

**UNIVERSITY OF GHANA**  
**SCHOOL OF ALLIED HEALTH SCIENCE**

**HEARING SCREENING OF NEWBORN BABIES AT KORLE  
BU TEACHING HOSPITAL, ACCRA, GHANA**

**BY**

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**THIS THESIS/DISSERTATION IS SUBMITTED TO THE UNIVERSITY  
OF GHANA, LEGON IN PARTIAL FULFILMENT OF THE  
REQUIREMENT FOR THE AWARD  
OF MSc AUDIOLOGY DEGREE.**

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## DECLARATION

I, **JOYCE ESENAM ANOMAH** hereby declare that this dissertation which is being submitted in partial fulfilment of the requirements for the degree of MSc. in Audiology is the result of my own independent research project or investigation and that, except where otherwise other sources are acknowledged with explicit references and are included in the reference list, this work has not previously been accepted in substance for any degree and neither is it being concurrently submitted in candidature for any degree.

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## **DEDICATION**

I dedicate this work with gratitude to my parents.



## ACKNOWLEDGEMENTS

In work of this capacity, it would be impracticable to acknowledge every individual who either through professional or personal interest gave me assistance. To all those who gave me invaluable assistance, I wish to extend my sincere appreciation for your love, patience and support.

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## ABSTRACT

**BACKGROUND:** Hearing loss is often referred to as the invisible handicap and has been defined as debilitating, isolating and a frequently occurring abnormality present at birth. Early identification of hearing loss is important because early auditory deprivation owing to congenital or early-onset hearing loss interferes with the development of the neural structures necessary for hearing and subsequent speech and language acquisition. Data on neonatal hearing screening in Ghana is very sparse.

**AIM:** To screen the hearing of neonates using otoacoustic emissions (OAEs) at the Korle-Bu Teaching Hospital (KBTH), Accra.

**METHODS:** A descriptive survey on 511 neonates aged 1–3 months who were attending clinic at the Reproductive Health Section (RHS) of the Korle-Bu Teaching Hospital (KBTH) during the period April 2013 and June 2013 was conducted. Mothers/caregivers of neonates answered questions on their health during pregnancy, duration of pregnancy and medical history of neonates. Neonates were screened with AuDx PRO otoacoustic emissions (OAE) instrument.

**RESULTS:** 511 neonates were screened for hearing loss at the KBTH of which females constituted 52.4% and 47.6% were males. 80.8% of the participants successfully passed the screening test in both ears during the initial screening and an additional 5.7% also passed after rescreening. However, 9.2% of the participants failed to report for rescreening. 11.5% of the population screened had risk factors. Among the total of 511 respondents, 99.2% of their mothers/caregivers showed no awareness of neonatal hearing screening. Only 0.8% of the respondents claimed to have some knowledge of neonatal hearing screening.

**CONCLUSION:** The risk factors for hearing loss identified with the neonates were birth asphyxia, neonatal jaundice, sepsis, chicken pox and respiratory distress. There were infants who had more than one risk factor. Even though 18% of the neonates were referred in either one or both ears, about 9.2% of them did not return for rescreening. Very few mothers/caretakers (0.8%) claimed to have some knowledge about neonatal hearing screening. The remaining 99.2% had no knowledge about neonatal hearing screening.



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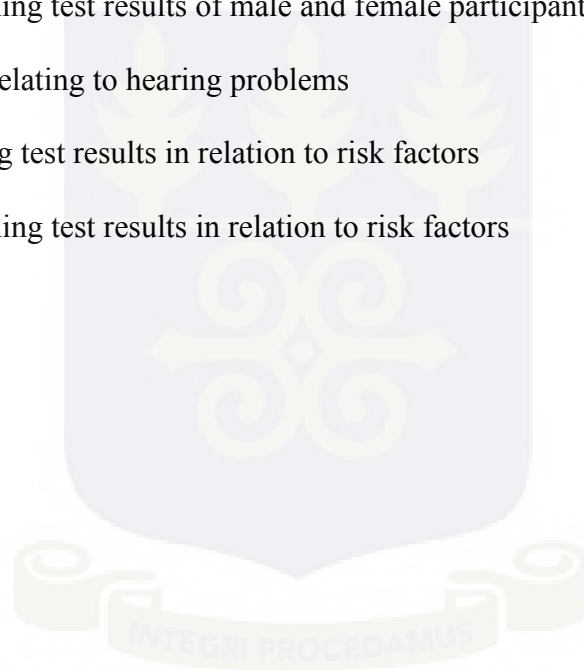
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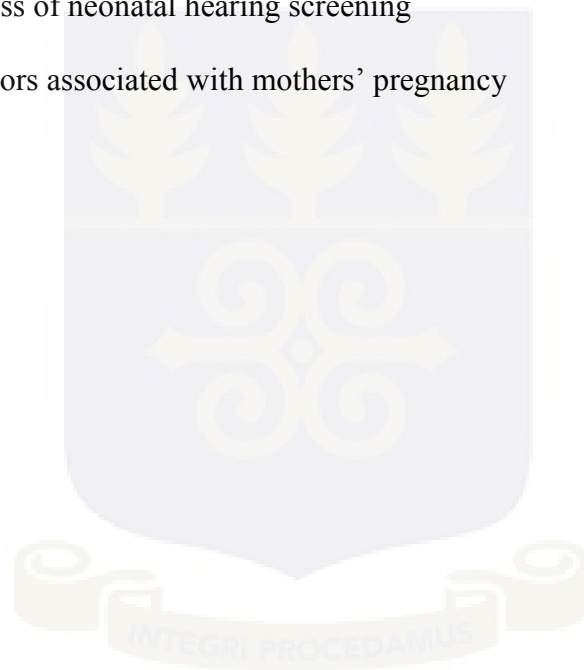
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## CHAPTER ONE

### INTRODUCTION

#### 1.1 BACKGROUND

Hearing loss is often referred to as the invisible handicap and has been defined as debilitating, isolating and a frequently occurring abnormality present at birth. (Lim & Fortaleza, 2000). The invisible nature of hearing loss makes detection difficult. For this reason, identification of hearing loss at the earliest possible age has been one of the aims of the field of Audiology during the last 60 years (Northern & Downs, 2002). Indeed, early identification of hearing loss is important because early auditory deprivation owing to congenital or early-onset hearing loss interferes with the development of the neural structures necessary for hearing and subsequent speech and language acquisition (Gravel & Tocci, 1998). This development of language and communication serves as the foundation of normal early childhood development. Any delay in acquiring these skills negatively influences literacy, academic achievement, social and personal development (Diefendorf, 2002). Hearing impairment may be conductive, sensorineural or mixed (combination of both conditions). Hearing impairments may affect one or both ears, as well as vary from mild to profound in degree, and may be congenital or acquired, transient, recurrent, or permanent.

Early detection of hearing loss in neonates and infants is very important for early intervention and has consequently become a major subject of study in the last century (Mencher et al., 2001). Children with hearing loss are at risk for poor academic achievement and delays in mastering language and critical thinking abilities and are prone to disturbances in social and emotional development later in life (Wagenfeld, 2003; Calderon, 1998). Delays in social, emotional and behavioral development stemming from a hearing loss in children hinder them from reaching

their full potential in life. Consequently, preventing such delays is the central aim of early detection programmes designed to identify hearing loss in neonates and to provide early screening and appropriate intervention. The benefits of early detection have been underscored by several authorities (McHale, 2003; Atkins, 2002; Arehart et al., 1998; Lasky et al., 1998). As a result, calls for universal hearing screening programmes for neonates and infants in every country have been proposed by the Joint Committee on Infant Hearing (JCIH, 2000). Early detection of hearing impairment in neonates is therefore critical for prompt intervention and prompt therapy.

## **1.2 RESEARCH PROBLEM STATEMENT**

The need for the identification of neonates and infants with risk factors before they are discharged from hospital cannot be over emphasised. In spite of this, there is sparse literature to determine the incidence and prevalence of hearing loss in neonates and infants in Ghana. This may be attributed to the lack of awareness of early hearing screening and the impact of hearing loss on the child's development. Furthermore, the low priority given to hearing loss screening is due to the lack of audiologists in many health institutions.

The inability of the Government of Ghana to implement a comprehensive hearing loss programme might also be due to the lack of resources such as equipment. One way to begin the process of getting started in developing and implementing a comprehensive early hearing identification programme is to develop a pilot study to assess the situation.

## **1.3 AIM OF THE STUDY**

The main aim of the study is to screen the hearing of neonates using otoacoustic emissions (OAEs) at the Korle-Bu Teaching Hospital (KBTH), Accra.

#### **1.4 OBJECTIVES OF STUDY**

The specific objectives in this study are:

- Compilation of subject profile
- Identification of risk factors of hearing loss, if any
- Screening for hearing loss in neonates using otoacoustic emissions
- Determination of awareness of neonatal hearing screening

#### **1.5 RESEARCH QUESTIONS**

The questions posed in respect of this research work are:

1. What are the characteristics (profile) of the children being screened?
2. What risk factors predispose children to hearing loss?
3. What is the follow up rate of referred cases?
4. What is the level of awareness of neonatal hearing screening?

#### **1.6 SIGNIFICANCE OF THIS STUDY**

Hearing loss is a significant problem among children in many countries worldwide. Of all the neonates born with significant hearing loss each year, about 90% of them are found in developing countries (Olusanya, Luxon, & Wirz, 2004). Developing countries lack clinical standards with regard to the implementation of screening programmes (Mencer, & DeVoe, 2001). This situation is compounded by the lack of proper equipment, staff and other facilities (Olusanya, Luxon, & Wirz, 2004). Although, hearing impairment might not be as life threatening as AIDS and meningitis, it can however lead to a reduced quality of life for the individual (Swanepoel et al., 2004).

In Ghana, there is a critical shortage of audiologists. This means that, the implementation of a total hearing screening programme will be difficult if not impossible. For countries which lack the resources for a comprehensive screening programme, 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 of a hearing loss based on established risk factors (Chiong et al., 2003). These risk factors are associated with children admitted to the neonatal intensive care unit (NICU) for at least 48 hours, or children who have syndromes associated with congenital hearing loss, children with a family history of hearing impairment, children with abnormality in the pinna as well as children with *in-utero* infection due to herpes and other viruses.

### **1.7 SCOPE OF WORK**

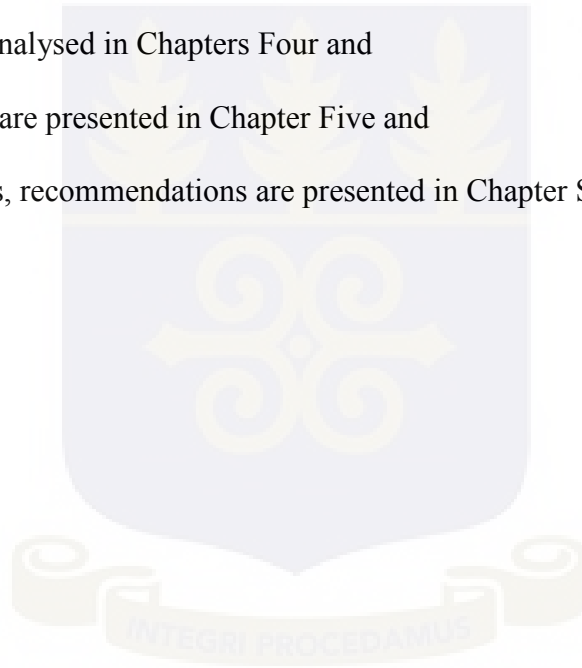
The project aimed at screening neonates using OAEs. Data from this study will be used to establish a database for the use of audiologists and other professionals in Ghana. This study is of significance because hearing loss in neonates is common in developing countries around the world. The problem is 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. The screening of neonates who visited the Weighing Centre at KBTH using OAEs
2. The tools used were a questionnaire sheet and the AuDx PRO Bio-Logic apparatus.
3. Analysis of data was done using a statistical package.

## 1.8 ORGANISATION OF WORK

The research work has been arranged in this volume as follows:

1. In Chapter One, introductory notes on hearing loss are outlined. In addition, the effects of hearing loss in children are discussed.
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 were collected. Factors that influence the data collection were also discussed.
4. The results are analysed in Chapters Four and
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. The importance of hearing is discussed as well as the difference between normal hearing and hearing loss. The importance of early identification and the historical perspective of New-born Hearing Screening (NHS) are also discussed. The current status of NHS in the developing world is subsequently discussed and Targeted New-born Hearing Screening (TNHS) is examined as a screening method for use in developing countries with limited resources and personnel. Challenges that may affect the success of NHS programme in developing countries and NHS in Ghana are subsequently discussed.

#### **2.2 IMPORTANCE OF HEARING**

Hearing improves lives and makes it possible to socialise, work, interact and communicate. A good ability to hear also helps to keep safe by warning of possible danger or alerting us to someone else's distress. Hearing is vital for us to be able to live and participate in life more fully. In view of these, individuals who have problems with their hearing may have feelings of isolation and even depression. Hearing makes available to us vast source of information. Hearing helps people to lead their everyday lives without limitations (Oticon.com,2013).

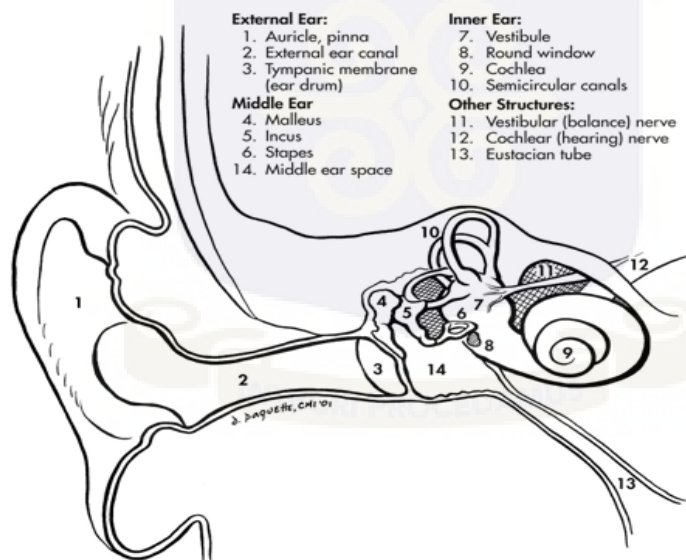
The ear, as small as it is, is a highly complex organ. It acts as sound filter, among other functions, and transforms every sound audible to us into accurate information the brain can prioritise (Oticon.com, 2013).

### 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. (Oticon.com, 2013).

### 2.4 HOW DO WE HEAR?

Sound travels through the air in waves resulting in a series of vibrations within the ear for hearing to occur (Fig. 2.1).



**Fig.2.1: Structure of the ear**

The sound travels both by air conduction and by bone conduction until it reaches the inner ear in individuals with normal hearing. A snail-shaped structure containing thousands of hair cells are found in the inner ear called the cochlea. These hair cells respond to sound and convert the mechanical vibrations into electrical signals. In effect, the electrical signals are sent up the

auditory nerve to the brain. The brain then interprets those signals into meaningful sounds such as speech. Hearing involves both the ear's ability to detect sounds and the brain's ability to interpret these sounds (Oticon.com, 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. The disturbance of the waves must be audible before it can be called sound. 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).

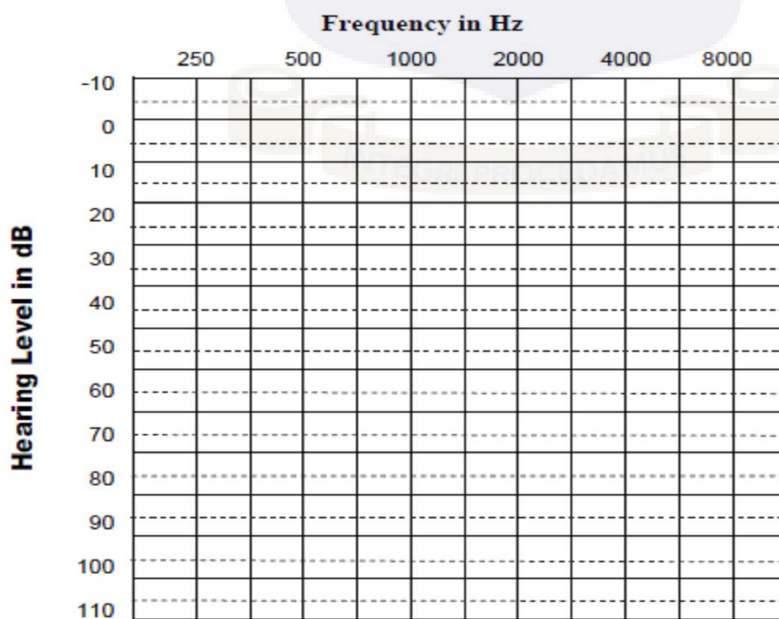
The auditory system of human beings is sensitive to a wide range of frequencies (20 – 20,000 Hz). The human auditory system is also sensitive to intensities ranging from 0 – 140 dB SPL. Frequencies within the speech range (250 – 6,000 Hz) are where humans are most sensitive to sound (Clinical Practice 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**

In general, hearing loss can occur if any part of the auditory system encounters a problem. These problems include malformation of the ear canal, problems with the tympanic membrane (eardrum), ossicles in middle the ear (malleus, incus, and stapes), the middle ear space, or the inner ear (cochlea) (Clinical Practice Guideline, 2007). 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 had 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 the frequencies of the sounds and the vertical axis depicts the hearing level in decibels (Clinical Practice Guideline, 2007).



**Fig. 2.2: Audiogram**

According to the American Speech-Language and Hearing Association (ASHA), an audiogram is a graph that shows the results of pure-tone hearing tests. It illustrates the type, degree, and configuration of hearing loss (ASHA, 2011). The frequency of the sound is measured in Hertz (Hz). The intensity of the sound is measured in decibels (dB). Each vertical line from left to right represents a pitch, or frequency, in Hertz (Hz). The graph starts with the lowest pitches on the left side and moves to the very highest pitches (frequencies) tested on the right side. The range of frequencies tested by the audiologist are 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000Hz, 4000 Hz, and 8000 Hz. Each horizontal line on the audiogram from top to bottom represents intensity in decibels (dB). Lines at the top of the chart (-10 dB and 0 dB) represent soft sounds. Lines at the bottom of the chart represent very intense sounds. (ASHA, 2011).

## **2.7 TYPES OF HEARING LOSS**

A hearing loss can be classified as a conductive, sensorineural, or mixed, based on the location of the problem. A hearing loss may also be labelled as unilateral (loss in one ear) or bilateral (loss in both ears). The degree of loss might be the same in both ears (symmetrical hearing loss), or it could be different for each ear (asymmetrical hearing loss). Types of hearing loss include:

### **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. 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.

Some of the causes of conductive hearing loss include:

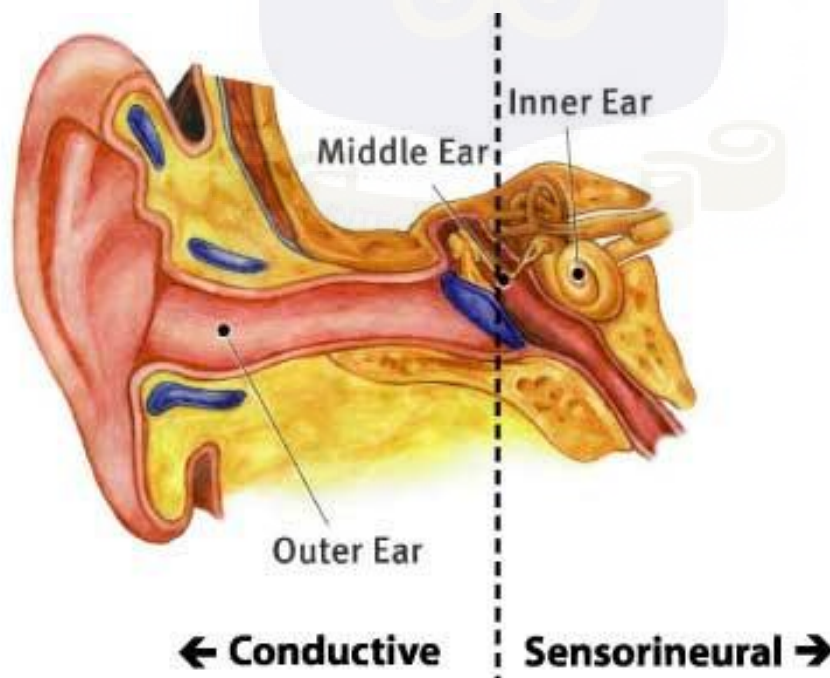
- **Cerumen obstruction:** Cerumen (ear wax) can be identified by a thorough examination of the ear with an otoscope and can usually be removed quickly. This condition may actually be worsened by an attempt to clean the ears with cotton swaps (Q-tips). (Conductive Hearing Loss: Causes and Treatments, 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, 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 2013).
- **Atresia of the 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 (Understanding Ear Infections, 2013)
- **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).
- **Cholesteatoma:** This may develop when the ear drum collapses to the point that the outer skin of the ear drum grows into the middle ear and becomes trapped. In spite of the ending of the word cholesteatoma, this is not a tumor but a benign collection of skin that can cause destruction of the middle ear structures and, if left untreated results in more

serious problems. This is almost always a surgical disease and may require a staged surgical approach (more than one surgery) in order to safely remove the cholesteatoma and restore hearing by repairing the damaged middle ear bones (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 (Fact Sheet: What You Should Know about Otosclerosis, 2013).



**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**

This type of hearing loss occurs due to damage to the cochlea hair cells or to the auditory nerve. Subsequently, neural impulses are not able to reach the brain in a normal manner. The air conduction thresholds are nearly the same as the bone conduction thresholds. According to the Hearing Loss Association of America (HLAA), during physical examination of the ear, sensorineural hearing loss may be overlooked due to the fact that the outer and middle ear will look normal. Sensorineural hearing loss is nearly always irreversible (Northern & Downs 1991). Some causes of sensorineural hearing losses are; exposure to loud noise, head trauma, virus or disease, autoimmune inner ear disease, hearing loss that runs in the family, aging (presbycusis), malformation of the inner ear, Meniere's Disease, otosclerosis and tumours (HLAA, 2013).

### **2.7.3 Mixed Hearing Loss**

This type of hearing loss results from problems in both the middle and the inner ear.

### **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 as 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 one of the hearing more 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** (Adapted from Clark, 1981)

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

Figure 2.4 identifies basic speech sounds during normal conversation. Consonants are higher pitched than vowels (they lie more to the right on the chart). They are also spoken more softly than vowels (they lie higher on the chart, in the lower decibel ranges) (The Essential Guide to Hearing Loss, 2013).

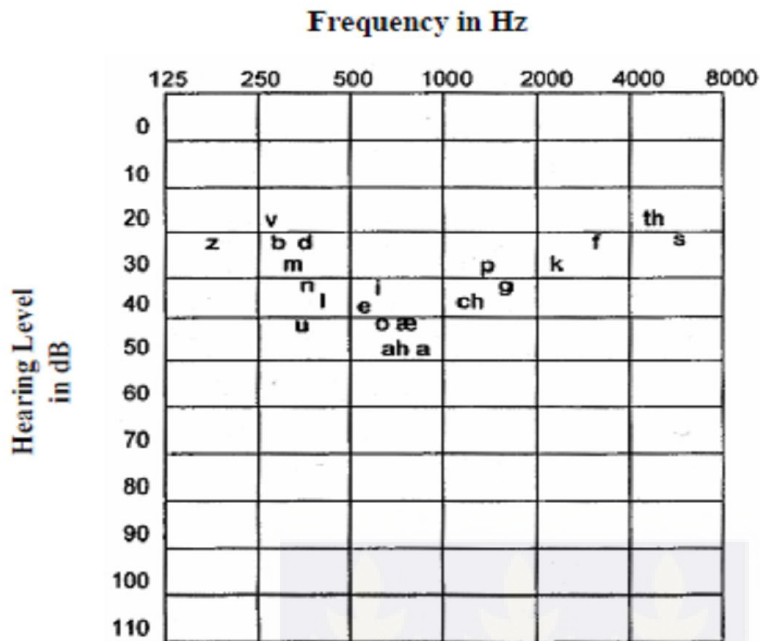
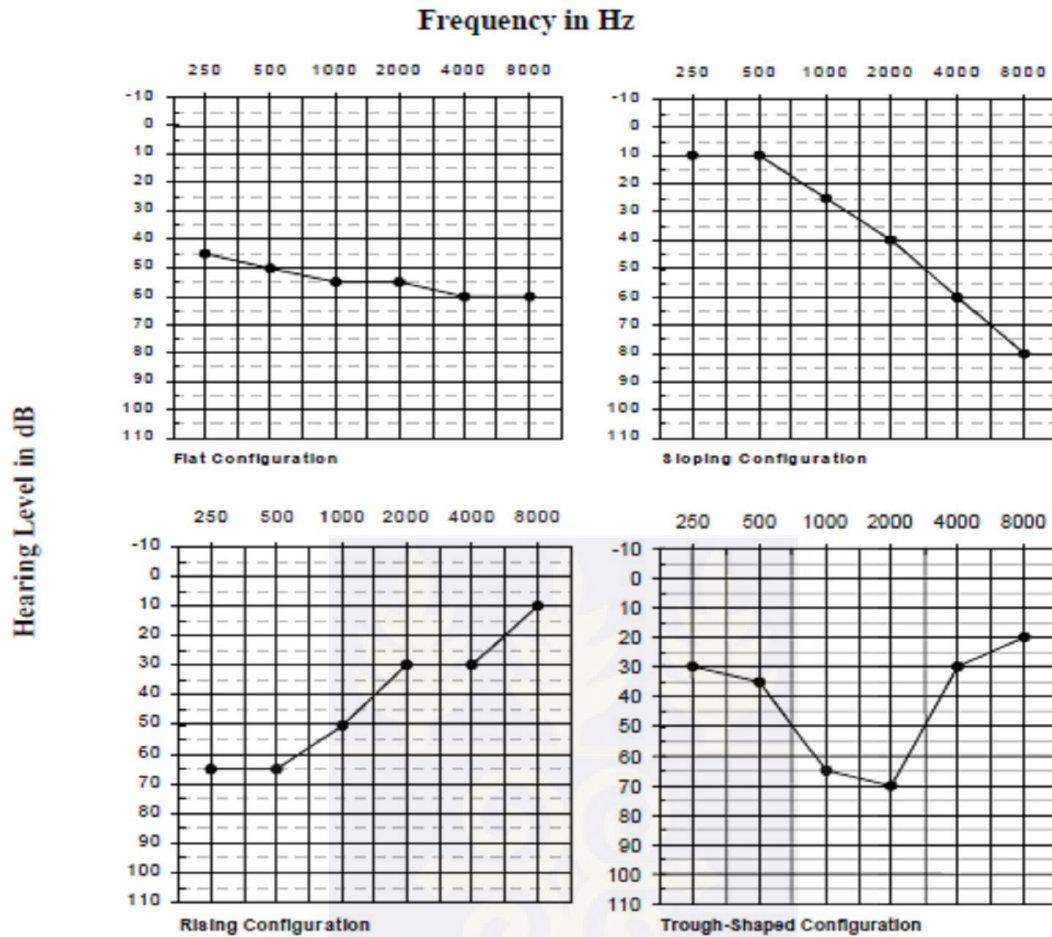


Fig.2.4: Example of Speech Sounds Audiogram (Adapted from: Stach, 1998)

## 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.

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



**Fig. 2.5:** Graph of the four general configurations of hearing loss (Clinical Practice Guideline, 2007)

**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 results 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).

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

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### **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

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### **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 microphone 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.

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### **Behavioral 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 behavioral response procedure.
  - *Visual reinforcement audiometry (VRA).* A conditioned behavioral 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 defects 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 et al., 2000).

If appropriate and if 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**

Yoshinaga-Itano, et al. (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 cutoff 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 5 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.

## **2.15 HISTORICAL PERSPECTIVE OF UNIVERSAL 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 producers 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.

Even though JCIH (2000) has identified certain risk indicators that are associated with infant and childhood hearing loss, 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).

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

<b>Risk factors for hearing loss</b>	
<b>1</b>	Admission to a neonatal intensive care unit (NICU) for 48 hours or longer
<b>2</b>	Family history of permanent childhood sensorineural hearing loss
<b>3</b>	<i>In utero</i> infection such as cytomegalovirus, herpes, toxoplasmosis, or rubella
<b>4</b>	Postnatal infections associated with hearing loss (such as bacterial or meningitis)
<b>5</b>	Exposure to ototoxic medications (such as aminoglycoside antibiotics, cisplatin chemotherapy agents, and certain loop diuretics)
<b>6</b>	Craniofacial anomalies, especially those with abnormalities of the ear or ear canal
<b>7</b>	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 extracorporeal membrane oxygenation (ECMO)
<b>8</b>	Findings associated with a syndrome known to include or be high risk for hearing loss <ol style="list-style-type: none"> <li>1. Syndromes associated with sensorineural and/or conductive hearing loss (such as Waardenburg syndrome)</li> <li>2. Syndromes associated with progressive hearing loss (such as neurofibromatosis and osteopetrosis)</li> <li>3. Genetic conditions that are likely to have associated hearing loss (such as Down syndrome and Usher syndrome)</li> <li>4. Neurodegenerative disorders (such as Hunter syndrome) or sensory motor neuropathies</li> </ol>
<b>9</b>	Head trauma (especially with fracture of the temporal bone)
<b>10</b>	Recurrent or persistent otitis media with effusion (OME) for at least 3 months
<b>11</b>	Parental or caregiver concern regarding hearing, speech, language, and/or developmental delay

(Adapted from: JCIH 2000)

A demonstration project using otoacoustic emissions screening in Rhode Island and Hawaii was financed by The Maternal and Child Health Bureau and Department of Education in 1989. The

National Institutes of Health Consensus Development Conference and its endorsement of universal newborn hearing screening became a reality because of the project in Rhode Island and Hawaii. (White and Behrens, 1993) as cited in Thompson 2007.

In September 1990, the Department of Health and Human Services released Healthy People 2000 (National Health Promotion and Disease Prevention Objectives). The objectives were a strategy to improve the health of Americans by the end of the century (Centers for Disease Control and Prevention, 2013). One of the objectives of The Healthy People 2010 goals was to increase the proportion of newborns who are screened for hearing loss by one month, newborns who do not pass the screening have audiologic evaluation by 3 months, and then should be enrolled in appropriate intervention services by 6 months (U.S. Department of Health and Human Services, 2000) as cited in JCIH, 2000.

## **2.16 NEONATAL HEARING SCREENING IN THE DEVELOPING 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 et al., 2006; Gopal et al., 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.

Infectious diseases are a deadly reality in a lot of developing countries. Because health care needs of people in developing countries are graded according to the degree of importance, life-threatening diseases are consequently the main priority in the health care system (Olusanya, 2000). As a result, emphasis is placed on saving the lives of citizens in healthcare systems rather than improving their quality of life (Olusanya, 2005). Dealing with infectious diseases is a problem that is hard to deal with in many developing countries for that reason any proposal for a NHS programme is met with some opposition (Swanepoel et al., 2005).

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. Furthermore, the demand for hearing aids and effective reinforcement in providing services also acts as a barrier for most developing countries. 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. However, using HRR alone was not adopted as a true hearing screening tool (Hayes, 2003). 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).

Identification of hearing loss in neonates younger than 6 months using behavioural observation audiometry (BOA) has been criticized as inaccurate and invalid (Diefendorf, 2002). According to data posted at the University of Michigan Health System website, BOA is used to measure the hearing acuity by using undefined responses to sound. The procedure is done by presenting acoustic stimulus to the neonate while the neonate is observed for responses. Even though the method to some extent can give an idea about the presence of a hearing loss, the limitation of the method is that it depends solely on the audiologist's observations to determine when a response to an acoustic stimulus has occurred (University of Michigan Health System, 2013).

Yoshinaga-Itano & 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 have pose 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 assessing

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 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 et al., 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 et al., 2005; Owens et al., 1993; Akdogan & Ozkan, 2006). Some significant factors that pose challenges to hearing screening programmes are outlined as follows:

**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 et al., 1996). 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., 1996). 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, 2012 & Hearing Evaluation in Children) 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 overlooked 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.

**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 a effects on a hearing screening programme (John et al., 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 et al., 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 et al., (2010).

## **2.18 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 countries (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.



## **CHAPTER THREE**

### **METHODOLOGY**

#### **3.0 INTRODUCTION**

This Chapter addresses the study design, sampling method, materials and equipment used in data collection as well as the data collection procedure.

#### **3.2 STUDY DESIGN**

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 use 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).

#### **3.3 SAMPLING METHOD**

Convenience sampling involves choosing the nearest individuals to serve as respondents and continuing that process until the required sample size has been obtained or those who happen to be available and accessible at the time (Cohen et al, 2007). This study employed convenience sampling. All neonates who were brought to the KBTH reproductive health section (RHS) 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.

### **3.4 STUDY SITE (S)**

This study was conducted at the KBTH in Accra. The sampling was done at the RHS of KBTH in Accra while interviews and screenings were performed at the Korle-Bu Hearing Assessment Centre (HAC).

### **3.5 STUDY POPULATION**

All infants aged 1–3 months attending clinic at the RHS of the KBTH during the period April 2013 and June 2013 were enrolled in this study. Neonates and infants were only enrolled in the study after written consent had been obtained from their mothers or caregivers (consent form attached as appendix A).

### **3.6 MATERIALS AND EQUIPMENT**

#### **3.6.1 Data Collection Material**

An open ended 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.

#### **3.6.2 Data Collection Instrumentation**

A handheld OAE instrument (AuDx PRO Bio-Logic) 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 AuDx PRO Bio-Logic device used in this study 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

### 3.6.3 Procedure for Data Collection

The RHS of KBTH was visited every weekday morning. The purpose and procedure for data collection was explained to mothers/care givers who were attending their two or six week’s

doctor's appointment. Mothers/caregivers who expressed interest in the study were asked to report to the HAC for hearing screening, data collection and interviews. Informed consent letters 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. The HAC is about hundred meters from the reproductive health section of the KBTH. A structured face-to-face interview (Appendix B) was conducted on 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 AuDX PRO OAE system and their results were recorded. The automated OAE results of the initial screening as well as follow-up results (referred neonates or infants) were recorded on the questionnaire sheet.

### **3.7 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 cry 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 later (at a time to coincide with the next doctor's appointment). If the neonate or infant was referred again in one or both ears at the rescreening appointment, he/she was referred to the HAC for further diagnostic evaluation.

### **3.8 OTOACOUSTIC EMISSIONS**

Otoacoustic emissions (OAEs) are acoustical signals that can be detected in the ear. They occur impulsively 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 & Glatke, 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).

### **3.9 ANATOMY AND PHYSIOLOGY OF OAEs.**

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).

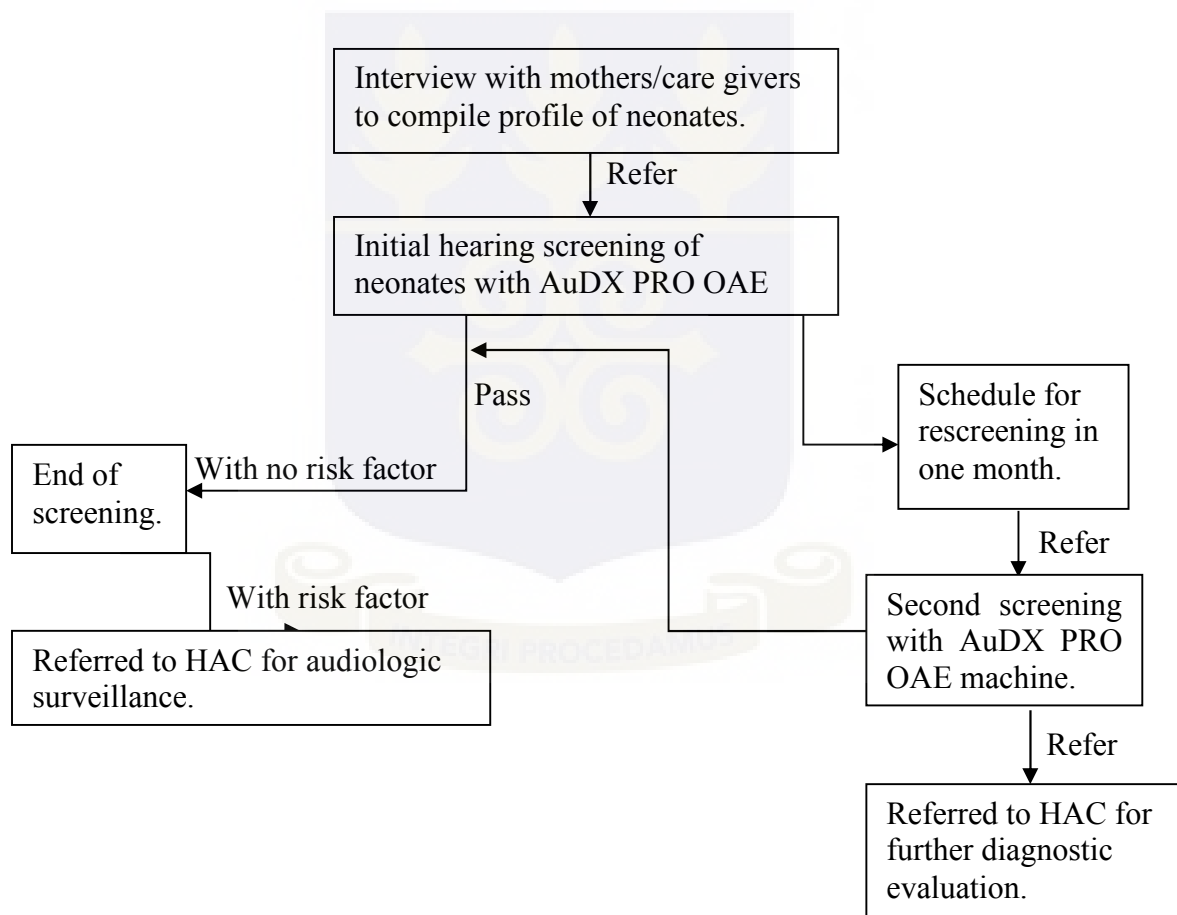
### **3.10 RECORDING OAE**

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 & Glatke, 1997).

For normal auditory function, the cochlea must be intact and functioning well. Both TOAEs and DPOAEs are screening tools that can be use 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).



**Fig. 3.1: Block diagram of instrumentation.**

### 3.11 VALIDITY AND RELIABILITY

Threats to validity and reliability cannot be removed completely but the effects of these threats can be minimized by 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, (AuDx PRO Bio-Logic system) was within calibration. A biologic calibration of the AuDx PRO Bio-Logic 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.
- 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 with 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 HAC at Korle-Bu.

### **3.12 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 visited the Korle-Bu RHS. The findings were entered into a Statistical Package for the Social Science (SPSS) version 16.0. spread sheet, analyzed, and the results discussed in chapter four.

### **3.13 ETHICAL CONSIDERATION**

Ethical clearance was obtained from the Ethics and Protocol review committee of the School of Allied Health Science (Appendix C). Permission was obtained from the KBTH'S HAC before data collection started (Appendix D). Consent was sought from parents and guardians of the subjects in data collection through a written notice from the school of allied health science (Appendix B). Assurance was given concerning confidentiality with regards to the data collection and safety.

## CHAPTER FOUR

### RESULTS

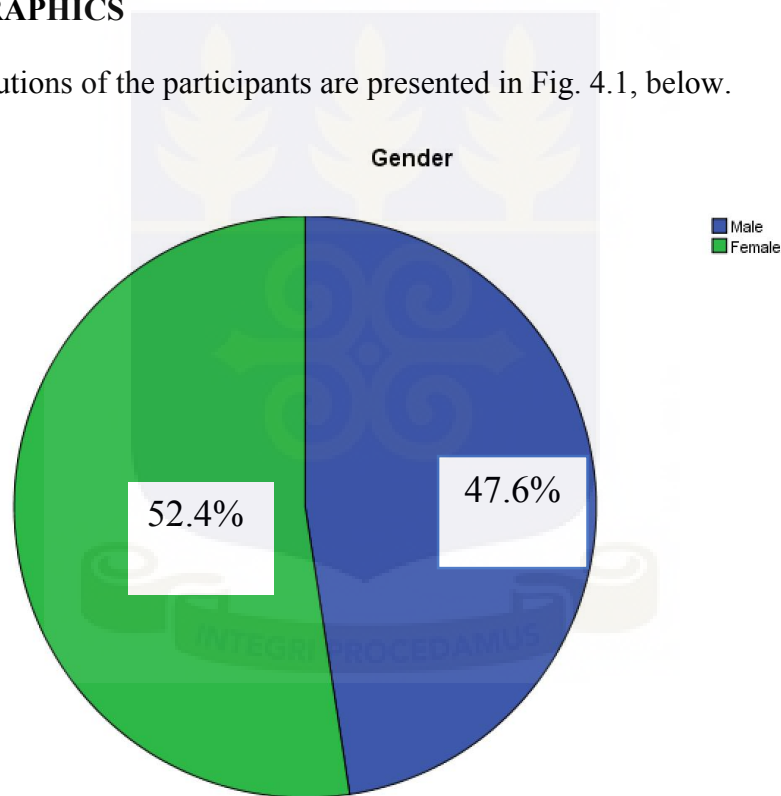
#### 4.1 INTRODUCTION

This chapter of the study provides the descriptive statistical results and analyses of the study.

The results are presented in both figures and tables. Below are the results of the study.

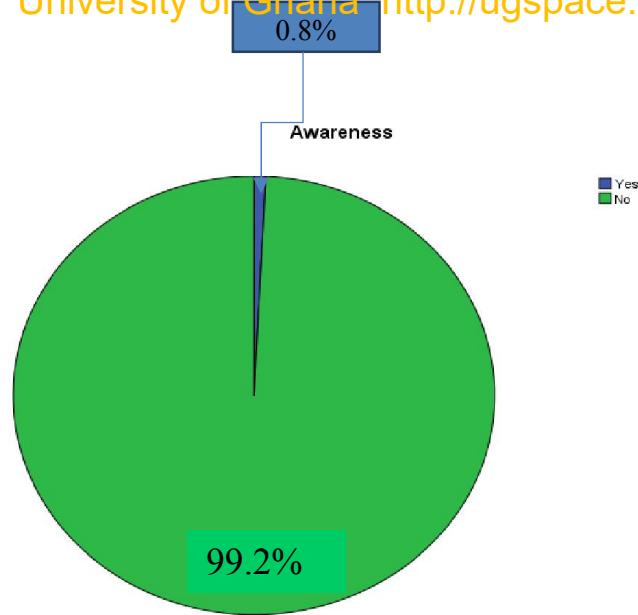
#### 4.2 DEMOGRAPHICS

The gender distributions of the participants are presented in Fig. 4.1, below.



**Fig. 4.1: Gender distribution of participants**

Figure 4.1 shows the gender distribution of the neonates in terms of percentages. From the figure, females constituted 52.4% while males were 47.6%.



**Fig. 4.2: Awareness of neonatal hearing screening**

Figure 4.2 provides a graphical view on parental awareness of neonatal hearing screening. Among the total of 511 respondents, 99.2% showed no awareness of neonatal hearing screening. Only 0.8% of the respondents claimed to have some knowledge of neonatal hearing screening. The results of the initial screening test are presented in Table 4.1.

**Table 4.1: Screening test results of male and female participants**

Results Category	Gender		Total	Percent (%)
	Male	Female		
Could Not Be Screened	1	4	5	0.98
Passed Both Ears	190	223	413	80.82
Passed Left Ear	15	12	27	5.28
Passed Right Ear	11	13	24	4.70
Failed Both Ears	26	16	42	8.22
Total	243	268	511	100.0

From Table 4.2, it can be deduced that the total number of children who underwent the screening exercise were 511 with the number of males ( $n = 243$ ) being less than the number of females ( $n = 268$ ). Out of this number, only 1% ( $n = 5$ ) could not be tested during the first screening exercise. However, 80.8% of the participants ( $n = 413$ ) successfully passed the screening test in both ears for the first test. The percentage of participants who passed in the left ear and therefore failed in the right ear was 5.3% ( $n = 27$ ). Similarly, 4.7% of the participants ( $n = 24$ ) passed in only the right ear and were therefore failed in the left ear. A total of 8.2% of the participants ( $n = 42$ ) failed in both ears for the first screening test and, as a result, were referred for a second screening. Most of these participants were males ( $n = 26$ ); females were fewer in number ( $n = 16$ ).

The results of the re-screening testing are shown in Table 4.2.

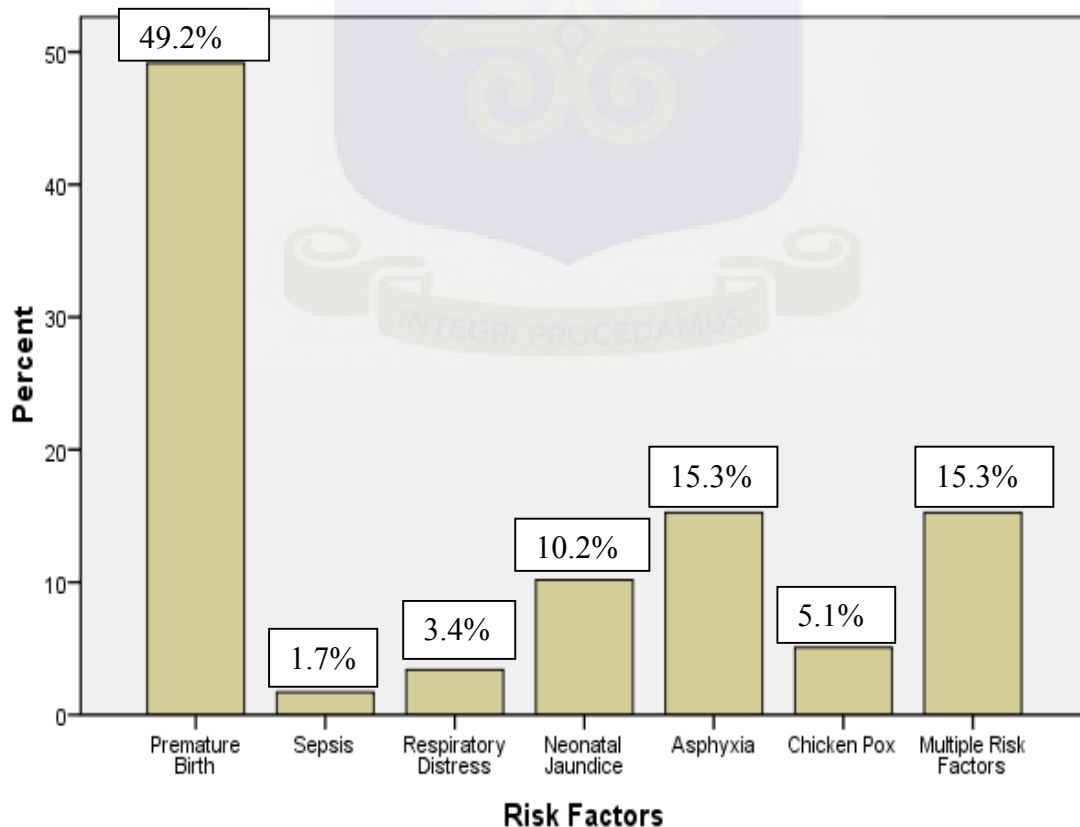
**Table 4.2: Rescreening test results of male and female participants**

Results Category	Gender		Total	Percent (%)
	Male	Female		
Passed in both ears	17	12	29	29.59
Passed in left ear	0	3	3	3.06
Passed in right ear	1	1	2	2.04
Failed in both ears	7	5	12	12.25
Failed to report for rescreening	27	20	47	47.96
Could not be rescreened	1	4	5	5.10
Total	53	45	98	100.0

Table 4.2 depicts the rescreening test results of neonates who did not pass the first screening. 19.2% of the participants ( $n = 98$ ) had failed in one or both ears or could not be tested for the first screening exercise and therefore ought to undergo a second screening. The rescreening test results established that an additional 29.6% of the participants ( $n = 29$ ) passed in both ears

(males: = 17; females  $n$ : 12). Moreover, 3.1% of the participants ( $n = 3$ ) consisting of only females passed in the left ear and as a result failed in the right and were referred for further audiologic assessment. Similarly, 2.0% of the participants ( $n = 2$ ) with an equal number of males and females passed in the right ear and therefore failed in the left ear. These neonates were also referred for further audiologic assessment. A total of 12.3% of the participants ( $n = 12$ ) consisting of both males ( $n = 7$ ) and females ( $n = 5$ ) still failed in both ears and were therefore referred for further audiologic assessment. However, 48.0% of the participants ( $n = 47$ ) failed to report for rescreening. There were more males ( $n = 27$ ) than females ( $n = 20$ ) in this category. A total of 3.3% of neonates failed in one or both ears after the initial and the rescreening testing in the current study.

Risk factors are associated with hearing loss. The identified risk factors and associated statistics are presented Fig. 4.3 and Table 4.3.



**Figure 4.3: Distribution of risk factors associated with mothers' pregnancy**

From the chart, it can be noted that the cases of premature birth were very predominant at 49.2% with the following: a) 1.7% were sepsis cases, b) 3.4% were respiratory distress cases, c) 10.2% were neonatal jaundice cases, d) 15.3% were asphyxia cases and 5.1% were due to chicken pox. Neonates who had or were exposed to more than one risk factor were categorized under the heading of multiple risk factors with 15.3%.

**Table 4.3: Factors relating to hearing problems**

Variable	Frequency ( <i>n</i> )	Percent (%)
<b>Maternal Pregnancy</b>		
Full Time	476	93.2%
Premature	35	6.8%
<b>Birth Delivery</b>		
Natural (%)	308	60.3%
C-Section	203	39.7%
<b>Genetic Disorder</b>		
Yes	0	0.0%
No	511	100.0%
<b>History of Hearing Loss</b>		
Yes	6	1.2%
No	505	98.8%
<b>Diagnosis of Birth Syndrome</b>		
Yes	0	0.0%
No	511	100.0%
<b>Head Trauma</b>		
Yes	3	0.6%
No	508	99.4%

Table 4.3 identifies the common risk factors associated with hearing loss. With reference to risk factors, only 6.8% of premature delivery cases were recorded ( $n = 35$ ). The remaining 93.2%

deliveries were full term cases ( $n = 476$ ). With regards to mode of birth delivery, 60.3% of the participants ( $n = 308$ ) had natural course of deliveries while 39.7% of the participants ( $n = 203$ ) underwent C-section. There was no case of genetic disorder among the participants.

Table 4.4 provides the distribution of the risk factors with respect to the screening test results. In all, 59 cases of risk factors were identified in the study. There were 29 cases of premature birth out of which 19 passed in both ears, 5 passed in only right ear and the remaining 5 failed in both ears. As a result, 10 cases of premature birth were referred for rescreening.

**Table 4.4: Screening test results in relation to risk factors**

Risk Factors	Passed on	Passed on	Passed on	Failed on	
	Both Ears	Left Ear	Right Ear	Both Ears	Total
premature birth	19	0	5	5	29
sepsis	1	0	0	0	1
respiratory distress	2	0	0	0	2
neonatal jaundice	6	0	0	0	6
asphyxia	8	0	1	0	9
chicken pox	2	1	0	0	3
multiple risk factors	9	0	0	0	9
<b>Total</b>	<b>47</b>	<b>1</b>	<b>6</b>	<b>5</b>	<b>59</b>

There was only one participant with sepsis that passed in both ears. There were 2 cases of respiratory distress and the neonates passed in both ears. There were six neonatal jaundice cases; all passed in both ears. There were nine cases of asphyxia of which eight passed in both ears and 1 in only the right ear. Three cases of chicken pox were recorded. Out of this, two passed in both ears and the one in only the left ear. Neonates who were exposed to multiple risk factors were nine all of whom passed in both ears.

**Table 4.5: Rescreening test results in relation to risk factors**

<b>Risk Factors</b>	<b>Passed in both Ears</b>	<b>Failed in Both Ears</b>	<b>Failed to report for Rescreening</b>	<b>Total</b>
Premature Birth	4	1	5	10
Sepsis	0	0	0	0
Respiratory Distress	0	0	0	0
Neonatal Jaundice	0	0	0	0
Asphyxia	0	0	1	1
Chicken Pox	0	0	1	1
Multiple Risk Factors	0	0	0	0
<b>Total</b>	4	1	7	12

Table 4.5 also displays the rescreening test results in relation to the risk factors identified. Out of the 10 referral cases of premature birth, four passed in both ears during rescreening, but one failed in both ears and therefore was referred for further audiological assessment. The remaining five failed to report for rescreening. There was only one referral case of asphyxia, however, the neonate refused to report for rescreening.

## 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

A total of 511 neonates were screened during the study consisting of 47.6% (243) males and 52.4% (268) females. About 5.28% ( $n = 27$ ) passed hearing in the left ear only and were referred in the right ear with a gender distribution of 55.56% males and 44.44% females respectively. Similarly, 4.7% of the participants ( $n = 24$ ) passed in only the right ear and referred in the left ear with a gender distribution 45.83% males and 54.17% females. A total of 8.2% of the participants ( $n = 42$ ) failed in both ears for the first screening test and consequently referred for second screening. Most of these referred participants were males ( $n = 26$ ).

#### 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 0.8% of the respondents claimed to have some knowledge of neonatal hearing screening. Currently, there are only 6 practising audiologists in Ghana whose 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 19.2% of neonates were referred during their first hearing screening test and that 1% of neonates could not be tested during their first visit. These results were slightly lower 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 3.3% 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. Hearing screening in the current study was conducted in a quiet room at the HAC at Korle-Bu while classroom play settings and homes were employed as venues in the study by Eiserman et al (2008).

There were 19.2% 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 most 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 no later than three months

(Department of Otolaryngology/ Head & Neck Surgery, 2013). Therefore, neonates who were referred in one or both ears 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 failed in the initial hearing screening, 6.7% them passed confirming the necessity of rescreening, while some failed in either one or both ears even after rescreening. This could be due to a noisy testing room, movement and crying during the test, hearing loss, fluid in the baby's ear or debris in the ear. As stated earlier since no diagnostic testing was done to confirm hearing loss due to time constrains.

Studies have showed that DPOAEs are known to be affected especially in the low frequencies by the presence of middle-ear conditions (Owens et al., 1993; Akdogan & Ozkan, 2006). It is therefore important to ensure that the status of the outer and middle ears are within the normal range as these structures form the pathway for stimuli to the inner ear and for reverse transmission of responses to the ear canal (American Academy of Audiology Childhood Hearing Screening Guidelines, 2011).

## **5.5 RISK FACTORS IDENTIFIED IN THE STUDY**

There was no case of genetic disorder among the participants as all the respondents answered "No" to the question "Does child have any genetic disorder?" In terms of history of hearing loss, 99.4% of the respondents ( $n = 508$ ) answered "No" to the question "Do any of your child's biological relatives have a hearing loss?" Only 1.2% of the respondents ( $n = 6$ ) responded "Yes" suggesting that they had a family history of hearing loss. There was no case of birth syndrome among the participants as all the participants responded "No" to the question "Was your child diagnosed at birth as having a syndrome?" With regards to head trauma, there was only 0.6% cases as 3 of the respondents answered "Yes" to the question "Has your child ever had any head trauma?"

Of the total number of neonates, 11.5% were identified with risk factors for hearing loss. Some of the risk factors identified were prematurity, sepsis, respiratory distress, neonatal jaundice, birth asphyxia and chicken pox. Neonates who had more than one risk factor were classified as having multiple risk factors. Out of a total number of 59 neonates identified with risk factors, 20.3% failed the initial screening, 1.8% of the neonates who failed during the initial screening did not turn up for rescreening. Neonates who failed rescreening test were referred for further audiologic assessment. Even though a greater number of neonates with risk factors for hearing loss passed the screening test, these neonates were referred for audiologic monitoring because the JCIH, (2000) recommends continues audiologic monitoring every 6 months until the age of 3 years for hearing loss for neonates that have passed the initial screening birth screening.

Of 511 neonates that participated in this study, 3.3% of neonates failed in one or both ears after rescreening but only 5.9% of neonates that failed in one or both ears showed any risk factors. Risk factors did not significantly predict refers in this study. The fact that 94.1% of newborns who failed hearing screening did not report any risk factors further supports the necessity of universal hearing screening instead of selective screening as recommended by the (JCIH, 2000).

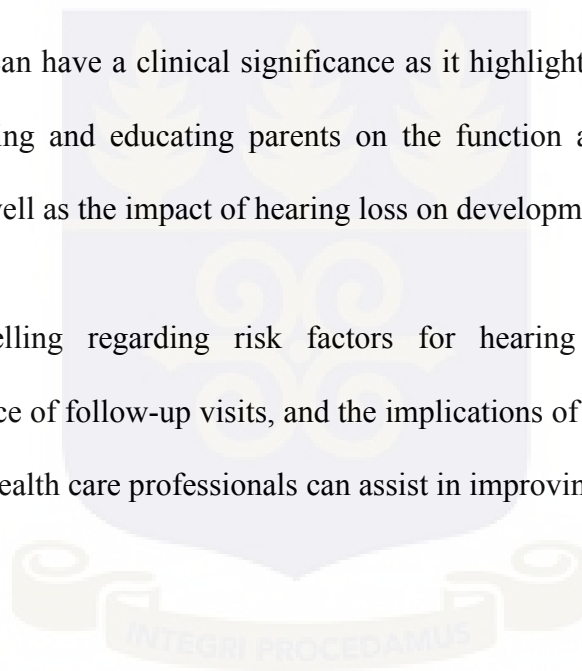
## **5.6 FOLLOW-UP RATE**

Roeser & Downs, (1981) cited in American Academy of Audiology Childhood Hearing Screening Guidelines (2011) have indicated that for a hearing screening protocol to be acceptable, it should correctly identify at least 90-95% of individuals with existing hearing loss and fail no more than 5-10% of individuals that would be considered to have acceptable hearing. In this study, diagnostic hearing evaluation was not carried out in the current study to ascertain why 2.3% of the participants failed in both ears, 0.6% in the right ear and 0.4% in the left ear after rescreening.

Despite the fact that 9.2% of neonates did not return for rescreening, this finding was far smaller than 68.6% that was recorded in a study by Kanji et al. (2010). The poor follow-up return rate in the current study may have been attributed to lack of awareness on the part of parent/guardians. 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.



## CHAPTER SIX

### CONCLUSIONS AND RECOMMENDATIONS

#### 6.1 INTRODUCTION

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

#### 6.2 CONCLUSION

The empirical research was conducted based on four research questions:

1. What are the characteristics (profile) of the children being screened?
2. What risk factors predispose children to hearing loss?
3. What is the follow-up rate of referred cases?
4. What is the level of awareness of neonatal hearing screening?

The neonates screened for hearing loss were babies who were born at KBTH and who reported for post-delivery doctor's appointment. The study sample comprised both well-baby and NICU graduates. The risk factors for hearing loss identified with the neonates were birth asphyxia, neonatal jaundice, sepsis, chicken pox and respiratory distress. There were infants who had more than one risk factor.

Even though 18% of the neonates were referred in either one or both ears, about 9.2% of them did not return for rescreening. Very few mothers/caretakers (0.8%) claimed to have some

knowledge about neonatal hearing screening. The remaining 99.2% had no knowledge about neonatal hearing screening.

### **6.3 LIMITATIONS OF THE RESEARCH**

The small sample size in the current study limited the generalization of results since it only included a small proportion of newborns within the period of the study. The size of this sample was significantly smaller than those in other studies.

No diagnostic evaluation was done for neonates who failed twice in the hearing screening program to ascertain if the reason(s) for failing were due to middle ear fluid, noisy testing room, movement and/ crying during the test, debris in the ear, risk factors relating to hearing loss or hearing loss. For this reason, no statistical inferences were made. No follow-up was made on neonates referred for diagnostic evaluation.

### **6.4 RECOMMENDATIONS FOR FUTURE RESEARCH**

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 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).
- Nurses, especially Ear, Neck 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.

- Hearing screenings should be conducted before neonates are discharged from the hospital or, a quiet room should be identified at the Reproductive Health Unit (KBTH) where hearing screenings can be conducted. Some mothers/caretakers did not bring their new-borns for screening because of the inconvenience in walking to the HAC.
- 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 is 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.

Despite the fact that the sample size for the current study was small; and therefore limited the generalization of the results, findings from the current study have significant implications for the implementation of universal new-born hearing screening programmes in Ghana.

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## **Appendix A**

### **UNIVERSITY OF GHANA SCHOOL OF ALLIED HEALTH SCIENCES COLLEGE OF HEALTH SCIENCES**

#### **INFORMATION SHEET**

##### **Introduction**

I am Ms Joyce Esenam Anomah, graduate student researcher at the University of Ghana School of Allied Sciences 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 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 Korle-Bu.

### **Duration.**

The research will take place over a period of six weeks. 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 centre in any way. You and your child will still have all the benefits that you

would otherwise have at this centre. 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 Joyce Esenam Anomah, at the University of Ghana School of Allied Sciences Tel: 0208486222. Email anomah4ryll@yahoo.

**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 have 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.

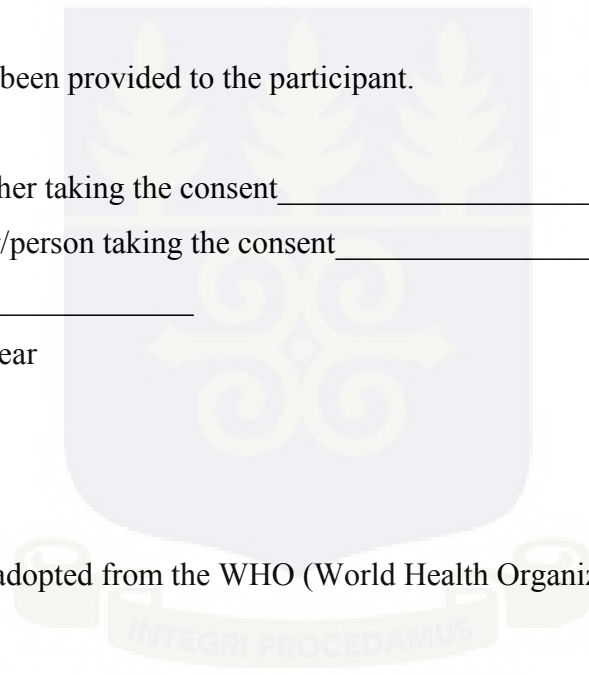
Printed name of researcher taking the consent \_\_\_\_\_

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 B**

**Hearing Screening Questionnaire**

**SCHOOL OF ALLIED HEALTH SCIENCES  
COLLEGE OF HEALTH SCIENCES  
UNIVERSITY OF GHANA**

**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 child exposed to any of the following during mother's pregnancy? Circle:

Toxoplasmosis YES / NO syphilis YES / NO rubella YES / NO

Cytomegalovirus YES / NO herpes YES/ NO other (explain)

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. Was your child diagnosed at birth as having a syndrome? (Such as Usher, Alport or Waardenburg) YES / NO

Explain:

8. Has your child ever had any head trauma? YES / NO

If yes explain:



**SCHOOL OF ALLIED HEALTH SCIENCES  
COLLEGE OF HEALTH SCIENCES  
UNIVERSITY OF GHANA  
ACADEMIC AFFAIRS**

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P. O. Box KB 143  
Korle Bu  
Accra  
Ghana

My Ref. No. SAHS/ 10310997  
Your Ref. No.

19<sup>th</sup> March, 2013.

Ms. Joyce E. Anomah,  
Dept. of Audiology  
SAHS,  
Korle Bu.

Dear Ms. Anomah,

**ETHICS CLEARANCE**

Ethics Identification Number: SAHS – ET. /10310997/AA/2A/2012-2013.

Following a meeting of the Ethics and Protocol Review Committee of the School of Allied Health Sciences held on Friday 10<sup>th</sup> April, 2013, I write on behalf of the Committee to approve your research proposal as follows:

**TITLE OF RESEARCH PROPOSAL:** "Hearing Screening of Newborn Babies at Korle-Bu Teaching Hospital Weighing Centre, Accra, Ghana"

This approval requires that you submit six-monthly review reports of the protocol to the Committee and a final full review to the Committee on completion of the research. The Committee may observe the procedures and records of the research during and after implementation.

Please note that any significant modification of the research must be submitted to the Committee for review and approval before its implementation.

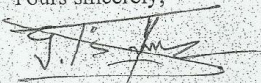
You are required to report all serious adverse events related to this research to the Committee within seven (7) days verbally and fourteen (14) days in writing.

As part of the review process, it is the Committee's duty to review the ethical aspects of any manuscript that may be produced from this research. You will therefore, be required to furnish the Committee with any manuscript for publication.

Please always quote the ethical identification number in all future correspondence in relation to this protocol.

Thank you.

Yours sincerely,



**Dr. (Maj. Rtd.) George Asare**  
**(Chairman, Ethics and Protocol Review Committee)**

cc    Dean  
      Co-ordinator, Dept. of Audiology  
      Senior Assistant Registrar

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P O Box KB 143,  
Korle Bu

My Ref. No. SAHS/

Your Ref. No.

March 21, 2013

The Head  
Hearing Assessment Centre  
Korle Bu Teaching Hospital

Dear Sir,

**PERMISSION TO CARRY MSc RESEARCH PROJECT AT THE HEARING  
ASSESSMENT CENTRE, KORLE BU TEACHING HOSPITAL**

Ms. Joyce Esenam Anomah is a 2<sup>nd</sup> year MSc Audiology student in the Department of Audiology of the University of Ghana School of Allied Health Sciences (SAHS).

She is conducting a MSc research project in neonatal new born hearing screening at the Hearing Assessment Centre of KBTH under the supervision of Dr E.D. Kitcher (KBTH) and Dr. N. Bofo (SAHS). The Ethical and Protocols Review Committee of the School has reviewed and passed his work as meeting all ethical requirements.

The Department would be most grateful if you could kindly grant her permission to carry out this important research project from April - June 2013 for the common good of the University and the hospital. Thank you.

Yours faithfully,

A handwritten signature in blue ink, appearing to read 'S. Anim-Sampong'.

**Dr. S. ANIM-SAMPONG**  
(Academic Coordinator)

cc: Dean (SAHS) Vice-Dean (SAHS) Dr. E.D. Kitcher (ENT, KBTH)



