NEONATAL HEARING SCREENING AT MOTHER AND BABY UNIT, KATH

BY

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A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF

MASTER OF SCIENCE

IN

AUDIOLOGY

SCHOOL OF MEDICAL SCIENCES

SEPTEMBER, 2015

DECLARATION

I, ANTWI, BIRAGO, BARBARA author of this thesis, "NEONATAL HEARING SCREENING AT MOTHER AND BABY UNIT KOMFO ANOKYE TEACHING HOSPITAL," do hereby declare that, apart from reference to past and current literature duly cited in this thesis, the entire research work presented in this thesis was done by me as a student of the Department of Eye, Ear, Nose and Throat, School of Medical Sciences, and KNUST.

It has neither in whole nor in part been submitted for a degree elsewhere.

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(**Head of Department)** **Signature** **Date**

DEDICATION

I dedicate this work to my beloved mother, The Late Alice Kyere who was my inspiration, my late father David Antwi my three children, Abenaa, Akua and Kofi and my husband Samuel Frimpong.

DEFINITION OF TERMS

1 ***Mother and Baby Unit* (MBU): unit** specializing in the **care** of ill or premature **newborn infants**.

2 ***Otoacoustic Emission*:** is a low-level sound **emitted** by the cochlea either spontaneously or evoked by an auditory stimulus. Specifically, OAEs provide information related to the function of the outer hair cells

3 ***Distortion Product Otoacoustic Emission*:** (DPOAE) are responses generated when the cochlea is stimulated simultaneously by two pure tone frequencies whose ratio is between 1.1 to 1.3.

4 ***Pass Criteria*:** Screening result for both ears that meets or exceeds set criteria and requires no follow-up, unless risk indicators for late-onset or progressive hearing loss exist.

5 ***Refer Criteria*:** Screening results that indicate a likelihood of hearing loss that requires a re-screening or diagnostic evaluation.

6 ***Hearing loss* :** reduction in the ability to hear sounds

7 ***Neonatal hearing Screening* :** detecting hearing impairment in newborns

8 ***Neonates:*** *a* baby who is less than 4 weeks old.

9 ***Congenital Hearing loss* :** is a hearing loss present at birth

10 ***.Risk Factors* :** is any attribute, characteristic or exposure of an individual that increases the likelihood of developing an impairment

11 **Early Intervention :** is a system of services that helps babies and toddlers with developmental delays or disabilities

LIST OF ABBREVIATIONS/ACRONYMS

ABR	Auditory Brain stem Response
ASHA:	American Speech –Language –Hearing Association
ANSI:	The American National Standards Institute
CPA	Condition Play Audio0metry
EOAE	Evoked Otoacoustic Emission
JCIH:	Joint Commission on Infant Hearing
KATH:	Komfo Anokye Teaching Hospital
KNUST:	Kwame Nkrumah University of Science and Technology
MBU:	Mother and Baby Unit
NICU	Neonatal Intensive Care Unit
NHS:	Neonatal Hearing Screening:
OAE	Otoacoustic Emission
SPL:	Sound pressure Level
TNHS:	Targeted Neonatal Hearing Screening
UNHS	Universal Neonatal Hearing Screening
VRA:	Visual Reinforcement Audiometry
WHO:	World Health Organization
PBE:	Pass Both Ears
PRE:	Pass Right Ear
PLE:	Pass Left Ear
CNT :	Could Not Be Tested

ACKNOWLEGEMENTS

The author wishes to express her thanks to the following people:

My course coordinator, Dr. Joseph Opoku-Buabeng, Consultant EENT Department SMS, Dr. Yaw Nyadu Offei (Audiologist, University of Education, Winneba. Mr. Gabriel Adu (Audiologist), retired Educationist, who was my supervisor, Mr. Levi Ofoe (Speech Therapist), Professor G. K. Amedofo (Clinical Audiologist Retired), Mrs. Grace Ocansey and Jemmima Fynne all at Korlebu Teaching Hospital Audiology Unit for their continual guidance throughout my study on both at professional and personal level. My husband, children, in-laws, grandchildren and siblings who allowed me to continue my education even though these were difficult times. May God bless you my late father and mother who had been my source of strength and encouragement. I really appreciate them being my backbone.

My course mates, Emelia, Kwadwo, Lawrencia, Mildred, Alexander and Alfred for working together as friends in difficult times.

ABSTRACT

The purpose of the study was done to identify hearing loss in neonates with risk factors at Mother and Baby Unit, Komfo Anokye Teaching Hospital .The research design and sampling method for the study was descriptive survey and purposive sampling. 100 neonates were under study consisted 55 (55%) males and 45(45%) females. Self-administered questionnaire designed for the purpose of providing a general description of neonates was used as data collection tool. The questionnaire provided for acquisition of important information identifying risk factors and identifying the awareness level of neonatal hearing screening by parents/caregivers and were self – administered Neonates were screened with the gsi Grason-Stadler Corti OAE system and their results were recorded. The automated OAE results of the initial screening as well as follow-up results were recorded on the questionnaire sheet. Seventy seven percent of the neonates77 (77%) passed the hearing screening, 4(4%) were referred in both ears, 3 (3%) of them could not be tested, 9 (9%) passed in right ear whilst 7(7%) passed in left ear only. An increased awareness amongst parents/caregivers and the general public are crucial for the long-term feasibility of such a programme

TABLE OF CONTENTS

Contents

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

1.1 Background Information

A pregnant mother dreams and wishes to deliver a healthy baby and to be discharged from the hospital with full assurance that the baby is well and healthy, especially when there are no complications during the delivery process. Lay down neonatal examination by health care professionals has therefore become an accepted and important procedure for detecting potentially serious conditions in apparently healthy neonates before discharge from health centers. Congenital hearing impairment, however, is an invisible disorder that cannot be detected through neonatal examination, even among babies that are considered to be at high risk. Screening for such abnormalities by using objective tests has therefore been acknowledged as vital care for the newborn.

According to Mehl and Thomson (1998), Hearing screening for congenital sensorineural hearing loss has been called 'the great omission'. Hearing impairment is one of the most common congenital disabilities, occurring in 1 to 2 infants per 1000 births. The existence of hearing loss at birth has been shown to be greater than that of most other illness and syndromes screened for at birth (e.g., phenylketonuria and sickle cell disease). The hearing impairment is considered higher in infants in the Neonatal Intensive Care Unit (NICU) with 1–2 cases per 200 infants; 1.9% bilateral and 0.6% unilateral. When hearing impairment in is not identified early it can have an adverse effect on the infants' speech and language acquisition, academic achievement, and social and emotional development. However, these negative effects can be minimized and even eliminated through early intervention at or before 6 months of age.

The main objective of universal neonatal hearing screening (UNHS) is to maximize linguistic and communicative competence and literacy development for impaired children

that are hard of hearing or deaf (Declau, Boudewyns, Van den Ende, Peeters, & van den Heyning, 2008).

WHO, (2010) posited that, early detection is an important factor in rendering appropriate support for hearing-impaired infants that will assist them to enjoy the same opportunities in their community alongside all other children. There are causes of hearing loss that may result in severe hearing loss in neonates. Some of them are genetic that accounts for at least 50 to 60 percent of childhood hearing loss and some environmental causes of hearing loss which include rubella embryopathy, prematurity, bacterial meningitis, and head trauma .There are many risk factors that can help pediatricians and hearing care professionals identify children are younger than 3 years who need hearing screening to confirmation presence or absence of hearing (Morton & Nance, 2006). Common risk factors associated with hearing loss are listed as:

- Family history of permanent hearing loss in childhood,
- Maternal infections during pregnancy or delivery (Toxoplasmosis, Syphilis, HIV, Hepatitis B, Rubella , CMV, Herpes simplex, and others),
- Physical problems of the head, face, ears, or neck (cleft lip/palate, ear pits/tags, atresia, and others)
- Ototoxic medications given in the neonatal period
- Syndrome associated with hearing loss (Pendred, Usher, Waardenburg, and neurofibromatosis) Admission to a neonatal intensive care unit greater than 5 days
- Prematurity (< 37 weeks)
- Hyperbilirubinemia

- Birth asphyxia with Apgar≤5 at 1minute or ≤6 at 5 minutes (Joint Committee on Infant Hearing, 2000). Detection of hearing loss among neonates is very subtle, therefore physiological hearing screening in neonates is the most effective means of early detection. The early identification of congenital hearing loss is necessary to minimize the consequences of hearing impairment on the future communication skills of a baby (Imam, El-Farrash, Taha, & Bishoy, 2013).

Several studies have shown that OAE hearing screening can be easily performed in pediatric practice and it will identify children with hearing problems. These studies show that OAE screening in early childhood settings helps identify approximately 1 of every 43 children as needing audiologic treatment or monitoring and 1 of every 600 children as having a permanent hearing loss that was not previously identified (Schuman, 2014).

1.2 Problem Statement

Screening for hearing loss in neonates is based on two ideas: First, a critical period exists for optimal language skills to develop, and earlier intervention produces better outcomes. Secondly, treatment of hearing defects has shown to improve communication (Wrightson, 2007). Therefore the need for the identification of neonates and infants with risk factors to be done before they are discharged from a hospital cannot be over emphasized. In spite of this there has been little study in Ghana to determine the incidence and prevalence of hearing loss in neonates and infants. This can be attributed to the need to address other health issues such as HIV/AIDS and cholera. Furthermore, the low priority given to hearing loss screening is due to the lack of hearing care professionals such as audiologists in many healthcare institutions in the country. The inability of the Government to implement a comprehensive neonatal hearing screening program might also be due to the lack of resources such as equipment, as well as other obstacles that need to be overcome if a program is to succeed. One way to begin the process of getting started in developing and

implementing a comprehensive early hearing identification program is to develop a pilot study at Mother and Baby Unit (MBU) at Komfo Anokye Teaching Hospital to assess the situation.

1.3 Significant of the Study

Hearing loss is often undetected in all ages in developing nations as routine hearing screening is uncommon, especially for neonates. Infant hearing screening allows for the prompt detection of congenital and early onset hearing loss, and is essential for timely intervention within the critical period for optimal speech and language development. Of all the neonates born with significant hearing loss about 90% of them are in the developing countries (Olusanya, Wirz, & Luxon, 2008). Third world countries lack clinical standards with regard to the implementation of screening programs (Mencher & DeVoe, 2001). This situation is compounded by lack of proper equipment, staff, and other facilities (Olusanya et al., 2008). Hearing impairment might not be as life threatening as AIDS and meningitis, but it can lead to a reduced quality of life for the individual (Swanepoel, Delport, & Swart, 2004). In Ghana, there is a shortage of audiologists. There are about five audiologist who were trained abroad and ten who are trained locally at University of Ghana. This means that the implementation of a total hearing screening program will be difficult .if not impossible. For countries that lack the resources for the comprehensive screening, targeted screening has been suggested (Olusanya, Luxon, & Wirz, 2004). Targeted screening is the process that attempts to identify and test all neonates and infants at risk for a hearing loss that is based on established risk factors (Chiong, Dv Llanes, Tirona-Remulla, Calaquian, & Reyes-Quintos, 2003). These risk factors include children who have been admitted to the neonatal intensive care unit (NICU) for at least forty eight hours, of those have a syndrome associated with congenital hearing loss, those with a family history of hearing impairment,

children with abnormal pinna (outer ears) as well as children with *utero* infection due to herpes and other viruses.

1.4 Aims and Objectives

The Joint Committee on Infant Hearing (JCIH) has set 3 goals for neonatal screening: screening should be completed by 1 month of age, diagnosis should be made by 3 months, and intervention and treatment should commence by 6 months. This was achieved by technologic advances in automated neonatal hearing-screening technology, resulting in the introduction of universal neonatal hearing screening (UNHS).

The main aim of this study was to screen the hearing of neonates with risk factors using otoacoustic emission at the Komfo Anokye Teaching hospital, (Mother and Baby Unit).

The specific objectives for the research included the following:

1. To identify neonates hearing on admission at MBU with otoacoustic emission;

2. To find out if there is any relationship between risk factors and hearing loss among neonates admitted at MBU, KATH;

3. To find out the awareness level of neonatal hearing screening among parents and caregivers.

1.5 Research Questions

i. What are the outline procedures for identifying hearing loss among neonates at MBU with otoacoustic emission?
ii. What are the risk indicators or factors of hearing loss among babies to be screened?
iii. What are the awareness level of neonatal hearing screening among parents and care givers?

1.6 The Scope of the Study

Screening for hearing in newborns satisfies the ethical standards for a public health intervention. However, this study is targeting the neonates at MBU since they have the risk factors. The project aims at screening neonates using OAEs. Data from this study will be used to establish a database for the use of audiologists and other health professionals in Ghana. This study is of significance because hearing loss in neonates is common in developing countries around the world. The problem is even more acute in Ghana where the necessary resources are lacking for the early identification of hearing loss in infants. It is therefore imperative to develop and implement a comprehensive and early warning identification programme to forestall the problems associated with late identification of hearing loss in children. This project consisted of the following steps:

1. Identification of hearing loss among neonates who are on admission at MBU KATH
2. The tools to be used will be a questionnaire sheet and the gsi Grason-Stadler Corti OAE system
3. Analysis of data will be done using frequency distribution tables and graphical interpretations to analyze the response.

1.7 Delimitation of the Study

Ideally the study ought to have covered the entire neonates at the labor ward during the study period ward at KATH to ensure fairness for all neonates but MBU was selected since they were identified to have risk factors for hearing loss.

1.8 Limitation of the study

Lack of awareness on the part of the parents and their significant others posed major obstacle to the study. Majority the parents and caregivers did not show interest since they

were not aware of the importance of the hearing screening. Secondly all the one hundred neonates screened were supposed to come for follow-ups but due to transportation problems from home the audiology center few returned. The reason was that most of the mothers were not residents from Kumasi which means they have to travel to the hearing assessment center.

1.9 Organisation of Work

The research work has been arranged in the following chapters:

1. In Chapter One, introductory notes on neonatal hearing screening are outlined. The problem statement of the study is presented. It contains the significance of the study, the aims and objective underlying the work as well as the scope of the work. Research questions relating to the study are also presented.
2. Chapter Two serves as a foundation for the research and provides a critical evaluation and interpretation of the relevant literature to the research.
3. Chapter Three gives a summary of the methodology and how the data was collected and discusses factors that influenced the data collection.
4. Chapter Four presents the results of this study.
5. The discussions are presented in Chapter Five and
6. The conclusions, recommendations are presented in Chapter Six.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter provides background for this research and gives a detailed review of literature that is relevant to the study.

For easy reference and better understanding the review literature would be under the following headings:

The importance of hearing, , the ear, how we hear, normal hearing, hearing loss, hearing loss types, degree of hearing loss ,configuration of hearing loss, detecting hearing loss in children, confirming hearing loss ,common intervention for children with hearing loss, incidence of hearing loss, importance of early interventions, historical perspective of universal hearing screening, neonatal hearing screening in developing world, neonatal hearing screening in Ghana, anatomy and physiology of OAE, otoacoustic emission, recording OAE, types and purpose of otoacoustic emission and challenges of neonatal hearing screening.

Screening for early detection of health problems is an integral part of a public healthcare system (Renolds, 1982). Screening has been defined by World Health Organization as a "medical investigation that does not arise from a patient request for advice for specific complains. The term covers all types of examinations and does not refer to their speed or accuracy" (WHO, 1971). This definition points to the routine, public health managed nature of the process in which an investigation is triggered by an administrative system and not a patient initiative. In this way "screening is a process by which individuals are identified who may have disease or disorders that are otherwise undetected (Harford, Bess, Bluestone & Klein, 1978, p.4).

Screening usually implies the examination of large population groups, "mass screening" is a term used commonly. Thorner and Remein (1982, p.408) make this explicit when they stated that the:

> "*basic purpose of screening for disease detected is to separate from large group of apparently well persons those who have a high probability of having the disease under study so that they may be given a diagnostic workup and, if diseased, brought to treatment"*

Miller (1996) cited Wilson and Junger (1968) ten basic principles that screening programmes should adhere to. These are:

i. The condition to be screened for should be an important health problem.
ii. There should be an accepted treatment for cases identified.
iii. Facilities for diagnoses and treatment should be available
iv. There should be a recognizable latent (early asymptomatic) stage in the condition
v. There should be a suitable test to employ in screening.
vi. The test should be accepted to the population.
vii. The natural history of the condition should be understood.
viii. There should be an agreed policy on whom to treat as patients
ix. The cost of case finding (including diagnoses' and treatment of those diagnose) should be non-wastefully balanced in relation to expenditure on medical care as a whole.
x. Case-finding should be an ongoing process and not a "one-off" project.

2.2 Importance of Hearing

Hearing normally plays an important role to our awareness and safety in our environment. Both ears when within the normal range of hearing help us to locate the source of sound

easily thus from our front, back, left and right directions. Additionally our hearing alerts us as warning systems to thunder storms, dog barking, and fast approaching vehicle and somebody treading behind. , Our hearing works in partnership with our central nervous system to decide what is important and what can be disregarded. The physiology of our external ear canals naturally enhances some specific frequencies important to speech understanding which forms the basis of our human interactions. The effectiveness at work places, our enjoyment of life, and even to the shaping of our decisions and destiny depends on the way we hear. Normal hearing can even keep our minds very sharp. Our hearing affects our emotions and actions every single day. One word can suddenly alter our mood. For instance watching a film with the music turned off, and it loses its power to engage: the suspense evaporates; the 'tear-jerking' scenes dry up. A piece of music can uplift our spirits, or push us into self-examination, or evoke a memory of an event or period in our life otherwise forgotten ("The Combined Effect of Our Old-Fashioned Myths About Reduced Hearing," n.d.).

2.3 The Ear

The ear is made up of three parts: the outer ear, the middle ear and the inner ear. The outer ear consists of the auricle and the ear canal. The shape of the auricle enables sound waves to be collected and directed through the ear canal to the middle ear. The middle ear consists of the ear drum and three very small bones known as the ossicles. They work together to amplify the sound that comes from the outer ear. The inner ear is made up of the auditory and vestibular apparatus which are responsible for hearing and balance respectively ("Hearing aids, information on hearing loss and tinnitus," n.d.).

2.4 How We Hear

The ear can be divided into three parts leading up to the brain thus the outer ear, middle ear and the inner ear. The outer ear consists of the ear canal and eardrum. Sound travels down the ear canal, striking the eardrum and causing it to move or vibrate. The middle ear is a space behind the eardrum that contains three small bones called ossicles. This chain of tiny bones is connected to the eardrum at one end and to an opening to the inner ear at the other end. Vibrations from the eardrum cause the ossicles to vibrate which, in turn, creates movement of the fluid in the inner ear. Movement of the fluid in the inner ear, or cochlea, causes changes in tiny structures called hair cells. This movement of the hair cells sends electric signals from the inner ear up the auditory nerve (also known as the hearing nerve) to the brain. The brain then interprets these electrical signals as sound.

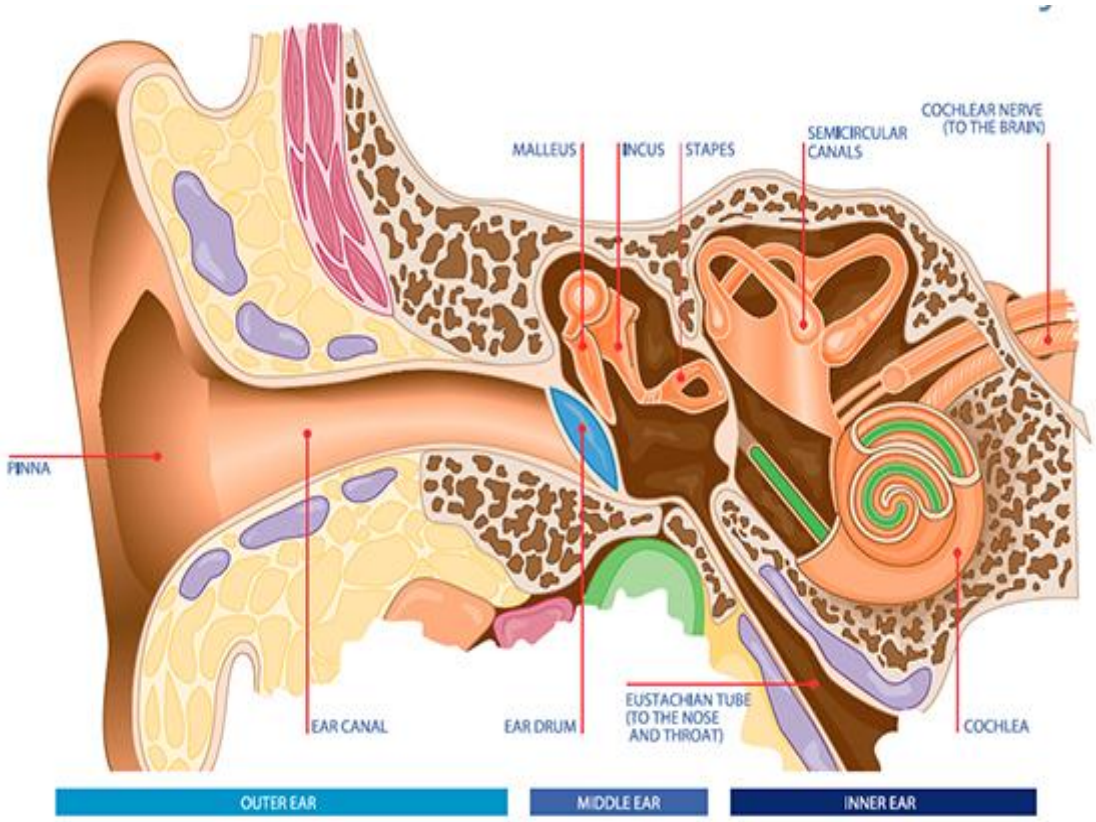


Fig.2.1: Structure of the ear (www.audira.org.uk/...hearing...hearing...hearing/.../16-hearing-our-most...Jan 20, 2013)

2.5 Normal Hearing

Vibration of objects produces sound. These vibrations generate waves of disturbance in a medium such as air, a fluid, or a solid. Sound waves vary in terms of frequency, which is measured in cycles per second or Hertz (Hz), and intensity which is measured in decibels (dB) at a certain sound pressure level (SPL). The intensity of the vibration is related to the perception of loudness (Clinical Practice Guideline, 2007).

The hearing mechanism of human beings is sensitive to a wide range of frequencies (20 – 20,000 Hz). The human auditory system is also sensitive to intensities ranging from 0 – 140 dB SPL. Frequencies within the speech range (250 – 6,000 Hz) are where humans are most sensitive to sound (Clinical Practice Guideline, 2007). The American National Standards Institute (ANSI), (1989), cited in Clinical Practice Guideline, 2007 defines normal hearing as the sound pressure level at which individuals can normally detect sound which is 0 dB HL for the purposes of hearing testing (audiometric evaluation). The 0 dB HL for a particular frequency is the normal threshold for that frequency averaged across tests with many individuals.

2.6 Hearing Loss

The Hearing Review (2005) defines hearing loss as an acute or long-term reduction in the ability to hear sounds. It can range in severity from mild to severe.

Hearing loss is a decrease in the ability to hear. It can vary from mild to total loss of hearing and occur in one or both ears (Thirdage, 2011). Hearing loss is permanent disability, depending on the severity and frequencies that are affected. It can cause profound damage to the development of speech, language and cognitive skills in children, especially if commencing before the acquisition of language. That damage in turn, affects the child's progress in school and, later his/her ability to obtain, keep and perform an occupation. For

all ages and for both sexes, it causes difficulties with interpersonal communication and leads to significant individual social problems, especially isolation and stigmatization (Andrews, 2008). There are different types of hearing loss, depending on which part of the hearing pathway is affected. A specialist will always try to localize where in the hearing pathway the problem lies, so as to be able to classify the hearing loss as belonging to one of the groups to be discussed. The groups are conductive, sensorineural, mixed and central hearing loss. This is most important in determining the appropriate treatment.

According to Hull (2001), hearing loss may be used to indicate the type of hearing problem (conductive hearing loss or sensorineural hearing loss) or that hearing ability has been lost, thus, a diminished ability to detect, recognize, discriminate, perceive, and/or comprehend auditory information.

Northern & Downs (1991), contended that speech that is badly distorted or interrupted can still make sense to an adult, but for a child who is to interpret speech and language, distorted speech may not be intelligible to him/her. Therefore, they proposed 15dB as cut-off point above which a child is considered to have a hearing impairment though the 1979 Guide by the American Academy of Otolaryngology and American Council of Otolaryngology, considered 25dB as a cut-off point above which an adult considered to have a handicapping hearing loss.

A child who cannot detect sounds within the normal range is considered to have a hearing loss. The amount of hearing loss is measured in terms of the specific detection level (in decibels HL) at each tested frequency. These values are plotted on a graph called an audiogram (Fig. 2.2). The horizontal axis on the graph shows hearing level in decibels and the vertical axis depicts the frequencies of the sounds (Clinical Practice Guideline, 2007).

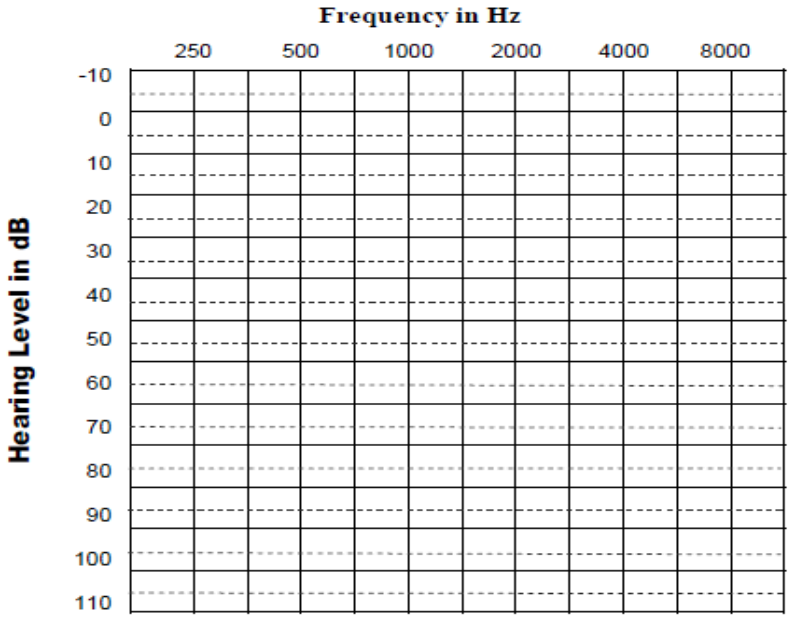


Fig. 2.2: Audiogram (Clinical Practice Guideline, 2007 NYSDOH Report of the Recommendations: Hearing Loss)

2.7 Hearing Loss Types

2. 7.1 Conductive Hearing Loss

- Conductive hearing loss is caused by interferences in the transmission of sound from the external auditory canal to the inner ear. Normally, conductive hearing loss causes a reduction in the ability to hear faint sounds and results in the individual hearing sounds at a reduced intensity or may not be heard at all. The main characteristic of this hearing loss is that there is a hearing loss for air-conducted sounds while the bone conducted sounds are heard normally. (Conductive Hearing Loss: Causes and Treatments, 2013).

Some of the causes of conductive hearing loss include:

- **Cerumen obstruction or impacted wax**: Cerumen (ear wax) can be identified as one of the commonest cause of hearing loss due to the improper functioning of the outer ear as result accumulation of cerumen in the external meatus or canal. Examination of the ear can be done with an otoscope and can usually be removed

quickly. This condition may actually be worsened by an attempt to clean the ears with cotton swaps (Q-tips) (Conductive Hearing Loss: Causes and Treatments, 2013).

- **Otitis Externa**: It is an infection (usually bacterial, although occasionally fungal) of the ear canal that may be related to water exposure. Otitis externa is often referred to as "swimmer's ear". Pain and tenderness of the ear are the most common symptoms of otitis externa but there can also be severe swelling of the canal that can cause conductive hearing loss (Sander, 2001).

- **Foreign body in ear Canal**: Foreign bodies refer to any object that is placed in the ear that is not supposed to be there and is identified during otoscopy. Common foreign bodies include beads, food, small batteries, and pieces of crayon, buttons and beans in children and cotton or the tips of cotton swaps in adults. Rarely do insects fly into the ear canal causing itching, pain and noise. Hearing may be influenced if a foreign body blocks the ear canal (Conductive Hearing Loss: Causes and Treatments, 2013).

- **Bony lesions of the ear canal**: These are malignant growths of bone along the walls of the ear canal consequently narrowing the ear canal, which may lead to frequent obstruction from a small amount of wax or water. These bony lesions can generally be managed with vigilant cleaning of ear wax to prevent blockade. In rare cases these lesions require surgical removal ("Hearing loss Causes - Mayo Clinic," n.d.).

- **Atresia of the External Ear Canal:** Complete malformation of the external ear canal is called atresia. Atresia may occur with complete or partial malformation of the pinna (outer ear) and is noted at birth. It is rarely associated with other congenital abnormalities and is most often only on one side (unilateral).

Management of congenital aural atresia is complex. Surgical treatment may be beneficial to either reconstruct the ear canal in select cases or to implant a device that vibrates the bone of the ear directly (Conductive Hearing Loss: Causes and Treatments, 2013)

- **Middle Ear Fluid or Infection (otitis media):** Otitis media is an infection in the small space behind the eardrum (middle ear). The middle ear space may be filled with fluid instead of air. Otitis media is divided into three types: acute otitis media, serous otitis media (middle ear fluid) or chronic otitis media. Acute otitis media occurs rapidly, is painful, and may cause fever. Serous otitis media often follows an acute otitis media infection or may occur on its own. Both conditions are common in children and are related to an inability to ventilate the middle ear space due to poor Eustachian tube function (the channel which connects the middle ear space with the nasal passage). Otitis media may be treated medically or with a myringotomy with tube insertion. Chronic otitis media is associated with damage to the ear drum or ossicles, and frequently requires surgery ("Ear Infection Facts: Causes, Acute Infections, Chronic Infections, and More," n.d.).

- **Tympanic Membrane Atelectasis or Retraction (collapse of the ear drum):** Poor Eustachian tube function may also result in excessive negative pressure behind the ear drum causing the ear drum to collapse onto the middle ear bones. Severe retraction of the ear drum may necessitate ear tube surgery or a surgery to rebuild the ear drum (tympanoplasty) (Conductive Hearing Loss: Causes and Treatments, 2013).

- **Tympanic Membrane Perforation**: A hole in the ear drum due to infections or trauma may result in hearing loss as the sound vibrations are not effectively captured by the damaged ear drum (Conductive Hearing Loss: Causes and Treatments, 2013).
- **Damage to the Middle Ear Ossicles:** This may result from trauma, infection, cholesteatoma or a retracted ear drum leading to conductive hearing loss. Surgical reconstruction of the ossicular chain is often successful in restoring hearing in these cases (Conductive Hearing Loss: Causes and Treatments, 2013).

Otosclerosis: This is an inherited disease in which the bone around the stapes bone hardens and the stapes fails to vibrate effectively. The conductive hearing loss slowly progresses in early adulthood. It affects women more often than men and affects slightly less than 1% of the population overall. This condition may be treated with a hearing aid or with a stapedectomy surgery which is highly effective in restoring hearing in most cases ("What You Should Know About Otosclerosis | American Academy of Otolaryngology-Head and Neck Surgery," n.d.).

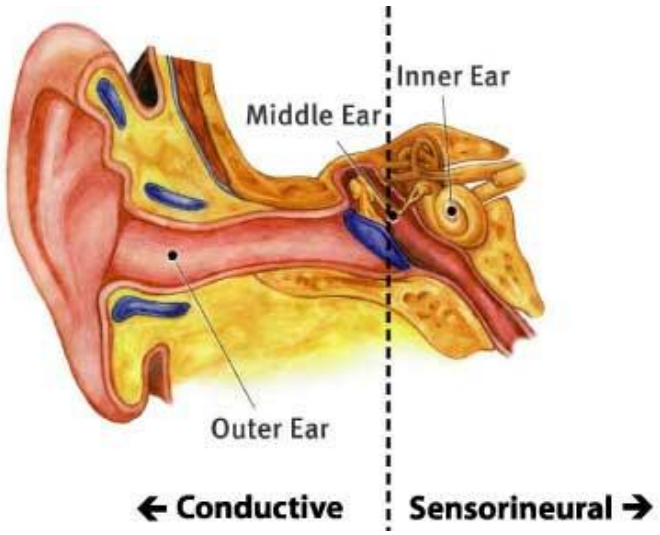


Fig 2.3: Types of hearing losses and where it occurs in the ear.
(Types of hearing loss, 2013)

2.7.2 Sensorineural Hearing Loss (SHL)

- Sensorineural hearing loss occurs when damage has been sustained by the sensory end organ or cochlear hair cells or dysfunction may be a fault from the auditory nerve .In SHL both air and bone conduction thresholds are nearly the same. This type of hearing loss may be congenital among neonates or acquired. The causative agent of SHL may be injury, ototoxic medication, childhood illness, measles, mumps, whooping cough meningitis or aging process known as prebyacusis and a brief prolong exposure to intense noise. It does not typically respond favorably to medical treatment. SHL causes difficulty in speech discrimination which may be accompanied with distorted speech. ("Hearing loss Causes - Mayo Clinic," n.d.).

2.7.3 Mixed Hearing Loss

- This type of hearing loss results from problems in both the middle and the inner ear. A mixed hearing loss can be thought of as a sensorineural hearing loss with a conductive component overlaying all or part of the audiometric range tested. So, in addition to some irreversible hearing loss caused by an inner ear or auditory nerve disorder, there is also a dysfunction of the middle ear mechanism that makes the hearing worse than the sensorineural loss alone. The conductive component may be amenable to medical treatment and reversal of the associated hearing loss, but the sensorineural component will most likely be permanent. Hearing aids can be beneficial for persons with a mixed hearing loss, but caution must be exercised by the hearing care professional and patient if the conductive component is due to an active ear infection. (http://www.betterhearing.org/hearingpedia/types-hearing-loss).

2.7.4 Central Auditory Disorder

Central Auditory Disorders results from problems in the processing of sound in higher auditory areas of the brain. This type of auditory problem affects more complex auditory

processes such as understanding speech when there is background noise. Children with a central auditory disorder may have normal hearing sensitivity and normal physiologic tests, such OAEs and auditory brainstem response (ABR) results. Because of the availability of new assessment methods, new auditory disorders such as *auditory neuropathy* (also called auditory dys-synchrony) are being identified. The disorder is characterized by the presence of normal OAE, abnormal or absent ABR, and poor speech understanding that is inconsistent with the behavioural audiogram (which may vary from normal hearing to profound hearing loss). Although the disorder is not yet clearly understood, it is thought to affect the transmission of information between the inner hair cells of the cochlea and the auditory nerve, or may be attributable to a disorder of the auditory nerve itself (JCIH, 2000).

2.8 Degree of Hearing Loss

Degree of hearing loss addresses the severity of the hearing loss. Table 2.1 shows commonly used classification systems. The numbers are representative of the patient's hearing loss range in decibels (dB HL) (ASHA, 2011).

Table 2.1: Commonly used classification systems of hearing loss (Clarke, 1981)

Degree of hearing loss	Hearing loss range (dB HL)
Normal	–10 to 15
Slight	16 to 25
Mild	26 to 40
Moderate	41 to 55
Moderately severe	56 to 70
Severe	71 to 90
Profound	91+

2.9 Configuration of Hearing Loss

The configuration, or shape, of the hearing loss depicts the degree and pattern of hearing loss across frequencies (tones) as demonstrated in audiograms. A high-frequency loss is described as a hearing loss that affects only the high tones and its configuration show good hearing in the low tones and poor hearing in the high tones. In the same way, if the low frequencies were affected, the configuration shows poorer hearing for low tones and better hearing for high tones indicating a low frequency hearing loss. Some hearing loss configurations are flat, showing the same amount of hearing loss for low and high tones. The four general configurations of hearing loss are shown in Fig. 2.5.

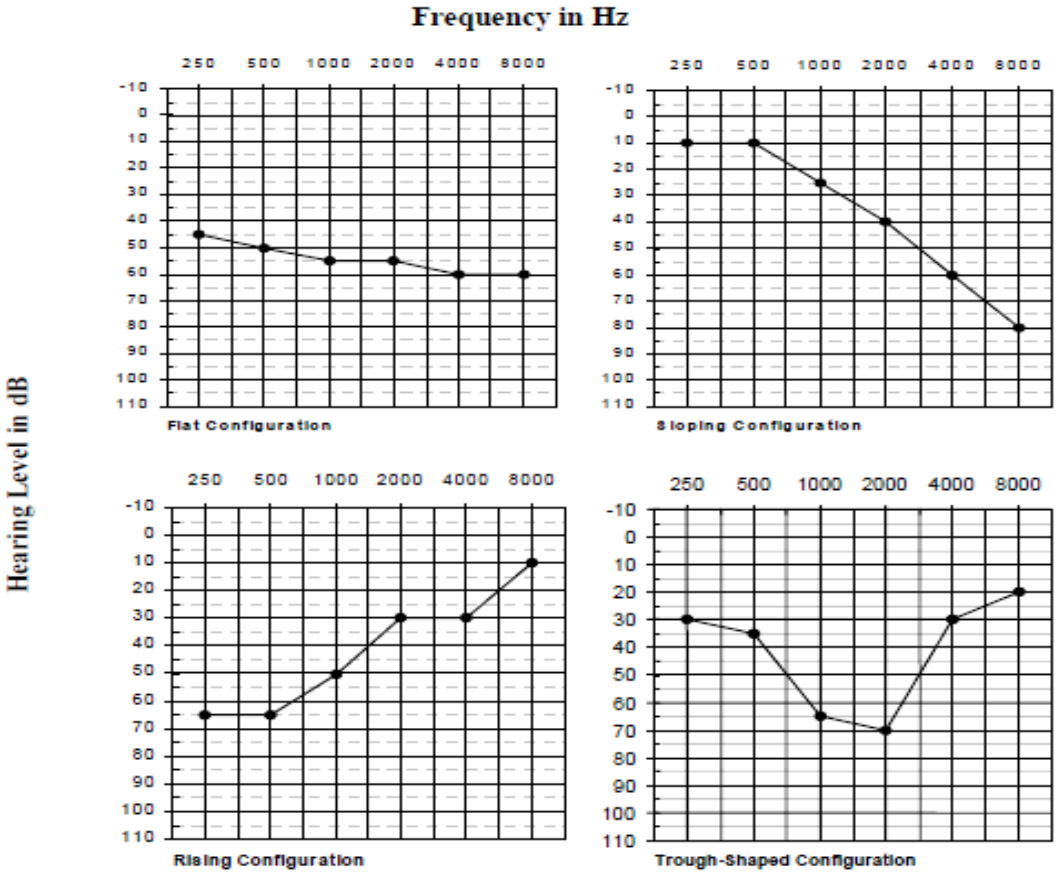


Fig. 2.5: Configurations of Hearing Loss (Clinical Practice Guideline, 2007)

A flat configuration describes a situation in which thresholds are essentially equal across test frequencies.

Sloping configuration portrays an instance where better (lower) thresholds in low-frequency regions and poorer (higher) thresholds in high-frequency regions.

Rising configuration depicts a case where there are poorer thresholds in low-frequency regions and better thresholds in higher-frequency regions.

Trough-shaped ("cookie-bite" or "U" shaped) describes a situation where there is greatest hearing loss in the mid-frequency range with better thresholds in low- and high-frequency region (Clinical Practice Guideline, 2007).

2.10 Detecting Hearing Loss in Children

In the past, hearing loss was detected by identifying children with risk indicators for hearing loss. Infants with one or more of these indicators were the only ones tested for hearing loss. However, by using this method of identification of hearing loss, many infants and young children with hearing loss were not detected until they were older. Sometimes, audiologic testing was done because parental concerns about the child's hearing were expressed. Health care professionals or early childhood professionals sometimes noticed behaviours that heightened suspicion that the infant or young child might have a hearing loss. More often than not, infants and young children were not suspected of having a hearing loss until the child demonstrated delays or disorders in speech and language acquisition (at approximately 2 years of age) ***(***Clinical Practice Guideline, 2007).

Due to the abundance of evidence that early detection and intervention results in better outcomes for young children with hearing loss, many countries have implemented universal screening of all babies for hearing loss. Screening programmes identify newborns or

children that might have a hearing problem. Children who fail or do not pass the newborn screening test are referred for further audiological follow-up.

Oftentimes, most babies referred for further audiological assessment turn out to have normal hearing during follow-up testing. However, implementation of universal newborn screening procedures result in a rise of early detection of those infants who have congenital or early-onset hearing loss. As much as universal newborn screening helps in identifying newborns and children with hearing loss, parents as well as health care and early childhood professionals are still involved in detecting hearing loss in infants and young children. This is due to the fact that not all hearing losses are present at birth, some infants and children still miss universal newborn hearing screening. Screening programmes may overlook some infants with a mild hearing loss (Clinical Practice Guideline, 2007).

2.11 Confirming Hearing Loss

For hearing loss to be confirmed, a battery of audiologic tests should be conducted. The age of the infant or child plays a major role in selecting specific tests and measures that are used to assess the child. However, in general, hearing history, physiologic procedures and behavioural procedures are part of a comprehensive hearing assessment designed to confirm hearing loss (Table 2.2).

Table 2.2: Components of a Comprehensive Hearing Assessment (*Adapted from: Gravel, 1999*)

Hearing history
• Parents' general concern about hearing and communication • Auditory behaviours (reacting to and recognizing sounds)
History of otitis media (ear infections and fluid within the middle ear) and other risk factors for hearing loss

Physiologic procedures or acoustic admittance measurements

- *Otoacoustic emissions*. OAE are low-level sounds produced by the sensory hair cells of the cochlea (primarily the outer hair cells of the inner ear) as part of the normal hearing process. Hair cells that are normally functioning emit acoustic energy that can be recorded by placing a small probe (containing a microphone) attached to a soft ear tip at the child's ear canal opening. The loudspeakers delivers test signals into the ear canal that evoke an acoustic response from the hair cells, and the responses are recorded by a second microphone in the probe. These responses are called evoked otoacoustic emissions (EOAE or most commonly, OAE).
- *Auditory brainstem response*. Used to estimate hearing threshold sensitivity using clicks or tones. These tests are also used to determine the integrity of the auditory pathway from the cochlea to the level of the brainstem. Small disc electrodes are pasted on the scalp and auditory potentials (electrical [neural] activity generated by the auditory nerve and brainstem) evoked by repetitive stimuli delivered by an earphone are recorded by a computer.
- *Middle ear muscle reflexes*. An involuntary middle ear muscle reflex to sounds is recorded, usually elicited by moderately loud tones or noises.
- *Tympanometry*. Assesses function of the middle ear. A probe attached to a soft, plastic ear tip is placed at the ear canal opening, and air pressure is varied in the ear canal. Tympanometry is not a hearing test.

Behavioural audiometry testing

- *Observation* of general awareness of sound (for example, mother's voice, environmental sounds, music) to determine a general level of auditory

responsiveness or function. This is an unconditioned behavioural response procedure.

- *Visual reinforcement audiometry (VRA)*. A conditioned behavioural test procedure useful for determining threshold sensitivity in infants beginning at approximately 6 months of age (developmental age). A head-turn response upon presentation of an audiometric test stimulus is rewarded by the illumination and activation of an attractive animated toy.
- *Conditioned play audiometry (CPA)*. A conditioned behavioural test procedure useful for determining threshold sensitivity in young children beginning at approximately 2 years of age (developmental age). A play response (block-drop, ring stack) made by the child in response to the presentation of an audiometric test stimulus is rewarded, usually by giving social praise.

2.12 Common Interventions for Children with Hearing Loss

According to Diefendorf (1997), the importance of early detection is not only about screening for hearing loss but goes beyond simply screening for hearing loss. There should be programmes that engage neonates with such loss and their families in a comprehensive plan of service delivery such as early intervention programmes.

For infants and young children with hearing loss, interventions aim at making the child's hearing better and reducing the difficulties in communication that may occur because of the hearing loss. Furthermore, interventions also aim at providing family education and support. Interventions that concentrate on the hearing loss may include a hearing aid which is an assistive device that amplifies sound. There is a variety of hearing aid shapes and sizes. Hearing aids also differ in the way they process signal, the number of channels, the

memory, circuitry and style. There is a wide range in cost, flexibility, ease of use, and durability (Clinical Practice Guideline, 2007).

There are other assistive devices which include tactile aids, frequency modulators (FM) systems, sound field systems, inductive loop systems and infrared systems. At other times, when there is enough evidence that the conventional hearing aids have limited or no benefit for a young child, the child may undergo cochlear implant surgery in which an electronic device is placed in the inner ear to stimulate the auditory nerve (Clinical Practice Guideline, 2007).

A primary focus of early intervention is to give assistance to families to develop the communicative competence of infants and children with hearing loss (Carney & Moeller, 1998; JCIH 2000). In view of this, different communication approaches can be used to help children with hearing loss. These approaches vary in the degree to which they depend on audition and/or vision along an auditory-visual continuum. Some of the approaches used are discussed below:

- **Auditory approaches:** *Auditory-Verbal* approaches underscore the idea that hearing is very important for developing spoken language. *Auditory-Oral* approaches also stress the role of hearing with the objective of developing spoken language but may add supplementary visual information from spoken language.

- **Combination approaches using vision to support English**: Cued Speech complements spoken language visually by means of using eight handshapes to denote the consonants of speech and four different hand locations near the face and neck to represent the vowels. Total Communication (TC) approaches employ the use of signs, speech, hearing, and gestures to communicate using English grammar.

- **Visual approaches using American Sign Language (ASL):** In the Deaf community ASL is the language that is commonly used. ASL is a complete language even though it has no written or spoken form. People, who use the Bilingual approach, use ASL as the primary language and English as a second language. Bilingual-Bicultural (Bi-Bi) approach uses ASL as the primary language with English as a second language as well as also incorporating instruction in Deaf culture (Clinical Practice Guideline, 2007).

Regardless of the chosen communication approach, parent's involvement in the communication intervention is an important factor of its success in promoting the communicative abilities of the child with hearing loss (Reamy & Brackett, 1999).

2.13 Incidence of Hearing Loss

Congenital hearing loss has recently been identified as one of the most common birth defect present in newborns, with an occurrence of permanent hearing loss ranging from 2-3/1000 live births (Vohr, 2003).

Worldwide, hearing loss is regarded the most prevalent impairment. An estimated 10% of almost 600 million people worldwide have mild or worse hearing impairment while 250 million have moderate or worse hearing impairment. Two-thirds of the world's populace that are hearing impaired live in developing countries. The number of people with hearing impairment is huge and getting precise figures in the developing world is intricate as a consequence of inadequate records (Traynor, 2011).

According to Tucci *et al*. (2010), people having moderate-to-profound hearing loss in both ears are more than 278 million across the globe and indicated further that a large number of

these people (people with hearing loss) reside in developing countries. In developed countries, the incidence of congenital, bilateral sensorineural hearing loss is estimated at 2 to 4 per 1,000 live births, while in developing countries, the incidence of congenital is estimated to be not less than 6 per 1000 live births.

According to the World Health Organization (WHO), hearing-impaired children often experience delays in development of speech, language and cognitive skills, which may slow learning and result in difficulty progressing effectively in school (WHO, 2010). Some effects of hearing impairment include inability to understand speech sounds that often results in a reduced ability to communicate, delay or interruption in language acquisition, economic and educational disadvantage, social isolation and stigmatization (Mathers, Smith, & Concha, 2000).

If appropriate and early interventions are not provided within the critical period of central auditory pathway development, congenital and early childhood onset deafness or severe-to-profound hearing impairment may affect the auditory neuropathway of children at a later developmental stage. Early detection is an extremely important element in providing appropriate support for deaf and hearing-impaired babies that will help them enjoy equal opportunities in society alongside all other children (World Health Organization, 2010).

2.14 The Importance of Early Identification

Arehart, Yoshinaga-Itano, Thomson, Gabbard, and Brown (1998), conducted a study and compared the receptive and expressive language skills of two groups of deaf-or-hard of hearing children identified through early universal newborn hearing screening programmes. In the first group were children whose hearing losses were identified by six months of age

(earlier identified children) and in the second group, children with hearing losses that were identified after six months (later identified children). Intervention services were provided for all the children in both groups within two months after identification.

The earlier identified children demonstrated appreciably better receptive and expressive language than the later identified children. The language difference between the two groups of children was very large. This provided the evidence to demonstrate that early identification and intervention of children who were deaf or hard-of-hearing could actually achieve nearly normal language acquisition by three years of age and that early identification was the key to improved language outcomes. Six months of age was the critical cut-off period for early identification that would achieve normal speech and language development.

Moeller (2000) examined the vocabulary competence of 112 children who were enrolled in a comprehensive intervention programme for five years. The children were enrolled at different ages into the programme. The participants of the research (children) were identified through high-risk registries, child find programmes, and parent self-referral.

The children who were enrolled in a comprehensive intervention programme aged between 2 days and 54 months. Verbal reasoning skills were investigated and results revealed that children who were enrolled in intervention programmes early (before 11 months of age) had superior vocabulary and verbal reasoning at 5 years of age than other children who received intervention at later ages. Kennedy *et al.* (2006) conducted a study in the United Kingdom. The study reported that a group of children identified early (at birth) with bilateral permanent congenital hearing loss had higher language scores than a group with similar

hearing loss identified late and who had no screening at birth. The children in this study were tested at approximately 8 years of age.

The primary justification for early identification of hearing impairment in infants relates to the impact of hearing impairment on speech and language acquisition, academic achievement, and social/emotional development. The first 3 years of life are the most important for speech and language acquisition. Consequently, if a child is hard of hearing or deaf at birth or experiences hearing loss in infancy or early childhood, it is likely that child will not receive adequate auditory, linguistic, and social stimulation requisite to speech and language learning, social and emotional development, and that family functioning will suffer. The goal of early identification and intervention is to minimize or prevent these adverse effects. National Institutes of Health Consensus Development Conference Statement (1993)

2.15 Historical Perspective Newborn Hearing Screening

Screening is the process of rapid and simple tests, examinations, or other procedures to large numbers of persons that will identify those persons with a high probability of a disorder from those persons who probably do not have the disorder. Screening always involves a standard or a gauge below or above which the persons involved are suspect. Screening is different from diagnostics. Screening generally considers a large population of people typically without any obvious symptoms of disease or medical condition in order to isolate those who are assumed to have the disease and who need diagnostic test procedures to confirm whether they have the disorder or not (Last, 1983; as cited in Northern & Downs 1991).

In view of the fact that hearing impairment is comparatively invisible, for the past sixty years, hearing screening tests have been used to find children who need further audiological evaluation. In an effort to identify severe-to-profound hearing loss and to administer early

habilitative measures, hearing screening for infants and neonates has been instituted during the past twenty-five (25) years (Northern & Downs, 1991).

The importance of auditory development and language acquisition for infants is the reason why it is required for any congenital hearing loss, no matter the severity, to be identified early because even a slight hearing loss can hinder auditory development (Northern & Downs, 1991).

Efforts to improve early identification of hearing loss began in 1969. Representatives from the Academy of Paediatrics, the Academy of Ophthalmology and Otolaryngology as well as the American Speech-Language and Hearing Association, formed a national committee whose aim was to make recommendations for infant hearing screening. The committee became the Joint Committee on Infant Hearing (JCIH). The committee at first recommended screening newborns for hearing loss by using behavioural observation and high-risk criteria, thus screening newborns that had one or more conditions that predisposed them to hearing loss (Northern & Downs, 1991). The JCIH in 1982 recommended seven criteria for identifying infants at risk of hearing impairment and also recommended that until their hearing was assessed accurately, there should be follow-up audiological evaluation on the newborns (American-Speech-Language Association, 1982). Due to recent studies of the causes and transmission of disease, the JCIH (2000) has identified certain risk indicators that are associated with infant and childhood hearing loss (Clinical Practice Guideline, 2007). These risk indicators for hearing loss in infants and young children are shown in Table 2.3.

Table 2.3: Risk indicators for hearing loss in infants and young children

	Risk factors for hearing loss
1.	Admission to a neonatal intensive care unit (NICU) for 48 hours or longer
2.	Family history of permanent childhood sensorineural hearing loss
3.	*In utero* infection such as cytomegalovirus, herpes, toxoplasmosis, or rubella
4.	Postnatal infections associated with hearing loss (such as bacterial or meningitis)
5.	Exposure to ototoxic medications (such as aminoglycoside antibiotics, cisplatin chemotherapy agents, and certain loop diuretics)
6.	Craniofacial anomalies, especially those with abnormalities of the ear or ear canal
7.	Neonatal indicators: Birth weight less than 1,500 grams; Hyperbilirubinemia requiring exchange transfusion; Persistent pulmonary newborn hypertension requiring mechanical ventilation; conditions requiring the use of extracorporal membrane oxygenation (ECMO)
8.	Findings associated with a syndrome known to include or be high risk for hearing loss i. Syndromes associated with sensorineural and/or conductive hearing loss (such as Wardenburg syndrome) ii. Syndromes associated with progressive hearing loss (such as neurofibromatosis and osteopetrosis) iii. Genetic conditions that are likely to have associated hearing loss (such as Down syndrome and Usher syndrome) iv. Neurodegenerative disorders (such as Hunter syndrome) or sensory motor neuropathies
9.	Head trauma (especially with fracture of the temporal bone)
10.	Recurrent or persistent otitis media with effusion (OME) for at least 3months
11.	Parental or caregiver concern regarding hearing, speech, language, and/or developmental delay

(Adapted from: JCIH, 2000)

There are many infants and young children with hearing loss that have no obvious risk indicators. In the same way, a child with a risk indicator may not have hearing loss (Clinical Practice Guideline, 2007). Consequently, the JCIH endorsed the universal screening of all infants through an integrated, interdisciplinary system of Early Hearing Detection and Intervention (EHDI) because of advances in screening technology (JCIH, 2000). In 2007, the JCIH specifically recommended that newborns in well nurseries be screened using EOAEs or ABRs.

2.16 Neonatal Hearing Screening (NHS) in the Development World

Even though two-thirds of persons with hearing impairment across the globe live in developing countries, there are few services (national programmes for the identification of people especially infants with hearing loss, prevention and rehabilitation of hearing impairment) in a large number of these countries and few trained staff to deal with the problem (World Health Organization, 2012). Statistics on the subject of the prevalence of hearing loss in developing countries is inadequate, but available figures suggest that 1–5 per 1000 infants have hearing loss (Olusanya et al., 2006).

The age at which hearing loss is identified varies between 24 months and 5.8 years in developing countries (Lasisi, Ayodele, & Ijaduola, 2006; Gopal, Hugo, & Louw, 2001). Hearing loss is usually identified because children fail to reach communication milestones, or as a result of a delay in speech and language development (Gopal et al., 2001). Among the environmental factors that affect the populace of developing countries such as those in Sub-Saharan Africa are: 1) poor access to healthcare services, 2) malnutrition, 3) infections and 4) poverty (Lasisi et al., 2006; Swanepoel et al., 2005). These problems affect infants especially in the first few years of life, which are crucial years for physical, intellectual and emotional development (UNICEF, 2004).

The effects of hearing loss including damage to the development of speech, language and cognitive skills, particularly in children with congenital or pre-lingual hearing loss, social isolation, difficulties in securing jobs, slow progress in school and stigmatization in all ages and both sexes, can affect the health, economic and social well-being of an individual, family and the community at large (Olusanya, 2005; Swanepoel et al., 2005). The most deprived communities are those located in rural areas that have limited access to healthcare facilities and/or where transportation for medical assistance is minimal (UNICEF, 2004). Inadequate access to healthcare and environmental problems increase the probability of hearing loss in the paediatric population (Swanepoel et al., 2005). Identification of hearing loss as early as possible has been overshadowed due to different priorities in developing nations.

Gopal *et al.* (2001) proposed that several factors hindered early identification and provision of intervention for children with hearing loss in developing countries and ascribed the dearth of statistics regarding prevalence and epidemiology of neonatal hearing loss as one of the reasons for ineffective NHS programme. Inadequate human resources and lack of appropriate technology also impede the planning and implementation of early identification programmes. In addition, the sustainability of an early identification programme is affected by inconsistent and fragmented follow-up services. Finally, the variety of spoken languages in these developing countries is also a factor that affects early identification of children with hearing loss (Olusanya, 2005). As published, misunderstanding of socio-cultural issues and health-related behavioural changes were contributing factors to the failure of many public health programmes that were implemented in the past (Olusanya, 2005).

Wall *et al*. (2001), also indicated that there are no distinct or well defined reasons why NHS has not been widely adopted in the public health sector worldwide, but suggested that part

of the problem could be due to the lack of uniform support between medical personnel, particularly in view of the increasing financial strain and inadequate resources within healthcare services. Other NHS methods can be used in screening infants and neonates as starting point in countries that have limited resources and personnel to implement the universal newborn hearing screening. An example of such an alternative method is the screening of infants and neonates that are at highest risk for developing hearing loss, such as NICU infants (JCIH).

The NICU is a special care nursery unit where neonates born prematurely or have other medical conditions are cared for. NICU also takes care of neonates that have some risk factors recognized by the JCIH position statement as causing hearing loss. Admission to NICU for more than 48 hours was added as a risk factor for congenital hearing loss by the 2000 JCIH position statement. For countries with inadequate resources and limited personnel to implement NHS, screening of neonates in NICU offers a valid starting point because a number of neonates with risk factors for hearing loss are found in the NICU (Mencher & DeVoe, 2001).

The High-Risk Register (HRR), which is a checklist of conditions, is known to exhibit a higher-than-normal prevalence of hearing loss. As a result, the list was allowed for screening neonates who were at high-risk of hearing loss. If the HRR had to be used to identify hearing loss in the high-risk populace, then it had to be used together with other behavioural tests (Hayes, 2003). Using the HRR alone to identify hearing loss is ineffective because it identifies only 50% of neonates with hearing loss (Olusanya et al., 2004; Johnson, 2002; Lutman & Grandori, 1999).

Yoshinaga-Itano and Gravel, (2001), reported that about 40% to 50% of neonates that have hearing losses would be missed if the BOA method had been used in screening their auditory abilities instead of objective, electrophysiological screening methods. In cases where a neonate's response to sound has to be observed to determine the condition of the auditory system this have posed a lot of difficulties in identifying neonates with hearing loss (Diefendorf, 2002). Attention, cooperation and the state of the neonate are factors that can affect assessment of the neonate's hearing sensitivity (Johnson, 2002). It is in an effort to eliminate the limitations of subjective testing procedures such as behavioural audiometry that an objective NHS have to be employed to compensate for a probable observer-biased explanation of auditory system sensitivity (Northern & Downs, 2002).

2.17 Neonatal Hearing Screening In Ghana

Reports from the World Health Organization (WHO) indicates that 250 million people across the globe live with a disabling hearing impairment of which two-thirds reside in developing counties (WHO, 2005). There is inadequate data on the prevalence of hearing loss in neonates in developing countries compared to the availability of prevalence data for infant hearing loss in developed countries (Olusanya et al., 2004; Swanepoel, 2004; Swanepoel et al., 2004; Olusanya 2000). Research, however, states that there may be higher rates of severe-to-profound bilateral hearing loss in Sub-Saharan Africa (Olusanya et al., 2004).

Ghana is situated in Sub-Saharan Africa. Ghana covers about 238.837 square kilometres and shares borders with Ivory Coast to the West, Burkina Faso to the North, Togo to the East and the Gulf of Guinea to the South. Even though languages and dialects are classified into four main linguistic groups, there are over seventy (70) languages and dialects spoken in Ghana (Facts about Ghana, 2013).

The World Bank classifies Ghana as a lower middle income country in terms of income level. Ghana had an estimated total population of 24.97 million in 2011 (World Bank, 2013). Factors such as the use of multiple languages, diverse cultural practices, income inequalities, poverty, limited employment opportunities may pose challenges to the development and implementation of NHS programme (anecdotal evidence). Although extensive work on neonatal hearing screening has been done in some developing countries, data on neonatal hearing screening in Ghana is however very sparse. Therefore there is the need to know if it is important for neonatal hearing screening to be implemented in Ghana hence the impetus for the present investigation.

2.18 Anatomy and Physiology of OAE.

When sound is used to evoke an emission, the sound is transmitted through the outer ear, where the auditory stimulus is converted from an acoustical signal to a mechanical signal at the tympanic membrane and is transmitted through the middle ear ossicles (malleus, incus and stapes). The footplate of the stapes moves at the oval window, causing a travelling wave in the cochlea which is filled with fluid. The travelling wave in the fluid of cochlear causes the basilar membrane to move. Each portion of the basilar membrane is maximally sensitive to only a limited frequency range. The arrangement is a tonotopic gradient. Areas closest to the oval window are more sensitive to high-frequency stimuli and areas further away from the oval window are most sensitive to lower-frequency stimuli. Therefore, during the recording of OAEs by the probe microphone, the first responses originate from the highest-frequency cochlear areas because the travel distance is shorter. Responses from the lower-frequency areas, closer to the cochlear apex arrive later.

When the basilar membrane moves, the hair cells are set into motion and an electromechanical response is produced, while an afferent signal is transmitted and an efferent signal is emitted. The efferent signal is transmitted back through the auditory pathway, and the signal is measured in the outer ear canal. As stated earlier, the responses from the high-frequency area arrive first, before responses from lower-frequency areas. Outer hair cells are located in the Organ of Corti on the basilar membrane. These hair cells are motile. The three rows of outer hair cells have stereocilia arranged in a W formation. The stereocilia move as a unit because they are linked to each other. These are the outer hair cells believed to underlie OAE generation (A Handbook of Clinical Practice 2011).

2.19 Otoacoustic Emissions

Otoacoustic emissions (OAEs) are acoustical signals that can be detected in the ear. They occur spontaneously as narrow-band tone signals. They also occur as a result of stimulation of the ear and are supposed to occur because of vibrations generated at different locations within the cochlear. OAEs are detected by reason of vibrations moving toward the base of the cochlear resulting in the movements of the ossicles. The displacement of the ossicles sets the tympanic membrane into motion just like a diaphragm of a loudspeaker. Measurements of OAEs provide the researcher with a hint of the dynamics of the cochlear function in response to sound. (Robinette & Glattke, 1997).

The normal cochlea, aside from receiving sound, also produces low-intensity sounds which are known as OAEs. These low-intensity sounds are produced specifically by the cochlea and, most likely by the outer hair cells of the cochlear as they expand and contract (A Handbook of Clinical Practice, 2011). Distortion product otoacoustic emissions (DPOAEs) are sounds emitted in response to two simultaneous tones of different frequencies (Kathleen & Campbell, 2012).

2.20 Recording OAE

The instrument used to measure OAEs generally consists of an acoustic ear-canal probe. The probe contains a loudspeaker, a microphone and signal separating system. The loudspeaker stimulates the ear while the microphone records all the sounds in the ear. The separating system differentiates between the sounds from the cochlear and other sounds. The probe seals the ear canal to prevent ambient noise from entering the ear and to maximize OAE recording (Robinette & Glattke, 1997).

For normal auditory function, the cochlea must be intact and functioning well. Both TOAEs and DPOAEs are screening tools that can be used to evaluate the status of the cochlear. Other features that make OAEs an excellent screening tool are; the neonate does not need to participate in the test actively, it is non-invasive, the time use for measurement is minimal and data obtained from the test are reliable (Martin & Clark 1996).

To record OAEs, it is essential to have unobstructed outer ear canal, a good seal of the ear canal with the probe, optimal positioning of the probe, absence of any middle ear pathology, outer hair cells of the cochlear must be functioning well, a quiescent patient and relatively quiet recording environment (Kathleen & Campbell, 2012).

2.21. Types and Purpose of Otoacoustic Emissions

Otoacoustic emissions are low- level sometimes audible sounds produced by vibration movement in the cochlea The main objectives of otoacoustic emission (OAE) tests is to find out how the hair cells in the cochlea is functioning The purpose of. OAE test is used to screen hearing of neonates, determine hearing sensitivity to differentiate between the sensory and neural components of sensorineural hearing loss and for functional (feigned) hearing loss

The four types of otoacoustic emissions are as follows:

i. Spontaneous otoacoustic emissions (SOAEs) occur naturally in many people with normal hearing without external stimulus.
ii. Transient otoacoustic emissions (TOAEs) are measured after presenting a brief stimulus to the ear.
iii. Distortion product otoacoustic emissions (DPOAEs)are presented by introducing two tonal stimuli at the same time of different frequencies -
iv. Sustained-frequency otoacoustic emissions (SFOAEs) – are presented in response to continuous tone.

Some of the causes of absent otoacoustic emissions include the following:

i. Non pathological: Poor probe tip placement, standing waves, cerumen occlusion, vernix caseosa in infants , uncooperative patient
ii. Pathologic causes: Outer ear: Stenosis, otitis externa, cysts etc.
iii. Tympanic membrane: Perforations. Grommets usually don't complicate recordings;
iv. Middle ear: Otosclerosis, ossicular disruption, cholesteatoma, otitis media;
v. Cochlea: Exposure to ototoxic drugs, Noise exposure.

emedicine.medscape.com/article/835943-overview Retrieved 3/9/2015

The main function of OAE tests is to assess the function of cochlear hair cells. These tests could be used:

To screen children and neonates for hearing disabilities;

i. Estimate hearing sensitivity within a limited range of frequencies;
ii. To differentiate sensory and neural components in sensorineural hearing loss;
iii. To rule out malingering (functional hearing loss**).**

www.drtbalu.co.in/oto_**emission**.html *(Retrieved3/9/2015*

2.22 Challenges of Neonatal Hearing Screening

Although early identification and early intervention for children with hearing loss have positive results, there are some challenges that affect the successful implementation of NHS. Some of these challenges are: initiating and sustaining high-quality diagnostic and follow-up services that lay emphasis on family involvement. Owing to these challenges, the development of a universal NHS programme has become a difficulty (Mencher, Davis, DeVoe, Beresford, & Bamford, 2001).

The success and effectiveness of a hearing screening programme are affected by some specific challenges that interfere with the long-term feasibility of such a programme. The success of hearing screening programme is measured by the outcome (follow-up services, coverage and referral rates, and the effects of NHS on parents/caregivers) of the programme (White, 2003; Prieve et al., 2000). Middle ear pathologies comprising of cerumen in the canal, middle ear effusion, and collapsing ear canals are also an important factor that affect the success of a screening programme. Middle ear pathologies influence the results of electrophysiological testing and consequently do not give room for accurate diagnosis of sensorineural hearing loss (Boone, Bower, & Martin, 2005; Owens, McCoy, Lonsbury-Martin, & Martin, 1993; Akdogan & Ozkan, 2006).

Some significant factors that pose challenges to hearing screening programmes are outlined as follows:

i. **Middle ear effusion -** Most of the neonates who will be referred for further audiological assessment from NHS will be due to middle ear effusion (MEE) (Boone et al., 2005; Sutton, Gleadle, & Rowe, 2009). As much as the MEE will lead

to false positive results, it needs to be resolved so that a possible sensorineural hearing loss can be differentiated from a more likely MEE diagnosis (Sutton et al., 2009). The fact that false positive results are likely to occur when there is a presence of MEE poses a major problem for a successful implementation of a hearing screening programme by decreasing its efficiency.

Referral rate - The main aim of NHS programmes is to use the most valuable and efficient protocols to identify hearing loss in neonates (Gravel et al., 2000); because a valuable and competent protocol isolates neonates at risk for hearing loss, from neonates with normal hearing (Swanepoel, 2004; Kileny & Lesperance, 2001). Aside the fact that target population, adaption of pass-fail criteria, screening technologies, state of the nursery (the test environment), training, supervision and experience of personnel involved in the screening process may influence the referral rate of a screening programme. The screening protocol may also influence the referral rate of a NHS programme (Gravel et al., 2000; State of New Jersey Department of Health and Hearing Evaluation in Children & Hearing Evaluation in Children, 2012). Eiserman *et al.* (2008) reported a 5.7% referral rate in a multi-step strategy adopted in screening migrant children enrolled in Head Start programmes using DPOAEs. Krueger and Ferguson (2002), also reported a referral rate of 6.3% in a study conducted using their DPOAEs screening.

There are differences in the referral rates with regards to the screening technology used, but these differences are not significant (Swanepoel, 2004). An example is the referral rates for NHS in the USA which varies between 2-6%, depending on the screening protocol used (White, 2003). In view of this, a great care should be used in selecting a screening protocol if an effective NHS programme is to be realised. The

characteristics of the target population (well babies or NICU) should also be taken into consideration.

A major advantage of NHS programme with a low referral rate is that the number of parents that will go through unnecessary anxiety as a result of incorrect screening results will be reduced. Monetary and personnel resources that are used on follow-up services will also be reduced in a hearing screening programme that has a very low rate of referrals (Gravel et al., 2000). Factors such as consistent low referral rates and a good communication between a programme's personnel, and an effective parental education all contribute appreciably to a successful NHS programme (Lim & Fortaleza, 2000).

Effects of screening on parents - The effects of hearing screening results should not be over looked in the implementation of a hearing screening programme (Mencher et al., 2001). The parents of neonates who are referred to hearing screening programmes are most often than not disturbed and nervous. These feelings should not be ignored because according to Yoshinaga-Itano & Gravel (2001), negative emotions such as fear, depression or anger, are present in 10% of parents of neonates who fail a hearing screening. Another factor to take into consideration for a successful hearing screening programme is the psychological consequences of screening. These psychological consequences need to be addressed since reports indicate that some parents may go through feelings of anxiety during NHS (Magnuson & Hergils, 1999).

The results of studies conducted in a well-baby nursery, revealed that most parents showed a positive attitude and little anxiety towards NHS programmes (Yoshinaga-

Itano, 2003; Magnuson & Hergils, 1999). Yoshinaga-Itano (2003) also found that parents of children who were identified early for hearing loss were likely to have less stress when compared with parents of children who were identified late for hearing loss.

iv. **Follow-up -** For an effective and successful implementation of an NHS programme, an efficient measure must be employed to track neonates that are referred for a follow-up diagnostic testing (Mencher & DeVoe, 2001; Lim & Fortaleza, 2000; Diefendorf, 1997).

A poor follow up rate can have effects on a hearing screening programme (John, Balraj, & Kurien, 2009) and could be due to lack of awareness of hearing loss screening and the impact of hearing loss on the child's development (Hatzopoulos, Qirjazi, & Martini, 2007). Available data suggest that about 20% to 30% of neonates who fail a hearing screening test will fail to show up for a follow-up diagnostic evaluation (Kileny & Lesperance, 2001).

The New York State Multi-centre State-wide Screening Project also reported that there was a 72% follow-up rate for the first years of the NHS programme, while the follow-up rates with respect to the number of neonates who returned for further diagnostic testing increased in successive years (Prieve et al., 2000). A 68.6% follow-up rate was reported in a study conducted by (Kanji, Khoza-Shangase, & Ballot, 2010).

CHAPTER THREE

METHODOLOGY

3.0 Introduction

The rationale of this project is to screen the hearing of neonates with risk factors using otoacoustic emission at the Komfo Anokye teaching hospital, (Mother and Baby care unit). This Chapter addresses the study design, sampling method, materials and equipment used in data collection as well as the data collection procedure.

3.1 Study design

Research design is the strategy, the plan, and the structure of conducting a research project (Carriger, 2000). Research design can be thought of as the structure of research -- it is the "glue" that holds all of the elements in a research project together (William, 2009).

A descriptive survey design was employed for the study. Typically, surveys gather data at a particular point in time with the intention of describing existing conditions, or identifying standards against which existing conditions can be compared. Surveys can also be used to determine the relationships that exist between specific events. The research design enabled gathering of standardized information and provision of descriptive, inferential and explanatory information. Descriptive surveys describe data on variables of interest (Cohen et al., 2007). *dissertation.laerd.com/**purposive-sampling**.php*

3.2 Sampling Method

Purposive sampling represents a group of different non-probability sampling techniques and is also known as judgmental**,** selective or subjective sampling. Purposive sampling relies on the judgment of the researcher when it comes to selecting the units (e.g., people, cases/organizations, events, pieces of data) that are to be studied.

This study employed convenience sampling. All neonates who were admitted at MBU at KATH within the period of the study were enrolled as participants provided informed consent was obtained from the parent/care giver after the data collection procedure was explained to them

3.3 Study Location

This study was conducted at the Komfo Anokye Teaching Hospital Child Health Directorate. The sampling was done at the Mother and Baby Unit KATH in Kumasi while interviews and screenings were performed at the MBU ward and Kumasi Hearing Assessment Centre (KHAC).

3.4 Study Population

Neonates aged 1–28 days admitted at MBU at the KATH during the period March -May 2015 were enrolled in this study. Neonates were only enrolled in the study after written consent had been obtained from their mothers or caregivers (consent form attached as appendix A).

3.5 Materials and Equipment

3.5.1 Data Collection Material

Self-administered questionnaire (Appendix B) designed for the purpose of providing a general description of neonates was used as data collection tool. The questionnaire provided for acquisition of important information (biographic data), identifying risk factors and identifying the awareness level of neonatal hearing screening by parents/caregivers and were self – administered. Total number of neonates for the study was 100 comprising 55 males and 45 females.

3.5.2 Data Collection Instrumentation

A handheld OAE instrument (gsi Grason-Stadler Corti) was used to screen for hearing sensitivity in the neonates. According to JCIH (2000), OAEs, either transient-evoked OAEs (TEOAE) or distortion-product OAEs (DPOAE), and/or ABRs are included in the current physiologic measures used for detecting unilateral or bilateral hearing loss of different severities. OAE technology is non-invasive and its measurements are easily recorded in neonates and infants with strong correlation with peripheral hearing sensitivity. Screening technologies that incorporate automated response detection are preferred over operator–dependent ones. Automated response detection reduces the effects of screener bias and errors on test results, and ensures test consistency in the screening programme (JCIH, 2000).

The handheld device used in this study was gsi Grason-Stadler Corti which included pre-set DPOAE screening protocols to determine hearing sensitivity in neonates and infants and yielded an automated pass or refers result. Table 3.1 indicates automated OAE screening test protocols.

Table 3.1: Automated OAE screening test protocols

Stimulus parameters	
L1	65dB SPL
L2	55 dB SPL
F2/F1 ratio	1.2
Number of samples per set	60

Table 3.2: Pass and Refer criteria

Pass/Refer criteria 2-5 kHz screen, 3 of 4 for pass	
Minimum DP amplitude	– 8
Minimum DP-NF amplitude	6
Number of frequencies for pass	3
Frequencies used for screening	5, 4, 3, and 2 kHz

3.5.3 Procedure for Data Collection

The MBU of KATH was visited every weekday morning. The purpose and procedure for data collection was explained to mothers/care givers whose babies were on admission. Mothers/caregivers who expressed interest in the study were giving permission for their babies hearing to be screened, data collected and interviewed. Informed consent letter were signed by all participants willing to participate in the study (Appendix A). Data were collected over a period of three (3) months. The screening was conducted in a quiet room with less background noise (50-55 dB) and fewer interruptions. A structured face-to-face interview (Appendix B) was conducted with each of the mothers/caregivers, privately, to compile the profile of the neonates. The risk factors for hearing loss were identified by making use of information provided by mothers/caregivers as well as the medical histories of the neonates or infants. Neonates were also screened with the gsi Grason-Stadler Corti system and their results were recorded. The automated OAE results of the initial screening as well as follow-up results (referred neonates) were recorded on the questionnaire sheet.

3.6 Hearing Screening Protocol

Before the administration of the screening test procedure, the neonate or infant was held in a comfortable position in the mother/ caregiver's arms. The appropriate test probe size was selected and inserted in the neonates' ear. The automated otoacoustic emission (AOAE) screening module was then selected and the screening performed on both ears. The results were automatically reported as "pass" or "refer" on the instrument. If a neonate cried during the testing or did not cooperate during the screening process, a later date was given for the mother/caretaker to bring the neonate back for screening. If a neonate was referred for one or both ears, the result was recorded on the questionnaire sheet (Appendix B) and a rescreening appointment was scheduled on a later date usually one month after the baby had been discharged If the neonate was referred again in one or both ears at the rescreening appointment, he/she was referred to the KHAC for further diagnostic evaluation.

3.7 Otoacoustic Emissions

Otoacoustic emissions (OAEs) are acoustical signals that can be detected in the ear. They occur spontaneously as narrow-band tone signals. They also occur as a result of stimulation of the ear and are supposed to occur because of vibrations generated at different locations within the cochlear. OAEs are detected by reason of vibrations moving toward the base of the cochlear resulting in the movements of the ossicles. The displacement of the ossicles sets the tympanic membrane into motion just like a diaphragm of a loudspeaker. Measurements of OAEs provide the researcher with a hint of the dynamics of the cochlear function in response to sound. (Robinette & Glattke, 1997).

The normal cochlea, aside from receiving sound, also produces low-intensity sounds which are known as OAEs. These low-intensity sounds are produced specifically by the cochlea and, most likely by the outer hair cells of the cochlear as they expand and contract (A

Handbook of Clinical Practice, 2011). Distortion product otoacoustic emissions (DPOAEs) are sounds emitted in response to two simultaneous tones of different frequencies (Kathleen & Campbell, 2012).

3.8 Validity and Reliability

Threats to validity and reliability cannot be removed completely but the effects of these threats can be minimized by paying attention to validity and reliability throughout a piece of research (Cohen et al, 2007). The validity of a screening protocol is the degree to which results are consistent with the actual presence or absence of the disorder. Sensitivity and specificity are used to identify the validity of a screening test. The sensitivity of a test is defined as its accuracy in correctly predicting individuals with the condition one is looking for (in this case, children who have potential hearing loss). The specificity of a test is also defined as its accuracy in correctly identifying individuals who do not have the condition. (Roeser & Downs, 1981) as cited in American Academy of Audiology Childhood Hearing Screening Guidelines (2011).

Reliability has to do with the quality of the measurement. In its everyday sense, reliability is the consistency or repeatability of one's measures. To make the results of this study valid and reliable the following were done;

- The data collection equipment, (gsi Grason-Stadler Corti) was within calibration. A biologic calibration of the gsi Grason-Stadler Corti was done before the commencement of data collection each morning.
- All interviews were conducted by the researcher except in cases where language was a barrier for which an interpreter was requested
- The researcher collected and recorded all data alone to ensure consistency.

- The screening of neonates was done in a quiet room with less background noise to reduce the effects of noise on screening results
- Proper selection and placement of the probe tip was done for a good acoustic seal to mitigate the effects of background noise.

The procedure for data collection was in three parts. The first part involved an interview with the mothers of neonates. The second part consisted of an initial screening of the neonates for hearing loss using distortion product otoacoustic emissions (DPOAEs) followed by a second-stage screening also with DPOAEs two weeks later for neonates who were referred in the initial screening. If a neonate did not pass the second-stage screening, he/she was referred for diagnostic testing.

DPOAE testing resulted in a ‘‘pass’’ or ‘‘refer’’ test outcome. ‘‘Refer’’ outcomes during the stages of screening were an indication that additional tests were required to fully assess the hearing status of the child. The two-stage screening with DPOAEs was conducted in a quiet room reserved for this purpose. Those who were referred during the second screening were scheduled for a diagnostic evaluation at the KHAC Ear Nose and Throat Department (ENT)

3.10 Data Management Plan

This project generated data on the background information (biographic data), identified risk factors and awareness level of neonatal hearing screening among parents/caregivers prevalence and incidence of hearing loss in neonates who were admitted at Mother and Baby Unit.

3.11 Ethical Consideration

Ethical clearance was obtained from the Ethics Review Committee of KNUST and Research Unit of KATH (Appendix C). Permission was obtained from the KATH'S MBU before data collection started (Appendix D). Consent was sought from parents and guardians of the subjects in data collection through a written notice. Assurance was given concerning confidentiality with regards to the data collection and safety of test procedure.

CHAPTER FOUR

RESULTS

4.1 Introduction

This chapter of the study focused on the data analyses and presentation of the results obtained. The results combine descriptive statistics and charts to provide clear illustration of the results obtained.

Table 4.1: Days of admission

Days	Frequency	Percentage
Below 10days	81	81.0
10 days-20days	15	15.0
20 days and above	4	4.0
Total	100	100.0

Table 4.1 above showed days of admission of the neonates at MBU. The mean days of admission and standard deviation of the respondents are 7 and 4.5 days respectively. The mean birth weight and standard deviation also stood at 3.05 kg and 0.74 kg respectively.

4.2 Demographic Data Presentation

Samples of one hundred (100) respondents were taken out of the one thousand (1000) neonates who were on admission within the study period. The data revealed 55% of the respondents were males and their female counterparts formed the remaining 45%. Table 4.1 and 4.2 show the days of admission and gender distribution of the target population.

Table 4.2: Gender

Gender	Frequency	Percentage
Male	55	55.0
Female	45	45.0
Total	**100**	**100.0**

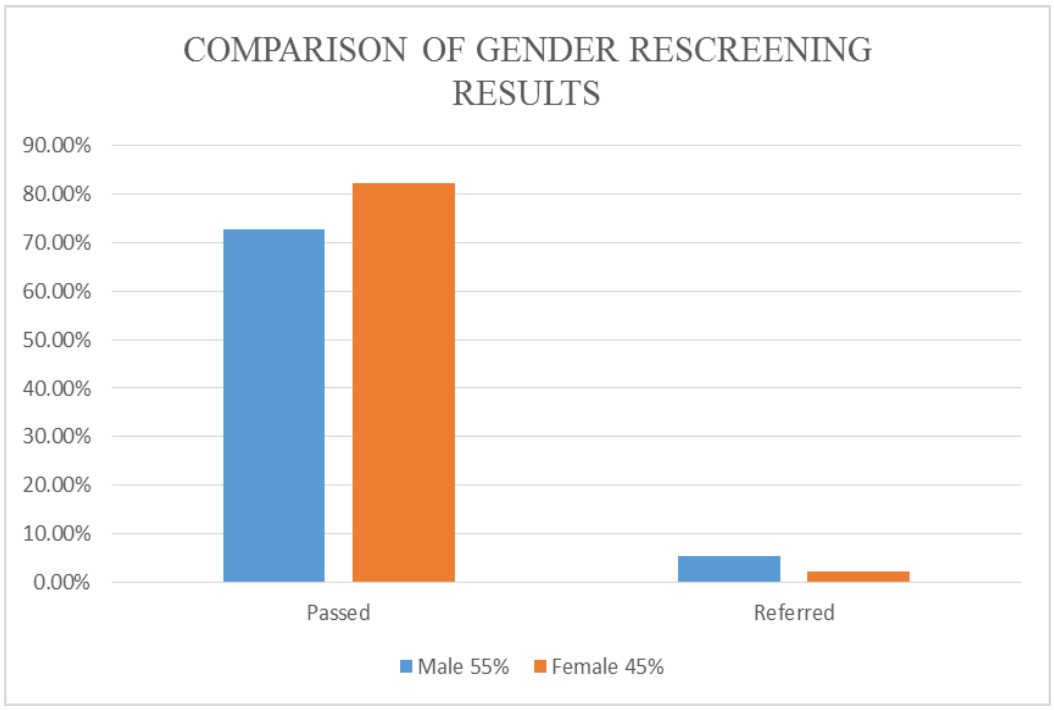


Fig 4.1: Comparison of Gender Rescreening results.

Figure 4.1represented the comparison between male 55(55%) and female 45(45%) neonates who were screened during the study. After the rescreening 40 forty (72.7%) male neonates and 37(82.2%) females passed. Three 3(5.5%) of the male category were referred whilst 1(2.2%) female was referred

4.3 Presentation of Awareness Data Analysis

Table 4.3 provides a table presentation of parental awareness of neonatal hearing screening**.** Out of the sample of 100 respondents interviewed 91% of them told the researcher they have no knowledge of neonatal hearing screening and only 9% of the respondents claimed to have some knowledge of neonatal hearing losses screening. They were asked through which medium did they get to know of neonatal hearing screening and they mentioned they read the information as part of their introduction course in special education.

Table 4.3: Awareness of neonatal hearing screening

Response	Frequency	Percentage
Yes	9	9.0
No	91	91.0
Total	**100**	**100.00**

4.4 Presentation of Test (Screening) Results

Table 4.4 shows the test (screening) results of the target population of the study. From the table, 65% of the participants passed in both ears of test (screening) that was done. 9% of the target population could not be tested as a result to either obstruction of the external ear, noisy environment, middle ear pathology, wrong positioning and selection of the probe, 11% of the population passed only in the right ear test whilst 5% passed only in the left ear test and 10% of the population was referred in both ears. This indicated that 35 (35%) neonates out of the 100 were to be rescreened to confirm the presence or absence of hearing loss being unilateral or bilateral.

Table 4.4: Test (screening) results of the targeted population

Results Category	Frequency	Percentage (%)
Pass both Ears	65	65
Pass right Ear	11	11
Pass left Ear	5	5
Could not be tested	9	9
Referred	10	10
Total	**100**	**100**

A graphical presentation was made for of the test (screening) results to show how each of the variables stand in Figure 4.2 It is evident from the bar graph that those who passed the test in both ears were in a clear majority while those who passed the left ear test were the least among them. Others were also referred for retesting in two weeks.

Fig. 4.2: A Bar graph showing the test results distribution

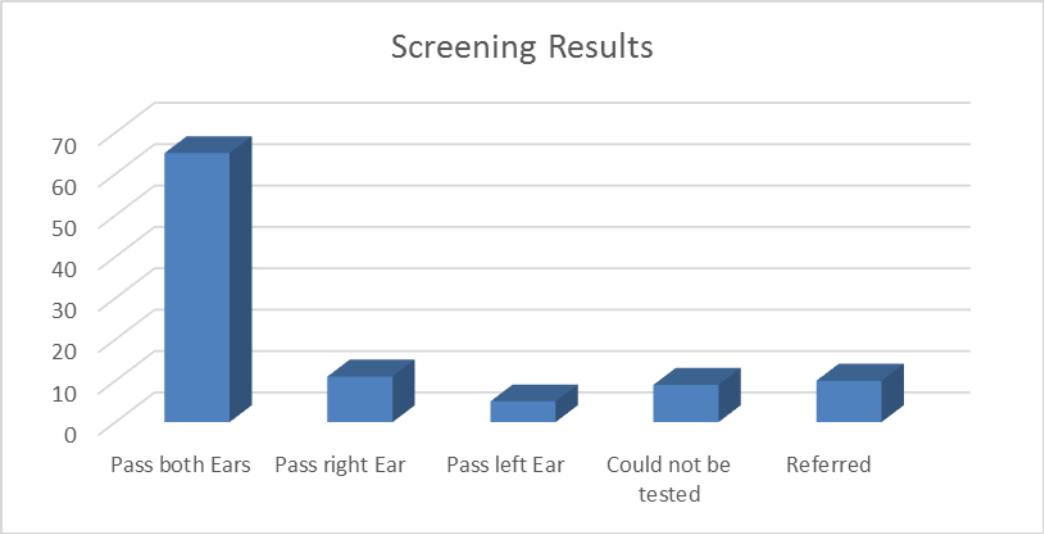


Table 4.5 is the presentation of the screening test results and gender distribution of the study. It is clear from Table 4.5 that, out of 65% of respondents who passed the test in both ears, 34% of that population were male population while 31% were female population. Of the 11% respondents who passed the right ear, 6% were male and 5% were female. 9% of the population could not be tested out of which 5% of them were males and 4% were

females. A total of 10% were referred for further test. 4% of that population formed the female category whereas 6% formed the male category

Table 4.5 Cross tabulation of gender and test (screening) results

Gender	Pass both Ears	Pass right Ear	Pass left Ear	Could not tested	Referred	Percentage (%)
Male	34%	6%	4%	5%	6%	55
Female	31%	5%	1%	4%	4%	45
Total	**65%**	**11%**	**5%**	**9%**	**10%**	**100**

Table 4.6 describes gender results after the rescreening of 35 neonates referred in both or either ears. Total of 12 neonates passed both ears 6 each from the gender male and female.3 males were referred whilst only 1 female was referred. 2 of the females could not be tested and 1 male still remained not compliant.4 of them passed unilaterally.

Table 4.6 Cross tabulation of gender and rescreening results

Gender	Pass Both Ear	Pass right Ear	Pass Left Ear	Could not be tested	Referred
Male	6	0	2	1	3
Female	6	2	0	2	1
Total	**12**	2	2	3	4

Table 4.6 describes gender results after the rescreening of 35 neonates referred in both or either ears. A total of 12 neonates passed both ears 6 were males and 6 were female. Three

males and 1 female were referred. Two of the females could not be tested and 1 male still remained not compliant.4 of them passed unilaterally.

Table 4.7: Rescreening Results

Results Category	Frequency	Percentage (%)
Pass both Ears	12	34.3%)
Pass right Ear	9	25.7%
Pass left Ear	7	17.1%
Referred	4	11.4%
Could not be tested	3	11.4%
Total	**35**	**100**

Table 4.7 presents the rescreening results. The targeted population of the rescreening included those that were referred in both or either ear and those that could not be tested in the initial test conducted. A total of 4 neonates (11.4%) were referred and 4 (11.4%) of them could not be tested in the rescreening conducted. Table 4.7 shows that 12 (34.3%) of the populations passed in both ears, 9 (25. 7%) passed only in the right ear and 7 (17.1%) passed in the left ear. Thus a total number of 23 (65. 7%) was referred to Komfo Anokye Teaching Hospital to see the ENT Consultants for medical and diagnostic Audiological assessment.

Table 4.8 reveals a summary of the initial and rescreening results. In the results 77(77%) neonates had normal hearing as at the time of the test. 20(20%) neonates needed further diagnostic assessment and the remaining 3 (3%) were to be rescreened till a confirmed result obtained.

Table 4.8: Summary of initial and rescreening results

Results Category	Frequency	Percentage
Passed both ears	77	77
Passed Right ear	9	9
Passed Left	7	7
Could not be tested	3	3
Referred in both ears	4	4
Total	**100**	**100**

The various forms of delivery that were identified during the research are given in Table 4.9. included Prolong Labor, Assisted Delivery, C-Section and spontaneous Virginal delivery (SVD). It is obvious from the table that Spontaneous Vaginal Delivery (SVD) recorded the greatest percentage followed by C-section then followed by Prolong Labor with Assisted Delivery recording the least percentage (frequency)**.**

Table.4.9: Type of Delivery.

Delivery	Frequency	Percentage
SVD	51	51.0
C-Section	20	20.0
Prolong Labor	17	17.0
Assisted Delivery	12	12.0
Total	**100**	**100.0**

Table 4.10 depicts maternal pregnancy that was captured during the study period. It indicates that 74 (74%) of the respondents had full term duration of gestation period whilst 26 (26%) of them had preterm pregnancy.

Table 4.10 Gestation Period

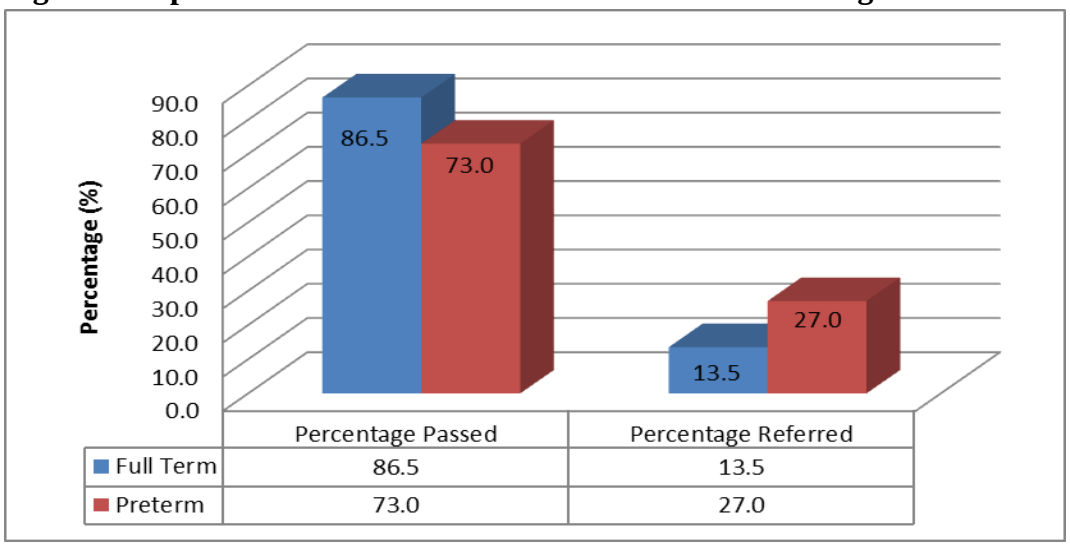
Gestation Age	Frequency	Percentage
Full Term	74	74.0
Premature	26	26.0
Total	**100**	**100**

Table 4.11 explains the comparison between gestation period and rescreening. According to the table, 64 (86.5%) neonates passed the rescreening test out of the 74 neonates who had full term pregnancy duration and 10 (13.5 %) of them were referred. For the preterm category, out of the 26 neonates, 19 (73.0%) passed the rescreening test and 7 (27.0%) of them were referred.

Table 4.11 Comparison between Gestation Period and rescreening results

Gestation Age	Frequency	Passed	Referred	Percentage passed	Percentage Referred
Full Term	74	64	10	86.5	13.5
Preterm	26	19	7	73.0	27.0

Fig.4.3 Comparison between Gestation Period and rescreening results



According to the figure, 64 (86.5%) neonates passed after the rescreening test out of the 74 neonates who had full term pregnancy duration and 10 (13.5 %) of them were referred. For the preterm category, out of the 26 neonates, 19 (73.0%) passed after the rescreening test and 7 (27.0%) of them were referred.

Table 4.12 lists the risk factors that were identified among the neonates who were on admission at MBU during the study period.

Table 4.12: Risk factors relating to hearing problems

Risk feature	Frequency	Percentage
Infection during pregnancy	3	3
Craniofacial anomalies	6	6
Ototoxic medication during pregnancy	3	3
Syndrome associated with hearing losses	4	4
Preterm	26	26
Birth asphyxia	22	22
Neonatal jaundice	36	36
Total	100	100

The above table lists the risk factors that were identified among the neonates who were on admission at MBU during the study period. Neonatal jaundice was the most frequent risk identified with 36 (36%) neonates followed by birth asphyxia with 22 (22%), preterm neonates were 26 (26%) craniofacial anomalies were 6(6%) and ototoxic medication during pregnancy had 3 (3%) each.

Table 4.13 Risk factors associated with initial and re- screening results

Risk factors	Could not be tested	Pass both Ears	Pass left Ear	Pass right Ear	Referred both Ears	Total
Syndrome associate with hearing losses	1	1	0	2	0	4
Infection during pregnancy	0	3	0	0	0	3
Birth Asphyxia	0	17	1	2	2	22
Craniofacial Anomalies	0	4	2	0	0	6
Neonatal Jaundice	0	30	2	2	2	36
Ototoxic Medications	0	2	0	1	0	3
Preterm	2	20	2	2	0	26
Total	**3**	**77**	**7**	**9**	**4**	**100**

From the above table, 77 neonates with above risk factors identified during the study passed in both ears for initial and rescreening test. Four(4) of them were referred in both ears and they were from the category of neonates with birth asphyxia and neonatal jaundice, 3 of them could not be tested as a result of external and middle ear

Pathology, 16 passed in either ear. 23% of the neonates need to be registered for diagnostic hearing assessment protocol by ENT consultant and audiologist,

CHAPTER FIVE

DISCUSSION

5.1 Introduction

This Chapter discusses the results and analyses of the data. The results are subsequently discussed by integrating them with the literature and drawing out the significance of the results obtained.

5.2 Demographics

Amini et al (2014) assessing neonates hearing with OAE found out that, of 38 cases who failed the test, 22 were males and 16 were females. In this study a total of 100 neonates were screened consisting of 55.0% (55) males and 45% (45) females. 77% (*n* = 77) passed in both ears 4% (n=4) referred in both ears , 9% (n = 9) passed in RE only, 7% (n = 7) passed only in LE and 3% (n=3) could not be tested. Thus those who were referred in both ears, could not be tested and those referred in one ear were booked for follow up and diagnostic hearing assessment. This study revealed that out of the 77% who passed in both ears, 40(72.7%) of them were males and 37(82.2%) females. 3(5.5%) out 4 neonates who were referred bilaterally were males and remaining 1(2.2%) was a female (Iran Red Crescent Med J. (2014)

5.3 Awareness of Neonatal Hearing Screening

The results of the study revealed a very low level of awareness of neonatal hearing screening by the parents/caregivers of neonates. Only 9% of the respondents claimed to have some knowledge of neonatal hearing screening. Olusanya and colleagues (2015) confirmed this in their study by listing the causes of low awareness as follows:

Lack of hearing care personnel training amongst health workers, Importance of early identification and intervention, Provision of appropriate support for parents and caregivers, and Lack of audiologists

1. Lack of ear and hearing care personnel and lack of professional training amongst health workers already involved in screening newborn babies and preschool children for other conditions. Lack of awareness on the part of health workers caring for newborn and preschool children about the benefits of ear and hearing screening and of early intervention. Moreover, parents and the community are not aware that early detection and early intervention can make a difference to the whole of a child's life. For many countries, one major challenge is the lack of contact between the majority of mothers and their babies and the health system.

2, According to WHO (2010) ensuring high levels of awareness among stakeholders of the vital importance of early identification of hearing loss is crucial. Systematic and comprehensive information should therefore be provided to parents, physicians, audiologists, policy-makers, educators and all other stakeholders on the importance of hearing, the consequences of not identifying hearing loss early, and the benefits of identifying and treating hearing loss. Achieving such levels of awareness will generally require a variety of approaches (such as printed materials, web sites, newspapers, training of health care providers, radio and television announcements, and use of social media). It is important that all public-awareness information be culturally appropriate and sensitive to differences in language and customs within a particular area. Many examples of materials that have been used in countries that have already implemented successful newborn and infant hearing screening programmes are available, but these materials will often have to be modified appropriately for use in a new area.

3. Further on this issue of awareness WHO posited that it is particularly important to make sure that those who provide health care to very young children are educated on the importance of early identification of hearing loss, as well as on the newborn and infant hearing screening procedures being implemented in their area. Parents often turn to health care providers for advice and assistance. Health care providers will only be able to provide appropriate support and assistance if they have been well educated. Primary health care providers are often in a good position to help the family access all the various services they need, such as ophthalmological examinations, genetic evaluations and counselling, speech-language therapy and enrolment in educational programmes.

Currently, there are only six practicing audiologists in Ghana where the population is nearly 25 million people. The ratio of people to audiologists in Ghana makes access to audiological services difficult. Due to the heavy work load, there is little or no time for awareness programmes on infant hearing screening. This may be the result of the low awareness level in parents/caregivers of neonates that participated in the study.

5.4 Referral Rate

The results of the current study revealed that 35% neonates were referred during their first hearing screening test. Out of the 35 referral 9 (9%) of neonates could not be tested during their first visit. These results were slightly higher compared to the results of a multi-step strategy adopted in screening migrant children enrolled in Head Start programmes using DPOAEs and conducted by Eiserman *et al*. (2008) which showed that the referral rate for the first stage of DPOAE screening was 18%, whereas 6% of the children were classified as "can't test" due to excessive internal or external noise. After three screenings, 5.7% of the children were referred which was higher than the 4% recorded in the current study. Krueger

and Ferguson (2002) reported a referral rate of 6.3% in their DPOAEs screening which was also higher than the referral rate recorded in the current study.

The difference in referral rates may be attributed to the use of different protocols. The rescreening in the current study was conducted in a very conducive environment in the Audiology testing room at KATH while classroom play settings and homes were employed as venues in the study by Eiserman *et al*. (2008).

There were 17% of neonates referred in either one or both ears during their first hearing screening visit, which could be due to many factors. If a neonate did not pass the hearing screening, it did not necessarily mean there was a hearing loss. A refer result may be an indication of any of these reasons: fluid in the baby's ear, testing room too noisy, movement and/ crying during the test, hearing loss or debris in the ear (State of New Jersey Department of Health and Hearing Evaluation in Children, 2012 & Hearing Evaluation in Children, 2013). Even though some babies passed the follow-up hearing testing, it is equally very important for referred neonates in one or both ears to have follow-up testing. This approach provides the best way to ensure the hearing of neonates (My baby's hearing, 2013).

According to the Columbia Department of Otolaryngology, Head & Neck Surgery, rescreening should be done within one month of initial screening, but not later than three months (Department of Otolaryngology/ Head & Neck Surgery, 2013). Therefore, neonates who were referred in one or both ears or could not be tested during the initial screening in the current study were scheduled on a later date usually one month later for rescreening. After rescreening of neonates that were referred in the initial hearing screening, 34.3% of them passed confirming the necessity of rescreening, while some referred in either one or both ears even after rescreening. This could be due to, movement and crying during the test,

hearing loss, fluid or debris in the neonates' ear. As stated earlier no diagnostic testing was done to confirm hearing loss due to time constrain

5.5 Risk Factors identified in the Study

The total number of risk factors, e.g. medicated by total length of stay in the neonatal intensive care unit and length of artificial ventilation, is the best predictor of risk for hearing loss of perinatal origin (Scandinavian Audiology 1997.Seven (7) out of the ten (10) risk factors established by the Joint Committee on Infant Hearing in 1994 were identified in the NICU at MBU in this study. The four most common were 36%(N=36) neonates with neonatal jaundice out of which 30 of them passed in both ears 4 of them passed in either ear and 2 were referred in both ears. According to MedicneNet .com. the complications associated with neonatal jaundice occur when bilirubin levels reach toxic levels, and the bilirubin gets into the central nervous system and damages the brain. The brain toxicity can either be reversible (early acute bilirubin encephalopathy) or the damage may be permanent and irreversible (kernicterus). Permanent damage may lead to cerebral palsy, deafness, and intellectual impairment. Severe hyperbilirubinemia can result in damage to the auditory nerve and/or brainstem nuclei in the auditory system, neurons in the cochlear nuclei, in particular are severely damaged. It can involve lesions of the basal gan-glia and can affect the oculomotor system, vesti-bular systems and the cellebellum (NewbornScreen@health.ok.gov 2011). These two literatures confirm why some of the neonates with neonatal jaundice were referred for the hearing screening.

Birth asphyxia risk factor neonates were 22(22%).Seventeen (17) of them passed the screening in both ears, 3 passed in either ear. Preterm neonates were 26(26%) out of which 20(20%) passed in both ears, 2 could not be tested 4 passed either ear. Preterm babies are more vulnerable than full term babies. Neonates with craniofacial anomalies were 6 (6%) and 4 passed in both ears whilst 2 were referred unilaterally. Otologic malformations and

hearing loss are common features in Pfeiffer syndrome. They are mainly due to external auditory canal or middle ear malformation. For example atresic or stenotic auditory canal, hypoplasic ossicules or fixed ossicular chain, hypoplasic or enlarged middle ear cavity can be common findings. The inner ear is usually normal though an enlarged internal acoustic meatus may be present. (Cremers et al., 1981) Neonates with infections and ototoxic risk factors were 6.3 in each group. The last risk factor from the study was syndrome associated with hearing loss and 4 (4%) neonates of the population were identified. 74% of the participants had full term delivery of which 86.5% passed the hearing screening and 13.5% were in the referred category .26% of the neonates were preterm delivered and 73% passed the hearing test whilst 27% were referred for follow up screening.

5.6 Follow-Up Rate.

A total of 23(23%) neonates who failed in either ear, could not be tested and referred after the rescreening in this study need subsequent diagnostic test, Mencher and DeVoe, 2001; Lim and Fortaleza, 2000; Diefendorf, 1997 stated that for an effective and successful implementation of an NHS programme, an efficient measure must be employed to track neonates that are referred for a follow-up diagnostic testing.

The poor follow-up return rate in the current study may have been attributed to lack of awareness on the part of parent/guardians. The results of the study revealed a very low level of awareness of neonatal hearing screening by the parents/caregivers of neonates. Only 9% of the respondents claimed to have some knowledge of neonatal hearing screening A survey of mothers of new-born infants revealed that poor follow-up was related to the lack of awareness within the community with regard to hearing loss screening, the impact of hearing loss on the child's development, and the importance of strategies to reduce these consequences (Hatzopoulos et al., 2007).

A poor follow-up rate can have a clinical significance as it highlights the important role of the audiologist in counselling and educating parents on the function and importance of regular hearing assessment as well as the impact of hearing loss on development (John et al., 2009).

Education and counselling regarding risk factors for hearing loss, reasons for early identification, importance of follow-up visits, and the implications of undetected hearing loss by audiologists and other health care professionals can assist in improving follow-up return rates.

A poor follow up rate can have effects on a hearing screening programme (John, Balraj, & Kurien, 2009) and could be due to lack of awareness of hearing loss screening and the impact of hearing loss on the child's development (Hatzopoulos, Qirjazi, & Martini, 2007). Available data suggest that about 20% to 30% of neonates who fail a hearing screening test will fail to show up for a follow-up diagnostic evaluation (Kileny & Lesperance, 2001).

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

A study on the hearing screening of neonates at MBU KATH has been performed. In this Chapter, conclusions arising from the results in the study are presented. Recommendations for academic and professional consideration for future actions are also indicated.

6.2 Conclusions

During the study period one thousand noenates (1000) were admitted out of which one hundred were screened with otoacoustic emission equipment of which 55.0% (55) were males and 45% (45) were females. A total of 10% of the participants (n = 10) were referred in both ears for further test by the audiologist. After the rescreening, 6% (n = 6) out the 10 previously referred passed and remaining 4% (n = 4) were referred for further diagnostic audiologic assessment. This study revealed that out of the 77% who passed in both ears, 40(72.7%) of them were males and 37(82.2%) females. 3(5.5%) out 4 neonates who were referred bilaterally were males and remaining 1(2.2%) was a female.

The procedure for data collection was in three parts. The first part involved an interview with the mothers of neonates. The second part consisted of an initial screening of the neonates for hearing loss using distortion product otoacoustic emissions (DPOAEs) followed by a second-stage screening also with DPOAEs two weeks later for neonates who were referred in the initial screening A handheld OAE instrument (gsi Grason-Stadler Corti) was used to screen for hearing sensitivity in the neonates. According to JCIH (2000), OAEs, either transient-evoked OAEs (TEOAE) or distortion-product OAEs (DPOAE), and/or ABRs are included in the current physiologic measures used for detecting unilateral or

bilateral hearing loss of different severities. DPOAE testing resulted in a ‘‘pass’’ or ‘‘refer’’ test outcome. ‘‘Refer’’ outcomes during the stages of screening were an indication that additional tests were required to fully assess the hearing status of the child

The neonates screened for hearing loss were babies who were on admission at MBU with the following risk factors:

- Family history of permanent hearing loss in childhood
- Maternal infections during pregnancy or delivery (Toxoplasmosis , Syphilis, HIV, Hepatitis B,
- Rubella , CMV, Herpes simplex, and others)
- Physical problems of the head, face, ears, or neck (cleft lip/palate, ear pits/tags, atresia, and others)
- Ototoxic medications given in the neonatal period
- Syndrome associated with hearing loss (Pendred, Usher, Waardenburg, and neurofibromatosis)
- Admission to a neonatal intensive care unit greater than 5 days
- Prematurity (< 37 weeks)
- Hyperbilirubinemia

The results of the study revealed a very low level of awareness of neonatal hearing screening by the parents/caregivers of neonates. Only 9% of the respondents claimed to have some knowledge of neonatal hearing screening. Low level of awareness and follow-up rate was among the limitations of the study.

6.3 Recommendations

The results obtained and conclusions drawn from the research indicated several significant aspects that require further investigation. Recommendations for improving hearing screening in neonates are listed below:

- Hearing screening should be done at various health centres by trained ENT nurses, midwifes and audiologist because EHDI through national systems NHS have been endorsed by the JCIH Year 2007 Position Statement (JCIH, 2000). Thus the hearing of all infants should be screened with objective and physiological measures to identify infants with congenital hearing loss.
- All infants who pass new-born hearing screening but who have risk indicators for hearing loss should undergo ongoing audiologic surveillance (JCIH, 2000).
- Hearing screenings should be conducted before neonates are discharged from the hospital or, a quiet room should be identified at the Mother and Baby Unit (KATH) where hearing screenings can be conducted.
- Awareness of neonatal hearing screening is essential for the successful implementation of a screening programme. An increased awareness amongst parents/caregivers and the general public are crucial for the long-term feasibility of such a programme. Nursing staff are not routinely involved in hearing screenings in Ghana, but their role involves constant involvement and information exchange with parents/caregivers. Audiologists can regularly provide nurses with information regarding hearing screening results so that they can relay this information to parent/caregivers. This relay of information could even be done during the antenatal period.
- Nurses, especially Ear, Nose and Throat (ENT) nurses, should be trained to conduct hearing screening with technologies that provide automated pass-refer criteria

(JCIH, 2000) so that audiologists can monitor the screening programs since there are few audiologists in Ghana to perform the screening themselves.

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APPENDIX A

INFORMATION SHEET

Introduction

I am Miss Barbara Birago Antwi, graduate student researcher at the Kwame Nkrumah University of Science and Technology at School of Medical Sciences, Eye Ear Nose and Throat Department conducting research on Hearing Screening in new born children. I am going to give you information and invite you to have your child participate in this research. You do not have to decide today whether or not you agree that your child may participate in the research. Before you decide, you can talk to anyone you feel comfortable with. There may be some words that you do not understand. Please ask me to stop as we go through the information and I will take time to explain. If you have questions later, you can ask them of me.

Purpose

Hearing loss screening in neonates has been advocated by the the Joint Committee on Infant Hearing (JCIH, 2000).This is because there is evidence that early detection of hearing loss in neonates has many benefits. The purpose of this research is to screen neonates who are on admission at MBU in order to detect hearing loss early to enable a timely intervention.

Participant selection

Hearing loss in children is common; however, if it is detected early, remedial measures can be put in place. We are inviting you to take part in this research because it is important that your child be screened for hearing loss. We are asking if you would allow your child to participate.

Voluntary Participation

Your decision to have your child participate in this study is entirely voluntary. It is your choice whether to have your child participate or not. If you choose not to consent, all the services you and your child receive at this clinic will continue and nothing will change. You may also choose to change your mind later and stop participating, even if you agreed earlier, and the services you and/or your child receives at the clinic will continue.

Description of the Process

The child will be screened by audiologists or personnel with experience in audiological testing of younger children. A two-stage screening protocol will be implemented consisting of an initial screening with distortion product evoked otoacoustic emissions (DPOAE) followed by a second-stage screening also with DPOAE 1 or 2 weeks later for referred babies. If a baby does not pass the second-stage screening, he/she will be referred for diagnostic testing.

DPOAE testing will result in a ‘‘pass’’ or ‘‘refer’’ test outcome. ‘‘Refer’’ outcomes during the stages of screening indicate that additional tests are required to more fully assess the hearing status of the child. Those who will fail the second screening will be scheduled for a diagnostic evaluation at the audiology centre at Hearing Assessment KATH.

Duration.

The research will take place over a period of two months (Febuary-March2015). During that time, it will be necessary for you to come to the clinic hospital once more should your child obtain a “refer” response in today’s screening. We would like to meet with you two weeks after this initial screening for a final screening.

Risks

There is no human risk for participating in this research.

Benefits

If your child participates in this research, and if there is hearing loss detected, he/she will be referred for further diagnosis.

Confidentiality

The information that we collect from this research project will be kept confidential. Information about your child that will be collected from the research will be secured and only those directly involved in this research will have access to it. Any information referring specifically to your child will have a code that will only be known to those involved in the research. The code will be secured with a lock and key.

Right to Refuse or Withdraw

You do not have to agree to your child taking part in this research if you do not wish to do so and refusing to allow your child to participate will not affect your treatment or your child's treatment at this ward in any way. You and your child will still have all the benefits that you would otherwise have at this ward. You may stop your child from participating in the research at any time that you wish without either you or your child losing any of your rights as a patient here. Neither your treatment nor your child's treatment at this centre will be affected in any way.

Whom to Contact

If you have any questions you may ask them now or later, even after the study has started. If you wish to ask questions later, you may contact me, Ms Barbara Birago Antwi, at the ENT Department KATH Tel: 0277599827. Email frimbarbs@yahoo.com

APPENDIX B

Certificate of Consent

I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions that I have asked have been answered to my satisfaction. I consent voluntarily for my child to participate as a participant in this study.

Name of Participant_____

Name of Parent or Guardian_____

Signature of Parent or Guardian_____

Date _____

Day/month/year

If Illiterate

A literate witness must sign (if possible, this person should be selected by the researcher and should have no connection to the research team). Participants who are illiterate will include their thumb print as well.

I have witnessed the accurate reading of the consent form to the parent of the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Printed name of witness_____ AND Thumb print of parent

Signature of witness _____

Date _____

Day/month/year

Statement by the Researcher Taking Consent

I have accurately read aloud the information sheet to the parent of the potential participant, and to the best of my ability made sure that the person understands that the following will be done:

1……

2……

3……

I confirm that the parent was given an opportunity to ask questions about the study, and that all the questions asked by the parent having been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

A copy of this ICF has been provided to the participant.

Printed name of researcher taking the consent_____

Signature of Researcher/person taking the consent_____

Date _____

Day/month/year

.This consent form was adopted from the WHO (World Health Organization) informed consent form template.

APPENDIX C

Hearing Screening Questionnaire

COLLEGE OF HEALTH SCIENCE

SCHOOL OF MEDICAL SCIENCES

Ear-Nose and Throat Department

KWAME NKRUMA UNIVERSITY OF SCIENCE AND TECHNOLOGY

INFANT HEARING SCREENING QUESTIONNAIRE FORM

CHILD'S NAME:_____

DOB:_____

PARENT'S NAME: _____

PHONE:_____

ADDRESS: _____

DATE:_____

GENDER: _____ SCREENED BY_____

_____

Answer all questions and explain where necessary. In the case of YES/NO circle as appropriate.

1. Have you heard of infant hearing screening? YES / NO

   If yes, through which medium? Television / print media / advert, state other

2. Maternal Pregnancy: (circle one) Full term. Premature.

3. Birth Delivery: (circle one) Natural C- Section Prolonged Labour

4. Was the baby admitted for having any of these Risk-Factors? Circle:

i Maternal infections during pregnancy or delivery (Toxoplasmosis , Syphilis, HIV, Hepatitis B,

ii Rubella, CMV, Herpes simplex, and others)

iii Physical problems of the head, face, ears, or neck (cleft lip/palate, ear pits/tags, atresia, and others)

iv Ototoxic medications given in the neonatal period

v Syndrome associated with hearing loss (Pendred, Usher, Waardenburg, and neurofibromatosis)

vi Admission to a neonatal intensive care unit greater than 5 days

Prematurity (< 37 weeks)

vii Asphyxia

5. Does child have any genetic disorder? YES / NO

If yes explain:

6. Does any of your child's biologic relatives have a hearing loss? YES/ NO

If yes explain:

7. Has your child ever had any head trauma? YES / NO If yes explain: