives an average of 130 neonates per month. This hospital receives big number of neonates, even though this hospital is district hospital it receives pregnant women compared to men. Neonatology unit in this hospital is located in the middle of the hospital. NCU has 7 Nurses A_1, 2 Midwife A_1, 2 Midwife A_0, 1 Nurse A_2 and 3 pediatric doctors.). Muhima is located in Kigali City, Nyarugenge District, Muhima secto sector. This hospital was considered as hospital four in order to keep anonymity.

Working in these hospitals will give a picture of the noise level is in NCUs of Kigali, as the research will be done in four selected public hospitals with NCUs as there are six hospitals in

Kigali. Four hospitals among six is a big number to give a picture of how noise level is in NCUs of public hospitals in Kigali.

3.5. STUDY POPULATION

These will be NICUs in four selected public hospitals of Kigali city; (Kibagabaga hospital, Muhima hospital, Rwanda military hospital and University teaching hospital of Kigali). NUs consist of different ward; like KMC, improving neonates and critical ill neonates (NICU). NICU in this study means a room with critical ill neonates and very low preterm neonates. Different researchers proved that preterm neonates were affected by noise compared to full term (Aly and Ahmed, 2016 p. 4). School-age children who were admitted in NICU with VLBW were diagnosed with neurodevelopmental disorders (Blourchian and Sharafi, 2015). That is why the researcher chose to conduct study in NICU.

3.5.1. Inclusion criteria

Inclusion criteria were public hospitals with NICU in Kigali city. Ward with critical ill neonates and very low preterm infants which this study calls NICU.

3.5.2. Exclusion criteria

Exclusion criteria were private hospitals, public hospitals without neonatal care unit, and hospitals outside Kigali city. Also health centers and clinics were excluded. Other ward apart from NICU in the NU

3.6. SAMPLING

3.6.1. Sampling strategy

The sampling strategy that was used for selecting the hospitals was probability simple random. Probability simple is whereby each element has equal chances of being selected from all population units (Polit and Beck, 2017). The hospitals were numbered and in a consequent manner by writing each number on a separate piece of paper. These pieces of paper were mixed and put into a box and then numbers were drawn in a random manner. Sampling frames were six hospitals and among them four hospitals were randomly selected.

The sampling strategy for time was time sampling where data were collected over different times of the day in seven days. Time sampling is a sampling method that involves the acquisition of representative samples by observing subjects at different time intervals (Harrop and Daniels, 1986; Prykanowski et al 2018). This time were collected purposively where **morning time** (7:00am to 8:00am), **ward round** when NICU was full of student, residence doctors, and nurses. **Lunch time** (12:00pm to 1:00pm) when HCP has gone, only one or two remains, **midnight** (12:00am to 1:00am) all these were applied to all hospitals except **during shift** changing where two hospitals were done at 5:00pm to 6pm and other two it was done at 7:00pm to 8:00pm.

3.6.2. Sample size

The sample size, in this case, refers to the number of records to be taken. Its determination is based on the following steps:

Step 1: Base Sample-size calculation

The appropriate sample size was determined largely from the application of this formula for proportions (Cochran, 1963; Krejcie & Morgan, 1970; Israel, 2013) preferred to the one based on the means due to lack of the values of variances estimates.

$$n \approx \frac{Z_{\alpha/2}^{2}.p.(1-p)}{d^{2}}$$ (Israel, 2013)

Where n= required sample size, Z = standard value of 1.96 corresponding to a 95% confidence interval, p = percentage picking a choice (standard value of 0.5), d = margin of error at 5% (level of significance). The use of the standard values listed above provides a basic sample size of 384 participants.

Step 2: Design Effect

As this study was carried out in four randomly selected hospitals, namely, CHUK, RMH, Kibagababa and Muhima, a Design Effect (DE) will be considered. This DE stands as a ratio between the variance of the chosen sampling design and the variance of the simple random sampling. Its ratio ranges from 1 and it helps to take into account the fact that the study will use a respondent-driven sampling (RDS). A study by Salganik (2006) suggests to use the ratio of 2 in the case of RDS leading to multiplying by 2 the base sample size of step 1, mean *n x DE = 384 x 2 = 768.*

Thus, DE may be simply interpreted as the factor by which the sample size would have to be increased in order to produce survey estimates with the same precision as a simple random sample. n x DE = 384 x 2 = **768.**

Step 3: Contingency

During a research, the tool may fail to record properly needed data. This is called contingency, and in case it occurs, it can increase the bias of the estimators due to the lack of the required number of responses for one or more characteristics under study. To correct this, it is generally proposed to consider a non-response rate of 5%, and then increase by 5% to account for contingencies such as non-response or recording error. For this research, the sample size becomes n + 5% = 768 x 1.05 = 806.4. The total sample size to be used in this research is 840 times. The minimum sample to use was 806.4 and the study used 840 which are above the minimum estimated time.

In other wards sample size was time sample, where 5 different timeframe which are; [**morning** (7: 00 – 8:00), **ward round** (varies), **lunch time** (12:00 – 1:00), **shift changing** (5:00 – 6:00, 7:00 – 8:00) and **night shift** (11:00 – 12:00)] were considered in a one day. In each timeframe noise level were measured in 6 different stations as described in data collection procedure.

Five timeframe times six station (5*6) generate 30 samples in a single day. Noise levels were measured in seven (7) days in each NICU among 4 different settings.

Total sample per hospital in a week =30*7=210.

Total sample from all four (4) hospital=210*4=840.

3.7. VALIDITY AND RELIABILITY

3.7.1. Validity

The validity of a research tool refers to the extent to which a tool really measures what it intends to measure (Polit and Beck 2014, p. 205). The instrument is valid as, it was manufactured to measure the sound level and has been used for that purpose. Its accuracy is +/-1.4 dB.

Observation checklist was used for possible sources of noise given by J Neille which was used in their study *"A study investigating sound sources and noise levels in neonatal intensive care* *units"* (Neille et al., 2014). The content validity ensures that the tool is measuring the concept of interest (Polit and Beck 2010)

3.7.1.1.Content validity relating objectives, conceptual framework and tool used

Table 3.1.Content validity relating objectives, conceptual framework and tool used

Objective of the study	Components of the Conceptual framework	Tool used
To measure sound levels in NICU of selected public hospitals of Kigali city	**Noise level**	Sound level meter (decibel)
To compare these sound levels at the NICU to that recommended by AAP		
To identify possible sources of noise levels in NCU of selected public hospitals of Kigali city	Nurse talking loudly, Monitors and alarms, telephone ringing, oxygen being administered , staff activity, Group discussions over incubators during handover, Metal trolleys wheeled around, Metal drawers and cupboards being closed, Door of incubator (closing and opening), Infusion pumps, Mother interactions during feeding, Mother talking on phones, Chairs being moved around, Babies crying	Observation checklist

Table 3.1. Demonstrate how the objective matches with conceptual frame work and the tool used in data collection.

3.7.2. Reliability

Reliability refers to the ability of a research behold to yield consistently the same results with the extent to which the results of a study or a measure over-repeated testing periods (Roberts et al, 2006). Reliability of the instrument was proved by the manufactures of the instrument. The same sound level meter was used throughout all data collecting so as to standardize the data collecting procedure and minimize measurement errors which may influence validity. Six repeated sound level readings were taken in each NICU at each time of the day so as to ensure reliability. Reliability was also maintained by averaging the means readings taken over seven different days of the week days. This helped to decrease the chances of bias caused by the "Halo effect" whereby HCP within the NICU wanted to create a favorable impression, if they felt that their work was being scrutinized. Readings were averaged so as to obtain the most accurate readings that reflect the sound levels of the NICU at each hospital. Pilot study was also done to test how the instrument works. It was done during lunch time at Kibagabaga NCU for three days during the same circumstances and on the same station with mean values of 65.7 dB, 65.6 dB and 65.4 respectively. The pilot study found out that the instrument was calibrating and working well.

Measures

Data presentations were done in six sections which are the following;

Section1: Sound levels on different days (Monday, Tuesday, Wednesday, Thursday, Friday, Saturday and Sunday) at the four hospitals were measured in dB. Means, minimum and maximum sound levels, confidence interval and P value were used (table 4.2).

Section 2: Sound levels in different shifts of the days; these were done in four hospitals and were measured in dB. Mean, minimum and maximum sound levels, confidence interval and P value were used (table 4.3).

Section 3: Sound levels of hospital 1, 2, 3 and 4 with different station of the NICU; these were measured in dB. Those tables consist of mean, minimum and maximum sound levels, confidence interval and P value (table 4.4, 4.5, 4.6, and table 4.7).

4: Comparing sound levels of four hospitals. They were measured in dB (figure 4.1).

Section 5: Sound levels were compared with AAP recommendation. Different days of sound level and different shift were measured in dB (figure 4.2 and 4.3).

Section 6: The following are possible sources of noise; Nurses talking loudly, Monitors and alarms, telephone ringing, oxygen being administered, staff activity, Group discussions over incubators during handover, Metal trolleys wheeled around, Metal drawers and cupboards being closed, Door of incubator (closing and opening), Infusion pumps, Mother interactions during feeding, Mother talking on phones, Chairs being moved around, Babies crying (figure 4.4).

3.8. DATA COLLECTION

3.8.1. Data Collection instruments

Data was collected using sound level meter. Sound level meter called Velleman DEM 200 instrument weigh sound pressure level with digital readings. It is a decibel monitor pressure tester, audio sound noise level meter and measures noise between 30dB to 130dB, resolution 0.1 dB, accuracy: +/-1.4 dB, frequency weighting: A; approximates function characteristics of the human ear (Gray and Philbin, 2000). This instrument measures sound level which is numerically adjusted to reflect the frequency-dependent nature of human hearing at low sound levels (Valizadeh, 2013). It measures minimum and maximum noise level. Observation checklist was used for possible sources of noise given by J Neille which was used in their study (Neille et al., 2014).

3.8.2. Data collection procedure

Data was collected in four selected public hospitals in Kigali city with NICU by measuring sound level. The sound level in NICU was measured using a sound level meter device. The meter was calibrated before starting measurements at each new measurement location. Readings were taken in six different areas/stations at five different times of the day (morning time, ward round, lunch time, shift changing and midnight). The same stations were also used for the whole week of data collection. The sound level within each NICU was identified by means of taking six readings (from stations) at each time and the readings were then averaged to get sound level at each time of the day. The noise level was corrected for the whole week at each hospital. Data capture sheet was used in documentation of data collected. Observational checklist was also used to assess the possible sources of noise.

Data collector assistants were two who were fresh graduate in midwifery department; one was working during the day up to shift changing and the other was taking midnight measurer. They were used because data were collected from morning to midnight during different time interval for the whole week, at each hospital. They were trained on the use of the instrument and how to use observational checklist. The investigator was the one to supervise them daily and also daily report was given.

Table 3.2. Description of different days when data was collected

Days	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Hospital 1	18/3/19	19/03/19	20/03/19	21/03/19	22/03/19	23/03/19	24/03/19
Hospital 2	01/4/19	02/04/19	03/04/19	04/04/19	05/04/19	06/04/19	07/04/19
Hospital 3	04/3/19	05/03/19	06/03/19	07/03/19	08/03/19	09/03/19	10/03/19
Hospital 4	11/3/19	12/03/19	13/03/19	14/03/19	15/03/19	16/03/19	17/03/19

Table 3.2 shows different dates and days, when data were collected. Data were collected at each hospital over a week over a week on different days (from Monday to Sunday).

Description of different stations where noise measurement were taken

Measurements were taken at the following stations of the NICU room and averaged so as to provide a more representative sound level:

Table 3.3: Stations in which readings were taken at Hospital 1

Station	Description
1	Nearest the entrance and nurses' station
2	Near nurses' station
3	Further from nurses' station
4	Nearest the nurses' station
5	Furthest from the nurses' station
6	Near the nurses' station

Table 3.4: Stations in which readings were taken at Hospital 2

Station	**Description**
1	Nearest the entrance and near nurses' station
2	Near nurses' station
3	Furthest from nurses' station
4	Furthest from nurses' station
5	Nearest the nurses' station
6	Near the nurse station

Table 3.5. Stations in which readings were taken at Hospital 3

Station	Description
1	Near the entrance and nursing station
2	Nearest KMC entrance
3	Near KMC entrance
4	Nearest oxygen concentrator
5	Further from the nurses' station
6	Near the nurses' station

Table 3.6: Stations in which readings were taken at Hospital 4

Station	Description
1	Nearest the entrance and nurses' station
2	Further from the nurses' station
3	Further from nurses' station
4	furthest from the nurses' station
5	Furthest from the nurses' station
6	Nearest the nurse station

Table 3.7. Description of different time when noise measurement were taken

Measurements were taken at the following times of the day in the NICU environment and averaged so as to provide a more representative sound level:

Hospital	Description	Time
1	Morning	7: 00am to 8:00am
	Ward Round	Varies according to availability of the Doctor
	Lunch Time	12:00pm to 1:00pm
	Shift Changing	7:00pm to 8:00pm
	Mid-Night	12:00am to 1:00am
2	Morning	7: 00am to 8:00am
	Ward Round	Varies according to availability of the Doctor
	Lunch Time	12:00pm to 1:00pm
	Shift Changing	7:00pm to 8:00pm
	Mid-Night	12:00am to 1:00am
3	Morning	7: 00am to 8:00am
	Ward Round	Varies according to availability of the Doctor
	Lunch Time	12:00pm to 1:00pm
	Shift Changing	5:00pm to 6:00pm
	Mid-Night	12:00am to 1:00am
4	Morning	7: 00am to 8:00am
	Ward Round	Varies according to availability of the Doctor
	Lunch Time	12:00pm to 1:00pm
	Shift Changing	5:00pm to 6:00pm
	Mid-Night	12:00am to 1:00am

3.9. DATA ANALYSIS

Data collected were analyzed using descriptive statistics in terms of mean, standard deviation, maximum and minimum which were presented in a figures and table. Inferential statistics was also used; where one way analysis of variance (ANOVA) was used to assess the significance and direction of the relationship between the time of the day, station, different days and the level of noise within each hospital. Data were entered in Microsoft's Excel 13 and then imported in statistical package for Social Sciences (SPSS) version 22 was used in data analysis. Maximal and minimal values were also calculated for each time in each station along with their standard deviation (SD) to summarize the data. All results were reported as dB (logarithmic scale). The mean of sound levels were compared to the current 45 dB recommendation by AAP (AAP, 1997).

3.10. ETHICAL CONSIDERATIONS

Ethical clearance was granted by Institution Review Board (IRB) of the College Medicine and Health Science, University of Rwanda with Reference: CMHS/IRB/022/2019 (annex 6) after reviewing the proposal. The topic was changed and amendment letter was given with Reference: No 065/CMHS IRB/2019(annex 7). Request letter to carry out research and data collection was submitted to the Director Generals of selected hospitals and the permission for data collection was granted (annexure 8, 9, 10 & 11)

The researcher verbally explains to the head of neonatal unit the purpose of the study, benefits and reassuring confidentiality of all information that was obtained. Confidentiality and anonymity were also maintained by withholding the names of the hospitals and coding the hospitals. The hospital director were given the freedom of choice (autonomy) to participate in this research study and other steps were also taken in acting in beneficence as well as non-maleficence.

3.11. DATA MANAGEMENT

Data were recorded on data collection forms during each visit to the NCU. The data were stored within a lock up cupboard with only the researcher having access to the key. All file will be kept confidential locked for a period of five years then destroyed. The soft copies of data were kept in a password controlled personal computer. All data were kept strictly confidential at all times with names of the participating hospitals being withheld in this final research write up.

3.12. DATA DISSEMINATION

The final report will be communicated to the supervisors and defense panel members, and then submitted to University of Rwanda library. The findings from this study will be disseminated to different stakeholders that may have positive influence referring to the recommendations that was made. Research article will be submitted to peer review journal for publications. The findings will also be presented in conferences.

3.14. CONCLUSION TO CHAPTER THREE

In chapter three the chapter the researcher discusses on the methodology the researcher followed to conduct this study. The research design, research approach, research setting, population, sampling, sampling strategy, sample size, Ethical research norms were respected in this study and measures were taken to ensure validity and reliability of instruments . There were some limitations to the conduct of this study, which are highlighted here.

CHAPTER THREE: RESULT PRESENTATION

4.1. INTRODUCTION

This study was conducted in four public hospitals (two district hospital and two referral hospital) in Kigali city with NCU. This chapter answers the main aim of the study which is determining the noise levels and its sources in neonatal care unit of selected public hospital. The results also addresses specific objective of the study which are; to measure sound levels in NCU of selected public hospitals of Kigali city, to identify possible sources of noise levels in NCU of selected public hospitals of Kigali city, to establish if there are differences in the sound levels in the NCU of the selected hospitals, to compare these sound levels at the NCU to that recommended by the AAP. AAP was used instead of WHO as WHO is global to the whole hospital but AAP is specific to pediatrics. Data were obtained using a sound level meter to measure sound level and observational checklist to assess possible sources of noise. Those measured were analyzed using Microsoft excel and SPSS 22 to get the result.

4.2. DESCRIPTION OF HOSPITAL LAYOUTS

A brief description of the hospitals used in the study. This description illustrating the stations where the sound level meter was placed in NICU during data collection

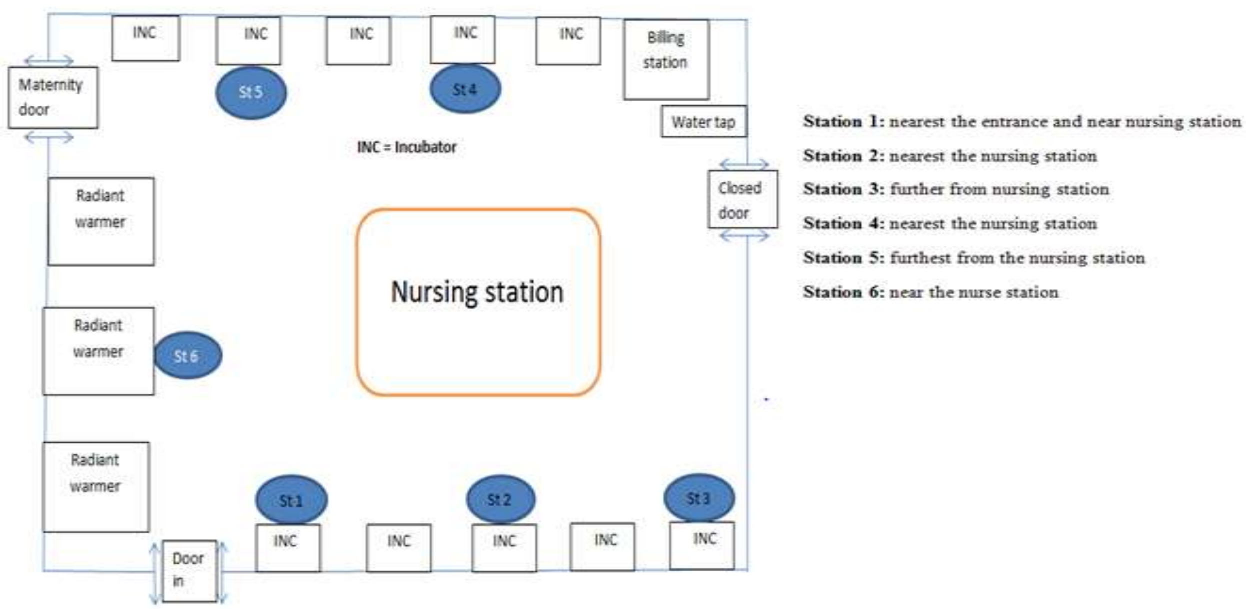


Figure 4.2. Hospital 1: Referral hospital

Figure 1 is a referral hospital with NCU which consist of different ward. Measurement were taken in what we can call high care ward with critical ill newborn and preterm. This ward consisting of 10 incubators, 3 radiant warmers, nursing station in central, billing station, water tap, three doors; one connecting NCU with maternity, another is the entrance and by passes through a ward of improving neonates in crib and the third is located near the car parking but always closed. The numbering of incubators above was done in accordance with that used by the hospital. St1, st2, st2, st3, st4, st4, st5 and st6 are stations where the SLM was put when collecting data.

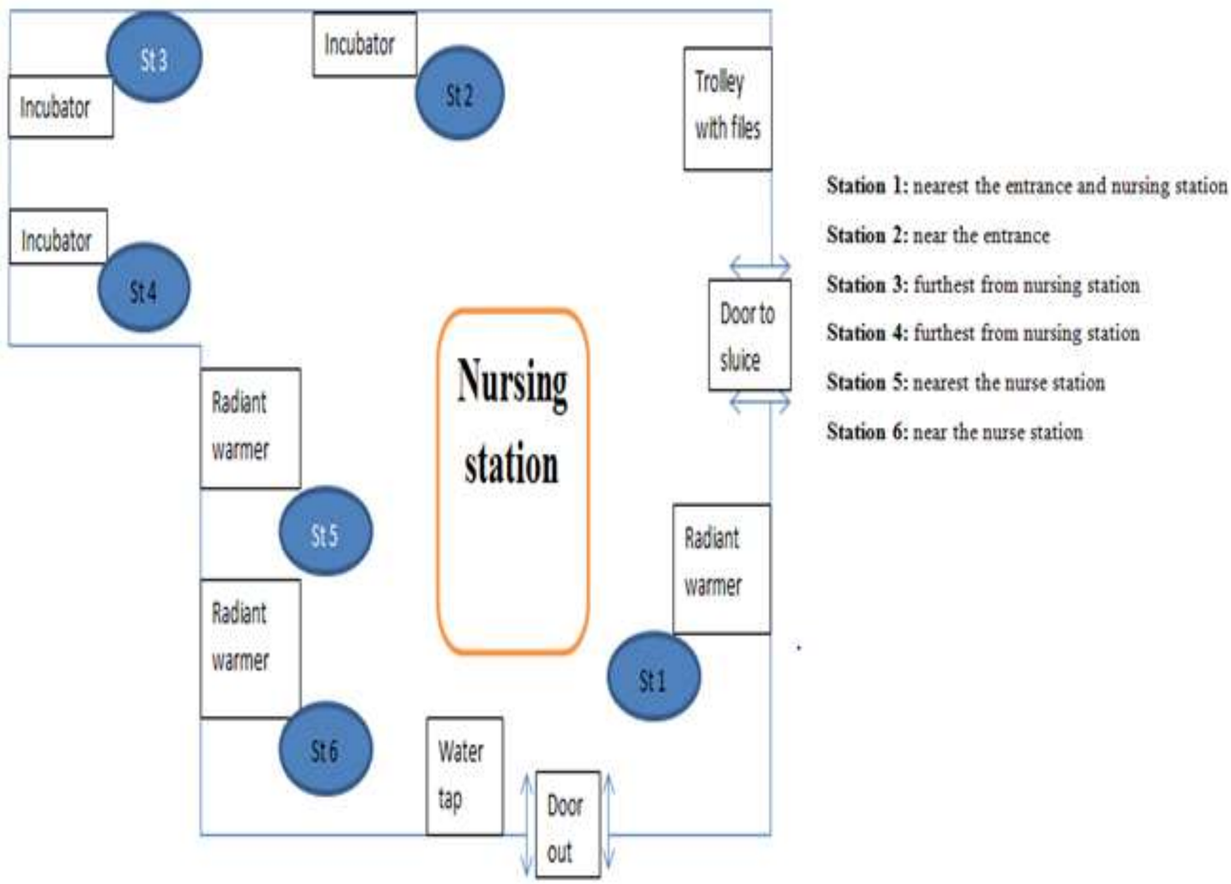


Figure 4.3. Hospital 2: Referral hospital

Figure 2 is a referral hospital with NCU which consist of five wards. One admits newborn who are born in that hospital but not critical ill, the second admits newborn from outside the hospital, the third one is KMC, the fourth admits neonates who are improving and the fifth is NICU admitting critical ill neonates and very preterm neonates. Data were taken in NICU with critical ill newborn and preterm. During the time of data collection there were 3 incubators and

3 radiant warmers. The capacity is 6 beds but increases according to the need, nursing station near the entrance, water tap, two doors; one is the entrance and another is the door to the sluice room and wash room. St1, st2, st2, st3, st4, st4, st5 and st6 are stations where the SLM was put when collecting data.

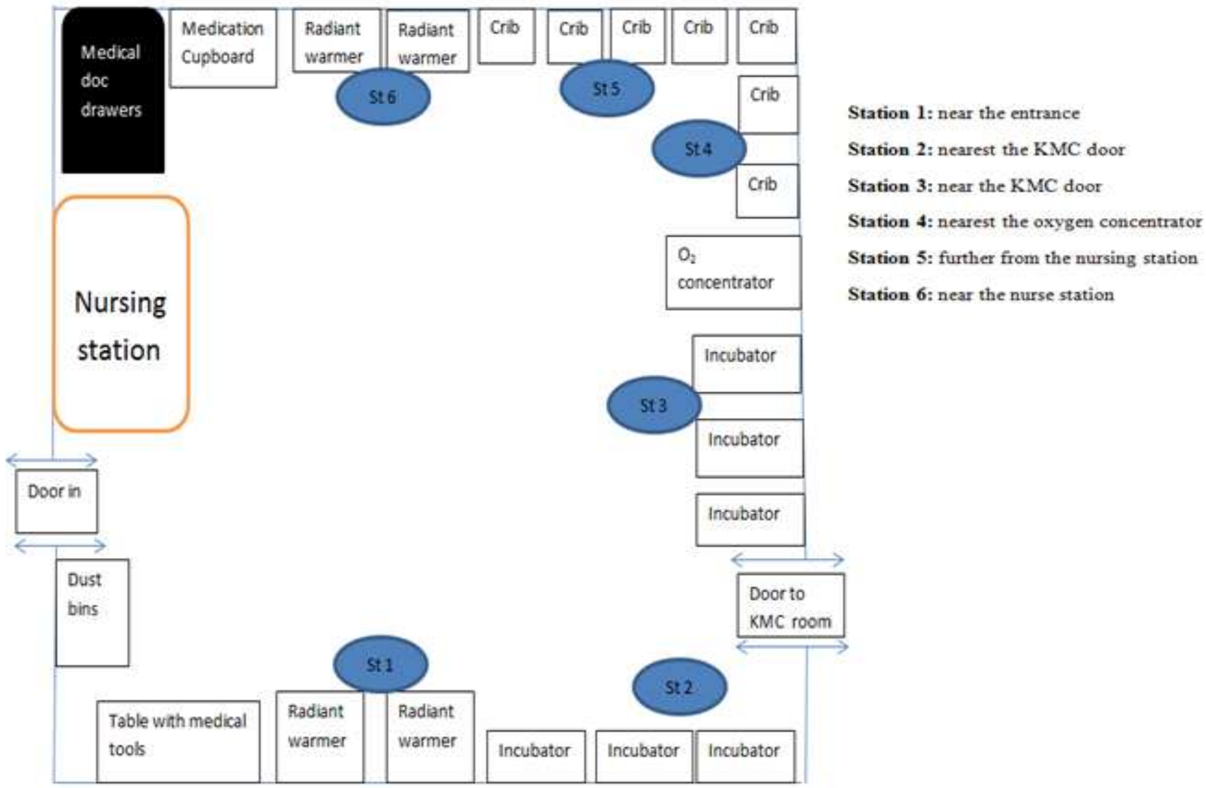


Figure 4.4. Hospital 3: District hospital

Figure 3 is a district hospital with NCU which consist of two wards. The first ward admits critical ill neonates and very preterm neonates. In the same room there are neonates who are improving while the second is KMC. Measurement were taken in what we can call high care ward with critical ill newborn, preterm and improving neonates. It consists of 5 incubators, 4 radiant warmers and 7 cribs. The numbering of incubators above was done in accordance with that used by the hospital. St1, st2, st2, st3, st4, st4, st5 and st6 are stations where the SLM was put when collecting data.

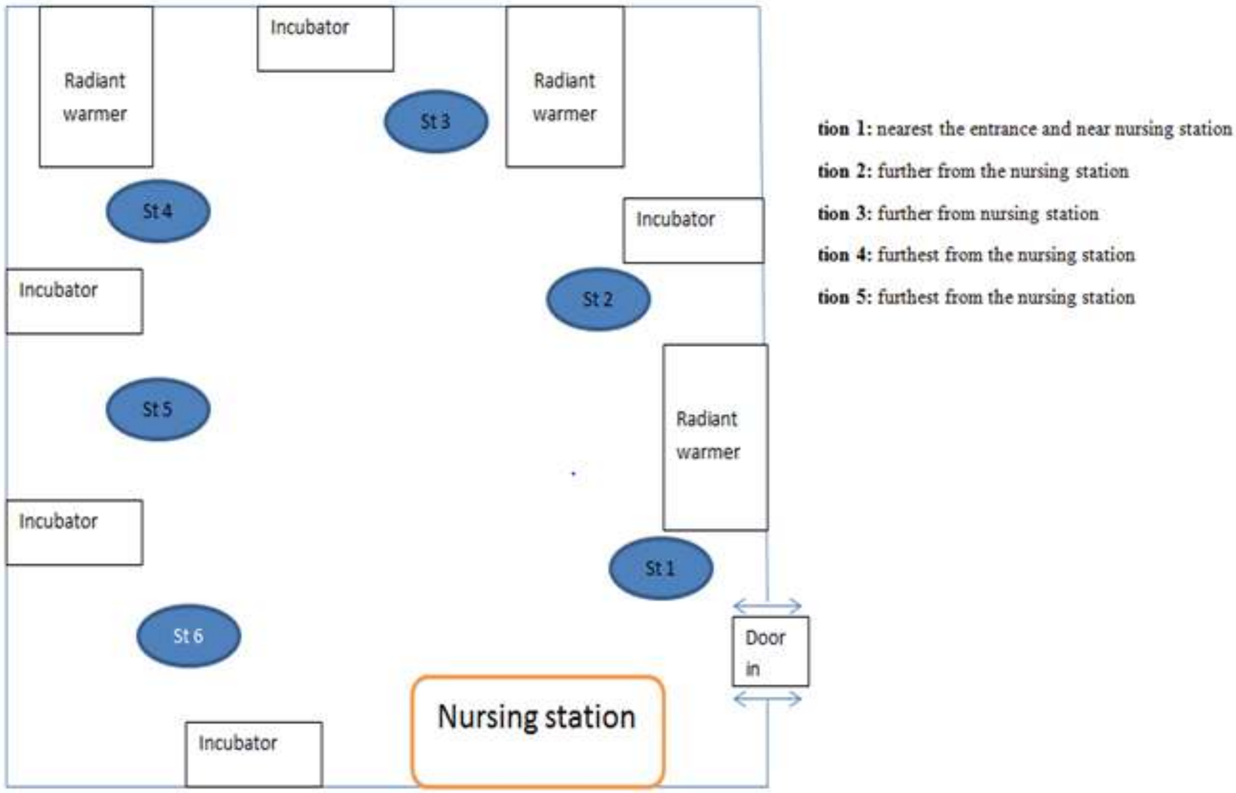


Figure 4.5. Hospital 4: District hospital

Figure 4 is a district hospital with NCU which consist of three wards. One admitting critical ill neonates and very preterm neonates, the second admits neonates who are improving and the third one is KMC with two rooms. Measurement were taken in what we can call high care ward with critical ill newborn and preterm. It is a small room that consists of 5 incubators, 3 radiant warmers, nursing station near the entrance and another nursing station behind the room near its entrance. The numbering of incubators above was done in accordance with that used by the hospital. St1, st2, st2, st3, st4, st4, st5 and st6 are stations where the SLM was put when collecting data.

Table 4.8. Summary of important descriptive characteristics of each hospital

	HOSPITALS			
	1	**2**	**3**	**4**
Number of beds	10 Inc & 3 RW = 13 in an open room	3 Inc & 3 RW = 6 but may increase according to the need. All in an open room	5 Inc, 4 RW & 7 cribs = 16 in an open room	5 Inc & 3 RW = 8 in an open room
Number of HCP	*5 day duty *3 night duty	*5 day duty *4 night duty	*5 day duty *2 night duty	*4 day duty *2 night duty
Number of neonates admitted in NICU	12	6	16	8
Feeding time and personnel to feed	Every 3 hours. Mother are responsible	Every 3 hours. Nurses are responsible	Every 3 hours. Mother are responsible	Every 3 hours. Mother are responsible
Visiting hours	All the time but only parents of the baby	All the time but only parents of the baby	All the time but only parents of the baby	All the time but only parents of the baby
Loudest station	Near the entrance on station 1 (63.7dB)	Near the entrance on station 1 (64.8dB)	Near the entrance on station 1 (67.1dB)	Near the entrance on station 1 (65.5 dB)

RW: Radiant Warmer   Inc: Incubator

4.3. SOUND LEVELS RECORDED

In addressing the main aim of the study to determining the sound levels and it sources in NCU of selected hospital in Kigali city the following results were obtained. The results were presented by averages taken for each time and station within Hospital 1, 2, 3 and 4 over the whole week at each hospital. Also maximum, minimum and standard deviation were identified in the result at each hospital.

4.3.1. Measurements of sound level per day at each hospital

Table 4.9: mean, minimum and maximum sound level in different days at all Hospitals

Hospital	**Days**	Mean sound (dB)	SD	Minimum	Maximum	95% C I	P value
1	Monday	62	1.4	58.9	65.8	61.5 - 62.5	0.004
	Tuesday	61.8	1.6	57.3	63.5	61.2 - 62.4	
	Wednesday	63.4	2.7	60.3	72.3	62.2 - 64.3	
	Thursday	62.5	2.6	56.8	69.5	61.4 - 63.4	
	Friday	63.5	3.4	56.1	72.3	62.2 - 64.8	
	Saturday	62.3	1.3	60.7	65.4	61.8 - 62.8	
	Sunday	60.9	2.3	56.6	64.7	60.0 - 61.8	
2	Monday	64.2	2.3	58.0	70.5	63.3 - 65.0	0.05
	Tuesday	63.9	2.2	60.9	72.5	63.0 - 64.7	
	Wednesday	64.7	2.1	61.3	70	64.0 - 65.4	
	Thursday	65.6	2.1	61.6	69.6	64.8 - 66.4	
	Friday	63.9	2.3	58	68.2	63.1 - 64.8	
	Saturday	64	2.3	59.9	69.1	63.2 - 64.9	
	Sunday	64.4	2.4	59.7	71.9	64.0 - 65.2	
3	Monday	66.4	2.2	62.9	72.3	65.6 - 67.2	0.002
	Tuesday	65.5	3.1	59.4	74	64.2 - 67.7	
	Wednesday	66.7	2.7	62.4	76.5	65.7 - 66.5	
	Thursday	66.1	1.7	63.0	71.3	65.4 - 66.7	
	Friday	67.7	1.9	64.0	72.7	66.9 - 68 .4	
	Saturday	65.6	1.7	63	70.3	64.9 - 66.3	
	Sunday	65.9	2.3	59.4	69.4	65.2 - 66.5	
4	Monday	63.7	5.9	50.4	74.8	61.5 - 65.9	0.000
	Tuesday	65	3.3	59.9	70.9	63.7 - 66.2	
	Wednesday	63	5.1	54.9	74	61.1 - 64.9	
	Thursday	64.3	3.7	58.8	74.9	62.9 - 65.7	
	Friday	65.2	3.7	58.5	72.2	63.8 66.5	
	Saturday	65.9	3.7	55.1	72.6	64.5 67.2	
	Sunday	68	4.3	61.7	77	66.5 69.7	

CI: Confidence interval SD: Standard Deviation

The sound levels at the hospital one during different days varied but were all above 60.9 dB. Sound was high on Friday 63.5 dB and was low on Sunday 60.9 dB. Standard deviation varied from different days similar. The result of hospital was statistically significant (P = 0.004).

The result of noise level at hospital two during different days. Noise levels show no much variation as P = 0.05 within different days of the week but were all above 63.9 dB. Sound was high on Thursday 65.6 dB and low on Tuesday and Friday 63.9 dB. The maximum and minimum values showed less variation from Monday to Sunday. Standard deviation was quite similar.

Noise level at hospital three during seven days of the week. Noise was different from day to day where P = 0.002 and they were all above 65.5 dB. Sound was high on Friday with level of noise of 67.7 dB. The maximum and minimum values varied from Monday to Sunday. Standard deviation was different and showed much variation on Tuesday with value of 3.1.

The result of noise level at hospital four during seven days of the week. Noise was statistical significant (P = 0.000) and they were all above 65.9 dB. Sound was high on Sunday with level of noise of 68 dB and was low on Wednesday with 63dB. The maximum and minimum values varied from Monday to Sunday. Standard deviation varied from different days and the highest was 5.9.

4.3.2. Measurements of sound level in different shift within hospital 1, 2, 3 and 4

The number of people in the NCU differs from on shift to the other. Working staff in the morning duty shift consisted of nurses, midwives, nurse/midwife students, resident doctors, and specialized doctors. Cleaners and mothers of admitted newborns were also allowed to visit and some of the hospitals allowed mothers to feed their newborns in. In the night the working staff reduced and the number of visitors. During the ward round the number of staff is high and discussing on different cases of admitted newborn. Lunch time most of the staff have gone to lunch and the number reduced.

Table 4.10: Summary of all hospitals showing; mean level, minimum and maximum sound level

Hospital	Shift	Mean sound (dB)	SD	Min	Max	95% C I	P value
1	Morning	62.7	2.1	57.2	66.8	62.1 - 63.3	0.000
	Ward round	63.9	3.1	57.7	72.2	62.9 - 64.9	
	Lunch time	62	1.7	56.8	65.3	61.4 - 62.5	
	Shift changing	62.5	1.7	57.7	67.8	61.9 - 63	
	Mid-night	62.3	2	56.1	64	61.1 - 61.1	
2	Morning	64.7	2.3	59.8	69.6	63.9 - 65.4	0.003
	Ward round	64.5	2.1	59.7	70	63.8 - 65.1	
	Lunch time	63.9	2	61.2	70.5	64 - 65.3	
	Shift changing	65	2.5	61.4	72.5	64.1 - 65.7	
	Mid-night	63.2	2	58	66.3	64 - 64.7	
3	Morning	66.4	2.5	59.3	72.6	65.6 - 67.2	0.001
	Ward round	67.1	2.4	63.3	76.5	66.3 - 67.8	
	Lunch time	65.9	1.9	61.5	71	65.3 - 66.5	
	Shift changing	66.5	2.2	63.1	74	65.8 - 67.2	
	Midnight	65.1	1.9	61.75	70.2	64.5 - 65.7	
4	Morning	65.3	4	55	74.8	64.9 - 66.5	0.001
	Ward round	65.3	4.2	55	75	64 - 66.6	
	Lunch time	62.2	4.1	50.3	68	61 - 63.5	
	Shift changing	63.9	5.3	54.1	77	62.2 - 65.5	
	Midnight	68.3	1.8	64.2	72	67.7 - 68.8	

Min: minimum Max: maximum SD: standard deviation P: p value

Table 4.3 shows the summary of all hospitals during different shifts of the day. Lunch time and midnight had the list noise level compared to other shift. Noise level was high during ward round in all hospitals. It was also high during shift changing in hospital 2 and 3 but less in hospital 1 and 4. Hospital 1 had the highest noise level during ward round (63.9dB) and night duty shift (63.2dB) compared to other shifts. The result of hospital 1 during different shifts were statistical significant (P <0.001). The second hospital had the largest noise during shift changing with level of 65dB followed by morning time. All this time there is hand over of neonates to the replacing shift. The result was statistical significant (P = 0.003) at this hospital. Hospital 3 had the highest noise during ward round (67.1dB) and shift changing (66.5dB). The result of this hospital was statistical significant (P = 0.001). Hospital 4 had the highest noise during the night shift (68.3 dB), followed by ward round (65.3dB) and the result was statically significant (P = 0.001). Standard deviation was varied from one hospital to the other and had larger variation on the fourth hospital.

Table 4.3.3: Measurements of sound level in different shift at each hospital

Table below shows the result from different station of NICU room where data were collected. The result is the average of all shifts and seven days.

Table 4.11: Mean, minimum and maximum sound level in different stations at Hospital 1

The following is the description of stations at hospital 1;

Station 1: nearest the entrance and near nursing station

Station 2: nearest the nursing station

Station 3: further from nursing station

Station 4: nearest the nursing station

Station 5: furthest from the nursing station

Station 6: near the nurse station

Hospital	stations	Mean sound (dB)	SD	minimum	maximum	95% C I	P value
1	1	63.7	2.8	58.9	72.3	62.6 - 64.6	0.05
	2	62.4	2.9	56.1	70.5	61.4 - 63.4	
	3	61.8	2.3	56.8	67.1	61 - 63.1	
	4	62.6	1.3	61.0	66.2	61.0 - 70.0	
	5	61.8	2.1	57.2	67.8	60.9 - 68.3	
	6	61.7	2.4	57.2	66.9	62.0 - 69.6	

C I: Confidence Interval SD: Standard Deviation

The table above show sound levels of different stations in hospital 1. The highest level was on station 1 (63.7dB) which was taken nearest the entrance and nurses' station and station 2 (62.4dB) which was also very near nurse station. There was a big variation between maximum and minimum. Standard deviation was quite similar and there were no much difference of sound level within stations as P = 0.05

Table 4.12: Mean, minimum and maximum sound level in different stations at Hospital 2

The following is the description of stations at hospital 2;

Station 1: nearest the entrance and nursing station

Station 2: near the entrance to the sluice room and bath room

Station 3: furthest from nursing station

Station 4: furthest from nursing station

Station 5: nearest the nurse station

Station 6: near the nurse station

Hospital	stations	Mean sound (dB)	SD	Minimum	Maximum	95% C I		P value
2	1	64.8	2.7	60.2	72.5	63.8 -	72.5	0.7
	2	64.7	2.8	65.6	70.5	63.7 -	70.5	
	3	64.4	2.3	65.2	69.6	63.5 -	69.0	
	4	64.3	2.2	65.0	70.0	63.5 -	70.0	
	5	64.2	1.8	64.8	68.3	63.4 -	68.3	
	6	64.4	1.7	64.6	69.6	64.0 -	69.6	

C I: Confidence Interval SD: Standard Deviation

This table show sound levels of different stations in hospital 2. The highest level was on station 1 (64.8dB) which was taken nearest the entrance and nurses' station and followed by station 2 (64.7dB) which was also very near door to the sluice room and bath room. Standard deviation was quite similar except on station 6 which was a bit low. This table was not statically significant (P = 0.7)

Table 4.13: Mean, minimum and maximum sound level in different stations at Hospital 3

The following is the description of stations at hospital 3;

Station 1: near the entrance

Station 2: nearest the KMC door

Station 3: near the KMC door

Station 4: nearest the oxygen concentrator

Station 5: further from the nursing station

Station 6: near the nurse station

Hospital	Stations	Mean sound (dB)	SD	Minimum	Maximum	95% C I		P value
3	1	67.1	2.8	59.4	76.5	66.1-	68.0	0.008
	2	66.8	1.9	63.1	71.4	66.2 -	67.5	
	3	65.5	1.7	61.5	69.8	64.9 -	66.2	
	4	66.3	2.6	62.1	74.0	65.4 -	67.3	
	5	65.3	1.6	61.8	68.5	64.8 -	65.9	
	6	66.2	2.4	62.1	72.7	65.9 -	67.1	

C I: Confidence Interval SD: Standard Deviation

The table above show sound levels of different stations in hospital 3. The highest level was on station 1 (67.1dB) which was taken nearest the entrance and station 2 (66.8 dB) which was also very near to the entrance of KMC. There was a big variation between maximum and minimum. Standard deviation was quite similar except on station one where it was high with 2.8 compared to other. The result were statistical significant (P = 0.008)

Table 4.14: Mean, minimum and maximum sound level in different stations at Hospital 4

The following is the description of stations at hospital 4;

Station 1: nearest the entrance and near nursing station

Station 2: further from the nursing station

Station 3: further from nursing station

Station 4: furthest from the nursing station

Station 5: furthest from the nursing station

Station 6: nearest the nurse station

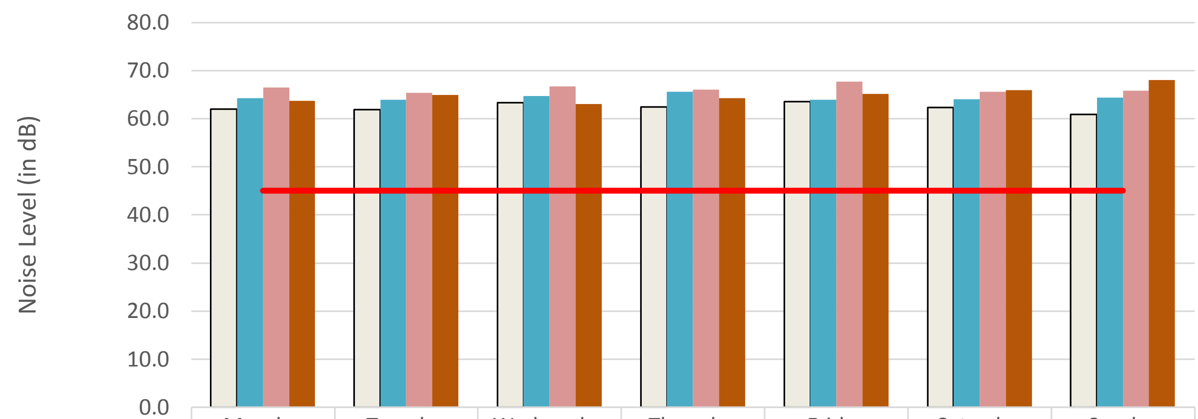
Hospital	Stations	Mean sound (dB)	SD	Minimum	Maximum	95% C I	P value
Four	1	65.5	4.4	55.1	74.8	63.9 - 67.0	0.99
	2	64.7	4.1	52.0	76.6	63.3 - 66.2	
	3	64.8	4.4	54.0	77.0	63.3 - 66.3	
	4	64.9	4.4	55.4	76.3	63.4 - 66.4	
	5	65.1	5.1	50.4	74.0	63.3 - 66.7	
	6	65.0	4.8	55.1	75.1	64.4 - 65.5	

C I: Confidence Interval SD: Standard Deviation

The table above show sound levels of different stations in hospital 4. The highest level was on station 1 (65.5 dB) which was taken nearest the entrance and nurses’ station. The second with high sound was station 6 (65 dB) which was also very near the nurses. There was a big variation between maximum and minimum. Standard deviation was quite similar except on station five which was high with 5.1 compared to others. The result were not statistical significant (P = 0.9)

4.4. COMPARING SOUND LEVELS AT THE NICU TO THAT RECOMMENDED BY THE AAP

WHO recommends that noise in hospital facilities should not exceed mean sound of 35 dB and AAP recommended mean sound of 45 dB in NICU (Schokry, 2016). AAP was chose to be used as it is specific to NICU whereas WHO is global to the whole hospital.



	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Hospital 1	62.0	61.8	63.4	62.5	63.5	62.3	60.9
Hospital 2	64.2	63.9	64.7	65.6	64.0	64.1	64.3
Hospital 3	66.4	65.4	66.7	66.1	67.7	65.6	65.9
Hospital 4	63.7	65.0	63.0	64.3	65.2	65.9	68.0
Standard	45.0	45.0	45.0	45.0	45.0	45.0	45.0

Figure 4.6.Comparing sound levels per day at each hospital with AAP

Sound levels during different day at different hospitals were above the recommendation of AAP which is 45db. It was statistical significant ($P < 0.05$)

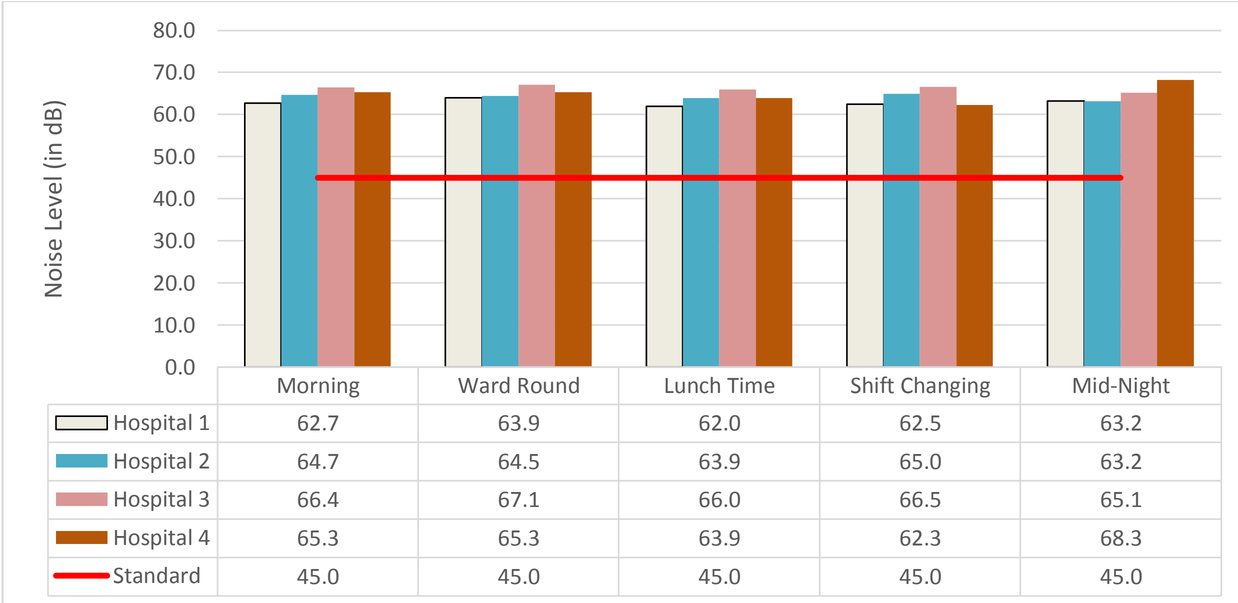


Figure 4. 7.Comparing of sound levels per shift at each hospital with AAP

The above figure shows how sound levels during different shift at different hospitals were above the recommendation of AAP which is 45db. The result was statistical significant ($P < 0.05$)

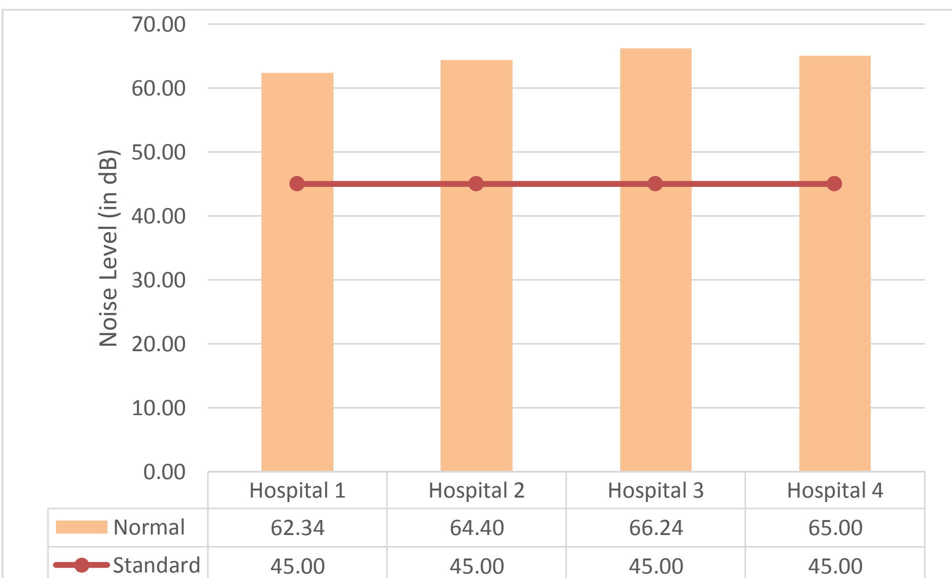


Figure 4.8 **Comparing sound levels of hospitals with recommended**

The figure above shows how sound level was high in different hospitals compared to the recommendation of AAP. The results above were statistically significant ($P < 0.001$)

4.5. SUMMARY OF POSSIBLE SOURCES OF NOISE LEVELS IN HOSPITALS 1, 2, 3 AND 4

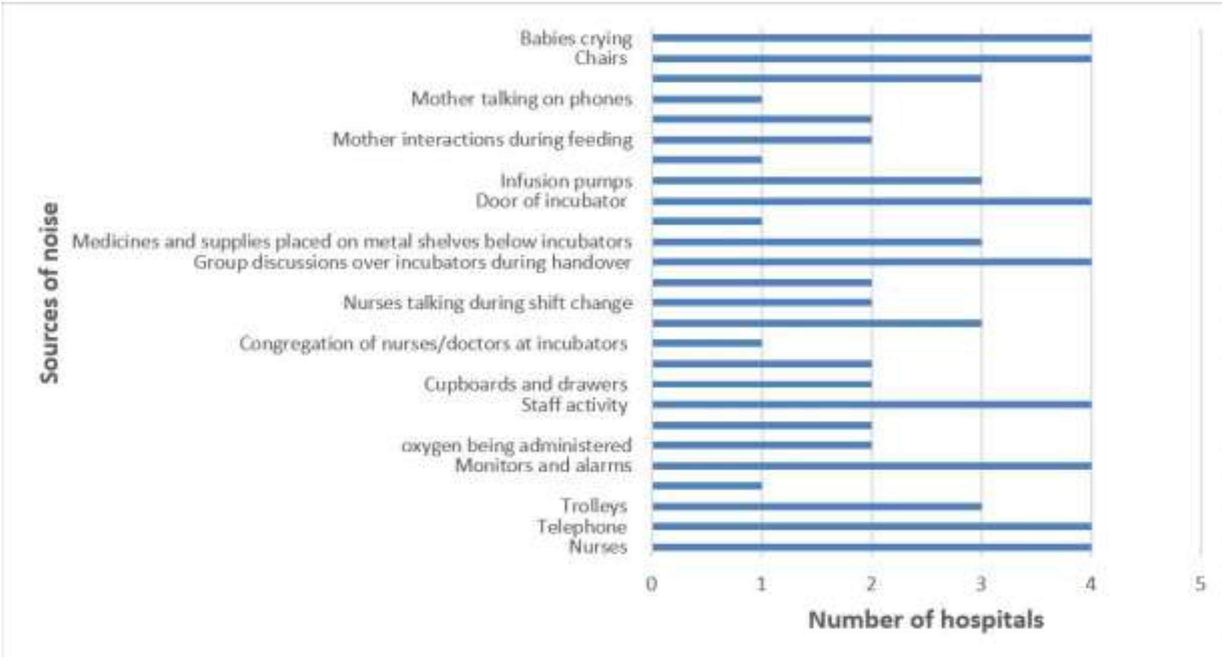


Figure 4.7. Possible sources of noise

In this figure showing possible source of noise, talking/conversation was seen to all of the, hospitals. Telephone ringing, staff activity, monitor and alarms, door of incubator closing and opening, chairs moved around and babies crying were also seen to all hospitals.

4.6. CONCLUSION

The results of this study were analyzed using descriptive and inferential statistic. The research findings were presented in tables and figures. The total mean of sound level is 64.5 dB of 840 measurements taken in all 4 hospitals and the measurements of all hospitals were statistically significant ($P < 0.001$). On observation of sources of noise conversation had the highest frequency.

CHAPTER FIVE: DISCUSSION

5.1. INTRODUCTION

The average sound levels measured in the NICU of all the four hospital were above the maximum level of 45 dB recommended by the American Academy of Pediatrics, 1997. The basal noise level recorded in this study exceeds the noise level recommended by the WHO of 30 - 40 Db (WHO, 2000) and AAP of 45 dB (AAP, 1997). According to AAP, lack of compliance to the standard would result in the risk of negative effects on the health of premature neonates (AAP, 1997 p. 6). High noise levels in NICU are the major source of environmental stress to premature neonates, which affect; heart rate, respiratory rate, blood pressure, oxygen saturation and intracranial pressure (Peng et. al, 2009). This sound level which is greater than the recommended standards has been noted in a number of studies carried out in various NICUs of Africa as well as internationally.

5.2. MEASUREMENT OF NOISE LEVEL

Sound levels varied based on time of day and location within the unit. The measured values were higher than standard levels of NICU. Previous similar studies also reported the same results. A study done in South Australia reported that; maximum sound level was 74.5dB in NICU (Ramm et al., 2017 p. 30). Another study done by Santos et al, (2018) in Portuguese NICUs showed maximum sound level of 71.7 dB and in this study maximum sound to all hospitals in NICU was 77.0 dB. The records of mean, maximum and minimum sound levels were high and mainly during morning shifts compared to the night shift. The reason for high noise during the morning was due to more activities; such as faculty residents, undergraduate, nursing students round, administrative activities, in addition to noise generated by instruments and equipment (Joshi and Tada, 2016 p. 1360).

The sound level during different shifts was high > 45dB and statistically significant $p < 0.05$. Noise levels increased during morning shifts was high to all hospitals compared to the night shift this was also reported in other studies; (Matook et al., 2010, Garrido et al., 2017 p124 and Ramm et al., 2017 p38). Reduction of noise level during the night may be was due to small number of nurses at that time compared to the day shift. Sound levels during every shift of the day at all hospitals were statistically significant with $p < 0.05$ and also Blourchian and Sharafi (2015) found out noise level during each shifts were statistically significant with $p = 0.002$. Sound was high on Thursday 65.6 dB at the hospital two and also a study done by Santos et al,

(2015) found out that Thursday sound level was high at 79.7 dB. Noise level was low on Tuesday at hospital two and another study showed that it was lowest 53.6 dB on Saturday (Santos et al., 2015 p. 126).

The highest measure among the day time was during ward rounds and shift changing in all hospital. Ward rounds were the noisiest times due to the greatest number of people present in the round. In the study done by Valizadeh et al, 2013 found out that sound levels had direct relationship with the number of people present at the ward ($p = 0.007$). While shift changing is the time nurses do handover leading to increased noise. Ward round mean sound levels in all 4 hospitals (1, 2, 3 and 4) were 64 dB, 64.5 dB, 67.1 dB and 65.9 dB respectively which was consistent with other studies done by Ramm et al., 2017 with 52.4 dB and Joshi and Tada, 2016 which was between 50 – 95 dB. The lowest sound level among day shifts was seen during the midnight within 3 hospitals (1, 2 and 3) were 62.3 dB, 63.2 dB and 65.1 dB respectively. Another study detected the lowest measure at night with 61dB (Valizadeh et al, 2013 p. 18).

The result for station/location one which is near the entrance at each hospital (hospital 1, 2, 3 and 4) was high compared to other stations with measures 63.7 dB, 64.8dB, 67.1 dB and 65.5 dB respectively. Which is the same as the study done by Neille et al., (2014) that reported that sound level was higher on the measurement taken near the entrance (67,6 dB) and near nurses tea room (62.4 dB). Sound level was also high near nurses' station which was ranging from 62.4 dB to 66.8 dB. Sound level as reported by Valizadeh et al, 2013 during 6 locations was significant differences $p = 0.135$ between sound levels, this is the same as hospital 2 and 4 which was not statistically significant $p = 0.7$ and $p = 0.9$ respectively.

5.3. COMPARING NOISE LEVEL WITH THE RECOMMENDED

The mean sound in this study was varying between 61.8 dB to 77.0 dB which was high to the recommendation of AAP. A study done by Schokry (2016) showed a variation between 56 and 81dB which was greater than the recommended by AAP. This was the same as the study done in Santa Marta- Colombia by Garrido et al., 2017 in their study with sound ranging from 49 – 92 which was above the recommendation. A study done in Iran reported that Sound levels ranged between 56.10 dB and 104.80 dB which were higher than standard levels according to the recommendation of AAP (Valizadeh et al, 2013 p. 19). Another study done in an urban city like this study with increased number of neonate reported the mean sound level ranging 51 dB - 95 dB greater than the recommended level (Joshi and Tada, 2016 p. 1360).

A study done in Portugal showed that noise levels were excessive in all the areas of the NICUs, exceeding the recommendation, with levels ranging between 48.7 dB to 71.7 dB (Santos et al., 2018 p. 125). The average level of noise was 11–14 dB above the recommendation of AAP (Smith, Ortmann and Clark, 2018 p. 121) An exceptional study reported that; the lowest A-weighted sound level of 38 dB was reported only from one nursery in Lund, Sweden, which was the only nursery that confirmed with the AAP recommendations for sound levels in NICU to be below 45 dB (D'Souza et al., 2015 p. 62). In the study of Parra et al, (2017 p1912) sound level was greater than the recommended by AAP ranging from 65.4 dB to 97 dB.

5.4. SOURCES OF NOISE LEVEL

The findings from this study revealed that; high noise level was due to numerous source of sound. The possible sources may be the following; talking/conversations, staff activity, monitors, alarms, phones and others. Another study done in South Africa reported the same that conversations were always higher compared to other sources of noise and another largest sound source was alarm monitors (Aljawadi et.al. 2017 p. 2743). Another study found out that phone ring tones and neonatal crying had the highest result (Blourchian and Sharafi, 2015 p. 23). This is the same to what was observed in this study phone ring and neonate crying was seen to all hospitals. Noise sources was greater than 45dB, with the exceptional high-frequency oscillatory from the ventilator (Neille et al., 2014 p. 6) which was absent in all NICU during the time of data collection.

Only one hospital among the four has ventilation but during data collection it was not administered to any neonate. So there was no input of ventilation to the source of noise to all hospital. Some of the source of noise can be prevented eg HCP conversation, phone ring etc but others like alarm monitors, infusion pump. Also a study done by Santos et al, (2018) suggested that, this equipment could be modified for the safety of the neonates. HCP and family members' conversation, the dropping equipment, contributes to the high sound level in NICU (Sá, et al 2018 p. 6).

5.5 LIMITATIONS OF THE STUDY

There are no appropriate specific standard limits for NICU; the one use was a bit specific to neonates was AAP but is specific compared to WHO. There was no NICU standard sound level in national guideline. The readings were not taken inside the incubator, rather taken as close to the neonates head as possible in the attempt to record a representative sound level reading. But this might have not shown the exact noise level that affect the newborn. Noise sources where not measured in order to elaborate the level of noise it contributed. There may still have been bais due to “halo effect”, as HCP may have pretended and changed the behavior, but though precautions were taken to average noise levels and keep bias to minimum.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1. INTRODUCTION

Noise is a worldwide problem both in developing countries and developed countries. In the final chapter, there is conclusion and recommendations for ministry of health, hospitals where researcher were conducted, to education and future research.

6.2. CONCLUSION

In all the NICUs, the noise level generated was greater than the safe limits established by WHO and AAP. These noise levels in all hospitals were high during the ward rounds and station near the entrance. The noise level ranged from 61.8 dB to 77.0 dB which was above the recommendation of AAP safe for neonates. The most frequent noise source was HCP conversation in NICU. HCP can play a big part in noise level reduction. The findings of high noise level have an effect on the neonatal care admitted in NICU. This will help in noise level reduction and monitoring in order to prevent the impact of noise to vulnerable neonates. Advocacy is needed for the health of neonates towards the noise free environment.

6.3 RECOMMENDATION

Ministry of Health

To establish national standard limits of sound level specifically to NICU in national guideline. There is also a need to develop noise mapping, action plans, and community involvement, informing the media and decision makers about the impact of noise mostly to preterm neonates.

Hospitals

To avoid unreasonable noise seems to be necessary like conversations which were seen to all hospitals. They have to use pipeline oxygen; that is fixed through the wall in order to decrease sound level exposure to neonates. There is need to build noise barriers, sound protection or using sound absorbent materials. Every NICU requires a sound level assessment system in order to measure noise and try to reduce it to the recommended standard of sound levels. Raising awareness, about noise exposure when planning the settings where newborns will be admitted. To turn off noise at the source and masking unwanted sound from the monitor and setting up noise control campaigns in hospitals. Neonatal beds (radiant warmer or incubators) have to be put far from the entrance and nursing station. HCPs should prevent discussion near neonates in NICU mostly during ward rounds. This can be done in another room.

Education

There is a need to train health professionals on maintaining recommended level of sound. It is advisable to educate HCPs to have ability to recognize noise pollution by measuring noise levels. They should also receive trainings on the impact on noise level to neonates

Future Research

There is a need to design the standard limits of sound levels specific to neonates. Future research should measure the level of noise source. Sound level should also be measured in rural areas and other hospitals where the research were not conducted. There is a need also to develop software program that analyzes sound levels in the NICU to track the frequency with which these types of events occur. This will eliminate human observer bias and error, when using sound level digital. Measure noise inside the incubator and compare it to that one outside the incubator.

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ANNEXES

ANNEX 1: NOISE MEASUREMENT TOOL

Noise measurement was done using SOUND LEVEL METER (Velleman 200). See the pictures.

ANNEX 2: DATA CAPTURE SHEET OF NOISE MEASUREMENTS

Hospital ……………………………

Date ……………………………….

Day ………………………………..

Time ………………………………

STATIONS		
1		
2		
3		
4		
5		
6		

ANNEX 3: PERMISSION TO USE THE TOOL

Joanne Neille <Joanne.Neille@wits.ac.za> October 15, 2018, 11:37 AM

Dusabe Ruth < milsruth@gmail.com>

Dear Dusabe Ruth

Attached please find a copy of the original undergraduate project on which the article was based. You can refer the appendix to see how the data were captured.

Kind regards

JOANNE NEILLE, PHD

SENIOR LECTURER

DEPARTMENT OF SPEECH PATHOLOGY AND AUDIOLOGY

TEL: 0117174574

FAX: 0865536060

ANNEX 4: POSSIBLE SOURCES OF NOISE LEVEL

		YES	NO
1	Nurses wearing high heeled shoes		
2	Nurses talking loudly		
3	Telephone ringing		
4	Heated cribs		
5	Trolleys wheeled around		
6	Monitors and alarms		
7	Noise due to oxygen being administered		
8	Staff activity (nurses, doctors and cleaning staff) - talking		
9	Cupboards and drawers being closed		
10	Congregation of nurses at the foot of incubators talking		
11	Nurses singing during shift change		
12	Group discussions over incubators during handover		
13	Metal pedal bins closing		
14	Swing doors slamming closed		
15	Metal trolleys wheeled around		
16	Metal drawers and cupboards being closed		
17	Television		
18	High frequency oscillatory ventilator		
19	Medicines and supplies placed on metal shelves below incubators		
20	Door of incubator (closing and opening)		
21	Infusion pumps		
22	Air conditioning		
23	Mother interactions during feeding		
24	Mother talking on phones		
25	Chairs being moved around		
26	Babies crying		

(Neile et al, 2014)

ANNEX 5: REQUEST LETTER TO CARRY DATA COLLECTION

21/01/2019

DUSABE RUTH
School of Nursing and Midwifery
College of Medicine and Health Sciences
University of Rwanda

To ....

Dear Sir

RE: Request to carry out research and data collection at your your Institution

I am by Names of DUSABE Ruth a student in Masters in Nursing Science, neonatal track at the college of Medicine and Health Sciences. As a prerequisite to complete masters, I am supposed to carry out research and my study is entitled ***"Determine Noise level and its source in Neonatal care Unit of Public hospitals in Kigali"***. My research will contribute to the existing knowledge on the appropriate and standard noise acceptable in Neonatal care Units in Rwanda.

I have submitted the requirements to the CMHS institutional Review board and an Ethical Clearance Letter has been granted to me Ref: CMHS/1RB/022/2019 dated 14/01/2019. The tools to used and the ethical standards to be followed have been accepted. It is against this background that I seek authorisation to carry out research and collect data at your institution. Kindly find attached the letter from CMHS institutional Review Board.

I hope my request will be put under your kind consideration.

Sincerely,

DUSABE Ruth

Masters in Nursing Science neonatal track
School of Nursing and Midwifery
College of medicine and health sciences
University of Rwanda
Email: milsruth@gmail.com
Tel: +250788444395

ANNEX 6: AMANDMENT REQUEST APPROVED

UNIVERSITY OF RWANDA

COLLEGE OF MEDICINE AND HEALTH SCIENCES

CMHS INSTITUTIONAL REVIEW BOARD (IRB)

Kigali, 31st January, 2019
No 065 /CMHS IRB/2019

DUSABE Ruth

School of Nursing and Midwifery, CMHS, UR

Re: Amendment Request for Research Protocol

Dear DUSABE Ruth

We thank you for submitting your request for research project amendments in the project titled "Determine Noise level and its source in Neonatal Intensive Care Unit of Public Hospitals in Kigali".

After reviewing your protocol, the amendments have been approved with a change in the title from *"Determine Noise level and its source in Neonatal Intensive Care Unit of Public Hospitals in Kigali"* to ***"Determine Noise Level and its source in Neonatal Care Units of Selected Public Hospitals in Kigali".***

We wish you success in this important study.

Professor Gahutu Jean Bosco
Chairperson Institutional Review Board,
College of Medicine and Health Sciences, UR

Cc:

- Principal College of Medicine and Health Sciences, UR
- University Director of Research and Innovations, UR

EMAIL: researchcenter@ur.ac.rw P.O. Box: 3286, Kigali, Rwanda WEBSITE: http://cmhs.ur.ac.rw/ www.ur.ac.rw

ANNEX 7: UR ETHICAL CLEARANCE LETTER

UNIVERSITY OF RWANDA

COLLEGE OF MEDICINE AND HEALTH SCIENCES

CMHS INSTITUTIONAL REVIEW BOARD (IRB)

Kigali, 14/01/2019
Ref: CMHS/IRB/**022**/2019

DUSABE Ruth
School of Nursing and Midwifery, CMHS, UR

Dear DUSABE Ruth

RE: ETHICAL CLEARANCE

Reference is made to your application for ethical clearance for the study entitled ***"Determine Noise Level and Its Source in Neonatal Intensive Care Unit of Public Hospitals in Kigali."***

Having reviewed your protocol and found it satisfying the ethical requirements, your study is hereby granted ethical clearance. The ethical clearance is valid for one year starting from the date it is issued and shall be renewed on request. You will be required to submit the progress report and any major changes made in the proposal during the implementation stage. In addition, at the end, the IRB shall need to be given the final report of your study.

We wish you success in this important study.

Professor Jean Bosco GAHUTU
Chairperson Institutional Review Board,
College of Medicine and Health Sciences, UR

Cc:

- Principal College of Medicine and Health Sciences, UR
- University Director of Research and Postgraduate studies, UR

EMAIL: *researchcenter@ur.ac.rw* P.O. Box: 3286, Kigali, Rwanda WEBSITE: http://cmhs.ur.ac.rw/ www.ur.ac.rw

ANNEX 8: CHUK APPROVAL LETTER

CENTRE HOSPITALIER UNIVERSITAIRE
UNIVERSITY TEACHING HOSPITAL

Ethics Committee / Comité d'éthique

February 25th, 2019 **Ref.: EC/CHUK/032/2019**

Review Approval Notice

Dear Ruth Dusabe ,

Your research project: "**Determine noise level and its source in neonatal care unit at CHUK**".

During the meeting of the Ethics Committee of University Teaching Hospital of Kigali (CHUK) that was held on 25th February, 2019 to evaluate your request for ethical approval of the above mentioned research project, we are pleased to inform you that the Ethics Committee/CHUK has approved your research project.

You are required to present the results of your study to CHUK Ethics Committee before publication.

PS: Please note that the present approval is valid for 12 months.

Yours sincerely,

ETHICS COMMITTEE CHUK

Dr. Emmanuel Rusingiza
The Chairperson, Ethics Committee,
University Teaching Hospital of Kigali

<<University teaching hospital of Kigali Ethics committee operates according to standard operating procedures (Sops) which are updated on an annual basis and in compliance with GCP and Ethics guidelines and regulations>>

B.P. :655 Kigali- RWANDA www.chk.rw Tél. Fax : 00 (250) 576638 E-mail :chuk.hospital@chukigali.rw

ANNEX 9: KIBAGABAGA HOSPITAL APPROVAL LETTER

21/01/2019

DUSABE RUTH
School of Nursing and Midwifery
College of Medicine and Health Sciences
University of Rwanda

Accord

To
The Director of Kibagaga Hospital
Kigali
Rwanda

Dear Sir

RE: Request to carry out research and data collection at your Institution

I am by Names of DUSABE Ruth a student in Masters in Nursing Science, neonatal track at the college of Medicine and Health Sciences. As a prerequisite to complete masters, I am supposed to carry out research and my study is entitled ***"Determine Noise level and its source in Neonatal care Unit of Public hospitals in Kigali"***. My research will contribute to the existing knowledge on the appropriate and standard noise acceptable in Neonatal care Units in Rwanda.

I have submitted the requirements to the CMHS institutional Review board and an Ethical Clearance Letter has been granted to me Ref: CMHS/1RB/022/2019 dated 14/01/2019. The tools to use and the ethical standards to be followed have been accepted. It is against this background that I seek authorisation to carry out research and collect data at your institution. Kindly find attached the letter from CMHS institutional Review Board.

I hope my request will be put under your kind consideration.

Sincerely,

DUSABE Ruth

Masters in Nursing Science neonatal track
School of Nursing and Midwifery
College of medicine and health sciences
University of Rwanda
Email: milsruth@gmail.com
Tel: +250788444395

ANNEX 10: MUHIMA HOSPITAL APPROVAL LETTER

REPUBLIC OF RWANDA

Kigali, February 11nd 2019

KIGALI CITY
NYARUGENGE DISTRICT
MUHIMA HOSPITAL
P.O. BOX 2456 KIGALI
Tél. /Fax : +252 50 37 7
E-mail : muhima.hospital@moh.gov.rw

DUSABE Ruth

Re: Your request for conducting a study at Muhima District Hospital

Dear Ruth,

Reference made to your letter received on January 31st 2019 requesting to conduct a study at Muhima District Hospital for your research project entitled: *Determine Noise level and its source in neonatal intensive care unit of public hospitals in Kigali.*

I would like to inform you that your request is approved and at the end the administration of Muhima hospital shall need to be given the final report of your study.

Yours sincerely,

MANIRAGUHA YEZE Aimée Victoire

Chief Ethic Committee

MUHIMA HOSPITAL
- ETHIC COMMITTEE -

Cc:

- Clinical Director
- Director of Nursing

ANNEX 11: RWANDA MILITARY HOSPITAL APPROVAL LETTER

REPUBLIC OF RWANDA
RWANDA MILITARY HOSPITAL
Website: www.rwandamilitaryhospital.rw
P.O. Box: 3377 Kigali. Tel: (+250)252586420. Hotline: 4060
Email: info@rmh.rw

March 29, 2019 Ref.: RMH/IRB/009/2019

REVIEW APPROVAL NOTICE

Dear **DUSABE Ruth**
School of Nursing and Midwifery, CMHS
University of Rwanda

Your Research Project: **"Determine Noise Level and its Source in Neonatal Intensive Care Unit of Public Hospitals in Kigali".**

With respect to your application for ethical approval to conduct the above stated study at Rwanda Military Hospital, I am pleased to confirm that the RMH/Institutional Review Board (IRB) has approved your study. This approval lasts for a period of **12 months** from the date of this notice, and after which, you will be required to seek another approval if the study is not yet completed.

You are welcome to seek other support or report any other study related matter to the Research office at Rwanda Military Hospital during the period of approval.

You will be required to **submit the progress report** and any major changes made in the proposal during the implementation stage. In addition, you are required to **present the results** of your study to the RMH/IRB before publication.

Sincerely,

Prof. Alex M. Buteera
Colonel
Chairperson Institutional Review Board, RMH

ANNEX 12: Budget

Table 1. Preparation of research project proposal

Number	Activities	Description personnel	Number of days	Number of personnel/ days	Unit price Rwf	Total price Rwf
1	Proposal preparation, presentation and submission	1 Research	14	1x14=14	3000	42,000
2	Getting IRB (from University of Rwanda and hospitals) permission (from the hospital, transport deposit fees and communication)	1 Research	3	1x3=3	10 000	30 000
Subtotal						72,000

Table 2 Budget for survey

Number	Activities	Description personnel	Number of days	Number of personnel/ days	Unit price Rwf	Total price Rwf
1.	Visiting the study area	1Research	2	1x2=2	5000	10000
2	Data collection (restoration and transport)	1 Research 6 Assistant	60 10	1x60=60 6x60=360	5000 5000	300000 1 800 000
Subtotal						2 100 000

Table 3. Production of the report

number	Activities	no of person	no of days	Tot. no of days	Unit price Rwf	Total Price Rwf
1	Data coding and entry	1	5	5	5000	25 000
2	Data analysis	1	5	5	5000	25 000
3	Results presentation	1	1	1	5000	5000
Subtotal						55 000

Table 4. Feedback of research project

Number	Activities	no of person	no of days	Tot. no of days	Unit price Rwf	Total price Rwf
1.	Submission final report	1	1	1	5000	5 000
2.	Report distribution	3	1	1	5000	5000
Subtotal						10 000

Table 5. Stationary and materials

Materials	Quantity	Unity price Rwf	Total price Rwf
Flash disk	2	5000	10000
Reams of paper	1	3500	3500
Pencils	5	100	500
Pens	5	100	500
Printing & photocopy			100 000
Proposal & report binding	20	2000	40000
Subtotal			154 500

Table 6. Budget summary

Description/ Rwf	Subtotal/ Rwf
Preparation of research project proposal	72 000
Budget for survey	2 100 000
Production of the report	55 000
Feedback of research project	10 000
Stationary and materials	154 500
General total	2 391 500 Rwf