

**A HEARING SCREENING PROGRAMME FOR INFANTS
FROM A NEONATAL INTENSIVE CARE UNIT IN A
SOUTH AFRICAN PROVINCIAL HOSPITAL**

BY
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LIST OF ABBREVIATIONS

AABR	-	Automated Auditory Brainstem Response
AOAE	-	Automated Oto-Acoustic Emissions
AAA	-	American Academy of Audiology
AAP	-	American Academy of Pediatrics
ABR	-	Auditory Brainstem Response
AIDS	-	Auto-Immune Deficiency Syndrome
AN/AD	-	Auditory Neuropathy/ Auditory Dys-Synchrony
ASHA	-	American Speech-Language-Hearing Association
daPa	-	Deca Pascal
DPOAE	-	Distortion Product Oto-Acoustic Emissions
EHDI	-	Early Hearing Detection and Intervention
HIV	-	Human Immune Virus
HPCSA	-	Health Professions Council of South Africa
HRR	-	High Risk Register
JCIH	-	Joint Committee on Infant Hearing
MEE	-	Middle Ear Effusion
NHS	-	Neonatal Hearing Screening
NICU	-	Neonatal Intensive Care Unit
OAE	-	Oto-Acoustic Emissions
TEOAE	-	Transient-Evoked Oto-Acoustic Emissions
TNHS	-	Target-Based Newborn Hearing Screening
UNHS	-	Universal Newborn Hearing Screening
UNICEF	-	United Nations Children's Fund
USA	-	United States of America
WHO	-	World Health Organization

ABSTRACT

TITLE: A hearing screening programme for infants from a neonatal intensive care unit in a South African provincial hospital

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The field of early detection and intervention of hearing loss in neonates and infants has been marked by a growing international body of research investigating hearing screening programmes, protocols and outcomes of early detection for hearing loss. In South Africa, screening for neonates and infants in general and particularly for hearing loss is not common practice and is not meeting the needs of the South African population, with very few infants identified with hearing loss early in life. The Year 2002 Hearing Screening Position Statement recommends an intermediate step toward universal screening in the form of Targeted Newborn Hearing Screening (TNHS) as an option for developing countries with limited resources. The Neonatal Intensive Care Unit (NICU) provides a starting point for TNHS because it encompasses a number of risk factors for hearing loss.

A combined descriptive and exploratory research methodology was followed to provide a comprehensive perspective on longitudinal hearing screening for NICU neonates and infants at a provincial hospital in South Africa. The quantitative methods included a structured interview to compile risk factor information. Immittance measurements used included acoustic reflex measurements, 226 Hz and 1000 Hz tympanometry. Automated Otoacoustic Emission (AOAE) as well as Automated Auditory Brainstem Response (AABR) screening was conducted. Routine follow-up visits at three month intervals were booked if a subject passed the screen and a follow-up

screening for further testing was booked if a subject referred the screening. A total of 49 neonates and infants as well as mothers were enrolled in the first year and followed up for the second year of data collection period.

The results indicated that the NICU had potential as platform for TNHS in South Africa. The high incidence of risk factors reported is more when compared with developed countries and highlights the importance of hearing screening in the at risk population for a developing country. The results confirmed reports that 226 Hz probe tone tympanometry produces erroneous responses in young infants. A high correspondence between high frequency tympanometry and AOA results was found and underlines the need for differential diagnosis to accurately detect middle ear effusion and/or sensorineural hearing loss in neonates and infants. The unilateral AOA refer rate (7%) was within range of the reported values for initial screening at discharge from the NICU. AABR results indicated a relatively high unilateral refer result (24%) and may be attributed to irritability and restlessness. The highest referral rates in the current study were recorded during the second and third visit and may be attributed to the presence of middle-ear pathology in older infants. The perceptions of mothers emphasized the lack of awareness regarding hearing and hearing loss in South Africa. Lack of knowledge may be a contributing actor to poor compliance with screening follow-up. Despite prevailing challenges, such as a low follow-up return rate, lack of awareness regarding the benefits of early detection of hearing loss, the effect of middle ear effusion on screening results, the cost of hearing screening and different priorities of the national healthcare system, such as Human Immunodeficiency Virus, demonstrated the NICU promise as platform for TNHS in South Africa. TNHS programmes may serve as starting point to direct universal neonatal hearing screening programmes in South Africa.

Key words: *auditory brainstem response, early hearing detection and intervention, electrophysiology, immittance measurements, neonatal intensive care unit, otoacoustic emission, parental perceptions, risk factors, targeted neonatal hearing screening.*

OPSOMMING

TITEL:	‘n Gehoorsiftingsprogram vir babas van ‘n neonatale intensiewe sorgeenheid in ‘n provinsiale hospitaal in Suid-Afrika.
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Die veld van vroeë deteksie en intervensie van gehoorverlies in neonate en babas word gekenmerk deur omvattende internasionale navorsing wat gehoorsiftingsprogramme, protokolle en uitkomst van vroeë deteksie van gehoorverlies ondersoek. In Suid-Afrika is sifting van neonate en babas in die algemeen en spesifiek vir gehoorverlies nog nie algemeen nie. Die behoeftes van die Suid-Afrikaanse bevolking word nie in voorsien nie en min babas met gehoorverlies word vroeg geïdentifiseer. Die Jaar 2002 Gehoorsiftingsverklaring beveel Geteikende Neonatale Gehoorsifting (GNGS) aan as inisiële stap vir universiële gehoorsifting as ‘n opsie vir ontwikkelende lande met beperkte hulpbronne. Die Neonatale Intensiewe Sorgeenheid (NIS) voorsien ‘n beginpunt vir GNGS omdat daar verskeie risiko faktore vir gehoorverlies voorkom.

‘n Gekombineerde beskrywende en eksploratiewe ontwerp is gevolg om ‘n omvattende perspektief op longitudinale gehoorsifting vir NIS neonate en babas by ‘n provinsiale hospitaal in Suid-Afrika te voorsien. Die kwantitatiewe metodes het ‘n gestruktureerde onderhoud ingesluit om risiko faktore vir gehoorverlies te ondersoek. Die immittansiemetings wat gebruik is sluit akoestiese refleksmetings, asook 226 Hz en 1000 Hz tympanometrie in. Outomatiese Otoakoestiese Emissie (OOAE) asook Outomatiese Ouditiewe Breinstam Response (OBR) sifting is uitgevoer. Roetine opvolgbesoeke in drie-maandelikse intervalle is gedoen op proefpesone wat sifting geslaag het en ‘n opvolg besoek is gemaak vir verdere toetsing indien sifting nie geslaag

was nie. 'n Totaal van 49 neonate en babas, asook moeders is ingesluit gedurende die eerste jaar van die studie en is opgevolg vir die tweede jaar van die data-insamelings periode.

Die resultate dui aan dat die NIS potensiaal het as platform vir GNGS in Suid-Afrika. Die hoë insidensie van risiko faktore is meer as wat vir 'n ontwikkelde land beskryf word en beklemtoon die belang van gehoorsifting vir neonate met 'n bevestigde risiko vir gehoorverlies in 'n ontwikkelende land. Die resultate bevestig dat 226 Hz tympanometrie onbetroubare resultate in jong babas produseer. 'n Hoë korrespondensie tussen 1000 Hz tympanometrie en OOEAE resultate is gevind en beklemtoon die belang van differensiale diagnose om akkuraat middelloorinfeksie en/of sensories-neurale gehoorverlies in neonate en babas te identifiseer. Die unilaterale OOEAE verwysingspersentasie (7%) was inlyn met ander waardes wat vir inisiële sifting na ontslaan uit die NIS aanbeveel word. OOBRE resultate dui op 'n relatiewe hoë unilaterale verwysingspersentasie (24%) en kan moontlik toegeskryf word aan rusteloosheid in die proefpersone. Die hoogste verwysingsresultate in die huidige studie is tydens die tweede en derde besoek aangeteken en kan toegeskryf word aan moontlike middelloorinfeksie in ouer babas. Die persepsies van moeders beklemtoon die beperkte bewustheid van gehoor en gehoorverlies in Suid-Afrika. Beperkte kennis mag 'n bydraende faktor wees vir die swak opvolgkoers na gehoorsifting. Ondanks sekere uitdagings, soos 'n lae opvolgkoers, beperkte kennis oor die voordele van vroeë deteksie van gehoorverlies, die effek van middelloor-infeksie op siftingsresultate, die kostes van gehoorsifting en ander prioriteite binne die nasionale gesondheidsstelsel, soos Menslike Immunitetsvirus, demonstreer die NIS potensiaal as platform vir GNGS in Suid-Afrika. GNGS programme kan dien as beginpunt vir universiële neonatale gehoorsiftingsprogramme in Suid-Afrika.

Kernwoorde: *elektrofisiologie, geteikende neonatale gehoorsifting, immittansiemetings, neonatale intensiewe sorgaanwese, otoakoestiese emissie, ouditiwe breinstam respons, persepsies van ouers, risiko faktore, vroeë deteksie en intervensie van gehoorverlies.*

CHAPTER 1

INTRODUCTION AND RATIONALE

This chapter aims to introduce the problem statement in the current study, provide a rationale, describe the terminology and present an outline of the chapters.

1.1 INTRODUCTION

“Hearing loss is often referred to as the invisible handicap. It is debilitating, isolating, and is a frequently occurring abnormality present at birth.” (Lim & Fortaleza, 2000:S137)

The early detection of hearing loss in neonates and infants has been the subject of study for at least the last century (Mencher, Davis, DeVoe, Beresford & Bamford, 2001:3). The invisible nature of hearing loss makes it difficult to detect, and therefore during the last 60 years the field of audiology has aimed to identify hearing loss at the earliest possible age (Northern & Downs, 2002:259). Identifying hearing loss as soon as possible is important because early auditory deprivation owing to a congenital or early-onset hearing loss interferes with the development of the neural structures necessary for hearing, and for subsequent speech and language acquisition (Gravel & Tocci, 1998:2). This development of language and communication serves as the foundation of normal early childhood development. Any delays in acquiring these skills negatively influence literacy (reading and writing), academic achievement, and social and personal development (Diefendorf, 2002:469).

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, 2003:671; Calderon, 1998:1). Delays in social, emotional and behavioural development stemming from a hearing loss in these children can, as just mentioned, 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 infants and to provide appropriate early intervention.

Screening for and early intervention for hearing loss in neonates and infants has been widely advocated in order to avoid delays in early childhood development, based on a growing body of research findings (McHale, 2003:1; Atkins, 2002:1; Arehart, Yoshinaga-Itano, Thomson, Gabbard & Stredler Brown, 1998:101; Lasky, Wiorek & Becker, 1998:47). Empirical evidence in support of the benefits of early detection and intervention hearing loss led to the Joint Committee on Infant Hearing (JCIH) Year 2000 Position Statement in the United States of America (USA), which advocated universal screening of all neonates and infants by Early Hearing Detection and Intervention (EHDI) Programmes (JCIH, 2000:10). The European Consensus Statement published in 1998 also specified the importance of NHS (Neonatal Hearing Screening) as a health priority (Hall, 2000:S113; Lutman & Grandori, 1999:95). Its authors concluded that NHS is necessary to give the *“new European citizen a greater opportunity and better quality of life into the next millennium.”*

Numerous other international bodies and organisations have also recognised the importance of NHS as an acceptable approach to identify hearing loss timeously, as a first step toward appropriate intervention. Examples of these bodies, organisations and groups include the Dutch NICU Neonatal Hearing Screening Study Group, the US Preventive Service Task Force, the Health Professions Council of South Africa (HPCSA), American Academy of Pediatrics (AAP), and the Health Technology Assessment Programme (AAP, 1999:527; Atkins, 2002:1; Davis, Bamford, Wilson, Ramkalawan, Forshaw, Wright, 1997:iv; HPCSA, 2002:1; JCIH, 2000:10; Van Straaten, Hille, Kok & Verkerk, 2003:332). The increasingly widespread recognition of the importance of identifying hearing loss as early as possible is leading to a greater number of NHS programmes being put in place across the world, especially in the developed countries.

Many studies in the USA, Canada, Netherlands, United Kingdom, Australia and Greece report that NHS programmes have been implemented successfully (Davis,

Bamford & Stevens, 2001:3; Kerschner, Meurer, Conway, Fleischfresser, Cowell, Seeliger & George, 2004:166; Gorga & Neely, 2003:103; Mencher & DeVoe, 2001:15; Psarommatis, Tsakanikos, Diamantopoulou, Douniadakis & Apostolopoulos, 2001:25; Russ, Poulakis, Barker, Wake, Rickards, Saunders & Oberklaid, 2003:389; Van Straaten et al., 2003: 333). These are countries boasting clearly-defined clinical guidelines and government funding and support, which are necessary for the successful implementation and sustainability of a NHS programme. Yet significant barriers must be overcome before NHS programmes can commence throughout the world (Mencher & DeVoe, 2001:19).

For instance, very little contextually-relevant, community-based research has been reported for NHS in African countries (McPherson & Swart, 1997:18; Swanepoel, Delpont & Swart, 2004:634). In South Africa, screening of neonates and infants in general and particularly for hearing loss is not common practice and is not meeting the needs of the South African population (Swanepoel et al., 2004:634). Hence very few infants with hearing loss are being identified early in South Africa (Swanepoel et al., 2004:634). With no national NHS programme being implemented in South Africa, only a small number of neonates and infants with hearing loss receive appropriate audiological services in a few private hospitals that offer NHS services. Some of the first challenges that need to be overcome include the facts that no legislation currently supports the implementation of NHS in South Africa and that consent from the paediatrician is needed before the screening may be performed.

The Professional Board of the Speech Language and Hearing Profession of the HPCSA released a document in 2002 recognising the value of NHS. This Position Statement complied with the JCIH (USA) Year 2000 Position Statement and accepted the statement as the principal document on NHS (HPCSA, 2002:1). The South African position statement recommends that family-centred intervention programmes delivered through integrated, interdisciplinary provincial and district health systems health care services should follow objective, physiological measurements for NHS (HPCSA, 2002:1; JCIH, 2000:10). The document further advocates that screening should begin by conducting targeted screening and then work up to universal screening of all neonates and infants by 2010, guided by a quality benchmark of 98% coverage of all newborns by then (HPCSA, 2002:2). The

JCIH describes a possible model for NHS programmes in developed countries which have resources and systems in place to support screening. Although the HPCSA position statement complies with the JCIH document, it is not certain that the suggested model of hearing loss for NHS is the optimal model for screening in South Africa. The screening models for successful NHS may differ between countries, but early intervention in and habilitation of hearing loss must remain the main aim of any such programme.

1.2 BACKGROUND

The USA was the first country to develop Universal Newborn Hearing Screening (UNHS) programmes, which have now become a powerful and widespread professional and technological movement (Hall, 2000:S113). The aim of UNHS is to identify and habilitate hearing loss; it is based on the principle that all neonates and infants should enjoy access to NHS using physiological measurements to allow for early intervention (JCIH, 2000:11). This should be greater in the frequency regions important for the perception of speech which, if a problem is not identified, may interfere with normal speech and language development (JCIH, 2000:11). The JCIH advocates that the disorder targeted for identification should be 30 dB HL across these frequencies. UNHS aims to diagnose hearing loss before three months of age by means of objective and physiological tests to help ensure intervention before six months of age, and recommends that neonates and infants who demonstrate risk factors for delayed or progressive hearing loss should be monitored for the first three years of their life (JCIH, 2000:10).

Since UNHS has been introduced the mean age at which a hearing loss is identified in the USA has been reduced from 12-13 months to between three and six months of age (Atkins, 2002:3). As a result, the fitting of hearing aids has also been taking place earlier. The age range for such fittings altered from 13-16 months to between five to seven months, following UNHS (Atkins, 2002:3). The benefits identified by research led to greater support for the implementation of UNHS programmes in the USA. The numbers of NHS programmes increased more than twenty-fold between 1993 and 1998, and by 2001, two-thirds of all hospitals had implemented UNHS

(White, 2003:81). In the USA, more than 90% of neonates are currently screened for hearing loss before being discharged from the hospital (ASHA, 2005:1). However, successful implementation of an early hearing detection programme requires careful consideration since there are significant barriers that may influence the outcomes of a NHS programme.

Adverse consequences such as financial implications, the need for follow-up visits, false positive results and maternal attitudes need to be considered and evaluated before a NHS programme can be implemented successfully. The costs of NHS ultimately affect the efficacy and sustainability of its programmes. Capital expenses incurred for the purchase of equipment, operating costs for personnel and disposables, screening technique, follow-up costs, the number of babies screened, and the presumption regarding the prevalence of hearing loss in neonates and infants all affect the cost of UNHS (Gorga & Neely, 2003:103; Diefendorf, 1997:8). The monetary costs which result when parents lose time from work, incur transportation expenses, and have unnecessary tests done, as well as the personal costs of parental anxiety, potential confusion, and disturbance of family life are also factors determining the cost-effectiveness of a screening programme (Diefendorf, 1997:8).

Even though these costs may reach enormous figures, NHS might have the potential for long-term cost-savings compared to the costs that could arise if no screening is carried out (Keren, Helfand, Homer, McPhillips & Lieu, 2002:862). Over the past decade consensus has been reached that the prospective benefits of NHS outweigh the harms of screening and justify the costs of NHS (Diefendorf, 1997:8). More studies regarding the long-term benefits of early intervention are needed in order to clarify the value of the early identification of a hearing loss in relation to the cost involved in the execution of the programme (Kezirian, White, Yueh & Sullivan, 2001:366). Other costs related to long-term data management and follow-up should be added to the equation (Diefendorf, 1997:9). The long-term costs in this respect have not yet been determined, but clinicians and consumers nevertheless advocate that excellent hearing health care services should be provided to neonates, infants and their families through UNHS (Diefendorf, 1997:9).

1.3 RATIONALE

Hearing loss in infants constitutes a significant health problem in the developing world (Olusanya et al., 2004:302). Worldwide, approximately 126 000 to 500 000 neonates are born with significant hearing loss each year, and about 90% of them are born in developing countries (Olusanya, Luxon & Wirz, 2004:294). The government and general population lack awareness regarding the importance of preventing bilateral permanent hearing loss in most developing countries, such as South Africa (Chiong, Llanes, Tirona-Remulla, Calaquian & Reyes-Quintos, 2003:214). Developing countries further lack clinical standards regarding the implementation of screening programmes (Mencher & DeVoe, 2001:19). The absence of proper equipment, staff, facilities, and other resources have also hindered the development of NHS programmes in the developing world (Mencher & DeVoe, 2001:19). Suitable equipment and sufficient human and material resources for NHS programmes are considered to be beyond the means of many developing nations (Olusanya et al., 2004:296).

In developing countries such as South Africa, healthcare priorities are often skewed owing to the overwhelming burden of life-threatening diseases such as the Human Immunodeficiency Virus or Acquired Immunodeficiency Syndrome (HIV/AIDS), which causes a disability such as hearing impairment to receive very little attention (Olusanya et al., 2004:296; Swanepoel et al., 2004:4). Although it is true that a hearing impairment is not a life-threatening disease like tetanus or meningitis, it may severely damage an individual's quality of life (Swanepoel et al., 2004:634). The low priority accorded to a disability such as hearing loss despite its consequences, has led to poor institutional support, research funding, and political advocacy for NHS in a country such as South Africa (Swanepoel et al., 2004:634).

HIV/AIDS hinders the distribution of resources in South Africa. It is a reality that has reached pandemic levels in South Africa over the last two decades and, in the midst of the high prevalence of mothers living with HIV/AIDS, many neonates are prenatally exposed to HIV/AIDS. The prevalence of HIV in neonates born to infected mothers increases from 14% in neonates younger than six weeks to 24% at three-to-six months of age (Rollins, Dedicoat, Danaviah, Page, Bishop, Kleinschmidt,

Coovadia & Cassol, 2002:389). Neonates born to HIV-positive mothers may be at risk of a hearing loss or for developing a hearing impairment shortly after birth (Druck & Ross, 2002:4; Matkin, Diefendorf & Erenberg, 1998:144). No data on the influence of HIV on neonates and infants exposed prenatally to HIV is currently available in South Africa, however.

Despite these challenges, such as HIV, recent research reports advocate NHS in developing countries, but, unfortunately, government and legislation do not yet promote the implementation of NHS in these countries (Kerschner et al., 2002:166; Van Straaten et al., 2003:333). A continual barrier to legislative support is the complete shortage of research concerning NHS in developing countries, such as South Africa. Before UNHS can become feasible in this country, the lack of contextually-relevant research regarding the circumstances and diverse challenges must be rectified. Manpower shortages, tracking and follow-up, provision of support services, attitudes, cultural and religious beliefs, economic uncertainties, health care workers' awareness and fatal diseases (Olusanya et al., 2004:301), offer real obstacles in a developing country like South Africa, which may impede the devising of NHS programmes. The developing world furthermore is short of courses offering tertiary, full-time training for audiologists (Olusanya et al., 2004:301). A clearer understanding of the South African context itself is essential to develop and implement speech-language and hearing services (Swanepoel, 2004:16). A shortage of trained audiologists, the HIV/AIDS pandemic, unemployment, poverty, illiteracy, the need for community-based services and other issues also constitute daily obstacles in the field of paediatric audiology in South Africa and exert an immense influence on service delivery in the country.

For countries such as South Africa, the JCIH recommends an intermediate step toward universal screening, in the form of Targeted Neonatal Hearing Screening (TNHS), as an option for developing countries with limited resources (Olusanya et al., 2004:298). TNHS is a method that attempts to identify and test all neonates and infants at risk for a hearing loss, based on established risk factors (Chiong et al., 2003:217; Olusanya et al., 2004:29; JCIH, 2000:20). Specific risk factors in this respect include: admission to the neonatal intensive care unit (NICU) for more than 48 hours, stigmata or syndromes associated with congenital hearing loss, family

history of permanent childhood sensorineural hearing loss, craniofacial anomalies and morphologic abnormalities of the pinna and ear canal, in-utero infections due to the herpes virus, cytomegalovirus, toxoplasmosis, rubella, and syphilis (JCIH, 2000:20). The South African Hearing Screening Position Statement has consequently recommended TNHS as a stepping-stone towards UNHS (HPCSA, 2002:1).

The specified hearing loss which should be identified early is a permanent unilateral or bilateral, sensorineural or conductive hearing loss greater than 30dB in the speech recognition frequencies (500-4000Hz), with Otoacoustic Emissions (OAE) and Automated Auditory Brainstem Response testing (AABR) (HPCSA, 2002:3; JCIH, 2000:11). Although the cost of OAE's and AABR's has fallen over the years, investigation of accurate operating expenses and efficacy are essential before a NHS is implemented, especially in developing countries (Swanepoel et al., 2004:31). Cost estimates for the implementation of TNHS in developing nations have not yet been documented, though (Olusanya et al., 2004:299). Therefore, before a developing country can consider implementing a TNHS programme, questions regarding the real cost, value and challenges of TNHS must be explored by pilot studies in these contexts.

The cost of TNHS has been of particular concern for developing nations (Mencher & DeVoe, 2001:17) since it is reported to be beyond the capacity of many of them (Olusanya et al., 2004:288). Although some studies have reported TNHS programmes to be inexpensive and feasible in such countries, the actual costs were not disclosed (Chiong et al., 2003:217; Olusanya et al., 2004:300).

Completing the screening procedure, through to diagnosis and appropriate rehabilitation, may also be difficult in these countries (Olusanya et al., 2004:301). Socio-economic conditions and the geographical locations of parents and caregivers play a fundamental role in this aspect and a number of parents may not be interested in continuing the process after their child has failed a screening, once he or she has been discharged from the health care system (Olusanya et al., 2004:301). Perceptions of parents and caregivers need to be addressed, even altered, to overcome the stigma attached to hearing loss in some developing

countries. Cultural and social stigmas attached to early childhood disabilities in some such countries prevent the integration of hearing-impaired children into the larger community owing to their isolation (Olusanya et al., 2004:297). Remote families and communities may suffer if a hearing loss goes undetected, which may result in communication deficits with social and financial consequences (Yoshinaga-Itano & Gravel, 2001:64). On the other hand, habilitation of a hearing loss early in life may minimise its consequences and may facilitate better integration of the hearing-impaired child into the extended family and general community. Integration may therefore, over a period, have the potential of generating a positive culture change towards hearing loss in a biased community (Olusanya et al., 2004:297). This type of change in a community is required before a NHS programme can be implemented successfully. It is therefore advisable for countries that do not have an EHDI programme to start with an NHS programme in the Neonatal Intensive Care Unit (NICU) (Van Straaten et al., 2003:336).

It is estimated that neonates who are admitted to the NICU represent 5-12% of all live births in most countries (Olusanya et al., 2004:298). The NICU encompasses many other previously-indicated risk factors in a single category, such as postnatal infections and neonatal conditions that need acute care. Studies have indicated a prevalence of unilateral congenital hearing loss of 0.6%, and of a bilateral congenital hearing loss of about two percent, after discharge from the NICU (Van Straaten et al., 2003:335; Yoon, Price, Gallagher, Fleisher & Messner, 2003: 355). The notably higher prevalence of hearing loss, compared to other birth defects in neonates (Olusanya et al., 2004:287), indicates an important need: the development of a widespread awareness with respect to identifying hearing loss in acute care settings. The estimated prevalence of bilateral sensorineural hearing loss in neonates and infants is one-to-two per 1, 000, but may be 10-20 times higher in neonates and infants discharged from the NICU and others with established risk factors (Olusanya et al., 2004:294; Van Straaten et al., 2003:336; Atkins, 2002:2; Meyer, Witte, Hildmann, Hennecke, Schunck, Maul, Franke, Fahnenstich, Rabe, Rossi, Hartmann & Gortner, 1999:903).

The NICU also provides a starting point for TNHS. Admission to the NICU for more than 48 hours comprises one of the major risk categories for hearing loss in

neonates (JCIH, 2000:10). The NICU as a risk factor in this regard has been studied extensively in developed countries such as the USA (Van Straaten et al., 2003:332; Polinski, 2003:99; Yoon et al., 2003:353). A study in the Philippines suggests that neonates admitted to a NICU in a developing country may be more seriously ill than such patients in a developed country (Chiong et al., 2003:217). Only limited reports regarding NHS programmes being implemented in the developing world are available, however.

1.4 PROBLEM STATEMENT

In South Africa, no studies have been conducted to determine the incidence of hearing loss for NICU neonates and infants, although the HPCSA advocates the early identification of neonates and infants with established risk factors before their discharge from hospital (HPCSA, 2002:4). Studies of this factor are consequently needed. The social and life-threatening disease issues in South Africa may delay the realisation of NHS programmes within the hearing health care field and could reinforce the lack of attention that hearing loss receives in South Africa. Swanepoel (2004:16) highlights the challenge of implementing NHS in a country with combined developing and developed sections by stating that *'It is this unique combination of first world benchmarks in a third world country that must stimulate creative initiatives to produce contextually relevant solutions for the delivery of speech-language and hearing services to all South African peoples'*. The challenge facing audiological services in this country is evidently to develop and implement a NHS programme with the limited resources available and diverse obstacles to overcome.

Pilot studies and contextual research are vital here. A single pilot study has been conducted to determine the incidence of CHL in very low birth weight neonates born in a public hospital in South Africa (Van Der Watt, 2003:i). The results concluded that the incidence of congenital hearing loss in such neonates who had been discharged from the NICU was 4.1% (Van Der Watt, 2003:i). Meyer et al. (1998:900) report that 5% of high-risk neonates exhibited pathologic ABR results. This figure is close to what Van Der Watt has reported.

The NICU has a unique population with neonates and infants exposed to a variety of risk factors, including environment, treatments, and clinical conditions (Polinski, 2003:99). Investigation of the NICU as a hearing screening context is therefore a priority if the benchmarks described in the South African Hearing Screening Position Statement Year 2002 are to be reached. However, it appears that no systematic NHS programme has yet been implemented in South Africa to identify hearing loss in neonates and infants discharged from the NICU in the public healthcare sector, and very limited data is consequently available to direct efforts to devise a TNHS programme in this context. The question that arises and which this study will aim to address therefore asks:

Is NHS in a NICU in a South African regional hospital a feasible option?

1.5 DEFINITION OF TERMS

In order to prevent misinterpretations the following key concepts, used in the current study, were defined by the researcher as follows:

- **Early Hearing Detection and Intervention (EHDI)**

EHDI programmes intend to screen neonates and infants for hearing loss as early as possible, in the Well Baby Nursery as well as in the Neonatal Intensive Care Units. Neonates and infants who are referred after this screening are booked for a follow-up visit. Such screening should be conducted by one month of age, be followed up diagnostically by three months, and the patient must be enrolled in appropriate intervention services by six months of age (ASHA, 2006:2). EHDI programmes aim to “maximise linguistic and communicative competence and literacy development for children who are hard of hearing or deaf” (JCIH, 2000:10).

- **Neonatal Hearing Screening (NHS)**

This general term refers to early detection and intervention of hearing loss in all neonates and infants by means of physiological measures such as ABR and/or OAE. The term in the current study refers to screening programmes that aim to identify hearing loss in neonates and infants at the youngest possible age. This is a general term and does not refer to universal hearing screening of newborns or targeted hearing screening of them.

- **Universal Newborn Hearing Screening (UNHS)**

The term refers to the identification and habilitation of hearing loss and is based on the principle that all neonates and infants should enjoy access to screening using physiological measures to allow for early intervention (JCIH, 2000:11). UNHS aims to diagnose hearing loss before three months of age by applying objective and physiological measurements in order to help ensure intervention before six months of age (JCIH, 2000:10). Neonates and infants that demonstrate risk factors for delayed or progressive hearing loss should be monitored for the first three years of their life and at least 98% of infants born in a hospital should be screened for such loss (JCIH, 2000:10).

- **Target-based Newborn Hearing Screening (TNHS)**

The term refers to a targeted population that requires this kind of screening. The target population in this context comprises neonates and infants that are at risk for hearing loss or for developing a hearing loss (Yoshinaga-Itano et al., 2004:298). A list of risk factors was compiled by the JCIH (2000:20), but other risk factors for hearing loss have also been described (Yoshikawa et al., 2004:366).

- **Developing country**

This term refers to countries with a centrally-planned economy that are marked by poverty and slow economic growth (United Nations, 1997:2), where the poor are

incapable of achieving a minimum level of living and cannot manage to pay for adequate food, clothing or housing. The life expectancies in these countries are low, the death rates of their children are high and millions of children receive no basic education (United Nations, 1997:2). Millions of young children also die annually under circumstances that in developed countries would not normally result in death (United Nations, 1997:2). Nations in the developing world are situated in Africa, Asia and some countries in the Pacific, Latin America and the Caribbean (United Nations, 2004:1). However, several significant differences in the development of these countries are evident and different levels of development can coexist in one country (Olusanya et al., 2004:289). The term is used in the current study to compare NHS programmes in countries with a developing economy and those with a developed economy. South Africa is considered a developing economy, but mixed sections of developed and developing regions exist within the country's boundaries (Fair & Louw, 1999:13).

- **Developed country**

In the present study, the term refers to countries with a developed economy and a high standard of living. Financial resources in these countries are used to improve the health and education of their poor (United Nations, 1997:2). This financial investment means higher productivity and more rapid economic growth (United Nations, 1997:2). Examples of developed market economies are found in Europe, excluding the European transition economies, Canada and the United States of America, Japan, Australia and New Zealand (United Nations, 2004:1).

1.6 OUTLINE OF THIS STUDY

A brief outline and description of the chapters included in the current study is offered in the following sections.

CHAPTER 1: INTRODUCTION & RATIONALE

The purpose of this chapter is to identify a specific research problem related to the screening of neonates' hearing in South Africa and to provide a rationale for the

current study. This chapter includes the research question and definitions of the terminology that will be used.

CHAPTER 2: INTERNATIONAL TRENDS IN THE HEARING SCREENING OF NEWBORNS: A SOUTH AFRICAN CHALLENGE

This chapter serves as a theoretical foundation for the empirical research and provides a critical evaluation and interpretation of the relevant literature, hence offering a critical perspective on EHDI services in the developed and developing world. The development and principles of UNHS are discussed, as well as the history of hearing screening methods, and current electrophysiological screening measures are evaluated. The current status of NHS in the developing world is subsequently discussed and TNHS is examined as a screening method for use in developing countries with limited resources for carrying out such screening. The South African Position Statement on Newborn Hearing Screening and the screening context in South Africa are evaluated in terms of specific contextual challenges and issues that may influence the efficacy of a NHS programme.

CHAPTER 3: METHODOLOGY

This chapter describes the operational framework that was utilised to conduct the empirical research, highlighting the ethical issues and the research context. The procedures followed and the apparatus used to achieve the main aim of the study are discussed. The selection and description of the research participants are explained, as well as the procedures followed in the collection of data. Relevant literature is cited to support the empirical research.

CHAPTER 4: RESULTS AND DISCUSSION

This chapter records the results obtained during the statistical analysis of the data. Results are presented and discussed according to the sub-aims stipulated in Chapter 3 and the relevant data is illustrated graphically. After each set of results, its clinical relevance and implications in relation to the literature will be discussed. A summary of its content concludes this chapter.

CHAPTER 5: CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

Here, the researcher critically evaluates the study and draws conclusions from the results obtained. Significant results are emphasised and their contribution to the literature is discussed. Regarding the aim of the study, a conclusion is formulated in order to answer the question posed. A critical evaluation of the current study emphasises its limitations and subsequent recommendations for further research are made.

1.7 SUMMARY

This chapter has introduced the existing frameworks for NHS and furnished background information. The rationale of the study and its problem statement were also discussed. The chapter concluded with definitions of important terminology in the study and an outline of all the chapters.

CHAPTER 2

INTERNATIONAL TRENDS IN NEWBORN HEARING SCREENING: A SOUTH AFRICAN CHALLENGE

The aim of this chapter is to provide a theoretical framework for the empirical component of this research project by means of a critical evaluation and interpretation of relevant literature.

2.1 INTRODUCTION

The field of neonatal hearing screening is based on an extensive body of research regarding the process and outcomes of early identification of hearing loss (Mencher, Davis, DeVoe, Beresford & Bamford, 2001:3; Diefendorf, 1997:43). Electrophysiological advancements in the identification of hearing loss, as well as advances in testing protocols, have significantly improved the accuracy, and efficacy of Early Hearing Detection and Intervention (EHDI) programmes (Mencher et al., 2001:3; Downs, 2000:285; Diefendorf, 1997:48), which work toward minimising the long-term effects of a hearing loss, by detecting such loss in the neonatal period. Minimising these consequences is a very important objective because of the long-term costs to individuals, families and society (in terms of quality of life and economically).

A national committee, the Joint Committee on Infant Hearing (JCIH), established during the 1960's in the USA, introduced the suggestion made by Marion Downs that widespread Universal Neonatal Hearing Screening (UNHS) be carried out (Northern & Downs, 2002:267). The committee consists of multidisciplinary partnerships that recognise NHS as a vital public health issue (Olusanya, 2005:737) and offers guidelines and recommendations for NHS in the USA and the rest of the world. The JCIH published position statements in 1982, 1990, 1994 and 2000, in order to report on the status of UNHS. These statements reported on hearing screening using a high-risk register, behavioural mass screening, targeted hearing screening, and

eventually UNHS itself in 2000 (JCIH, 2000:2). These position statements have contributed to the current global attention that NHS receives (Olusanya, 2005:737).

Since UNHS was initiated in the USA in the 1990's, hearing losses in a substantial number of neonates and infants have been detected early in their life, at least in the developed world, by using electrophysiological measurements (Nekahm, Weichbold, Welz-Mueller, Hirst-Stadlmann, 2001:23; Downs, 2000:285). Instead of limiting hearing screening to neonates that are at risk in this respect, all neonates are now included in the EHDI programmes in countries such as the USA and the UK (Diefendorf, 2002:471).

UNHS began to be carried out in the states of Rhode Island, Hawaii, and Colorado during the early 1990's (Yoshinaga-Itano, 2002:221). Evidence-based research has indicated since then that UNHS results in earlier identification of hearing loss, leading to quicker intervention (Yoshinaga-Itano, 2002:221). Developed countries throughout the world are now implementing UNHS programmes, which are being recommended as the standard of care for early detection of neonates and infants with hearing loss (Gracey, 2003:313; Yoshinaga-Itano, 2003:252). These include the USA, the United Kingdom, Canada, Australia, Japan, Sweden, Flemish Belgium, Spain, and Germany (Yoshinaga-Itano, 2003:252; Watkin, 1999:171; Meyer et al., 1999:900). Other countries throughout Europe and developing countries in Africa and Asia are still in the planning and pilot stages of NHS programmes (Olusanya et al., 2004: 287; Yoshinaga-Itano, 2001:252).

The introduction of Neonatal Hearing Screening (NHS) in the developing world is widely viewed as an unattainable goal for various reasons, including a dearth of prevalence data regarding hearing loss in the first year of life. This is due to a general paucity of up-to-date and descriptive epidemiological data on hearing loss in developing countries (Olusanya et al., 2004:288). The rationale, however, for EHDI being employed to detect neonates with hearing loss, also applies to developing countries such as South Africa (Swanepoel et al., 2004:634). The Professional Board for Speech, Language and Hearing Professions advocates targeted (risk-based) NHS as a feasible first step toward comprehensive hearing screening for South Africa (HPCSA, 2002:1). Since no official EHDI programmes are currently

being implemented in South Africa, target-based NHS provides South Africa with a starting point to identify neonates at risk for a congenital hearing loss, or a delayed and progressive hearing loss.

This chapter will investigate the developments in NHS, both internationally and in South Africa. It discusses the principles and benefits of NHS and provides an overview of the advances in technology (to detect hearing loss) that led to the development of UNHS. The status of NHS in the developed world is considered, and subsequently Target-based NHS (TNHS) will be described. The researcher will also describe the Neonatal Intensive Care Unit (NICU) as a starting point for TNHS, as far as developing countries with limited resources are concerned. An investigation of contextual issues and challenges in South Africa that may influence the efficacy of a hearing screening programme follows.

2.2 RATIONALE FOR NEONATAL HEARING SCREENING

Research estimates that the incidence of neonates with hearing loss is one per 1000 in the well-baby nursery, compared to an incidence of five to nine per 1000 in NICU graduates (Yoon et al., 2003:355; Meyer et al., 1999:903; Davis & Wood, 1992:82). The prevalence of bilateral hearing loss in NICU graduates may be ten times higher than in the well-baby nursery, with estimated rates of 4.8/1000 for NICU infants, compared to 0.49/1000 in the well-baby nursery (Mencher et al., 2001:7).

The impact of permanent bilateral hearing loss on a neonate or infant's development can be extensive, with lifelong consequences (Van Straaten et al., 2003:332). However, research indicates significant enhancement of speech and language development and eventual success in school for children with hearing loss if the loss is identified early in life (Diefendorf, 1997: 49). Early detection of such loss in the neonatal period allows for early treatment and habilitation of this type of loss, which may prevent the speech, language, developmental, and social problems related to a debilitating hearing loss. Research supports the multiple short- and long-term benefits of NHS for the lives of neonates and their families (Yoshinaga-Itano & Gravel, 2001:63). Positive empirical evidence in support of the implementation of

UNHS, new technology, and efforts at promulgating strong legislation have made UNHS a justifiable procedure for early identification of this loss (Mencher et al., 2001:3; Yoshinaga-Itano & Gravel, 2001:62; Diefendorf, 1997:43). Empirical evidence indicates that early intervention as regards neonates with hearing loss before the age of six months results in language and speech development within the normal range (Yoshinaga-Itano, Sedey, Coulter & Mehl, 1998:1171; Bamford & Davis, 1998:1).

Yoshinaga-Itano & Gravel (2001:63) report on the positive outcomes of early detection and appropriate intervention in such situations. According to these authors (2001:63), neonates identified earlier exhibit significantly better language, speech, and socio-emotional development than those identified later. The former neonates who receive appropriate intervention exhibit language development similar to their non-verbal cognitive development. The given researchers also report that such neonates who received early intervention and possess normal cognitive abilities could maintain language development in the low average for the age range of 0-5 years of age. Parents of these neonates also experience less parental stress, and better personal-social development is achieved in the child. Lastly, language development predicts speech intelligibility and the greater the delay in language development, the lower the probability of establishing intelligible speech in neonates with hearing loss.

Even though the positive outcomes of early detection of such loss have been investigated extensively, challenging factors influencing the successful implementation of NHS are widely reported. These include issues such as initiating and maintaining high-quality diagnostic, educational and follow-up services that emphasise family involvement (Mencher et al., 2001:3). These challenges have offered a hindrance to the development of uniform international and national NHS programmes (Mencher et al., 2001:3).

2.3 EFFICACY OF NEONATAL HEARING SCREENING: CHALLENGES

The success and efficacy of a hearing screening programme are affected by certain definite challenges that hinder the long-term feasibility of such a programme. Successful implementation relies primarily on measures of outcomes, such as follow-up services, coverage and referral rates, and the effects of NHS on parents/caregivers (White, 2003:1; Prieve et al., 2000:104). Another important factor that influences the success of a screening programme is the presence of middle-ear pathologies, such as middle ear effusion, cerumen or vernix and collapsing ear canals, which interfere with electrophysiological testing and do not allow for accurate diagnosis of sensorineural hearing loss (Boone, Bower & Martin, 2005:394). The middle-ear pathologies and other important factors constitute a challenge to a screening programme and are discussed in the following sections.

- Middle ear effusion

A large number of hearing problems identified after referral from NHS will be cases of middle ear effusion (MEE) (Boone et al., 2005:393; Sutton, Gleadle & Rowe, 1996:9), which exhibit false positive results, but MEE needs to be managed in order to distinguish between possible sensorineural hearing loss and the more likely MEE (Sutton et al., 1996:9). A challenge of NHS is that the screening does not aim to detect MEE per se, but intends to prevent problems due to MEE, whether developmental, educational, social, or medical (Klein, 2001:S2). Consequently MEE poses a significant challenge to the implementation of a successful NHS programme. The presence of MEE during screening may increase the false positive results of the programme and decrease its effectiveness, which is measured by a low referral rate for further testing in order to detect hearing loss.

MEE is described as a silent disease since it often occurs asymptotically during infancy (Engel, Anteunis, Volovics, Hendriks, Marres, 1999:247). A conductive hearing loss is the most common complication of acute MEE (Klein, 2001:S4). Acute or chronic MEE has significant consequences for a child's medical, educational and social welfare (Fowler & Shanks, 2002:186). Untreated MEE may even lead to continual perforation of the tympanic membrane and dislocation of the ossicles,

resulting in permanent conductive hearing loss (Klein, 2001:S4). Temporary and permanent hearing loss of this nature limits a child's exposure to a consistent, clear model of spoken language, which is crucial for the development of speech, language and hearing abilities (Yoshinaga-Itano & Gravel, 2001:62).

MEE is a common condition and there are many factors that can increase risk for it. Table 2.1 summarises some of the possible host factors that may encourage its development.

Table 2.1 Some host factors that may increase a neonate's risk for MEE

Study	Host factors	Explanation
Klein, 2001:S4	Age Sex Race Genetic predisposition Early onset of MEE Underlying disease Allergy Air pollution Exposure to tobacco smoke Not breastfeeding Season Sleeping position Poverty Use of a pacifier Day care	Some infants are more prone to developing MEE at least once by the age of 7 years. MEE is a common disease in the NICU population. The highest attack rate is found in infants from 6-18 months of age and MEE occurs more frequently in males than females. An episode of acute MEE in the first six months of life may indicate anatomical, physiological or immunological features that could result in recurrent and severe disease. An infant who has a genetic predisposition to MEE is more likely to develop MEE. Poverty, crowded living conditions, poor sanitation and inadequate medical care have been linked to recurrent acute MEE (Engel et al., 2001:138; Klein, 2001:S4).
Engel et al., 2001:138	Nasally-placed tubes Cranial growth Immune system Neuromotor function	

Table 2.1 indicates that a number of everyday occurrences in developing countries (such as South Africa), including allergies, air pollution, poverty, day care, nasal tubes and a poor immune system may increase a neonate's risk for MEE. Careful monitoring of the symptoms of ear infection is a way of identifying MEE as soon as possible, so as to prevent a possible conductive hearing loss. Technological developments in objective measurements by otoacoustic emissions (OAE's) and immittance measurements will greatly help with the identification of MEE in a neonate (Northern & Downs, 2002:80). This highlights the paediatric audiologists' role in the detection of MEE.

Untreated MEE leads to two consequences that need to be considered in the developing world. Firstly, conductive hearing loss associated with MEE is a significant problem in these regions, where illiteracy is rife (Klein, 2001:S4). Perception and comprehension of normal speech are crucial for those who are illiterate. Speech is the only means of communication for these people because they have not acquired the skills to read and write. Without language skills, they cannot develop speech abilities to interact with their environments, and consequently they are unable to function as contributing members of their society. Secondly, transient middle ear pathologies or outer ear constructions may comprise a major load on the healthcare system (Olusanya et al., 2004:296). In a developing country with limited access to medical services, middle ear pathologies may have long-term effects on a neonate's auditory development (Klein, 2001:S2). If the complications of MEE are recurrent, a permanent hearing loss may be the result (Klein, 2001:S2).

- Referral rate

Existing UNHS programmes aim to employ the most effective and efficient protocols to identify hearing loss in neonates (Gravel et al., 2000:131). An efficient protocol identifies neonates at risk for debilitating permanent childhood hearing loss, while passing neonates with normal hearing (Swanepoel, 2004b:41; Kileny & Lesperance, 2001:67). The screening protocol consists of multiple factors that affect the referral rate of a NHS programme. The target population, screening technologies, pass-fail criteria adopted, programme budget, characteristics of the nursery, test environment, and training, supervision and experience of screening personnel may affect the referral rate of a screening programme (Gravel et al., 2000:132).

The referral rates with respect to screening technologies differ, but not significantly (Swanepoel, 2004b:43). The typical referral rate for NHS in the USA varies between 2-6%, depending on the screening protocol utilised (White, 2003:84). In an analysis of a protocol employing automated auditory brainstem response (AABR), transient evoked otoacoustic emission (TEOAE) and TEOAE/AABR, these methods yielded referral rates of 3.21%, 6.49% and 4.67% respectively (Vohr et al., 2001b:242). The

multi-centre New York State project confirmed that a two-technology protocol lowered the referral rates of a screening programme. Gravel et al. (2000:132) examined the referral rate of the project as a function of a two-technology (TEOAE/ABR) versus a one-technology (TEOAE) protocol at eight hospitals in New York State. The study reported that hospitals which employ a two-technology in-patient screening protocol achieved lower referral rates at discharge, averaging at 2.5%, compared to 8% at hospitals that employ a one-technology protocol (Gravel et al., 2000:132).

The referral rate of these programmes is close to the 4% referral rate proposed by the American Academy of Pediatrics and the JCIH (JCIH, 2000:15; AAP, 1999:28). Such a rate for a NHS programme may also be affected by the length of time during which it has been implemented. The JCIH states that its suggested rate (4%) should be achieved after the first year of implementation (JCIH, 2000:15). Careful protocol selection and consideration of the target population's characteristics are necessary to achieve a referral rate that ensures an effective NHS programme.

A NHS programme with a low referral rate at discharge reduces the monetary and personnel resources expended on follow-up services. More importantly, a very low rate in this regard reduces the number of parents that may experience needless anxiety over what is eventually determined as an incorrect screening result (Gravel et al., 2000:139). Consistent low referral rates, high capture rates, communication between a programme's personnel, and parental education contribute significantly to the overall success of a NHS programme (Shoup et al., 2005:66; Lim & Fortaleza, 2000:S140). However, the importance of early detection goes beyond simply screening for hearing loss: programmes are intended to engage neonates with such loss and their families in a comprehensive plan of service delivery (Diefendorf, 1997:44).

- Effects of screening on parents

Early parent-neonate bonding and/or interaction fall tangentially within the discussion of screening for hearing loss in a neonate (Mencher et al., 2001:7). Disruption and anxiety being manifested in the parents of a neonate who fails an in-hospital hearing test should not be ignored because negative emotions, for example fear, depression, or anger, are present in 10% of parents of neonates referred for follow-up hearing screening (Yoshinaga-Itano & Gravel, 2001:63).

The psychological consequences of screening for parents need to be minimised in order for a NHS programme to be successful because reports indicate that parents may experience feelings of anxiety during NHS (Magnuson & Hergils, 1999:52). Studies regarding maternal worry in NHS have mostly been conducted in the well-baby nursery (Vohr et al., 2001:17; Magnuson & Hergils, 1999:47; Kennedy, 1999:73), but results demonstrated that the majority of parents expressed a positive attitude and very little anxiety toward NHS (Yoshinaga-Itano, 2003:265; Magnuson & Hergils, 1999:47). Yoshinaga-Itano (2003:205) has found that parents of early-identified children were not more likely to present with stress than parents of late-identified children.

The majority of parents of hearing-impaired children welcome NHS at birth (Watkin et al., 1995:260). A majority of 89% among parents with children with a hearing impairment would have appreciated a hearing screening test being performed on their neonate at birth (Watkin et al., 1995:260). On the other hand, 10% of mothers expressed ambivalence and scepticism towards UNHS (Watkin et al., 1995:260). A universal study conducted in Britain with respect to TEOAE similarly indicates that parental anxiety was low, and attitudes towards NHS were positive (Watkin, Baldwin, Dixon & Beckman, 1998:27). Table 2.2 summarises the results obtained regarding neonates discharged from the well-baby nursery.

Table 2.2 The attitudes of parents to NHS (Watkin et al., 1998:30)

Attitude	N	%
Leads to early diagnosis if the baby is deaf	268	95
Leads to early treatment if needed	279	98.9
Allows the parent to do something positive about the baby's health	276	97.9
Makes the parent worry unnecessarily	22	7.8
Wakes or upsets the baby	6	2.1

Table 2.2 illustrates that the majority of parents in the study by (Watkin et al., 1998:30) felt that NHS led to earlier diagnosis of hearing loss (95%) and intervention (98, 9%). Only a small number (7, 8%) felt that the screening had made them worry unnecessary. These results indicate that parents exhibited positive attitudes towards NHS and believed that it empowered them to make informed decisions regarding their neonate's future. In general, parents report that they are less concerned with their own anxiety than the neonate's potential hearing loss (Mencher et al., 2001:7).

Cost-effectiveness and maternal concern nevertheless need to be considered when deciding on a hearing screening protocol (Stevens, Hall, Davis, Davies & Dixon, 1998:14). Minimally-educated, high-risk parents find value in being included in the decision-making process regarding their neonate's health (Wall, Peralta-Carcelen, Fargason, Evans, Snyder & Woolley, 2001:292). NHS programmes create awareness of the importance of hearing, language, and speech development, and parents pay more attention to their neonate's communication skills after exposure to a hearing screening programme (Yoshinaga-Itano & Gravel, 2001:63).

Since parents may be potential victims of worry and concern, due to false-positive results, their attitudes, views, and anxieties should be considered before the implementation of a NHS programme (Weichbold Welzl-Mueller & Mussbacher, 2001:60). Unfortunately, only limited data is available about parental attitudes towards NHS in the developing world, even though parental support is essential for a successful NHS programme (Olusanya et al., 2004:296; Weichbold et al., 2001:60).

In developing countries, cultural customs and beliefs concerning childhood disabilities exist which may affect parental support of NHS, although the extent of such influence is uncertain, with no empirical evidence on the subject currently being available (Olusanya, Luxon & Wirz, 2006:620). A pilot study by Olusanya et al.

(2006:619) in Nigeria reported that parental attitudes were positive in the majority of mothers (95%) and that there was a high degree of acceptance of hearing aids (84%) as an option for early intervention. This degree of approval may indicate that parents are ready for the implementation of NHS programmes and that the attitudes and beliefs in developing countries may start to alter as NHS programmes are devised (Olusanya et al., 2006:620).

In addition to parental empowerment, education of the general community, nurses and health professionals comprises a vital component of a successful NHS programme and is often overlooked when developing such a programme (Lim & Fortaleza, 2000:S138; Diefendorf, 1997:53). Parents' concern about their neonate's hearing usually represents the first indication of a possible hearing loss and because physicians' knowledge about such a problem is limited the result may be that the neonate is only identified at a later age (Olusanya et al., 2006:620). Teamwork between healthcare professionals in the field of hearing, physicians and nurses is consequently necessary for an NHS programme to be effective. The opinion worldwide is that unless carefully administered NHS programmes are coupled with appropriate management, referrals and follow-up, NHS possesses the potential for serious negative consequences for the family and the neonate (Mencher et al., 2001:10; Diefendorf, 1997:52).

- Follow-up

Effective follow-up and tracking measures with respect to neonates referred for diagnostic testing must be in place in order for an NHS programme to be successful (Mencher & DeVoe, 2001:19; Lim & Fortaleza, 2000:S137; Diefendorf, 1997:47). Statistics indicate that 20% to 30% of neonates who do not pass a hearing screening test will fail to return for a follow-up diagnostic evaluation (Kileny & Lesperance, 2001:66).

The New York State multi-centre state-wide screening project reported a follow-up rate of 72% for the first years of the project, with increasing numbers of neonates returning for further diagnostic testing in successive years (Prieve et al., 2000:104).

The Hawaii UNHS programme increased its follow-up rates from 82% to 87% in the last years of the programme (Prince et al., 2003:1202). A recent study at Parkland Memorial Hospital in Texas was conducted to determine if the 'lost to follow-up' rate improves if the screening is repeated while the patient is still in hospital. The results are summarised in Table 2.3.

Table 2.3 Follow-up rates at Parkland Memorial Hospital (Shoup et al., 2005:66)

Year of study	Subjects	Lost to follow-up rate
Pilot Project	3759	44%
Year 1	15 297	17%
Year 2	16 384	11%
Year 3	16 099	11%
Year 4	15 943	1.7%

In the study, by Shoup et al. (2005:67), the protocol for hearing screening was altered from the Pilot Project to a protocol during Years 1, 2, 3 and 4 in order to maintain fulltime 24-hour coverage 7 days per week. During Years 2, 3 and 4, a re-screening by a technician 24 hours after the initial referral result was added to the protocol, and an audiologist conducted a final AABR test before discharge if the neonate did not pass the second screening (Shoup et al., 2005:67). The study indicated that repeated screening at planned intervals reduces the number of neonates requiring follow-up (Shoup et al., 2005:69). The improved follow-up rate in successive years suggests that NHS programmes advance over time (Prieve et al., 2000:104). However, mobile populations, poor services at out-patient departments, financial barriers and the time/efforts needed may hinder the return of neonates for additional testing; therefore the reducing of false-positive results is crucial to keep the number of follow-up screens minimal (Shoup et al., 2005:69).

Even though comprehensive and competent audiological follow-up and rehabilitation are essential at the beginning of a NHS programme, widespread experience in this field of audiology in fact cannot be offered at the start of a mass NHS Programme (Van Straaten et al., 2003:336). A country with stressed resources may fail to monitor the effectiveness of NHS implementation and if a NHS programme is not correctly implemented, problems may be identified before outcomes have been achieved over a period of time (Watkin, 1999:172). One of these difficulties is the cost of hearing screening.

- Cost of hearing screening

The costs of NHS are affected by various factors such as capital costs, operational expenses, screening protocol, follow-up services and costs, number of neonates and the expected prevalence of hearing loss (Gorga & Neely, 2003:103; Boshuizen, Van Der Lem, Kauffman-de Boer, Van Zanten, Oudesluys-Murphy & Verkerk, 2001:177; Kezirian et al., 2001:366; Kileny & Lesperance, 2001:67; Diefendorf, 1997:54). Various studies have been conducted to determine the costs of different screening protocols and are discussed in the following section.

Vohr et al. (2001b:242) investigated the costs of screening in using three different protocols. Similar results were obtained across TEOAE, AABR and two-step protocols respectively. The estimated costs were \$28.69, \$32.81 and \$33.05 per baby for the respective protocols (Vohr et al., 2001b:242). Kezirian et al. (2001:363) similarly researched the costs of OAE and AABR screening protocols. The estimated costs per screen varied between \$13 and \$25. The OAE delivered the most cost-effective screen, with an estimated cost of \$5100 per neonate who had been identified with hearing loss (Kezirian et al., 2001:363). The estimated total cost of identification of hearing loss making use of AABR reached \$9500 (Kezirian et al., 2001:363). The study indicated that an OAE/OAE protocol was the most cost-effective one for NHS (Kezirian et al., 2001:364; Yoshinaga-Itano & Gravel, 2001:64). Chiong et al. (2003:215) reported that the cost of screening neonates in hospital is between \$10 and \$50 per screen and is less than the cost of metabolic screening programmes.

A state-wide programme in the USA reported a cost of approximately \$12 600 to identify bilateral hearing loss (Yoshinaga-Itano & Gravel, 2001:64). This expense is still lower than that of establishing other birth defects. The cost of identifying hypothyroidism is \$10 000 and is even higher for hemoglobinopathy (\$23 000) and phenylketonuria (\$40 000) (Mehl & Thomson, 1998:5). The lower cost of identifying a hearing loss, compared to that of other birth defects, is an important justification for NHS in conjunction with other neonatal screening programmes.

As pointed out previously, individuals, families and communities may suffer if a hearing loss goes undetected, since it may result in communication deficits with social and financial consequences (Yoshinaga-Itano & Gravel, 2001:64). This constitutes a particular problem in developing countries where the social stigma attached to disability prevents the integration of children with hearing loss into the community owing to isolation (Olusanya et al., 2002:297). However, the long-term cost benefits of early identification of hearing loss validate NHS as a justifiable healthcare procedure, especially if the enhanced educational opportunities and improved quality of life are considered. The validity of NHS is not debated any longer in the developed world; the challenge is now to deliver the best service to the young hearing-impaired community in developed countries (Hall, 2000:396). Yet, as mentioned earlier, in the developing world there is a dearth of data on neonatal hearing loss, screening programmes and the age at which hearing loss is identified.

2.4 NEONATAL HEARING SCREENING IN THE DEVELOPING WORLD

Two-thirds of the world's persons with hearing impairment reside in developing countries; however, national programmes for the identification, prevention and rehabilitation of hearing impairment are lacking in the vast majority of them (World Health Organization, 2002:1; Olusanya, 2000:167). Data regarding the prevalence of hearing loss in developing countries is limited, but available figures report that one-to-five per 1000 of the paediatric population presents with hearing loss (Olusanya et al., 2006:621). Reported prevalence rates of hearing loss in developing countries are suspected to be lower than what they actually are, since under-reporting of cases of hearing loss is a significant problem in developing countries (Lasisi, Ayodele, Ijaduola, 2006:625; Swanepoel, 2004b:87). This may be attributed to the fact that not all cases of hearing loss are reported to the healthcare system. Furthermore, statistics regarding the age of identification and intervention are virtually non-existent because of the lack of routine NHS programmes in these countries.

The age of identification of hearing loss varies between 24 months and 5.8 years of age in developing countries (Lasisi et al., 2006:626; Gopal, Hugo & Louw,

2001:101). These cases are usually identified because of delayed speech and language development and communication milestones that are not reached (Gopal et al., 2001:102). These late identifications afford an indication of the priorities of a healthcare system in such countries.

Certain environmental factors such as poor access to healthcare services, infections, poverty and malnutrition affect the populations of developing countries, such as those in Sub-Saharan Africa (Lasisi et al., 2006:628; Swanepoel, Hugo & Louw, 2005a:13). These issues especially affect infants in the first few years of life, which are critical for physical, intellectual and emotional development (UNICEF, 2004:16). The ramifications of an unidentified or late-identified hearing loss are far-reaching. The social, economic, health and economic welfare of an individual, family and community is altered by such a loss (Olusanya, 2005:735; Swanepoel et al., 2005a:12). The most impoverished communities, situated largely in rural areas, have access to minimal or no healthcare facilities and transportation to medical assistance is limited (UNICEF, 2004:17). Minimal access to healthcare and environmental issues increases the probability of hearing loss in the paediatric population (Swanepoel et al., 2005a:12). Different priorities in developing nations because of the necessity of combating rampant infectious diseases overshadow the need to identify hearing loss as early in life as possible.

Infectious diseases are a deadly reality in many developing countries (Olusanya, 2000:167). Health care needs in developing countries are usually ranked in different priorities, and life-threatening diseases are consequently the main priority in the health care system (Olusanya, 2000:167). The focus of healthcare systems in developing countries therefore falls on saving the lives of citizens rather than on improving their quality of life (Olusanya, 2005:735). The problem of dealing with infectious diseases is an overwhelming burden for most developing countries, and therefore any plans for a NHS programme are met with natural resistance (Swanepoel et al., 2005a:14).

Gopal et al. (2001:100) propose that several factors constrain a developing country in identifying and providing intervention for young children with hearing loss. Firstly, the lack of data regarding prevalence and epidemiology of neonatal hearing loss

prevents such countries from planning an effective NHS programme. The lack of human resources in the hearing care field and of appropriate technology also hampers the planning and implementation of a programme. Furthermore, inconsistent and fragmented follow-up services influence the long-term benefit of implementing a programme. The need for hearing aids and effective back-up services in addition acts as a barrier for most developing countries. Lastly, the multiplicity of languages spoken in such a country and options for educational services is also a challenge for hearing health care services that one has to consider. Olusanya (2005:737) reports that a lack of understanding of socio-cultural issues and health-related behavioural changes contributed to the failure of many public health programmes in the past.

The reasons why UNHS has not been widely adopted in the public health sector worldwide are not clear, but may in part reflect the lack of uniform support amongst medical personnel, especially when considering the increasing financial strain and limited resources within healthcare services (Wall et al., 2001:292). In developing countries where resources are few and far between, alternative NHS methods may be required as an initial starting point. As suggested earlier, one such alternative is to begin by screening those neonates at highest risk for having or developing a hearing loss, such as Neonatal Intensive Care Unit (NICU) infants.

The NICU encompasses a number of risk factors for hearing loss, which were previously identified in the 1994 JCIH position statement, but the 2000 position statement also included admission to the NICU for more than 48 hours as a risk factor for congenital hearing loss. When resources are limited in a country, the NICU offers a valid starting point to use them, because a number of neonates with risk factors for hearing loss are grouped together in the NICU (Mencher & DeVoe, 2001:18).

The High-Risk Register (HRR) was accepted for screening the high-risk population, but was not adopted as a true hearing screening tool (Hayes, 2003:66). It was used in conjunction with other hearing screening tools, such as behavioural observation audiometry, to identify hearing loss in the high-risk population (Hayes, 2003:66). The HRR only identifies 50% of neonates with hearing loss, and its effectiveness as a

single screening device is therefore limited (Olusanya et al., 2004:288; Johnson, 2002:482; Lutman & Grandori, 1999:95).

Behavioural observation audiometry has been criticised as a potentially unreliable and invalid means to identify a hearing loss in neonates (Diefendorf, 2002:474). Reports indicate that 40% to 50% of neonates with a hearing loss would have been missed if the method of detection had been the behavioural hearing screening method instead of objective, electrophysiological screening of auditory abilities (Yoshinaga-Itano & Gravel, 2001:62).

Observations of neonate's responses to sound lead to difficulties in determining the status of the auditory system in neonates. Behavioural measures cannot reliably predict hearing loss in infants younger than six months of age (Diefendorf, 2002:471), because behavioural observations of neonate's responses to sound are sensitive to subjective interpretations by the observer and the orientating response only starts to develop at about 6 months of age (Hayes, 2003:66). Attention, cooperation and the state of the subject may hamper the estimate of the infant's hearing sensitivity (Johnson, 2002:483). The limitations of subjective testing procedures such as behavioural audiometry consequently emphasise the importance of employing an objective NHS instrument in order to compensate for possible observer-biased interpretations of auditory system sensitivity. Objective and reliable tools are necessary to screen this population (Northern & Downs, 2002:3).

The NICU offers a platform for Targeted Neonatal Hearing Screening (TNHS) in a developing country with limited resources, where restricted capital is available (Van Straaten et al., 2003:333; Mencher et al., 2001:7; Meyer et al., 1999:903). TNHS appears to be a comparatively inexpensive method of improving the age at which hearing loss is detected, in remote regions with limited medical access (Stevens et al., 1998:18).

Medical conditions such as a birth weight of less than 1500 grams (a low birth weight) constitute a known risk factor for neonates with hearing loss as well as syndromes known to include sensorineural or conductive hearing loss (Olusanya et al., 2004:293; Roizen, 1998:240). Although most prenatal infections are usually

asymptomatic, neonates exposed to in-utero infections are likely to be admitted to the NICU (Roizen, 1998:241). Progress in perinatal medicine has improved the survival rate of low-birth-weight and asphyxiated NICU neonates (Suzuki & Suzumura, 2004:255). Therefore, more neonates with complicated perinatal histories are surviving and as a result larger numbers of neonates with risks for hearing loss are also surviving.

NICU graduates exhibit an increased risk for hearing loss from exposure to a range of diverse factors, including environmental, medical, health and clinical conditions (Suzuki & Suzumura, 2004:255; Polinski, 2003:99; Yoon et al., 2003:354). Various studies of NHS in NICU graduates report on the medical conditions which are associated with hearing loss for the NICU population (Chiong et al., 2003:215; Van Straaten, et al., 2003:332; Yoon et al., 2002:353; Stewart, Mehl, Hall, Thomson, Carroll & Hamlett, 2000:s127; Meyer et al., 1999:900; Hess, Finckh-Kramer, Bartsch, Kewitz, Versmold & Gross, 1998:81). The screening protocols utilised in these studies employed different screening methods but included tympanometry, AOAEE's, and AABR's followed by diagnostic ABR's. The results obtained in eight recent NICU studies are summarised in Table 2.4.

Table 2.4 Summary of eight recent NICU hearing screening studies

Study	N	SNHL	Tympanometry #		OAE's		AABR's		ABR		Risk factors
			Unilateral Refer	Bilateral Refer	Unilateral Refer	Bilateral Refer	Unilateral Refer	Bilateral Refer	Unilateral Refer	Bilateral Refer	
Wroblewska-Seniuk et al. (2005)	218	*	**	**	20,1%	19,7%	**	**	**	**	Ototoxic medication, low Apgar, prematurity
Yoshikawa et al. (2004)	102	*	**	**	**	**	**	**	**	7,8%	Congenital infection, high C-reactive protein, chromosomal aberration
Chiong et al. (2003)	428	*	**	**	29%	20%	**	**	**	**	Rubella, TORCH, syphilis, trauma, ototoxic medication
Van Straaten et al. (2003)	2484	1,9%	**	**	**	**	**	3,1%	19,5%	62,3%	**
Yoon et al. (2002)	82	2,3%	8%	29%	5%	**	**	**	**	2,3%	PPHN, ECMO, ototoxic medication
Stewart et al. (2000)	788	1,5%	**	**	**	**	0,26%	0,63%	**	**	**
Meyer et al. (1999)	770	5%	**	**	13,1%	16,3%	3,3%	2%	**	**	Craniofacial anomalies, familial HL, sepsis, VLBW, mechanical ventilation, rubella, asphyxia, Down syndrome
Hess et al. (1998)	942	1,4%	**	**	**	26,5%	**	**	**	28,1%	Craniofacial anomalies, prematurity, rubella, CMV, familial HL

* No data available w = weeks
 ** No results obtained mo = months
 SNHL = Sensorineural Hearing Loss

CMV = Cytomegalovirus # Probe tone not specified
 PPHN = Persistent Pulmonary Hypertension
 VLBW = Very Low Birth Weight ECMO = Extracorporeal Membrane Oxygenation

From Table 2.4 it is evident that the percentage of infants who failed the OAE screening bilaterally ranged between 16, 3% and 26, 5%, while between 0, 63% and 3, 1% failed the AABR screening bilaterally. Research indicates that between 1% and 2% of NICU graduates will present with a hearing loss, which means the prevalence is approximately ten times higher for the NICU population than for the well-baby nursery (Van Straaten et al., 2003:333; Davis & Wood, 1992:78). The referral rate for pathologic AABR results of 1, 91% in the studies shown in Table 2.1 correlates with the reported prevalence of hearing loss of up to 2% in NICU graduates. These figures emphasise the importance of considering the presence of hearing loss and progressive hearing loss in NICU graduates (Huang, Kaga, Hashimoto, 2002:189).

The established risk factors for hearing loss in neonates that were present in the subject groups are summarized in Table 2.4. Developments in genetics, improvements in the NICU and the introduction of universal immunisation programmes have resulted in major changes in the epidemiology of hearing loss in infants (Bamiou, Macardle, Bitner-Glindzicz & Sirimanna, 2000:98). Owing to improvements in neonatal care, the neonatal mortality rate and prognosis of very ill neonates have altered markedly in recent years. The better prognosis and careful monitoring of critically ill neonates have in turn altered the epidemiology of hearing loss and the potential impact of the risk factors on the auditory development. Although neonatal care has improved over the years, the presence of risk factors for hearing loss may result in a congenital or late-onset/progressive hearing loss (Robertson, Tyebkhan, Hagler, Cheung, Peliowski & Etches, 2002:353). The NICU graduates display an increased risk for both types of hearing loss.

Hearing loss could be present during or after birth as early-onset or congenital hearing loss, or postnatally as late-onset, progressive, or acquired hearing loss, with varying degrees of severity in neonates and infants (Olusanya et al., 2004:288). The risk for late-onset, possibly progressive, sensorineural hearing loss among survivors of severe neonatal respiratory failure has, since the mid-1980's, resulted in growing concern (Robertson et al., 2002:353). Robertson et al. (2002:355) documented that 53% of survivors of severe neonatal respiratory

failure may suffer from a late-onset hearing loss that could be progressive in nature. They recommended that such failure should be an indication for long-term audiological surveillance (Robertson et al., 2002:353). Even though the risk for late-onset/progressive hearing loss in survivors of respiratory failure is large, other NICU conditions should also receive ongoing audiological surveillance which, together with education regarding hearing loss, is necessary to identify this type of loss (Olusanya et al., 2004:296).

Another type of hearing loss for which NICU infants are at increased risk is auditory neuropathy or auditory dys-synchrony (AN/AD). Currently, AN/AD is described as a condition in neonates and adults with normal outer hair cell function but abnormal neural function at the level of the cranial nerve VIII (Ngo, Tan, Balakrishnan, Lim & Lazaroo, 2006:1123; D'Agostino & Austin, 2004:344). The clinical results are observed as normal OAE's and / or cochlear microphonic response in the presence of an absent or severely abnormal ABR (Ngo et al., 2006:1123). AN/AD may be under-recognised in NICU graduates because current audiological protocols do not specifically aim to identify AN/AD, and may result in a neonate with AN/AD not being identified until after discharge (D'Agostino & Austin, 2004:344). Future screening protocols therefore need to be revised to detect AN/AD effectively, because OAE screening alone may fail to detect the disorder (D'Agostino & Austin, 2004:344).

Several factors place a neonate at risk for AN/AD: these include a high-risk neonatal history, a family history of congenital hearing loss, hyperbilirubinemia, prematurity, ototoxic medication, hypoxia and mitochondrial and metabolic disorders (D'Agostino & Austin, 2004:347). However, reports on these risk factors are small in sample size, offering only limited information about the neonatal histories (D'Agostino & Austin, 2004:347). The incidence of AN/AD is reported to range between 5 – 15% in the hearing-impaired population, but more research is needed to determine the actual incidence in the general population (D'Agostino & Austin, 2004:348). TNHS may be helpful in the identifying, measuring, and tracking of neonates at risk for congenital, late-onset hearing loss and AN/AD in countries with limited resources (Olusanya et al., 2004:296).

The high prevalence of hearing loss for NICU infants, and the positive empirical evidence of the benefits stemming from its early identification, makes NHS in this population an important healthcare priority (Roizen, 1998:240). However, the characteristics of the NICU population and risk factors for such loss may vary across communities and countries (Olusanya et al., 2004:296). Developing NHS programmes consequently requires careful consideration of the screening protocol for each specific context (Gravel et al., 2000:139). Specific contextual factors in countries may influence the implementation of a NHS programme, so that a programme developed and implemented in one country may not be applicable in another. Countries or even communities within a country should therefore be evaluated in order to identify specific issues pertaining to the effective development of a NHS programme (Swanepoel et al., 2006a:1242).

2.5 NEONATAL HEARING SCREENING IN SOUTH AFRICA

The World Health Organization (WHO) reports that 250 million people live with a disabling hearing impairment, and that two-thirds of these people reside in developing countries (WHO, 2005:1). In contrast to the availability of prevalence data for infant hearing loss in developed countries, there is an almost complete dearth of such data for developing countries (Olusanya et al., 2004:287; Swanepoel, 2004:11; Swanepoel et al., 2004:634; Olusanya 2000:167; McPherson & Swart, 1997:1). However, research has concluded that higher rates of severe-to-profound bilateral hearing loss may be expected in Sub-Saharan Africa (Olusanya et al., 2004:291). South Africa is the largest country in Sub-Saharan Africa, and is classified as an upper middle-income developing country with a GNI per capita of \$3,630 and producing 35% of the GDP of Sub-Saharan Africa (World Bank, 2005:1).

Development in South Africa is characterised by cluster growth at an average of 3% per year; however this country struggles to reduce unemployment (26%), poverty and inequality (World Bank, 2005:1). The diverse nature of the South African population clearly poses a number of unique challenges for the effective development and implementation of NHS programmes, which include multilingual and multicultural communities, income inequalities, hunger, poverty, limited employment opportunities, educational uncertainties, and socio-economic tensions (Swanepoel, 2004:15; Fair & Louw, 1999:14). These social and economic challenges place strain not only on the general population, but also, and more extensively, on the disabled population.

The recent national census of disabled persons in South Africa indicates that 0,94% of the South African population has a hearing impairment, and that such impairment represents 14,43% of the total disabled population (Education White Paper 6, Special Needs Education, 2001:14). This estimated prevalence of hearing loss is lower than that reported in the USA where approximately one in 1 000 neonates exhibit profound bilateral permanent hearing loss (Northern & Downs, 2002:3). The prevalence estimate of hearing loss in South Africa is probably not accurate, because of the social stigma related to disability amongst African communities, limited access to health care services and under-reporting of hearing loss present at birth (Swanepoel et al., 2004:634). The fact that no precise data is available also emphasises the importance of initiating systematic screening programmes such as NHS to address this gap.

The Professional Board for Speech, Language and Hearing Professions in South Africa acknowledges the value of early detection of and intervention for hearing loss and, as noted above, published a position statement on hearing screening within South Africa in 2002 which advocates early detection of neonates with hearing impairment through electrophysiological measurements for TNHS, followed by early intervention, provided by means of integrated interdisciplinary provincial and District Health Systems healthcare services (HPCSA, 2002:1). The aim of the programme is to allow habilitation or rehabilitation of the individual's capabilities and potential, so as to secure their full potential and contribution to society and the country's economy, through offering optimum, cost-effective

solutions for neonates identified with hearing impairment (HPCSA, 2002:1). The programmes aim to decrease the age of identification and intervention in South Africa.

The Position Statement summarises the goals for EHDI programmes in four statements (HPCSA, 2002:3). Firstly, screening for hearing loss should detect neonates at risk for such loss that hinders normal development. Secondly, the types of this loss which are targeted are unilateral or bilateral, conductive or sensorineural, and greater than 30 dB in the speech frequencies (0.5 – 4 kHz). Thirdly, by means of developmental screening programmes at Primary Healthcare clinics, all infants should receive ongoing monitoring of auditory development and communication skills, as well as of other sensory and motor milestones. Fourthly, quantifiable goals and quality indicators need to be determined for the monitoring and evaluation of EHDI programmes, with regular reviews to assure the quality of each programme.

Family and healthcare workers should work together in a family-centred, transdisciplinary team model within an individualised family plan in order to provide the necessary services (HPCSA, 2002:4). Services should be coordinated between families, paediatricians, audiologists, otolaryngologists, speech-language therapists, educators and other early intervention professionals (HPCSA, 2002:4).

The South African Hearing Screening Position Statement furnishes an objective for EHDI services by setting standards where none existed in the past (Swanepoel et al., 2004:634). However, it is important to evaluate the recommendations of the Position Statement critically within the South African context, and in particular, within the infrastructure of existing audiological and otolaryngology services (Swanepoel et al., 2004:634). The Department of Health advocates the creation of a comprehensive health information system to assist in the planning and management of health services, which is regarded as a joint responsibility of health districts, provinces, the private sector and the national department (Department of Health, 2003:3). This health information system also applies to the hearing healthcare profession and may assist existing audiological services in developing and implementing NHS programmes.

The Professional Board for Speech, Language and Hearing Professions advocates the following benchmarks and standards for the local South African community (HPCSA, 2002:5), summarised in Table 2.5.

Table 2.5 Benchmarks and standards for hearing screening in South Africa (Summarised from the South African Hearing Screening Position Statement (HPCSA, 2002:10))

Benchmark & Standards	Evaluation
<ol style="list-style-type: none"> 1. Appropriate technology should be utilised for risk-based NHS at public sector institutions to ensure that all socio-economic levels of society have access to the benefits of NHS; 2. NHS ought to take place in the well-baby nursery, at discharge from the NICU or at the six-week immunisation clinic; 3. Infants that attend their first immunisation at the community clinic should be screened for hearing loss with appropriate technology by 2005; 4. 98% of infants should be screened for hearing loss by 2010; 5. Babies that missed their in-hospital screen should be screened at the six-week immunisation clinic; 6. Hearing loss should be diagnosed by three months of age; 7. Options for communication should be discussed with the parents within a multi-professional team by three months of age; 8. Appropriate referral and early intervention should take place by six months of age; 9. All infants at risk for delayed onset or progressive hearing loss should receive ongoing audiological and medical monitoring for three years; 10. The high-risk register and behavioural observations are not reliable and accurate as stand-alone methods to screen for hearing loss. These measures should only be used in conjunction with electrophysiological tests such as the ABR and OAE; 11. Noise-emitting devices, for example a rattle, whistle or other instruments, are not endorsed for NHS; 12. Community-based developmental screening that incorporates communication milestones should be employed at primary health care level within the District Health Service model; 13. Adequate supporting infrastructure and services at regional levels for diagnostic audiological evaluation and therapeutic intervention should be available. Access to necessary assistive devices should be possible. 	<p style="text-align: center;"><i>There is limited funding for appropriate hearing screening technology at all public sector institutions</i></p> <p style="text-align: center;"><i>Home births are not considered</i></p> <p style="text-align: center;"><i>No formal programme at present screens neonates at community clinics</i></p> <p style="text-align: center;"><i>No mention of who should perform the screening at clinics</i></p> <p style="text-align: center;"><i>No mention of referrals to other healthcare workers (such as Ear-, Noise-, and Throat Specialists or Paediatricians)</i></p> <p style="text-align: center;"><i>No mention is made of how and where the referral, follow-up and monitoring services should function</i></p> <p style="text-align: center;"><i>Noise- emitting devices are still used in hospitals and clinics with no appropriate technology</i></p> <p style="text-align: center;"><i>No mentioning of the healthcare worker responsible for developmental screening or the referral and follow-up after screening</i></p> <p style="text-align: center;"><i>Limited funds for diagnostic equipment and assistive listening devices are not taken into account</i></p>

Table 2.5 indicates that the proposed benchmarks proposed by the JCIH year 2000 position statement are integrated into the benchmarks for South Africa but that guidelines for effective and practical implementation of these are lacking. The resources available to implement NHS programmes are not specified although monetary, infrastructure, personnel, equipment, follow-up services and intervention resources are necessary to develop a sustainable screening programme. Contextual challenges within the South African community further hinder the development and implementation of a NHS programme. The healthcare system of South Africa focuses on these other challenges, because they are issues that threaten the lives of citizens in the country.

The South African Hearing Screening Position Statement advocates that in addition to funds being made available for assistive devices and appropriate technology, money should be allocated to the training of personnel in the use of the instruments employed and in the administration of NHS programmes in the hospital and community (HPCSA, 2002:4). The reality in South Africa, however, is that disparities exist between the private and public audiological services (Swanepoel, 2004b:131). The majority of audiologists work in the private sector in South Africa and provide hearing healthcare services to a small number of the population; these services are usually provided to people living in first-world conditions who can afford them (Swanepoel, 2004b:131). The national healthcare system has to manage the majority of the population who live in third-world conditions and cannot afford the private rates. Only a small number of such people consequently enjoy access to these services (Swanepoel, 2006a:265).

The prevalence of hearing loss is expected to be higher in these communities because of the relationship between hearing loss and socio-economic deprivation (Kubba, 2004:123). This means that although the larger community of South Africa has limited access to qualified audiologists, it runs a higher risk for hearing loss because of poverty. Hence more audiologists need to be trained and offered positions in the national healthcare system, to cater for the needs of the majority of the South African population.

There is a paucity of knowledge regarding the prevalence and epidemiology of hearing loss in neonates across the entire South African population (McPherson & Swart, 1997:15). Epidemiological data on such loss in the South African community is limited: studies only report on small regions and are often not comparable because of methodological differences (Swanepoel, 2004b:134). Information on EHDI services in South Africa is even more difficult to obtain; yet is very important for the planning and implementation of widespread EHDI services which are based on accurate knowledge regarding infrastructure and service provision (Swanepoel, 2004b:134).

An unpublished undergraduate study reports that the provision of hearing screening services is limited to audiologists in South Africa because they are the only professionals trained to do the screening (Kathrada, 2000:54). The study was conducted in a metropolitan area in Kwa-Zulu Natal and established that the majority of healthcare professionals (administrators, neonatal nurses and paediatricians) had not heard of NHS previously (Kathrada, 2000:54). The lack of knowledge and awareness amongst nurses regarding hearing screening constitutes another obstacle in South Africa. Nurses are recommended as the personnel who should be trained to conduct such screening, but at present the low awareness levels of nurses and other healthcare professionals inhibit the development of NHS programmes in South Africa (Swanepoel, Hugo & Louw, 2005b:3).

Swanepoel et al. (2005b:6) investigated hearing screening at maternal and child health clinics in a developing South African community. The results indicate that clinics provide a suitable context for screening and provide a possibility for collaboration with the purpose of facilitating effective initial NHS programmes (Swanepoel, 2005b:6). The study also indicates an increased incidence of risk indicators increasing the risk for congenital hearing loss, poor participation in the follow-up process and subsequent unsatisfactory involvement in the early intervention process (Swanepoel, 2005b:6). These

challenges are realities that will affect the delivery of hearing healthcare services, especially those of hearing screening, in South Africa.

An in-depth understanding of such challenges is evidently necessary for the planning of a screening programme. These are discussed in the following sections.

2.6 CONTEXTUAL ISSUES THAT AFFECT THE EFFICACY OF NHS PROGRAMMES

The development and implementation of an EHDI programme in South Africa should be considered with the unique characteristics of the South African population in mind because these challenges may influence the long-term effectiveness of such a programme and determine whether such a programme realises its aims. The population in South Africa may be at risk for a particular disorder yet simultaneously exhibit inherent factors that increase the resilience to developing a disorder (Popich, 2003:23). South African people face very specific social, medical and economic challenges that characterise the general population. In order for relevant hearing care services to be delivered, especially regarding the early identification of neonatal hearing loss, a broad understanding of the local context is needed. South Africans are faced each day with conditions such as malaria, tuberculosis, poverty, HIV/AIDS and educational challenges. In the following section, some of the unique challenges that may influence the efficacy of a screening programme within the South African community are discussed.

2.6.1 Poverty

Poverty has a multitude of faces, numerous dimensions and threatens all aspects of childhood (UNICEF, 2004:15). It deprives children of capabilities to survive, develop and thrive and it inhibits the capacity of families and communities to care for children (UNICEF, 2004:16). Poverty and its

consequences comprise a major problem in Africa, both as a source and consequence of impairment (UNICEF, 2004:17). The presence of poverty leads to damage to the mental, physical, emotional and spiritual development of a child (UNICEF, 2004:17).

There is an association between deprivation or poverty and hearing impairment, but the link has received little attention (Kubba, MacAndie, Ritchie & MacFarlane, 2004:123). South Africa is a poverty-stricken nation, and a great number of children with disabilities live in extreme poverty, in inhospitable environments (Swanepoel, 2004a:14). Six out of ten children in South African reside in impoverished households (Children in 2001, 2001:114). Children living in poverty are more vulnerable to impairments, as factors related to poverty lead to preventable disability, which in turn propagates poverty (Swanepoel, 2004a:14). Poverty can exert a negative influence on a neonate with a hearing impairment, owing to poorer access to primary health care (Kubba et al., 2004:123). The healthcare needs of socio-economically deprived families therefore need to be considered when planning services; as such children are over-represented amongst hearing-impaired children (Kubba et al., 2004:125). Other factors have been discussed above.

2.6.2 Healthcare resources

The South African healthcare system is based on a primary healthcare philosophy that focuses on decentralisation of health services and places emphasis on community care (Swanepoel, 2004b:125). This means that the focus is placed on healthcare rather than medical care (Kritzinger, 2000:88). The health needs of the wider population are addressed by this approach.

However, primary ear and hearing care programmes have not been implemented in most developing countries (WHO, 2005:2). Hearing healthcare in developed countries has made significant progress but it still remains a problem in developing countries, especially Sub-Saharan Africa (Lasisi et al., 2005:626). In South Africa healthcare priorities are placed on saving lives

instead of improving quality of life (Swanepoel et al., 2005a:14). EHDI services are also challenged by natural resistance because of the invisible nature of hearing loss (Swanepoel et al., 2005a:14). The misdistribution of resources, low socio-economic levels and high infant mortality and morbidity rates has placed the focus on infectious diseases that influence the survival of a community (Swanepoel et al., 2005a:14).

Infectious diseases

Some infectious diseases such as malaria, tuberculosis and HIV/AIDS in the South African population that may influence the effective implementation of a NHS programmes are discussed in the following section.

HIV/AIDS

HIV/AIDS is now the leading cause of death in sub-Saharan Africa and represents a major cause of mortality in the world (Chakraborty, 2004:132). South Africa has an estimated population of 40 million people, of whom 28% are affected by HIV/AIDS and 21, 5% are living with HIV (Berry, 2004:2). Of the world's population, 13% of HIV-positive people live in South Africa and 5.6% of all children between the ages of two and 14 years carry the virus (Berry, 2004:2; Roux, 2003:9). Data report that five million children in Africa have been infected with HIV via vertical transmission during the last decade (Gisselquist et al., 2004:110). All over the world, paediatricians have found that the HIV/AIDS epidemic offers challenges and opportunities, and it is an enormous trial to meet the healthcare needs of infected children (Roux, 2003:9). The rapid progression of HIV-infection in South Africa influences every aspect of the social and economic wellbeing of citizens in South Africa, especially children (Children in 2001, 2001:85). Some of the largest numbers of children living with HIV/AIDS are to be found in South Africa and since HIV/AIDS may exert a profound influence on the prevalence of auditory impairments across the paediatric population, it must be considered before a NHS programme is implemented (Swanepoel, 2004a:11).

The magnitude of the HIV/AIDS epidemic overshadows priorities related to disability and quality of life, such as hearing loss, in South Africa (Swanepoel, 2004b:123). However, neonates born to HIV/AIDS-infected mothers are at an increased risk for acquiring a hearing loss due to notably lower birth weights and because HIV can affect every organ in the body (Spiegel & Bonwit, 2002:128). Neonates born to HIV-infected mothers are at risk for congenital hearing loss and for developing a hearing loss shortly after birth (Druck & Ross, 2003:2002:4). Neonates living with HIV/AIDS are also susceptible to infections and neurological complications that can diminish auditory function (Matkin et al., 1998:143).

Furthermore, HIV/AIDS is related to congenital hearing loss as a result of ototoxic medication taken by the mother for treatment of HIV-related problems (Swanepoel, 2004b:123), which may cross the placenta and damage the development of the foetal ear structure (Bankaitis, Christensen, Murphy & Morehouse, 1998:178). A recent study in South Africa found that 85% of neonates with HIV/AIDS between 6-12 months presented with abnormal middle ear functioning and excessive wax in the external ear canal (Bam, Kritzing & Louw, 2003:40). HIV/AIDS may affect the outer, middle and inner ear parts of a neonate. Hence HIV infection may have far-reaching effects on the etiological factors related to hearing loss and management of congenital hearing loss due to HIV/AIDS.

The increasing number of neonates that are prenatally exposed to HIV may increase the prevalence of auditory impairment in South Africa (Swanepoel, 2004b:124). The consequences of the weakened immune system may include complications of the central nervous system and auditory system in the exposed population. The increased prevalence of middle ear and outer ear pathologies as a result of the exposure to HIV/AIDS may also result in auditory impairment (Druck & Ross, 2002:4). The large population of neonates who live with HIV/AIDS will place further demands on the already fragile healthcare system. In addition, poverty offers a threat to the population in general because

it exacerbates the effect of HIV/AIDS (UNICEF, 2004:15). However, the HIV exposed population is an important group that will present with medical problems and will be in need of appropriate medical and consequent audiological services in South Africa (Swanepoel, 2004b:124).

As remarked earlier, the focus of healthcare priorities in South Africa is aligned towards life-threatening diseases, such as tuberculosis, which is on the rise in developing countries (UNICEF, 2004:8). This phenomenon is directly related to the HIV epidemic, and in South Africa 55% of tuberculosis cases are HIV-positive (Achmat & Roberts, 2005:6). Tuberculosis associated with HIV infection is the leading cause of death in South Africa (Achmat & Roberts, 2005:6).

Other infectious diseases

Another disease that threatens the well-being of South African citizens is malaria, which is estimated to cause 35% of the cases of preventable low birth weight in Africa (Child Malaria and Pregnancy Brochure, 2001:1). Neonates are at risk for placenta infection, which may lead to low birth weight, a major factor in neonatal illness and death (Malaria and Pregnancy Brochure, 2001:3). The risk for low birth weight and prematurity increases the neonate's risk for developing a hearing loss before, during or after birth. A birth weight of less than 1500 grams places a neonate at risk for a hearing loss, as noted above (JCIH, 2000:10).

It is evident that a good physical infrastructure, public interest and institutional support are prerequisites of an effective EHDI programme. Professionals of all levels in South Africa must therefore attempt to identify the underlying factors that prevent the implementation of a screening programme and work together to provide solutions, which are needed to reach the neonates and children with hearing healthcare services in South Africa that can least afford it, who enjoy only limited access and live in remote regions.

2.7 CONCLUSION

NHS is becoming the de facto medical/legal standard of care in developed countries such as the USA, United Kingdom and Australia, but it remains to date a practice almost exclusively reserved for those countries (Swanepoel, Hugo & Louw, 2006a:1242). However, a growing international awareness is providing more insight into the hidden disability of hearing loss in the developing world (Olusanya, 2005:735). There has also been an increasing awareness of the need to establish NHS programmes in South Africa in order to serve the population at large (Swanepoel et al., 2004:634; HPCSA, 2002:1).

The Professional Board for Speech, Language and Hearing Professions recommends that hearing screening should include well-baby nursery-, NICU neonates or six-week immunisation clinics by means of targeted screening (HPCSA, 2002:5). The NICU provides a starting point for screening in a community with limited resources, such as South Africa. However, NHS programmes are far from general in South Africa and are not meeting the needs of the general South African population.

The reality in South Africa is that the overwhelming burden of infectious diseases, such as HIV/AIDS and tuberculosis, has offered a consistent obstacle to gaining support from government and other institutions because of the attention and support that life-threatening diseases receive (Swanepoel et al., 2006a:1242). A dearth of prevalence studies and research into the aetiology of hearing loss exists in South Africa, and available research is limited to small groups, therefore being unrepresentative of the general population (McPherson & Swart, 1997:2).

The investigation of the NICU as a screening context is a priority stated in the benchmarks laid down in the South African Hearing Screening Position Statement 2002. It is consequently necessary to evaluate and describe pilot

hearing screening programmes in these units in order to provide empirical evidence which adds to the limited available data on NHS in South Africa.

2.8 SUMMARY

This chapter offered a critical evaluation of EHDI services in the developed and developing world. The principles and benefits of early detection and intervention of hearing loss were described. The development and principles of UNHS were discussed as well as the history of hearing screening methods, and current electrophysiological screening measures were evaluated. Subsequently the researcher discussed the current status of NHS in the developing world. TNHS was evaluated as a screening method in developing countries which possess limited resources for hearing screening. The principles contained in the South African Position Statement on Newborn Hearing Screening and the proposed benchmarks for NHS in South Africa were considered and the screening context was evaluated in terms of the specific contextual challenges and issues that may influence the efficacy of a NHS programme.

CHAPTER 3

METHODOLOGY

The aim of this chapter is to describe the methodological approach implemented in conducting the empirical research for the present study

3.1 INTRODUCTION

Social research entails gaining new knowledge about the social world by employing logical thinking, following rules and repeating research actions (Neuman, 2003:2). The aim of the current study was to report on a hearing screening programme in a Neonatal Intensive Care Unit (NICU) within the public health sector of South Africa so as to provide data where none existed before. A scientific approach was followed to record data as well as observations, in order to seek patterns of irregularities for the NICU screening context (Babbie, 2004:29). Since generalisation of observations can only occur after logical explanations of these observations, the design and method in the current study needed to be planned in order to answer the research question:

Is NHS in a NICU in a South African regional hospital a feasible option?

3.2 RESEARCH AIMS

Main aim

The main aim of the study was to critically describe a hearing screening programme at a NICU in a provincial hospital in South Africa.

The following sub-aims were formulated so as to achieve this main aim.

Sub-aims

- To describe the inherited and acquired risk factors for hearing loss in the sample;
- To describe the middle-ear functioning of the sample;
- To describe the AABR and AOAЕ screening results of the sample;
- To describe the follow-up screening results;
- To compare the middle-ear functioning and hearing screening results;
- To describe the perceptions of mothers and caregivers regarding neonatal hearing screening.

3.3 RESEARCH DESIGN

An exploratory, descriptive design was implemented during this study (Babbie, 2004:88; Fouche & De Vos, 2002:139). The research design can be described as the “blueprint” or customised plan devised to address diverse types of questions (Mouton, 2002:55).

An exploratory approach was followed to investigate a new hearing screening context, in a community and country lacking contextual research regarding NHS for NICU neonates and infants. Such research is conducted if the topic is new, or to familiarise the researcher with the latest facts and the research setting (Babbie, 2004:87; Neuman, 2003:29). Fresh ideas are generated by means of exploratory research (Neuman, 2003:29).

Objective measurement and description of variables occurred in a specific new screening context, the NICU of the said hospital. The researcher gathered descriptive data on the characteristics of the NICU population, bearing in mind that the purpose of descriptive studies is to examine and describe observations (Babbie, 2004:89). A descriptive study presents scientific details of a situation,

social setting, or relationships (Neuman, 2003:30). Descriptive research aims to locate new data, provide a detailed picture of the context investigated and report on the background and milieu of the research context (Neuman, 2003:29). However, Neuman (2003:30) also points out that descriptive and exploratory research in practice work together and it is not possible to separate them distinctively.

Babbie (2004:114) confirms that researchers must aim to focus on combined purposes in studies. The combined descriptive and exploratory research methodology in the current study consequently aimed to offer a comprehensive perspective on hearing screening in the new context mentioned.

The method of data collection involved the recording and measurement of the hearing status of neonates and infants, as well as of the perceptions of mothers and caregivers regarding NHS. These results were recorded using quantitative research methods, which in general investigate relationships amongst variables with the aim of explaining, predicting and controlling phenomena (Leedy & Omrod, 2001:100). Quantitative research often implements measuring instruments to understand certain concepts and variables (Delpont, 2002:165). In research, quantifiable results for a study are achieved by measuring the variables concerned. In the present case, the researcher investigated the mothers/caregivers and the neonates/infants discharged from the NICU.

The five sets of collected data were recorded on data collection sheets (Appendix B, C & D) for each subject. The quantitative data collected for each subject comprised:

- Background information and risk factors for hearing loss;
- Bilateral immittance screening measurements using 226Hz and 1000Hz probe tones;
- Hearing screening results using AABR and AOAEE;
- Perceptions of mothers and caregivers with respect to hearing screening;

- Follow-up immittance and hearing screening results.

3.4. RESEARCH CONTEXT

The selected research context in the current study was that of Kalafong Hospital, located in the City of Tshwane Metropolitan Municipality (CTMM). The CTMM covers a large area of 3 200 km² and has approximately 2 million residents. The Municipal Demarcation Board established that 68% of the population is black, 28% white and the rest coloured (1, 7%), Asian (1, 5%) and others (0, 7%). Figure 3.1 indicates that 27% of these residents are 15 years or younger; 39,7% are between 16 and 35 years of age; 28,5% are between 36 and 64 years old, and 4,7% are older than 65 years of age. Ninety-one percent of the population is literate (Annual Health Report 2002/2003, 2004:7).

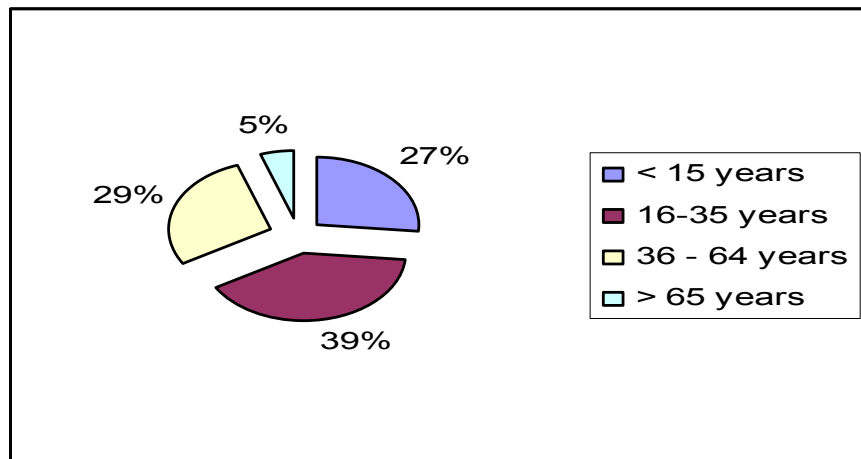


Figure 3.1 Age distribution in the City of Tshwane (Annual Health Report 2002/2003, 2004:7)

The service levels in the CTMM directly influence the health and well-being of the community (Annual Health Report 2002/2003, 2004:7). The lack of income and poor living conditions reinforce the effects of malnutrition and reduce immunity to common infections in this community. Some 306 034 unemployed and 457 713 economically inactive residents reside in the city of Tshwane; 98

704 households receive no income and 16 427 households have no toilet facilities (Annual Health Report 2002/2003, 2004:7). The risk for cholera and other diarrhoeal diseases is consequently high in these areas.

In terms of the South African National Health Bill, the district health system constitutes the medium for the provision of primary health care services to communities. Delegation of services offers integration of services through the provincial to the local government, in line with relevant legislation, e.g. Sections 126 and 156(4) of the constitution. Clinics, community health centres and district hospitals in the area offer primary health care, which aims to promote health, prevent illness and cure diseases without admitting a patient to a hospital (Annual Health Report 2002/2003, 2004:10).

The increasing number of people living with HIV/Aids challenges the healthcare system of South Africa. HIV/Aids, as an unprecedented catastrophe, is destroying public life in Tshwane. The effects of the HIV/Aids epidemic in South Africa and in Tshwane are in fact comparable to those of a war against this region (Annual Health Report 2002/2003, 2004:10). The following represent some challenges in Tshwane as described in the Annual Health Report 2002/2003 (2004:31).

- More than 10% of the inhabitants of the city are already infected with HIV and new infections take place daily;
- The economy of Tshwane is under siege, with productivity being minimised owing to increased absenteeism, increased staff turnover, low productivity, etc, and with the business capacity of the community coming under pressure;
- Cases of infant mortality have already risen by more than 100% between 1990 and 1999 (i.e. from 17,5 deaths per 1000 live births in 1990 to 35,7 in 1999);
- Tuberculosis has increased by 124%;

- A large number of children suffer from malnutrition and do not experience a safe home environment, parental attention, appropriate education, etc. This phenomenon creates a “lost generation”.

Kalafong Hospital is a regional hospital within the city of Tshwane, consisting of 28 wards, and can accommodate about 1000 patients. The hospital receives referrals from Gauteng, Pretoria, Mamelodi and Mpumalanga, and refers patients to Pretoria Academic Hospital. Consultants who work at Kalafong Hospital are dually employed by the University of Pretoria and the Gauteng Department of Health. They are responsible for the undergraduate and post-graduate training of medical students.

The Paediatric Department at Kalafong Hospital contains a NICU and High Care Unit of which the former can accommodate six patients and the latter 20 patients. The most common medical problems observed in the unit are pathologies in neonates with low birth weight, premature neonates and full-term neonates, especially neonates with lung pathologies. The medical personnel who manage and supervise the neonates and infants comprise trained nursing staff, specialist paediatricians and paediatricians in training (Source: Head of Paediatrics in the NICU at Kalafong Hospital).

The NICU at Kalafong Hospital represents the screening context selected for investigation because the Professional Board for Speech, Language and Hearing Professions' Year 2002 Position Statement advocates targeted NHS for South Africa (HPCSA, 2002:1). Since no official EHDI programme is currently being implemented, TNHS for NICU graduates provides a starting point to identify neonates and infants at risk for a congenital hearing loss, or a delayed and progressive hearing loss, in South Africa.

3.5 ETHICAL ISSUES

Ethical guidelines lay down standards in terms of which the researcher must evaluate professional conduct (Strydom, 2002:63). It is the ethical obligation of the researcher not to harm the subjects in a physical and/or emotional manner. Strydom (2002:63) groups the following ethical considerations together: harm to experimental subjects, informed consent and deception of subjects, violation of privacy, actions and competence of the researcher, publication of findings, and the debriefing of subjects. The researcher has addressed all the above-mentioned ethical issues to ensure that her research is based on scientific and professional principles. The following paragraphs discuss these issues with respect to the current study.

Harm to research subjects

The hearing screening of neonates and infants commenced once they had been discharged from the NICU and were in a stable condition, to ensure that the testing did not further strain an already stressed neonate or infant admitted to the NICU, since a researcher is ethically obliged to protect the subjects from the faintest possibility of physical and/or emotional harm (Strydom, 2002:64).

Informed consent and debriefing

Informed consent certifies that research subjects understand all the necessary information in order for them to provide cooperation during the study, thereby relieving any possible tension, aggression, resistance or insecurity in the subjects (Strydom, 2002:66). The interview must furnish opportunities to rectify any form of deception and must provide opportunities for the research subjects to ask questions (Strydom, 2002:67). In the current study, the interpreter discussed the study with the parents and caregivers and communicated any queries or uncertainties with the researcher, also acting as a link between the parents and researcher during data collection.

In this regard the interpreter discussed the aim of the research project with the mothers and caregivers before they were included in the study. Aspects of the

information given included their rights as mothers and caregivers, the testing procedure, and what to expect during testing. If a child failed the hearing screening, the caregivers were told about the next step that was to be taken, e.g. diagnostic testing. The researcher informed the mothers/caregivers that the ear probe did not hurt the baby. The mother or caregiver was required to sign the informed consent form before screening took place (Appendix A).

Violation of privacy and publications of findings

Confidentiality during and after the research project places an obligation on the researcher to protect the results obtained in the study, whether such privacy was requested or not (Strydom, 2002:68). The interpreter therefore informed the research participants in the current study that all information would be handled confidentially and that no names would be published. Every research participant received a research number that was used to refer to the data concerning the subjects. The results were filed and kept safe. Only the researcher, the interpreter and the paediatrician had access to the data collection sheets.

Actions and competency of researcher

A well-equipped researcher must assume responsibility for honouring promises made to the subjects, without making judgments on cultural aspects of the community studied (Strydom, 2002:70). The researcher therefore attempted to be sensitive to the different cultures and races included in the study. The interpreter assisted the researcher to communicate and interact with the multi-cultural study group in the most appropriate manner. The researcher performed all of the screening tests on all the neonates and infants so as to ensure consistency in the results.

The researcher is a qualified speech-language therapist and audiologist with work experience in the field of community-based rehabilitation service delivery and is registered with The Health Professions Council of South Africa. A paediatrician with more than 20 years of experience in the field of neonatal acute care assisted her. Specific and specialised knowledge in the

management of neonates and infants, furnished by the paediatrician, assisted the writer in the execution of the programme: this support was invaluable in conducting the research effectively. .

This project represented a collaborative endeavour between the Department of Communication Pathology and the Department of Paediatrics at Kalafong Hospital. The ethics committees of the Faculty of Health Sciences and Faculty of Humanities approved the proposal for the current study (see the attached Appendix E). The Head of Paediatrics in the NICU at Kalafong Hospital supported the study and assisted in conducting the fieldwork, while permission was obtained from the Head of the NICU here to access and study the medical records of the caregiver and neonate or infant (See Appendix F).

3.6. RESEARCH PARTICIPANTS

The research participants consisted of three fieldworkers (two researchers and one interpreter) and 49 pairs of research subjects, comprising a mother/caregiver and neonate/infant. The researchers served as fieldworkers regarding the collection of data for the study.

3.6.1 Criteria for selection of participants

The following criteria were adhered to:

Fieldworkers

The fieldworkers selected for the present study needed to have been exposed to the public health sector and to have had experience in cross-cultural interviewing. The interpreter was required to be fluent in vernacular languages other than Afrikaans and English, and to possess experience in community work, since familiarity with the linguistic and cultural diversity and socio-economic status of the selected community improves the interpretation process. As noted above, the fieldworkers in the current study comprised two

researchers and one interpreter. The qualifications of the fieldworkers are illustrated in Table 3.1.

Subjects

Neonates/infants and their mothers/caregivers acted as the subjects in the present study. Selection criteria were only specified for neonates and infants, since all mothers/caregivers of neonates/infants adhering to such criteria were included. Caregivers were defined as the persons primarily responsible for caring for the infant.

The following selection criteria were applied:

Discharge from the NICU

Subjects included in the current study had been discharged from the NICU and were alive at the time of data collection.

Age

The JCIH (2000:10) recommends NHS for all neonates and infants before discharge from hospital. In most cases, neonates and infants were indeed enrolled as subjects on discharge from the NICU, but in some instances, neonates and infants could not be screened on the day of discharge and had to return for an appointment on another date.

3.6.2 Selection procedures

The selection procedures employed for the inclusion of fieldworkers and research subjects follow.

Fieldworkers

One fieldworker, apart from the two researchers, was selected to act as the interpreter in the current study. The Head of the NICU guided the researcher in selecting the appropriate individual to act as the interpreter.

Subjects

The current study did not permit probability sampling, because all neonates and infants discharged from the NICU were enrolled as subjects if informed consent was obtained. Non-probability sampling is made use of in contexts where probability sampling is not appropriate or possible (Babbie, 2004:182). As previously mentioned, all neonates and infants alive at discharge from the NICU were selected as subjects. The interpreter compiled a list of all neonates and infants that might be included in the study, approached the mothers, and discussed a letter describing the research projects and assuring confidentiality (Appendix A). Neonates and infants were only enrolled in the study after written consent had been obtained from the mother (See Appendix A). The interpreter accompanied the researcher, to ensure optimum interaction and communication.

3.6.3. Description of participants

The fieldworkers and research subjects are described in the following section.

Fieldworkers

The researchers collected data for the current study, while the interpreter acted as the facilitator between the former and the subjects. A summary of the fieldworkers is indicated in Table 3.1.

Table 3.1 Description of fieldworkers

Number of fieldworkers	Gender	Age	Qualification
1	Female	26	Graduated B.Communication Pathology and registered for M.Communication Pathology
1	Male	28	Graduated D.Phil. Communication Pathology
1	Female	31	BPsychology, HIV Counsellor

The interpreter and HIV-counsellor was a volunteer working in the NICU at Kalafong Hospital; hence she was not employed by the hospital. She counselled the mothers of the neonates and infants admitted to the NICU before HIV-testing. In the current study, the two researchers briefed the

interpreter concerning the aim and process of the research. The interpreter then discussed the research project with the mothers, answered questions about the logistics of the research process, made appointments for hearing screening and acted as interpreter during the interviews. Without the interpreter, any communication and interaction between the researcher and mothers and caregivers would have been very difficult because of the language barrier.

Subjects

In the current study, 49 mothers/caregivers arrived for their initial appointment for the screening of their infant. At the end of data collection, the 49 neonates and infants discharged from the NICU at Kalafong Hospital and their mothers were enrolled as subjects in the current study. The caregivers who brought the infants for follow-up screening were the same caregivers that had been present at the initial screen. It was necessary that neonates and infants were registered patients at the provincial hospital.

An interview schedule was conducted with the caregivers at the initial screen in order to gather background and identifying information (Appendix B, section A). Figure 3.2 illustrates the age distribution of the neonates and infants included in the current study at the initial hearing screen.

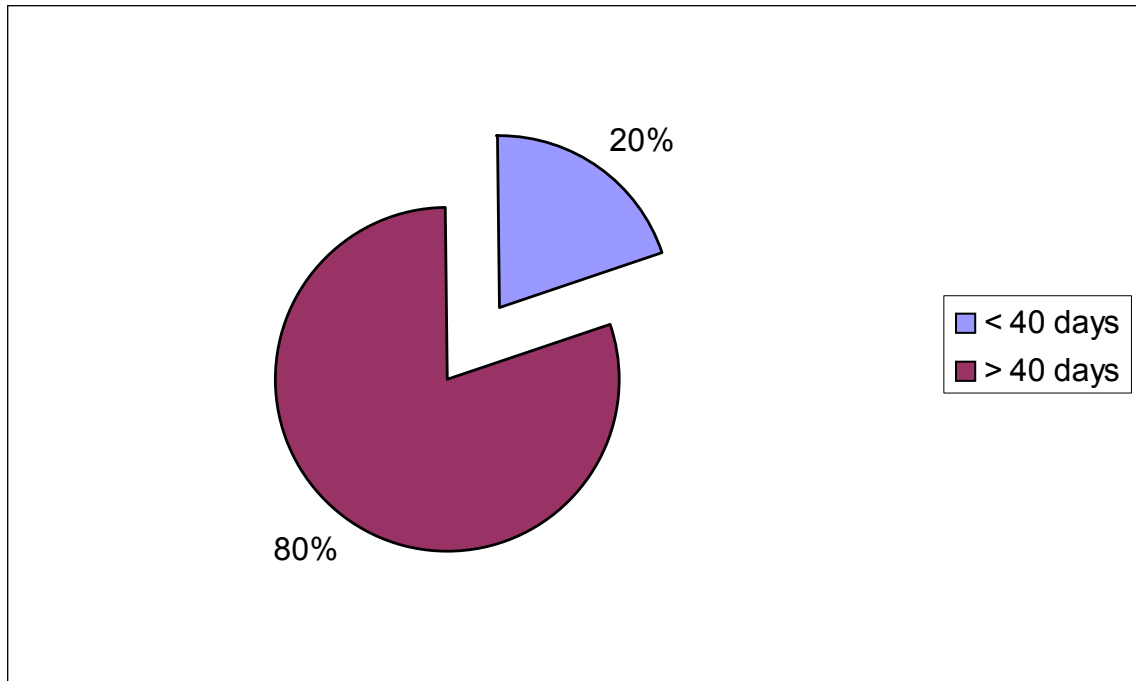


Figure 3.2 Age distributions of subjects younger and older than 40 days at the initial screen (n=49)

The majority (61%) of the subjects in current study were male; consequently 39% of them were female. The average age of the subjects was 73 days at the initial screen. In the current study, 96% of the subject sample was black and 2% coloured and white.

The home languages spoken by the subjects in the current study are illustrated in Figure 3.3.

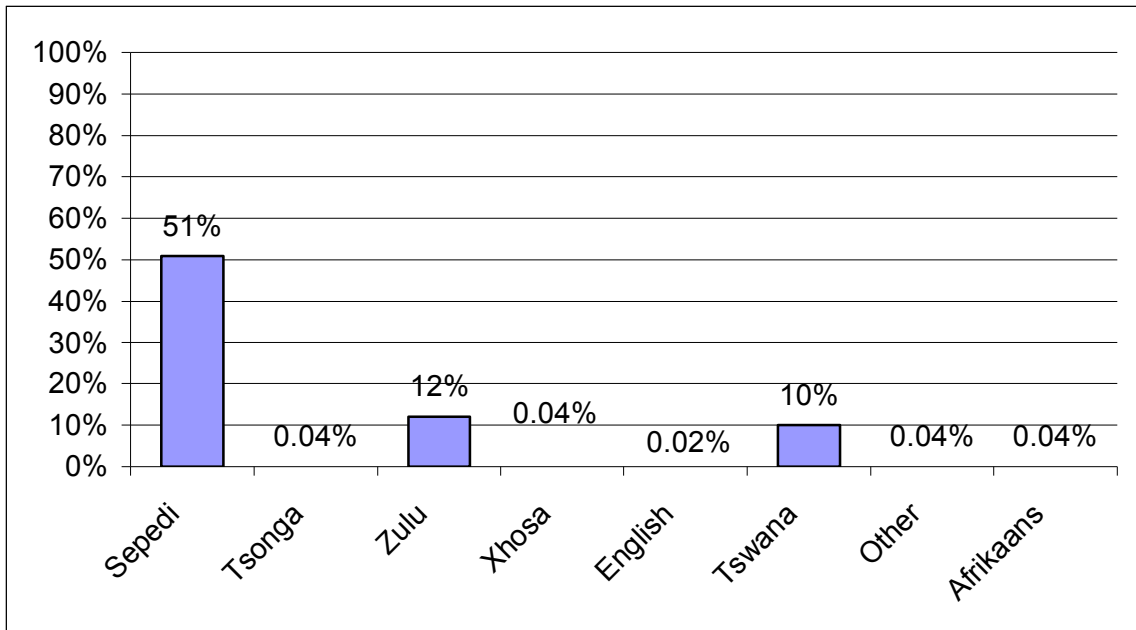


Figure 3.3 Home languages spoken in current study (n=45)

Figure 3.3 indicates that the predominant language spoken by the subjects was Sepedi. Zulu was spoken in six homes, English in one home and Afrikaans in two homes. Figure 3.4 illustrates the primary caregivers of the neonates and infants.

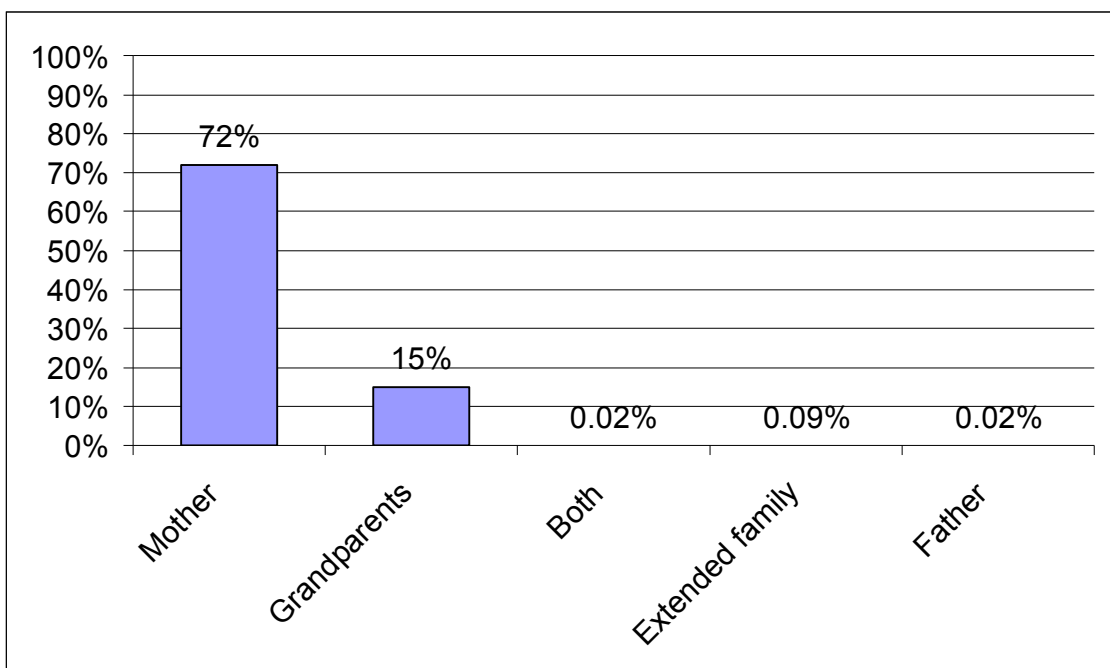


Figure 3.4 Primary caregivers in the study (n=47)

As Figure 3.4 shows, mothers comprised the primary caregivers in 72% of the sample and grandparents in 15% of the sample. Fathers were the primary caregivers in only 0, 02% of the sample. The majority (88%) of mothers in the current study were unemployed, with only 12% working.

3.7 MATERIAL AND APPARATUS

The material and apparatus used to record the various research data comprised the following:

3.7.1 Data Collection Material

The material used to collect data in the current study is discussed below. A recording sheet was compiled on which the data was recorded (Appendix B). Table 3.2 offers a description of data recorded in the study.

Table 3.2 Description of data recorded on recording sheets

Method of data collection	Material & Apparatus	Objective	Motivation
Interview and hospital file	<i>Interview schedule:</i> 1. Background information 2. Risk factor list (Appendix B)	1. To compile a profile of the subjects 2. To identify risk factors for hearing loss	A structured face-to-face interview was used because it leads to the highest response rate (Neuman, 2003:290).
Screening measurement	<i>Middle ear analyser</i>	To measure and record middle ear functioning for each neonate and infant.	A high frequency probe tone was used because it provides reliable results for infants (Margolis, 2003:383). A low probe tone was also used to compare the results of the two probe tones.
	<i>Combined AOA and AABR screening device</i>	To screen for hearing loss in neonates and infants.	Both measures are needed for an effective and comprehensive NHS programme because they provide information on the cochlear and retrocochlear parts of the auditory pathway (Hall et al., 2004:414).
	<i>Diagnostic ABR</i>	To evaluate the auditory functioning of neonates and infants who failed the first and second hearing screening tests.	ABR is recommended as the gold standard for assessment of hearing status in infants > six months (JCIH, 2000:15).
	<i>Recording sheet</i> (Appendix D)	To record if subjects returned for follow-up.	A recording sheet was used to record information accurately (Neuman, 2003:317).
Perceptions of caregivers	<i>Interview schedule</i> (Appendix C)	To compile a profile of the mother's perceptions of NHS.	A structured face-to-face interview was used because it results in the highest response rate (Neuman, 2003:290).

The instrument for collecting data was a recording sheet for the neonates and infants discharged from the NICU (Appendix B). The data sheet was divided into different sections to record this data.

Interview schedule

The researcher recorded biographical characteristics and risk factors for hearing loss during the interview schedule (Appendix B, section A & B). She completed the sections after interviewing the mother/caregiver and gathered supplementary information from the patient file. Section A consisted of background and identifying information, and section B comprised a checklist for

hearing loss in neonates and infants. Each section of the recording sheet is now discussed.

Background information

The questions in the interview schedule (Appendix B, section A) were intended to draw up a profile of the subjects in relation to the mother's age, gender, race, home language, employment and family structure. This section also recorded the gender and age of the neonates and infants.

The interview schedule consisted of 14 closed-ended questions aimed at obtaining a general description of the subjects. Such questions are quicker and easier for both the researcher and subjects to use because there are fewer irrelevant or confusing answers to questions (Neuman, 2003:278). These questions provide results so as to compare different subjects' responses. Subjects that are not fluent in the language in which the research is conducted are not placed at a disadvantage by these questions (Neuman, 2003:278), which were consequently the method chosen to interview the mothers and caregivers in order to simplify the interaction in the multilingual subject group.

Risk factor list

Section B (Appendix B) on the data-recording sheet was utilised to document risk factors for hearing loss. The focus of this section fell on the established risk factors during the first two years in an infant's life, as proposed by the JCIH (2000:20). The section consisted of areas for pre-conception, prenatal and perinatal causes for hearing loss. The list of risk factors was compiled and summarised from the JCIH 2000 and 1994 position statements (JCIH, 2000:10). Table 3.3 sums up the JCIH risk factors and the risk factors list compiled for the current study.

Table 3.3 List of risk factors for neonates and infants

Risk factors 0-28 days (JCIH, 1994)	Risk factors 0-28 days (JCIH, 2000)	Risk factors 29 days- 2 years (JCIH, 2000)	Current study risk factor list
<ol style="list-style-type: none"> 1. Family history of permanent childhood hearing loss 2. Hyperbilirubinemia requiring exchange transfusion 3. Congenital infections (TORCH) 4. Craniofacial anomalies 5. Birth weight < 1500 grams 6. Bacterial meningitis 7. Asphyxia (Apgar score of 0-4 at 1 minute or 0-6 at 5 minutes) 8. Mechanical ventilation lasting for longer than 5 days 9. Stigmata or other findings associated with a syndrome known to include a hearing loss 10. Ototoxic medications, including but not limited to aminoglycosides used in multiple courses or used in combination with loop diuretics 	<ol style="list-style-type: none"> 1. An illness or condition requiring admission for 48 hours or more to the Neonatal Intensive Care Unit (NICU) 2. Stigmata or other findings associated with a syndrome known to include a sensorineural and/or conductive hearing loss 3. Family history of permanent childhood hearing loss 4. Craniofacial anomalies 5. Congenital infections (STORCH) 	<ol style="list-style-type: none"> 1. Parental concern regarding speech, language, hearing and/or developmental delay 2. Family history of permanent childhood hearing loss 3. Stigmata or other findings associated with hearing loss 4. Postnatal infections associated with sensorineural hearing loss, such as bacterial meningitis 5. In-utero infections (STORCH) 6. Neonatal indicators – specifically hyperbilirubinemia at serum level requiring exchange transfusion, persistent pulmonary hypertension associated with mechanical ventilation, and conditions requiring the use of extracorporeal membrane oxygenation 7. Syndromes associated with progressive hearing loss such as neurofibromatosis, osteopetrosis, and Usher’s syndrome 8. Neurodegenerative disorders, such as Hunter’s syndrome, or sensory-motor neuropathies, such as Friedreich’s ataxia and Charcot-Marie-Tooth syndrome 9. Head trauma 10. Recurrent of persistent otitis media with effusion for at least 3 months 	<ol style="list-style-type: none"> 1. Family history of permanent childhood hearing loss 2. Hyperbilirubinemia requiring exchange transfusion 3. Congenital infections 4. (HIV was included as a risk for the current study) 5. Craniofacial anomalies 6. Birth weight < 1500 grams 7. Bacterial meningitis 8. Asphyxia (Apgar score of 0-4 at 1 minute or 0-6 at 5 minutes) 9. Ototoxic medications > 5 days 10. Persistent pulmonary hypertension associated with mechanical ventilation > 5 days 11. Syndrome present 12. NICU admittance and duration of stay

The risk factor list employed in the current study represented a combination of the JCIH 1994 and 2000 position statements. HIV was included as an in-utero infection for the current study because of the impact the infection is having on the South African population. HIV/AIDS continues to be one of the biggest challenges faced by South Africa today, alongside poverty, joblessness and other social ills, and the infection rate still escalates at a frightening pace (Boyer & Boyer, 2004:70; Department of Health, 2003:4). A significant proportion of children exposed to HIV will develop serious illness and die within the first year or two of life and in sub-Saharan Africa, 75% of all HIV-infected children will die before their fifth birthday (Department of Health 2003:2). These neonates and infants exposed to HIV may also be at risk for a hearing loss or for developing a hearing impairment shortly after birth (Druck & Ross, 2002:4; Matkin, Diefendorf & Erenberg, 1998:144). The risk of hearing loss, serious illness and death in this population supported the inclusion of HIV exposure as a risk factor and this was therefore recorded on the data-recording sheet.

The risk factor questions took the format of 14 closed-ended questions requiring a *yes, no, or information unavailable choice*. Three of these questions led to an additional question if a *yes* choice was made. This additional question requested a description of the *yes* choice and was used to describe the different types of congenital infections, Apgar score, type of syndrome present, and number of days spent in the NICU.

Perceptions of mothers regarding NHS

The questions of the interview schedule (Appendix C) aimed to acquire a profile of the caregiver's perceptions regarding NHS. Closed-ended questions were included on the recording sheet to ensure greater uniformity (Babbie, 2004:245). The options for each questions were *yes, no* and *uncertain* and were selected firstly not to confuse the subjects and to simplify processing of results (Babbie, 2004:245). These types of questions were selected to ensure the subjects did not feel compelled to provide more than one response (Babbie, 2004:245).

The interview schedule was divided into three sections to record perceptions before, during and after the NHS procedures. The interview was divided into different sections to ensure that the questions are clear and unambiguous (Babbie, 2004:246; Neuman, 2003:283). The questions asked were short, relevant and focused on their knowledge and perceptions of NHS (Babbie, 2004:248). Questions were formulated to ask for a single answer and not to confuse the subjects with confusing questions (Babbie, 2004:246).

3.7.2 Data Collection Apparatus

The apparatus used to screen the neonates and infants' hearing consisted of the following:

Impedance measurements

The apparatus used to record impedance measurements in the current study was an Impedance Audiometer AT235h. The calibration date for this Audiometer of the 2nd of February 2004, at the Department of Communication Pathology, was used to conduct these measurements. Tympanograms were measured using 226 Hz and 1000 Hz probe tones. A high-frequency probe tone was also employed because recent studies have demonstrated promising results for tympanometry in neonates and young infants using a 1000Hz probe tone (Kei et al., 2003:25; Margolis et al., 2003:383). The acoustic reflex was measured unilaterally at 1000Hz making use of a 226 Hz probe tone with a minimum deviation of 0, 02 being accepted as a reflex.

Hearing screening

A handheld AOA and AABR screening device was utilised to screen the hearing sensitivity of the subjects. AOA and AABR measures are easily recorded in neonates and infants and are strongly correlated with peripheral hearing sensitivity (JCIH, 2000:14). These predictions of auditory function are necessary

to identify possible hearing impairments in an at-risk population. Automated response detection is preferred over subjective operator interpretations and decision-making, because subjective interpretations of results may manipulate the accuracy of the outcomes (JCIH, 2000:14). The ABAerCub is the portable system which was used to perform the hearing screening (Biologic Systems Corp, 2002:7). Both the AOAe and AABR tests offered automated pass or refer criteria.

The collection parameters of the AABR were optimised for the said screening technology (Biologic Systems Corp, 2002:10). In this respect Table 3.4 lists the collection parameters for the current study.

Table 3.4 Data collection parameters for the AABR

Stimulus type	100 microsecond click
Stimulus polarity	Alternating
Stimulus rate	37.1
Stimulus intensity	35 dB nHL
Analysis window	21.33 msec
High pass filter	100 Hz
Low pass filter	1500 Hz
Amplifier gain	30 000
Channels	1
Montage	High forehead (active or non-inverting) Test ear (reference or inverting) Non-test ear (ground)
Minimum sweeps	1536
Maximum sweeps	12 288 (in two separate trials of 6144 sweeps each)
Date of last calibration	2 February 2004

The AOAe software included pre-set DPOAE (distortion product oto-acoustic emission) screening protocols to determine hearing sensitivity in neonates and infants. Table 3.5 indicates the AOAe screening test protocols.

Table 3.5 AOAE screening test protocols

Stimulus parameters	
L1	65 dB SPL
L2	55 dB SPL
F2/F1 ratio	1.2
Minimum # samples	40
Sample size	1024 points (20 msec sample)
Pass/Refer criteria 2-5 kHz screen, 3 of 4 for pass	
Minimum DP amplitude	-8
Minimum DP-NF amplitude	6 dB
Number of frequencies for pass	3
Frequencies used for screening	5, 4, 3, & 2 kHz

Diagnostic ABR

The diagnostic ABR was performed with a Biologic NavPro™ ABR connected to a laptop computer. EAR 3A insert earphones were used with disposable ear tips.

The test parameters of the Biologic NavPro™ ABR are presented in Table 3.6.

Table 3.6 Diagnostic ABR stimulus parameters

Stimulus	Click
Periodic stimulus rate	27/sec
Polarity	Rarefaction
Duration of click	0.10 msec
Intensity scale	dB nHL
Output	Monotic
Intensity	Starting intensity of 60 dB nHL

The recording parameters of the ABR are listed in Table 3.7.

Table 3.7 Diagnostic ABR recording parameters

Electrode placement	Mastoid (L&R) = ref & ground Fpz = Active
Maximum impedance	6 Ohms
Maximum impedance diff.	2
Low cut off filter	100 Hz
High cut off filter	3000 Hz
Volt rejection	40
Maximum number of sweeps	2000

3.8 DATA COLLECTION PROCEDURES

The NICU at Kalafong Hospital was visited on Wednesday mornings for the purposes of data collection with respect to the initial screen at discharge, routine follow-up screening at three-month intervals, and follow-up screening after referral as well as diagnostic testing. Data was collected in the current study over a period of 24 months. The screening was conducted at discharge and at follow-up in a room close to the NICU with limited background noise and where few interruptions were likely. Five sets of data were collected for each subject. A completed high-risk register, bilateral immittance screening results for two probe tone frequencies, and AOAE and AABR results were recorded. The perceptions of mothers and caregivers were noted after the hearing screening. Another data collection sheet was completed when a subject returned for a routine follow-up screening at the three-month interval, as well as for referrals after AOAE and AABR screening. Figure 3.5 shows the different data collected in the study.

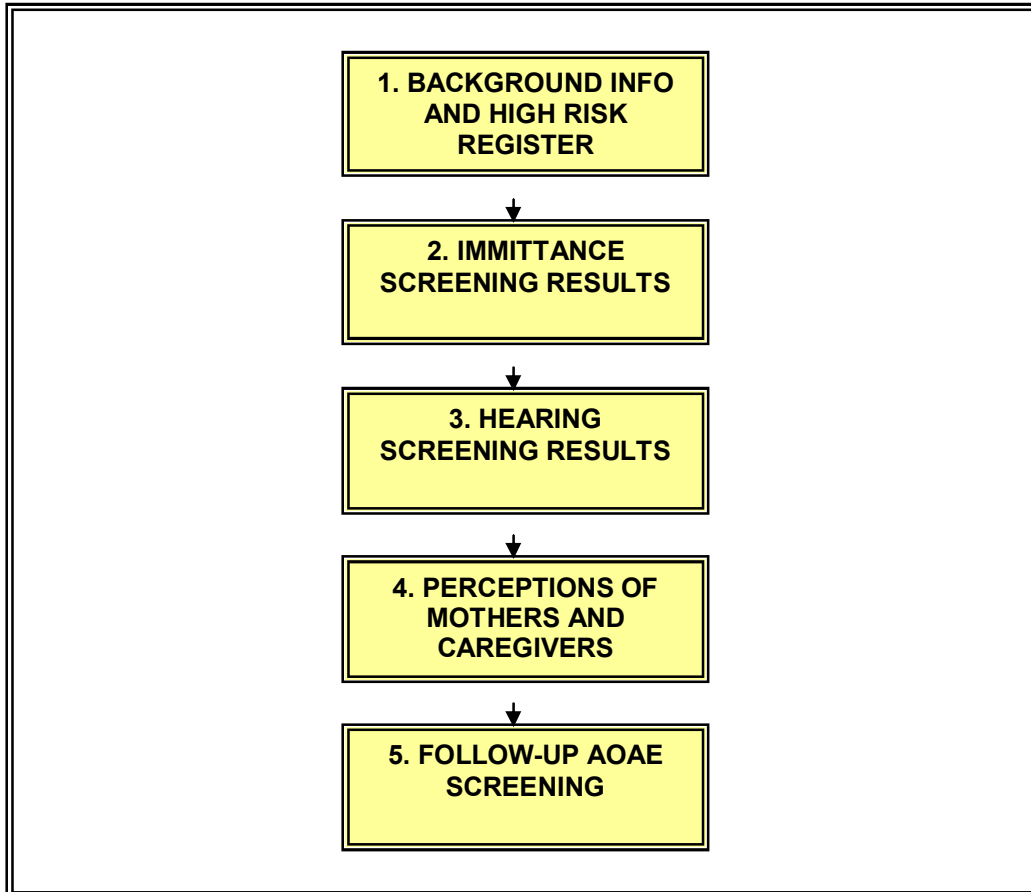


Figure 3.5 Data collection procedures followed in the current study

The following procedures were adhered to in collecting the data desired for the study.

3.8.1 Background information and high-risk register

The background information and risk factors for hearing loss was obtained during a structured interview, as was the hospital file (Appendix B). The interpreter acted as the facilitator between the researcher and subjects during each interview. The following procedures were used to gather information:

- The mother/caregiver was approached by the interpreter to enquire if they were willing to participate in the study and have the neonate or infant's

hearing screened. An informed consent letter was signed by all subjects willing to participate in the study (Appendix A);

- A structured interview (Appendix B) was conducted with the caregiver to collect background information on the neonate or infant's family dynamics. The first section of the data sheet recorded the identifying information regarding the mother/caregiver and neonate/infant. This section constituted a background section containing information regarding the caregiver's age, home language, race, educational levels of parents, marital status of parents, housing, employment of caregiver, health during pregnancy, duration of pregnancy, number of children still living, the subject's gender and age;
- The high-risk register was completed by making use of information given by the mother/caregiver and the medical history of the neonate or infant. Some risk factor information was not recorded in a few subjects' files by the medical practitioner after birth.

3.8.2 Immittance screening

Immittance measurements performed on the neonates and infants followed the structured interview. The measurements were made bilaterally with 226 Hz and 1000 Hz probe tones and the following procedures were employed:

- The neonate or infant's ear canal was observed to select the appropriate probe, which was then inserted in the neonate's ear;
- On a good seal the 226 Hz probe tympanogram, 1000 Hz probe tympanogram and acoustic reflexes with a 226 Hz probe tone were measured;
- The results for the tympanograms and acoustic reflex were recorded on the data collection sheet. Useful data regarding middle ear effusion and the presence of tympanic membrane perforations are provided by tympanometry (Wiley & Stoppenbach, 2002:169). Any "no seal" obtained during the testing was also recorded.

3.8.3 Hearing screening

The hearing screening was based on a screening protocol recommended for neonates and infants discharged from the NICU (Hall et al., 2004:414). It consisted of AOAЕ and AABR measurements. The protocol followed is presented in Figure 3.6.

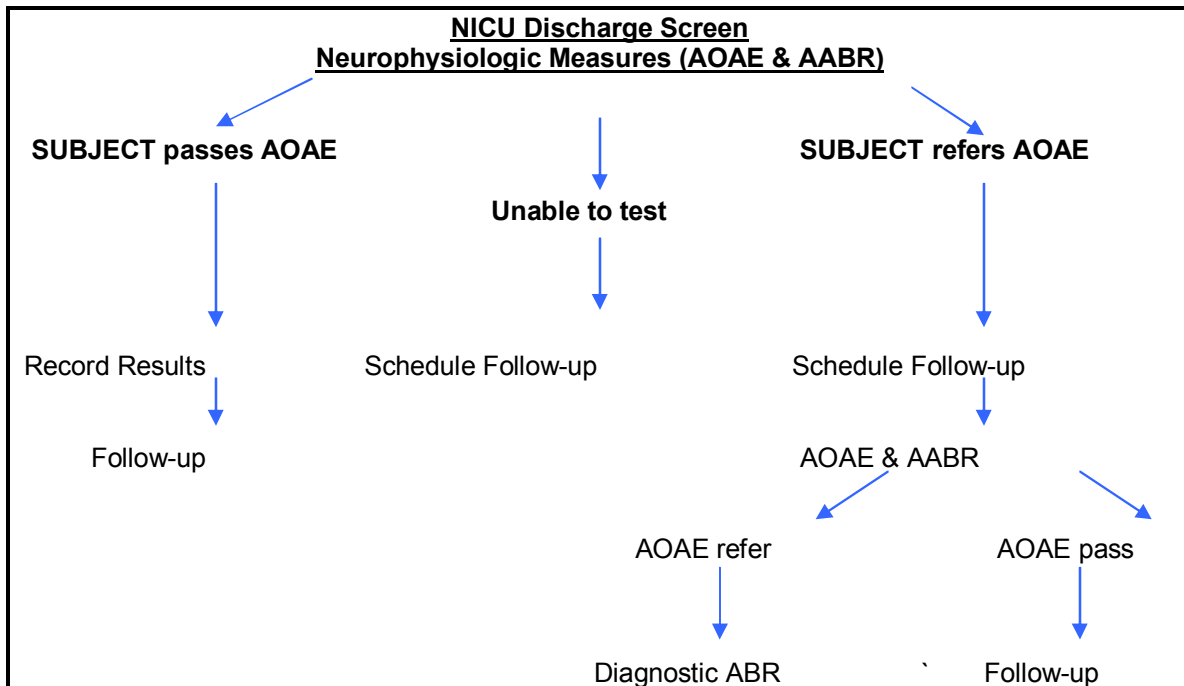


Figure 3.6 Components of hearing screening protocol

The hearing screening protocol for data collection is now described:

- The neonate or infant was placed in a comfortable position in the mother's or caregiver's arms before screening commenced;
- The appropriate probe size was selected and inserted in the subject's ear;
- The AOAE screening module was selected; the screening was performed on both ears. The results were indicated as pass or refer in the designated section on the data collection sheet (Appendix B);
- The AABR screening followed the AOAE screening and was performed bilaterally if possible. Results were likewise recorded on the data collection sheet;

- If a neonate or infant was restless and did not cooperate during the AABR screening a follow-up appointment was scheduled;
- A follow-up appointment was scheduled on a later date if the subject screening led to a refer result. An AOAE refer result, unilaterally or bilaterally, was recorded as a referral. The results obtained were recorded in the appropriate section on the data collections sheet (Appendix B);
- A diagnostic evaluation was scheduled if the follow-up AABR also revealed a refer result. A qualified audiologist from the Department of Communication Pathology, at the University of Pretoria, performed the diagnostic ABR in a suitably-identified room in the hospital. A portable diagnostic ABR was utilised for the purpose;
- Another follow-up appointment was scheduled if the neonate or infant did not cooperate during hearing screening.

3.8.4 Perceptions of mothers and caregiver regarding NHS

The perceptions of mothers and caregivers were recorded after the hearing screening of the neonate or infant. The interpreter assisted the researcher in conducting the interview if the mothers and caregivers were not fluent in English. The following procedures were adhered to:

- A structured interview (Appendix C) was conducted with the mothers and caregivers after the NHS to record the perceptions of the caregivers regarding the NHS process;
- Perceptions of mothers and caregivers before, during and after NHS were recorded;
- Opportunity was provided for mothers and caregivers to ask questions.

3.8.5 Routine follow-up screening at three-month intervals

The following procedures were followed at the three-month screening intervals:

- Follow-up screening was also conducted on Wednesday mornings. The mothers and caregivers in the waiting area of the NICU were requested to bring their neonate or infant and the hospital file into the hearing screening room;
- Immittance, AOAЕ, and AABR screening was performed on both ears if possible. The results of the follow-up screening were recorded on a different data collection sheet (Appendix D);
- A three-month follow-up visit was scheduled after the subject passed the AOAЕ screening bilaterally.

3.8.6. Follow-up for further testing

The following procedures were followed if a subject was referred for further testing:

- Follow-up screening was conducted on Wednesday mornings. The mothers and caregivers in the waiting area of the NICU were requested to bring their neonate or infant and the hospital file into the hearing screening room;
- Immittance, AOAЕ, and AABR screening was performed on both ears if possible. The results of the follow-up screening were recorded on a different data collection sheet (Appendix D);
- If a subject exhibited a unilateral or bilateral AOAЕ refer result, diagnostic ABR testing was booked on another date.

3.9 VALIDITY AND RELIABILITY

Validity and reliability are central issues in all research estimates (Neuman, 2003:178). They are not directly observable, but they are ideals for which researchers strive in order to conduct quality research (Neuman, 2003:178). The validity and reliability measures applied in the current study are discussed below.

Validity

Validity describes a measure that accurately reflects the concept it is intended to measure (Babbie, 2004:143). External validity is the ability of a research project to generalise research findings to settings outside the project itself (Babbie, 2004:255). If external validity is lacking in a project, the data obtained is useless for research (Babbie, 2004:255). Measurement validity refers to how well the conceptual and operational definitions in a study interconnect together (Neuman, 2003:182), in other words indicating that the measurement is valid for a particular definition and research plan (Neuman, 2003:182). The central idea of measurement validity is that the instrument should measure the concepts in question and provide an accurate measure of these concepts (Delpont, 2002:167). The validity issues in the current study were as follows:

- The NICU at Kalafong Hospital is an example of an acute-care centre for ill neonates and infants in South Africa. The results could not be generalised to the general population because of the small sample size in the current study;
- Mothers/caregivers and neonates/infants were included as subjects in the study in order to collect all the necessary information on risk factors and hearing status as well as their perceptions regarding hearing screening;
- The combined AOA and AABR screening protocol is recommended to detect cochlear and retro-cochlear hearing loss, especially in a population at risk for hearing loss (Hall et al., 2004:415).

Reliability

Reliability denotes that the numerical results should not vary during the measurement process or with the measurement instrument itself (Neuman, 2003:179). The quality of the measurement method suggests that the same data is collected each time in repeated observations (Babbie, 2004:141). The accuracy of the instrument is essential, to allow the researcher to measure reliable results and to maintain consistency between results (Delpont, 2002:168). The results provided by the measurement instrument should not vary because of the instrument itself. The following reliability issues were therefore addressed to ensure that reliable results were obtained in the current study.

- Reliability was maintained during the interview schedule by providing short and simple instructions, limiting the length of questions and filling in any incomplete results from the patient file;
- The audiological instruments used were calibrated before the research project commenced to ensure performance reliability;
- Only the two researchers recorded the data in the current study. This increased the consistency and reliability of the data collected and recorded, since data must be recorded in a consistent manner in order to analyse and interpret results effectively;
- The researchers were responsible for the coding of data throughout the study, again to maintain the consistency of the results. The coded data was verified more than once to validate the accuracy of the coding.

3.10 DATA ANALYSIS PROCEDURES

Babbie (2004:396) defines quantitative data analysis as the “numerical representation and manipulation of observations for the purpose of describing and explaining the phenomenon that those observations reflect”. Descriptive statistics were used to record the data in the current study; such statistics are

used to make inferences about larger populations by collecting data regarding smaller samples (Leedy & Omrod, 2001:259).

The small sample size in the current study did not permit inferential statistics but descriptive statistics were used to analyse the data in order to reach conclusions in the current study. The quantitative data recorded on the individual data recording sheets was coded and captured in digital format. The data obtained from the completed procedures was organised onto spreadsheets suitable for analysis, which were converted statistically in order to discern trends and patterns in the results, by using graphic representations and frequency tables. The analysis was performed using the Excel software in the Microsoft Word 2000 program. The data was statistically analysed in the current study in consultation with Dr. D.C.D. Swanepoel at the Department of Communication Pathology, University of Pretoria.

3.11 SUMMARY

This chapter explained the empirical method that was used to accomplish the main aim of the study. Ethical issues and the research context were highlighted. The procedures followed and the apparatus used to carry out this study were described. The researcher also described how the research participants were selected, as well as the procedures followed in the collection of data. Relevant literature was drawn on to support the empirical research.

CHAPTER 4

RESULTS AND DISCUSSION

This chapter presents the results of the current study according to its sub-aims. The results are subsequently discussed by integrating them with the literature, and drawing out the significance of the results obtained.

4.1 INTRODUCTION

The recommendation by the Professional Board for Speech, Language and Hearing Professions in its Year 2002 Hearing Screening Position Statement (HPCSA, 2002:2), that Targeted Neonatal Hearing Screening (TNHS) be carried out, has resulted in new challenges for the field of paediatric audiology in South Africa. Research conducted in the Neonatal Intensive Care Unit (NICU) constitutes one of the first steps to establish the feasibility of Neonatal Hearing Screening (NHS) programmes in South Africa. Empirical evidence is needed to serve as a platform for widespread implementation of NHS and is fundamental in the planning and execution of Early Hearing Detection and Intervention (EHDI) programmes in South Africa. This type of research is essential to achieve the aim of screening 98% of neonates by 2010 through Universal Neonatal Hearing Screening (UNHS) (HPCSA, 2002:2).

The first three chapters of this study described the rationale, relevant literature and methodology surrounding the research question. In this chapter, the results of each sub-aim will be presented, followed by an interpretation and discussion within the framework of the existing literature. The acquired and inherited risk factors for hearing loss, immittance and hearing screening results, the correspondence between results and the follow-up process will be considered and compared with each other. Lastly, the perceptions of mothers/caregivers

regarding NHS will be discussed. Figure 4.1 illustrates the contribution of the sub-aims to realising the main aim of the study.

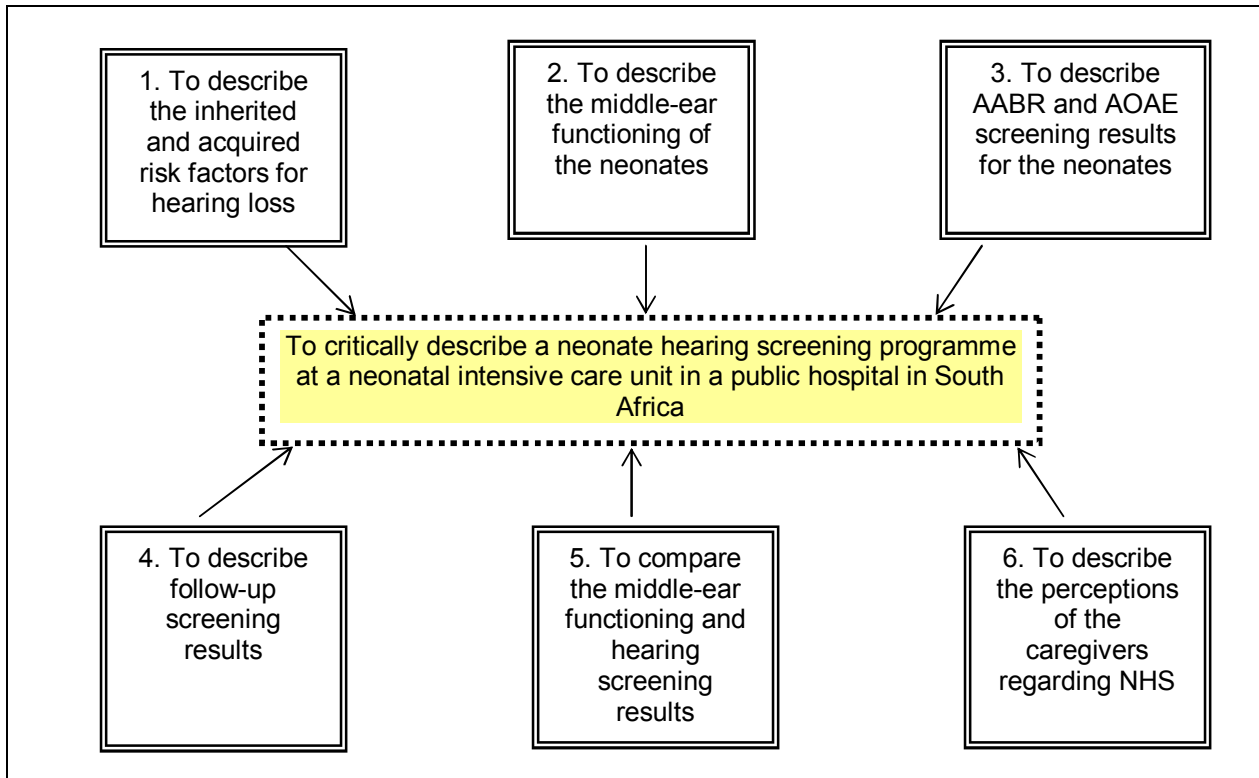


Figure 4.1 Main aim and sub-aims of the current study

The sub-aims were investigated and described in order to answer the research question of the study; it will be recalled that this enquired: **is NHS in a NICU in a South African regional hospital a feasible option?** The following section describes the results in the current study and will be structured according to the sub-aims as illustrated in Figure 4.1.

4.2 DESCRIPTION AND DISCUSSION: SUB AIM #1

To describe the inherited and acquired risk factors for hearing loss

The risk factors for hearing loss in the subject group will be discussed in the following sections, as recorded from the patient files and during the interview with the mother/caregiver (Appendix B).

4.2.1 Risk factors recorded in the current study

The number of risk factors recorded in the study is illustrated in Figure 4.2.

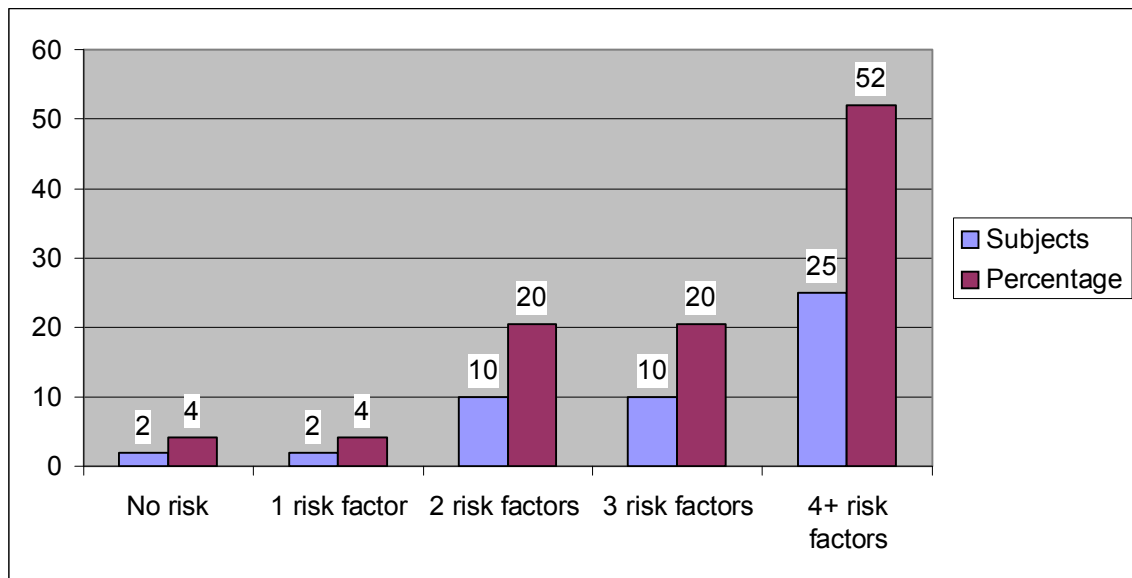


Figure 4.2 The number of risk factors recorded in the study

In the current study, four subjects (8%) of the group exhibited no risk factor or only one risk factor for hearing loss, 20 subjects (40%) evidenced two or three risk factors for such loss and the majority of subjects (52%) displayed four or more risk factors for this kind of loss. Table 4.1 summarises the risk factors recorded in the current study.

Table 4.1 Risk factors recorded in the current study (n=49)

Risk factor	Result	Description
a) Congenital infections	YES 2 % NO 98%	Congenital syphilis was present in one subject
b) Family history of childhood hearing loss	YES 6 % NO 63 % NOT RECORDED 31%	3 subjects reported a family history of hearing loss
c) Admission to NICU for more than 48 hours	YES 65 % NO 29 % NOT RECORDED 6 %	14 subjects spent less than 48 hours in the NICU
d) Birth weight of less than 1500 grams	YES 45 % NO 55 %	22 subjects had a birth weight of less than 1500 grams
e) Meningitis	YES 2 % NO 98%	1 subject presented with meningitis
f) Asphyxia	YES 12 % NO 70 % NOT RECORDED 18 %	8 subjects had a 1-min Apgar less than 4 and 6 subjects had a 5-min Apgar less than 6
g) Ototoxic medication	YES 86 % NO 4 % NOT RECORDED 10 %	41 subjects were exposed to ototoxic medication
h) Pulmonary hypertension	YES 63 % NO 10 % NOT RECORDED 27 %	31 subjects had recorded pulmonary hypertension
i) Hyperbilirubinaemia	YES 18 % NO 43 % NOT RECORDED 39 %	9 subjects had recorded hyperbilirubinaemia
j) HIV exposed	YES 18% NO 62 % NOT RECORDED 20 %	9 subjects were exposed to HIV prenatally
k) The following risk factors were not present in the study group: <ul style="list-style-type: none"> • Craniofacial defects • Syndrome 		

Table 4.1 indicates that the most common risk factors recorded comprised ototoxic medication (86%), pulmonary hypertension (63%) and admission to the NICU for more than 48 hours (65%). One subject (2%) presented with meningitis and one with congenital syphilis (2%). No craniofacial defects or syndromes were present in the subject group. A family history of hearing loss, ototoxic medication, pulmonary hypertension, admission to the NICU and exposure to the Human Immunodeficiency Virus (HIV) are discussed in the following sections. These risk factors were selected because they were the most prevalent in the subject group.

HIV-exposure is also included in the discussion because of the high incidence of HIV-infection amongst pregnant women.

- ***Family history of hearing loss***

In the study group, 6% of mothers reported a positive family history of congenital hearing loss, but this information was not available in 31% of subjects and the remaining 63% had no family history of this type of hearing loss. Even if a family history in this respect had been accurately recorded, it is difficult to distinguish between hearing loss caused by congenital factors and acquired hearing loss (caused by noise exposure or presbycusis) (Vohr, Carty, Moore & Letourneau, 1998:377). In the study by Vohr et al. (1998:377), 3% of parents reported a family history of hearing loss. In their study, a family history of congenital hearing loss was the most difficult information to collect because of these researchers' limited access to the parents. However, the parents in the current study were accessible and present during the recording of risk factors in this respect. A study by Swanepoel (2004b:226) conducted at maternal and child health clinics in South Africa, reported that a family history of congenital hearing loss was present in 13% of the subject group.

The incidence of 6% in the current study is significantly lower than that which Swanepoel (2004b:227) reported. The greater incidence of a family history of hearing loss in the study by Swanepoel (2004b:227) could be explained by three possible factors. Firstly, the mothers and caregivers might have misunderstood the question asked by the interpreter and provided an incorrect answer. This misunderstanding may have increased the incidence reported by the mothers and caregivers. Secondly, deprivation in a community is known to correspond with an increased incidence of congenital hearing loss in neonates (Kubba et al., 2004:125). The impoverishment in the community investigated by Swanepoel, owing to socio-economic factors, might have contributed to the higher reported incidence of congenital hearing loss there.

Accurate documentation of a family history of hearing loss is very important because hereditary deafness occurs in one-to-three neonates per 1000 live births (Northern & Downs, 2002:107). Hereditary factors represent a significant risk factor for pathological hearing screening results and are a probable cause of congenital hearing loss amongst the NICU graduate population (Hess et al., 1998; Meyer et al., 1999:903). Vohr et al. (1998:353) report that family history for hearing loss is the most prevalent (22 – 42%) risk factor in neonates at-risk for hearing loss; hence accurate recording of its presence is essential.

However, it is not always easy to elicit and record an accurate family history for generations earlier than the grandparents because often only one parent is available for the interview, and only limited information from the other side of the family is available (Northern & Downs, 2002:277). Since the mother/caregiver was the only relative available for the interview in the present study, incomplete information was provided as regards the history of the father's side of the family. The 6% of caregivers with a family history of hearing loss could not supply information on the degree, nature, onset or diagnosis of hearing loss in their relatives. Careful follow-up and parental counselling is advised for neonates who passed the hearing screening but are at risk for hearing loss (Northern & Downs, 2002:277). Parent or caregiver education with respect to the increased risk for hearing loss when there is a family history must be emphasised (Swanepoel, 2004b:228). Communication with parents regarding a family history of congenital hearing loss is therefore crucial when a neonate is admitted to the NICU for treatment. A proper case history is needed to record risk factors for hearing loss and other medical conditions affecting healthy hearing, such as exposure to HIV.

- ***HIV exposure***

In the current study 18% of the subjects were born to HIV-infected mothers, 62% of mothers were not infected and no information regarding HIV status was recorded in 20% of subjects' files. Perinatal infection occurs at a time of relative

immunological immaturity, and neonates may be immunosuppressed from birth, or the virus may evade the immune response of the neonate, which may result in an accelerated HIV-disease progression in neonates (Chakraborty, 2004:134).

Human Immunodeficiency Virus or Acquired Immunodeficiency Syndrome (HIV/AIDS) is one of the major challenges faced today by the South African population (Department of Health, 2003:ii). In South Africa, 5, 6 million individuals were living with HIV/AIDS in 2003, of whom 104 963 were infants (Department of Health, 2004:1). Females in their late twenties and early thirties are those mostly affected by HIV-infection and it is estimated that 38, 5% of pregnant women in this age group are HIV-positive (Department of Health, 2004:10). The prevalence rate of HIV-infection in females aged 20-24 years is 30, 8% (Department of Health, 2004:10). It is estimated that altogether 3, 3 million females between the ages 15 to 49 years are infected with HIV (Department of Health, 2004:13). HIV-exposure was included as a risk factor in the current study because of the generalised HIV epidemic and the high prevalence rate of infection in the pregnant population.

The fact that only 18% of mothers in the sample reported HIV-infection, compared to HIV-infection of 29, 5% among pregnant women attending antenatal care, indicates underreporting in the current study (Department of Health, 2004:6). Swanepoel (2004b:228) observes that only 1% of mothers attending maternal clinics in South Africa indicated that they were HIV-positive. That study also reports gross underreporting of HIV status (Swanepoel, 2004b:228). Underreporting could be ascribed to unawareness among mothers regarding their status or to their reluctance to disclose such information (Swanepoel, 2004b:228). The latter may occur because of fear of isolation or stereotyping in the South African context (Swanepoel, 2004b:228). This reluctance could have contributed to 20% of the sample not being familiar with their status; yet knowing the HIV-status of a mother could assist in the reliable documentation of risk

factors for hearing loss and in monitoring the impact of HIV/AIDS on auditory development.

Considerable interest in the underlying mechanism that may cause a hearing loss in neonates and infants exposed to HIV/AIDS is discernible in the literature. Sensorineural hearing loss may result after viral infection in the inner ear, causing a cochlear hearing loss (Yoshikawa et al., 2004:366; Gold & Tami, 1998:166). Children born to HIV/Aids-infected mothers are at risk for hearing loss due to increased vulnerability to infections such as meningitis and viral encephalitis (Chakraborty, 2004:135). Viral infections may also damage the upper respiratory tract; acute otitis media and myringitis may follow, with a conductive hearing loss because of the damage (Yoshikawa et al., 2004:366; Gold & Tami, 1998:166). Respiratory illness is reported as the most probable cause of death in HIV-infected children (Chakraborty, 2004:135).

The impaired immune system becomes vulnerable to life-threatening opportunistic infections in neonates exposed to HIV, which may lead to quantifiable audiological changes (Bankaitis & Schountz, 1998). The viral infection is usually subclinical or asymptomatic in the neonate, and sensory system complications, including sensorineural hearing loss, are common (Northern & Downs, 2002:281). However, HIV–infection as such is not currently listed by the JCIH as a risk factor for hearing loss.

A number of subjects in the current study had been exposed to HIV, which places them at risk for a possible hearing loss, as discussed in the previous paragraphs. Follow-up of exposed neonates and infants is essential to diagnose delayed-onset or progressive hearing loss as HIV-infection advances. The impact of HIV on the neonates' hearing is nevertheless difficult to determine, because of the immunosuppression caused by HIV in this population early after birth.

- ***Admission to the NICU***

A majority of subjects (65%) in the present study were admitted to the NICU for more than 48 hours. In the study group, the number of days which 6% of subjects spent in the NICU was not recorded. Only 29% of the sample was admitted to the NICU for less than two days. The average number of days spent in the NICU was 6, 7 days, with the shortest being a stay of one day and the longest being 27 days.

Admission for more than two days to the NICU was added as a risk factor to the JCIH position statement in 2000. The prevalence of hearing loss in healthy neonates is 0, 1%, but increases to 2-4% if they are admitted to the NICU (American Academy of Pediatrics, 1999:527). In a study by Wroblewska-Seniuk, Chojnacka, Pucher, Szczapa, Gadzinowski & Grzegorowski (2005:1353) the percentage of neonates admitted to the NICU for more than seven days was 3, 46%. These authors have observed that if neonates stayed in the NICU for more than seven days the possibility of a referral after screening increased (Wroblewska-Seniuk et al., 2005:1353). The study reports that the medical problems which are related to hearing impairment, such as asphyxia, hyperbilirubinemia, prematurity and low birth weight, may result in a prolonged NICU stay, which may increase the risk of developing a hearing loss. In the current study 16 subjects (33%) had been admitted to the NICU for more than seven days. This means that a third of the study group faced an increased risk for hearing loss. Ototoxic medication is often administered to treat the neonates and infants admitted to the NICU. Such medication administered in the current study is discussed below.

- ***Ototoxic medication***

Administration of ototoxic medication was the most prevalent risk factor for hearing loss recorded in the current study, because the majority (86%) of

subjects received such medication. However, the administration of medication was not recorded in the patient's file for 10% of the sample. It should be noted that the subjects only received one course of ototoxic medication and that the medication (usually Amiken) was not administered for longer than five days. This means that the risk for hearing loss because of exposure to ototoxic medication in the subject group was significantly less than it might have been. It has been established that such medication is a prominent risk factor related to a referral result after screening (Wroblewska-Seniuk et al., 2005:1355; Yoon et al., 2003:355; Hess et al., 1998:87). Table 4.2 therefore summarises the ototoxic medication administered in three NICU studies.

Table 4.2 Ototoxic medication administered in four reported NICU studies

Study	Percentage
Wroblewska-Seniuk et al. (2005:1355)	7, 8
Van Straaten et al. (2003:333)	8, 4
Chiong et al. (2003:216)	95, 7
Hess et al. (1998:85)	87

According to Table 4.2 the reported number of subjects that received ototoxic medication in the current study (86%) correlates with the number reported in the studies by Chiong et al. (2003:216) (95,7%) and Hess et al. (1998:85) (87%). However, Wroblewska-Seniuk et al. (2005:1355) reported that 7, 8% of their subjects, and Van Straaten et al. (2003:333) that 8, 4% of theirs, received ototoxic medication. It could be speculated that their neonates did not present with medical conditions which needed ototoxic intervention, such as sepsis, and were not critically ill, hence the low incidence of less than 10%. Van Straaten et al. (2003:333) reported that a large number of neonates receive a brief course of ototoxic medication, but that not all of them develop a hearing loss. These studies suggest that if ototoxic medication is the only risk factor as regards such loss, then the hearing impairment may in fact be of unknown aetiology (Wroblewska-Seniuk et al., 2005:1355; Hess et al., 1998:87). Not all neonates who are given aminoglycosides will develop a hearing loss, but proper monitoring

of the medication at serum level is recommended to detect any loss of high-frequency hearing (Hess et al., 1998:87).

Ototoxic medication (aminoglycosides and loop diuretics) may cause a permanent sensorineural hearing loss in neonates, but the individual susceptibility is unpredictable (Northern & Downs, 2002:96; Roizen, 1998:241). A number of research reports indicate that aminoglycosides used in multiple courses or in combination with loop diuretics are considered a risk factor for hearing loss in neonates and infants (Yoon et al., 2003:356; Northern & Downs, 2002:97). The hearing problem initially affects the higher frequencies, is symmetrical and maybe progressive, and is more disabling in the neonates and infants that must still acquire language (Yoon et al., 2003:356; Bamiou et al., 2000:99). However, the degree to which ototoxic medication contributes to the increased incidence of hearing loss amongst the NICU population is unclear (Roizen, 1998:241). The risk for such loss as regards the subjects in the current study was minimised because the ototoxic medication was not administered for more than five days and the course was not repeated. However, a large number of subjects in the current study presented with pulmonary hypertension that is strongly correlated with hearing loss; this matter is discussed next.

- ***Pulmonary hypertension***

A large number (63%) of subjects in the current study presented with pulmonary hypertension / respiratory distress requiring mechanical ventilation, but the presence of such distress was not recorded in the files of 27% of the sample. Wrobleska-Seniuk et al. (2005:1353) reported that 2, 86%, and Meyer et al. (1999:902) that 17, 2%, of their sample had been mechanically ventilated for more than five days. Van Straaten et al. (2003:333) reported an incidence of 29, 5% in their study group. The major difference between that which is reported in the current study compared to that which is reported in other NICU studies is to be noted in the number of days during which the subjects received mechanical

ventilation. The other NICU studies specify that their subjects received mechanical ventilation for more than five days. The number of days during which subjects in the current study received mechanical ventilation was not specified in their files. Subjects in the current study might have been given mechanical ventilation from their first day up to the end of their stay in the NICU. This may explain the difference in the low incidence reported by other studies and the high incidence found in the current study. Severe respiratory distress (persistent pulmonary hypertension) has been related to a bilateral, progressive or delayed onset sensorineural hearing loss in neonates (Polinski, 2003:99; Yoon et al., 2003:356). It has been demonstrated that neonates with severe respiratory distress exhibit a higher risk for hearing loss than other neonates discharged from the NICU (Northern & Downs, 2002:106).

Robertson et al (2002:353) reported on an important study into late-onset, progressive sensorineural hearing loss after severe neonatal respiratory failure. They studied a group of subjects, at the age of four years, who had survived severe neonatal respiratory failure, in order to document the occurrence of late-onset or progressive sensorineural hearing loss amongst the survivors. In the study group, 53% exhibited a sensorineural hearing loss and high-frequency hearing loss occurred in 65% of the subjects (Robertson et al., 2002:355). These authors concluded that sensorineural hearing loss occurs in a significant number of survivors of severe neonatal respiratory failure in term and near-term neonates, and that it is usually late in onset and may be progressive after onset (Robertson et al., 2002:355). They recommend that severe respiratory failure should be an indication for long-term audiological surveillance and follow-up throughout childhood (Robertson et al., 2002:355).

4.2.2 Summary of results and discussion for sub-aim #1

The results of sub-aim one are summarised in Table 4.3.

Table 4.3 Summary results and discussion of sub-aim #1

High risk register

- A small number of subjects (4%) showed no risk for hearing loss and more than half of them (52%) indicated more than four risks for hearing loss. The number of reported family histories of congenital hearing loss (6%) is greater than the 3% reported by Vohr et al. (1998:377). The incidence of 6% in the current study is significantly lower than what has been reported for a similar study in South Africa (Swanepoel; 2004b:227).
 - A number of subjects (65%) included in the current study had an established risk for hearing loss because of admission for more than 48 hours to the NICU. If neonates and infants are admitted to the NICU for more than seven days the possibility of a referral after screening increases (Wroblewska-Seniuk et al., 2005:1353).;
 - The incidence of risk factors for hearing loss may increase if the HIV-status of mothers is included as a risk factor. In the current study, 18% of the subjects were reportedly born to HIV-positive mothers;
 - Ototoxic medication was administered to the majority of subjects (86%). However, ototoxic medication was not given in dangerous dosages, because it was not administered for more than five days;
 - Pulmonary hypertension was present in 63% of the sample. It is an important risk factor to monitor because sensorineural hearing loss and late-onset hearing loss occur in a significant number of survivors of severe neonatal respiratory failure (Robertson et al., 2002:355).
-

4.3 DESCRIPTION AND DISCUSSION OF RESULTS: SUB-AIM #2

To describe the middle ear functioning of subjects in terms of immittance measurements

The results of the sub-aim are presented and discussed in terms of 1000 Hz, 226 Hz probe tone tympanometry and acoustic reflex measurements. These measurements were carried out at the first visit for hearing screening. The ages of the subjects at the first screen ranged between 4 and 210 days. Some of the subjects were only screened at an older age because the appointment scheduled at the time of discharge from the hospital could not be kept. Tympanometry was performed on 78% of the subjects for a 1000 Hz probe tone and 80% for a 226 Hz probe tone. Acoustic reflex measures were performed on 76% of subjects with a 226Hz probe tone. These immittance measures are discussed separately in the following sections.

The length of stay in the NICU is an important risk factor for MEE, especially with regard to neonates that are admitted to the NICU for more than 30 days (Sutton et al., 1996:12). However, the longest stay in the NICU in the current study was 27 days, so that the neonates in the current study did not exhibit this added risk factor.

4.3.1 1000 Hz tympanometry

The high-frequency tympanograms were divided into two categories – those presenting with a discernible peak and those without a discernible peak, between the ages of 0-4 weeks and 5-30 weeks. Recent studies indicate that a peaked 1000 Hz tympanogram suggests normal middle-ear functioning in neonates, while the absence of a peak implies the presence of middle-ear effusion (Kei et al., 2003:25). Figure 4.3 indicates the incidence of peaked high-frequency tympanograms in the ears of the subjects in the current study.

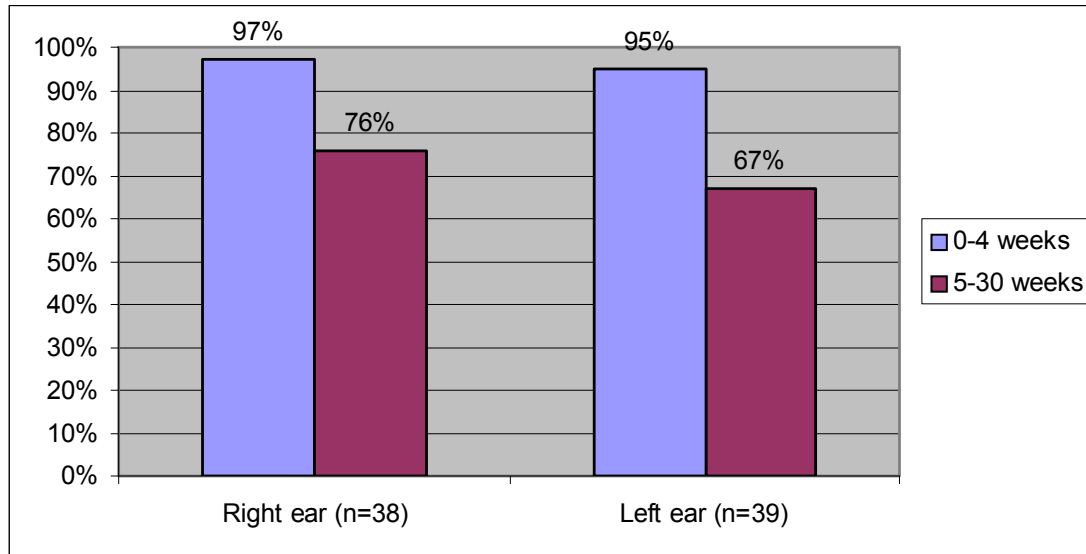


Figure 4.3 1000Hz peaked tympanograms per ear

Figure 4.3 indicates that subjects between 0-4 weeks of age (n=10) displayed 97% peaked tympanograms in the right ear and 95% in the left ear. Subjects between the ages 5-30 weeks (n=39) exhibited peaked audiograms in 76% in the right ear and 67% in the left ear. A single-peaked high frequency tympanogram is probably indicative of normal middle-ear functioning in healthy neonates, in the presence of a normal OAE, and indicates no risk factors for hearing loss (Kei et al., 2003:26).

In subjects aged 0-4 weeks, the incidence of peaked tympanograms was 96% for both ears. A study that investigated 170 healthy neonates between 1-6 days of age reported an incidence of peaked tympanograms in 92% of ears in the study group (Kei et al., 2003:23). The 1000 Hz tympanometric peak results for neonates in the current study and those reported by Kei et al. (2003:23) are close to a 678 Hz probe tone study conducted on a group of 200 NICU neonates, indicating a 91% incidence of discernible peaked tympanograms (Sutton et al., 1996:11). The incidence regarding single peaked tympanograms in the current study compares with research by Swanepoel (2004b) and Swanepoel et al.

(2006b:9) that reports an incidence of 92% of single peaked tympanograms in neonates' ears at maternal and child health clinics in South Africa.

The children aged between 5-30 weeks in the current study indicated an incidence of 72% of their ears with peaked tympanograms. A study conducted on NICU infants between 5-35 weeks who were close to discharge from hospital report that 82% of their ears had a single-peaked tympanogram (Margolis et al., 2003:388). Swanepoel (2004b:233) reports an incidence of 86% of peaked tympanograms for infants between 5-52 weeks of age at maternal and child health clinics in South Africa.

The lower incidence (72%) of peaked tympanograms measured in subjects between 5-30 weeks in the current study compares with the lower incidence of peaked tympanograms in subjects between 5-52 weeks (86%) reported by Swanepoel (2004b:233). The significantly lower incidence measured in older subjects may be suggestive of a higher incidence of MEE, which is the most likely cause of abnormal results in tympanometric measurements (Sutton et al., 1996:13). At present, little is known about the tympanometric patterns recorded in the first 24 hours of a newborn's life, and the youngest subject in the current study was four days of age (McKinley et al., 1997:219). Interpreting abnormal tympanometric results in isolation as an indication for MEE is not a reliable finding in the very-young paediatric population, because the presence of possible transient vernix caseosa in the ear canal of a neonate could influence the results of the measurement. However, the no-peak tympanograms do indicate that the high-risk population in the current study seems to present with more MEE than the other samples.

In the current study, 16% of subjects' ears had abnormal tympanometric results. These results compare with the 20% reported by Sutton et al. (1996:15) and the 18% reported by Margolis et al. (2003:388). Table 4.4 summarises the results for tympanometric results recorded with respect to both ears in the current study.

Table 4.4 Results of high frequency tympanometry recorded for both ears (n=38)

Category	Number of subjects*	Percentage of sample
Peak both ears	18	47%
No-peak both ears	6	16%
No-peak left ear	9	24%
No-peak right ear	5	13%

* Subjects with results for both ears

In the current study, 47% of the sample exhibited a peaked high frequency tympanogram in both ears. Table 4.4 also indicates that 53% of the sample had no peaked tympanograms in either ear. Only 16% of the sample had flat tympanograms bilaterally. No tympanometric measurements were made in 11 subjects (22%) of the sample.

4.3.2 226 Hz tympanometry

The 226 Hz tympanograms were also divided into two categories – those presenting with a discernible peak and those without a discernible peak, between the ages 0-4 weeks and 5-30 weeks. Figure 4.4 indicates the incidence of peaked 226 Hz tympanograms in the current study.

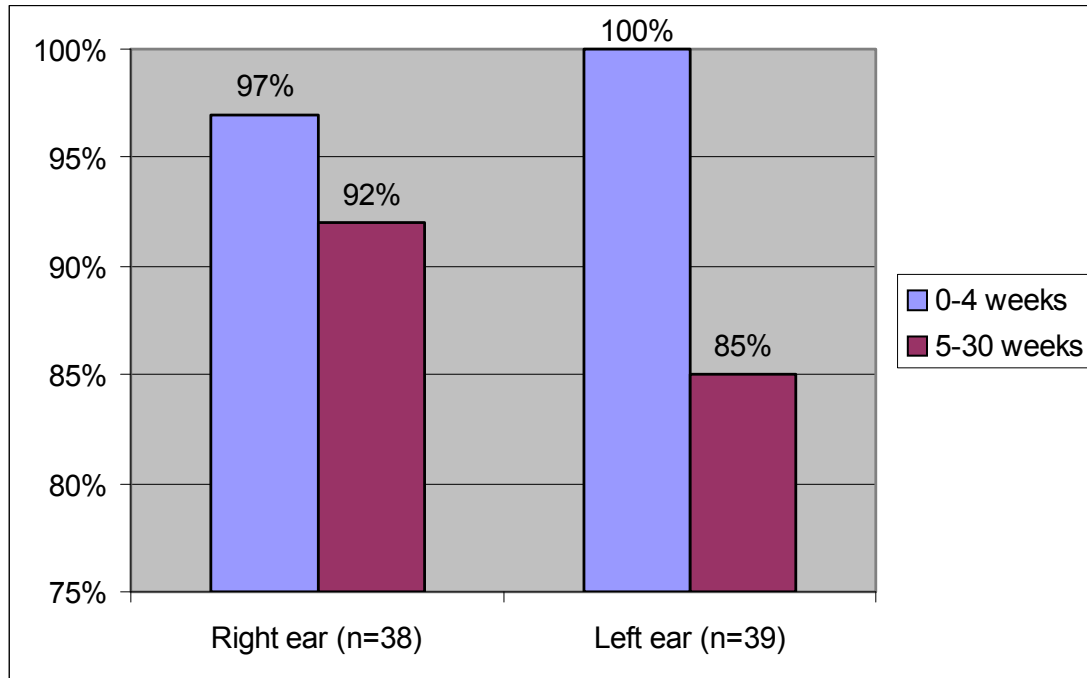


Figure 4.4 226 Hz peaked tympanograms in the ears

Low frequency tympanograms were recorded in 39 subjects, and the peaked tympanograms recorded in the right and left ear for subjects aged 0-4 weeks (n=10) and 5-30 weeks (n=39) are illustrated in Figure 4.4. Figure 4.4 indicates that subjects between 0-4 weeks of age exhibited 97% peaked tympanograms in the right ear and 100% in the left ear. Subjects between the ages of 5-30 weeks showed peaked audiograms of 92% in the right ear and 85% in the left ear. In subjects aged 0-4 weeks, 99% of their ears had peaked tympanograms, while this percentage was 89% in subjects aged 5-30 weeks of age.

The incidence of peaked tympanograms also decreases significantly in the older subject group, as with the high-frequency probe tone. The incidence decreases from 99% of peaked tympanograms in neonates to 98% of peaked tympanograms in older subjects. The lower incidence in subjects between 5-30 weeks of age may be suggestive of a higher incidence of MEE. The number of bilateral peaked 226 Hz tympanograms is summarised in Table 4.5.

Table 4.5 Results of 226Hz tympanometry recorded for both ears (n=39)

Category	Number of subjects*	Percentage of sample
Peak both ears	31	80%
No-peak both ears	2	5%
No-peak left ear	4	10%
No-peak right ear	2	5%

* Subjects with results for both ears

Table 4.5 indicates that 80% of the sample had a bilateral 226 Hz tympanogram and only 20% had no peak in either or both ears. The incidence of bilateral peaked tympanograms measured with a low-frequency probe tone (80%) in the current study is higher when compared with a high-frequency probe tone; see the previous section (47%).

The literature reports that conventional tympanometry with a 226 Hz probe tone is not an effective immittance measurement for neonates (Kei et al., 2003:21; Margolis et al., 2003:384; Palmu, Puhakka, Rahko & Takala, 1999:207; McKinley et al., 1997:218; Sutton et al., 1996:10). Kei et al. (2003:21) observe that conventional tympanometry produces erroneous results because of a high false-negative rate and different shaped tympanograms. Conventional tympanometry is not suitable for evaluation of the stiffness-dominated middle-ear system of neonates but high-frequency probe tone tympanometry has been shown to be more sensitive for middle-ear effusion in neonates (Kei et al., 2003:22; Margolis et al., 2003:384).

In the current study, the number of bilateral peaks was higher when the 226 Hz probe tone (80%) was used than with the 1000Hz probe tone (47%). The significant difference between peaked tympanograms employing conventional tympanometry and those making use of high frequencies may point towards the poor sensitivity, to middle-ear pathology, of conventional tympanometry in neonates younger than seven months of age.

4.3.3 Correspondence between high-frequency and conventional tympanometry

Correspondence between high-frequency and conventional tympanometry is necessary because of the false-negative rate of 226 Hz probe tone tympanometry. Conventional tympanometry produces unreliable results because of a high false-negative rate and different shaped tympanograms (Kei et al., 2003:21). Figure 4.5 indicates the percentage of the correspondence between 226 Hz and 1000 Hz tympanometry in each ear.

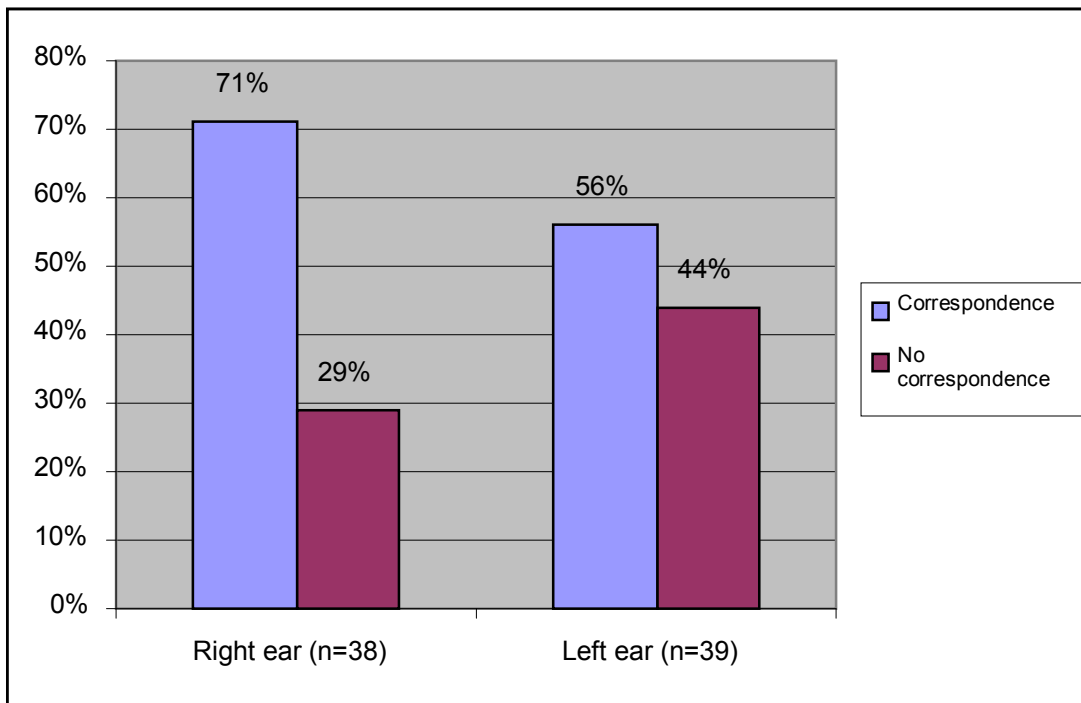


Figure 4.5 Correspondence between 226 Hz and 1000 Hz tympanometry

A correspondence of 71% in the right ear and 56% in the left is indicated. No correspondence was evident in 29% of right ears and 44% of left ears. A significant number of tympanograms correlated with each other in the current study, especially in the right ear. Figure 4.6 reviews the correspondence between peaked tympanograms in neonates and infants.

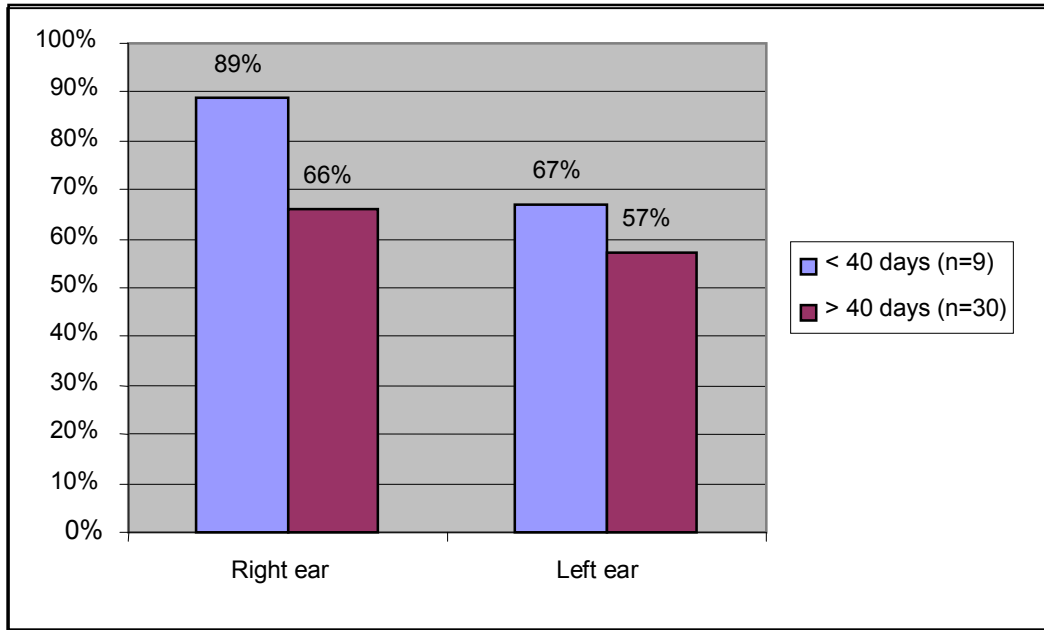


Figure 4.6 Correspondence between 226 Hz and 1000 Hz tympanometry in neonates and infants

As illustrated in Figure 4.6, 89% of their right ears and 67% of their left ears in neonates younger than 40 days exhibited correlating conventional and high-frequency tympanograms. In infants older than 40 days, 66% of the right ears and 57% of the left ears evidenced correlating tympanograms. Higher-correlating tympanograms were recorded in the right ear for neonates (89%) and infants (66%). In neonates younger than 40 days a significant difference of 22% was recorded between the tympanometric data for their left and right ears. In infants older than 40 days a difference of only 9% between the tympanometric data for the left and right ears was recorded. The fact that a lower incidence of correlation was measured in infants older than 40 days may be suggestive of a higher incidence of MEE owing to the fact that high-frequency probe tone tympanometry has been shown to be more sensitive as regards MEE in neonates than conventional tympanometry (Kei et al., 2003:22; Margolis et al., 2003:384). However, verification of the integrity of the middle-ear system by means of OAE measurement is needed before MEE can be confirmed.

4.3.4 Acoustic reflex measurement

Acoustic reflexes were measured with a 226Hz probe tone in 76% (37 subjects) of the sample. Figure 4.7 indicates the incidence of the present acoustic reflexes recorded in the ears of subjects in the age groups 0-4 weeks and 5-30 weeks in the current study.

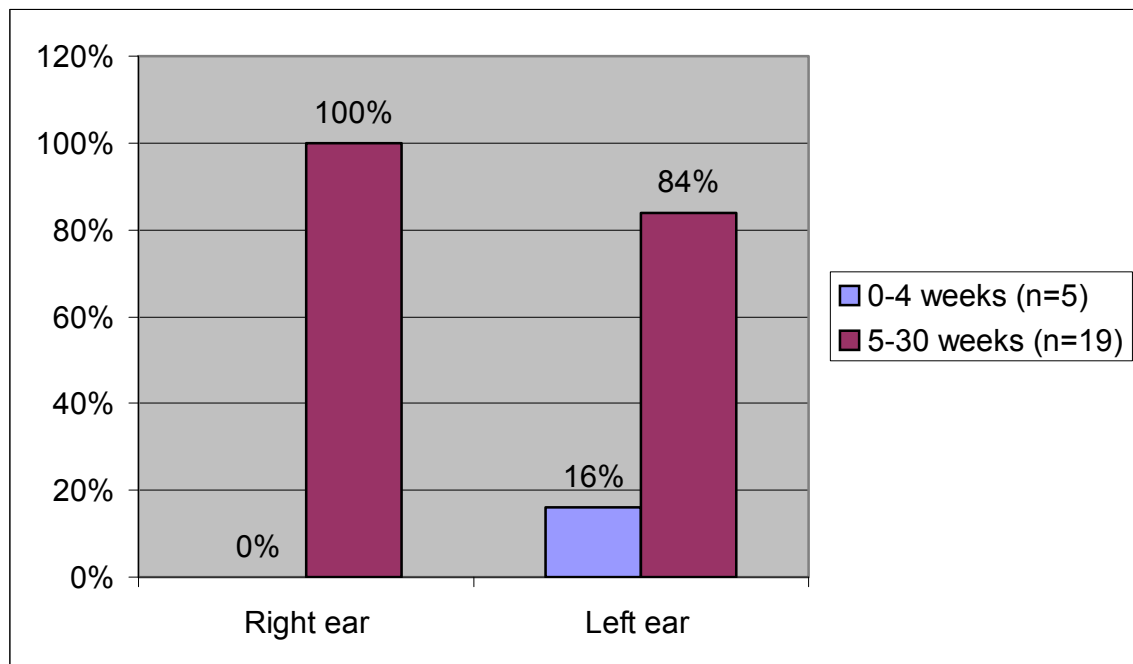


Figure 4.7 Present acoustic reflexes using a 226Hz probe tone

The subjects in the 0-4 week age group only evidenced 16% present reflexes in the left ear and no reflexes in the right ear. The older infants, aged between 5-30 weeks, exhibited 100% present reflexes in the right ear and 84% present reflexes in the left ear. The ears of subjects in the neonatal group alone reflected 8% present reflexes while those in the infant group displayed 92% present reflexes.

Swanepoel et al. (2006b:11) investigated high-frequency acoustic reflexes in 278 ears of neonatal subjects at maternal and child health clinics in South Africa. The study reports that 86% of these ears exhibited present acoustic reflexes. This incidence is significantly higher than the 16% for neonatal ears in the current

study. The reduced incidence in the current study can be attributed to the risk status of the neonates, the small sample size in the current study and the 226 Hz probe tone used. A high-frequency probe tone can be effectively used to elicit acoustic reflexes in the neonatal population (Swanepoel et al., 2006b:15). Table 4.6 summarises the results of acoustic reflexes measured in both ears.

Table 4.6 Results of 226Hz acoustic reflexes recorded for both ears (n=31)

Category	Number of subjects*	Percentage of sample
Present both ears	3	10%
Absent both ears	12	39%
Absent right ear	28	90%
Absent left ear	15	48%

* Subjects with results for both ears

Bilateral acoustic reflexes were obtained from 10% of subjects, a result which may primarily be attributed to the fact that reflex measurements commenced after bilateral 1000Hz and 226Hz tympanometry. The neonates showed restlessness and irritability during reflex testing after tympanometry using two probe tones. Table 4.6 points out that 39% of subjects had absent acoustic reflexes in both ears. Present reflexes were recorded in 52% of the left ears and 10% in the right ears.

The low percentage of present bilateral acoustic reflexes (10%) recorded in the current study may be attributed to the following factors.

- A low-frequency probe tone (226Hz) was used to elicit the acoustic reflexes;
- Acoustic reflex measurements were only performed after tympanometry at two probe tones, and AOAЕ and AABR screening was still to follow the immittance measurements.

According to Swanepoel et al. (2006b:9) a high number of present bilateral reflexes (86%) were recorded in 68% of neonatal subjects at maternal and child

clinics in South Africa. The probe tone used in the study by Swanepoel et al. (2006b:9) and Swanepoel (2004b:236) was a high-frequency probe tone of 1000Hz. The high-frequency probe tone used to activate the acoustic reflex supports research which reports that high-frequency tympanometry provides reliable results for middle-ear functioning in the young neonatal population. High-frequency immittance measurements yield more positive test results than conventional immittance measurements.

Another study by Sutton et al. (1996:12), who used a higher-frequency probe tone (678Hz) to record acoustic reflexes for the NICU population, reported that only 42% of subjects' ears had present reflexes. This figure is higher than the reported incidence of 36% of subjects' ears making use of a 226Hz probe tone in the current study. However, currently no norms regarding acoustic reflex measurements for neonates exist with which to compare the results.

4.3.5 Summary of results and discussion: sub-aim #2

Table 4.7 summarises the results from and description of middle-ear functioning in neonates in terms of immittance measurements.

Table 4.7 Summary of results and discussion for sub-aim #2

High-frequency (1000 Hz) tympanometry

- High-frequency tympanometry yielded results indicative of normal middle-ear transmission in 96% of ears in subjects between the ages 0-4 weeks and 72% in subjects aged 5-30 weeks. The significantly lower incidence measured in older subjects may be suggestive of a higher incidence of MEE. High-frequency peaked tympanograms may suggest normal middle-ear functioning in neonates while the absence of a peak may suggest the presence of middle-ear effusion (Kei et al., 2003:25). The no-peak tympanograms indicate that the high-risk population in the current study seems to present with more MEE than the other samples (Sutton et al., 1996:13; McKinley et al., 1997:219). The younger the infants, especially NICU infants, the less reliable tympanograms will be (Kei et al., 2003:25).

Conventional (226 Hz) tympanometry

- The 226 Hz tympanometry in the current study demonstrated a high incidence of tympanometric results suggestive of normal middle-ear function, in 99% of neonates' ears and 89% of infants' ears. The incidence of peaked tympanograms decreases from neonates to infants and may point to a higher incidence of MEE. However, literature reports that conventional tympanometry with a 226 Hz probe tone is not an effective immittance measurement for neonates; high-frequency tympanometry is more sensitive as regards MEE (Kei et al., 2003:21; Margolis et al., 2003:384; Palmu et al., 1999:207; McKinley et al., 1997:218; Sutton et al., 1996:10);

Comparison between conventional and high frequency tympanometry

- A correspondence of 71% in the right ear and 56% in the left was recorded in the current study. In neonates a significant difference of 22% was recorded between the tympanometric data for their left and right ears. In infants a difference of only 9% was recorded between the tympanometric data for their left and right ears. The lower incidence of correlating tympanograms measured in infants older than 40 days may be suggestive of a higher incidence of MEE due to the fact that high-frequency probe tone tympanometry has been shown to be more sensitive with respect to MEE in neonates than conventional tympanometry (Kei et al., 2003:22; Margolis et al., 2003:384).

Acoustic reflex measurements

- Acoustic reflexes were present in 16% of neonates' ears and 92% of infants' in the current study. The present reflexes are less than what has been reported (86%) for neonates' ears in South Africa (Swanepoel, 2004b:234). This may be attributed to the facts that a low probe tone (226 Hz) was used, the acoustic reflex testing followed the tympanometry testing and the neonates were irritable because of the time it took to record the tympanometry and acoustic reflex results.
-

4.4 DESCRIPTION AND DISCUSSION OF RESULTS: SUB-AIM #3

To describe the AOAE and AABR screening results

The hearing screening measures included AOAE and AABR testing in the current study. The following consideration of results describes the measures utilised according to the screening protocol as specified in Chapter 3. The results for each measure will be discussed separately in the following sections.

4.4.1 AOAE screening results

The initial AOAE screening procedure was performed on 46 subjects, which constitutes 94% of subjects in the current sample. The screening procedure was not performed on three members (6%) of the sample due to irritability, restlessness and noise artefacts on the AOAE screener. The pass rate of the AOAE screening per ear is illustrated in Figure 4.8 in terms of the two age groups: 0-4 weeks and 5-30 weeks.

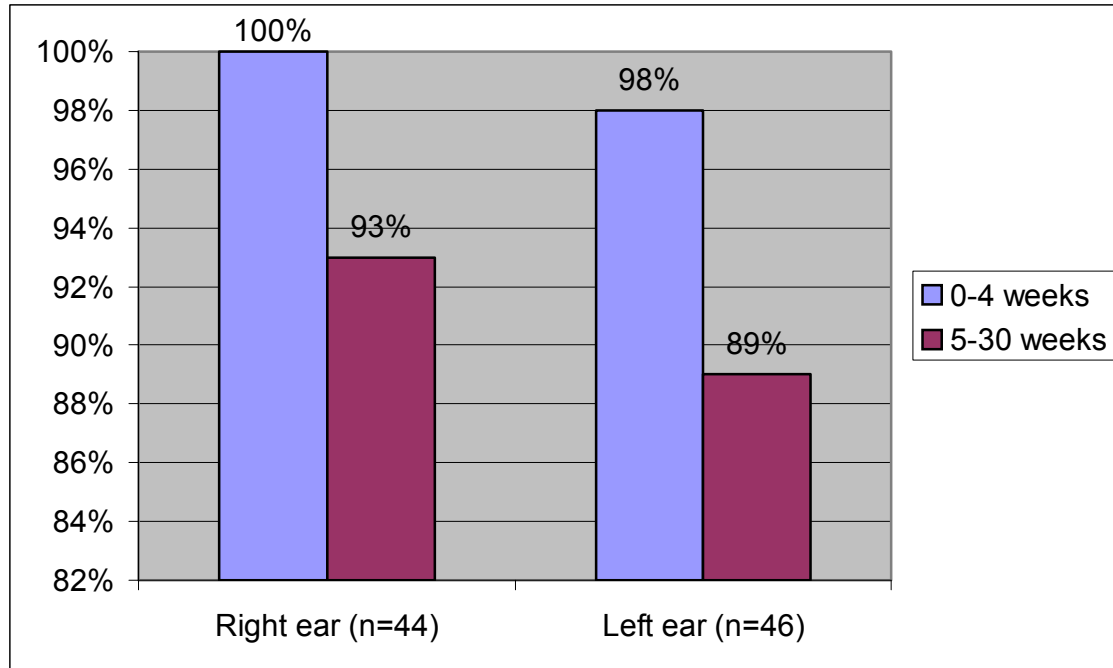


Figure 4.8 First AOA screening pass rate per ear

Figure 4.8 indicates that a significant percentage of the sample passed the AOA screening. In the age group 0-4 weeks (n=10), 99% of their ears passed this screening. In the 5-30 week age group (n=39) 91% of their ears did so. Swanepoel et al. (2006a:1241) investigated the OAE pass rate at maternal and child health clinics in South Africa. An analysis of the neonatal ears revealed a 95% pass rate, compared to a pass rate of 92% in infants aged 5-52 weeks. The results in the current study for neonates and older infants are similar to those which Swanepoel et al. (2006a:1241) report. The lower pass rate for older infants in the current study as well as for the infants in the study by Swanepoel et al. (2006a:1241) is close to the results reported for conventional and high-frequency tympanometry and may be indicative of a higher incidence of MEE in the older infant age group. The referral rate for neonates' ears is 1% and for older infants 8%, with a general referral rate of 5%. The general referral rate compares well to the referral rate reported in the study by Swanepoel (2004b:238) of 7% for healthy neonates and infants. Bilateral AOA screening was performed on 90% of the sample and the results of the AOA screening recorded for both ears are summarised in Table 4.8.

Table 4.8 Results of AOAE screening recorded for both ears at the first screen (n=44)

Category	Number of subjects*	Percentage of sample
Pass both ears	39	88%
Refer both ears	2	5%
Refer left ear	2	5%
Refer right ear	1	2%

* Subjects with results for both ears

Table 4.8 indicates that 88% of the sample passed the AOAE bilaterally while 12% evidenced a refer result either in both ears or in one ear. The referral rate was 2% and 5% for the right and left ear respectively. The unilateral referral rates in other NICU studies are discussed in the following section.

Chiong et al. (2003:216) report a unilateral referral rate of 20% after OAE screening in NICU graduates. This high percentage of referrals was attributed to very high-risk neonates or increased false-positives resulting from the relatively high level of background noise. Meyer et al. (1999:902) reported a unilateral referral rate of 13%. In a recent report by Khairi et al. (2005:678), a unilateral referral rate after OAE screening was 8%. All the above-mentioned studies were based on a unilateral screening criterion. The unilateral referral rate of 12% in the current study is in line with the unilateral referral rates reported by Meyer et al. (1999:902) and Khairi et al. (2005:678). Generally, the unilateral AOAE referral rate in the present study was therefore within the range of reported values for initial screening at discharge from the NICU (Khairi et al., 2005:678; Chiong et al., 2003:216; Meyer et al., 1999:902). The results in the current study report on screening for NICU infants at three months of age, whilst the other research studies report on infants screened at discharge from NICU. Therefore, the subjects in the present study were older than the subjects in the above-mentioned studies.

However, the bilateral referral rate (5%) in the current study is slightly higher than that which has been reported for healthy neonates. Hall et al. (2004:420) record

a bilateral referral rate for AOA of 2% with regard to healthy neonates in a well-baby nursery. In the study by Swanepoel (2004b:238) a bilateral referral rate of 3% is reported. The difference in the referral rates may be attributed to the fact that the subjects in the current study had been admitted to the NICU, the subjects exhibited confirmed risk factors for hearing loss and not all subjects were neonates. The initial referral rate of 5% in the current study is close to the referral rate of 4% proposed by the American Academy of Pediatrics (AAP) task force and the Joint Committee on Infant Hearing, but the referral rate could still be improved (JCIH, 2000:15; AAP, 1999:28).

4.4.2 AABR screening results

The AABR screening was performed following the immittance and AOA measurements. AABR screening was performed on 82% of subjects' right ears and 76% of their left ears. The percentage of subjects' ears that passed the initial AABR screening is illustrated in Figure 4.9 in terms of those who were 0-4 weeks of age ($n=10$) and those who were 5-30 weeks of age ($n=39$). No statistically significant difference between the left and right ears was evident.

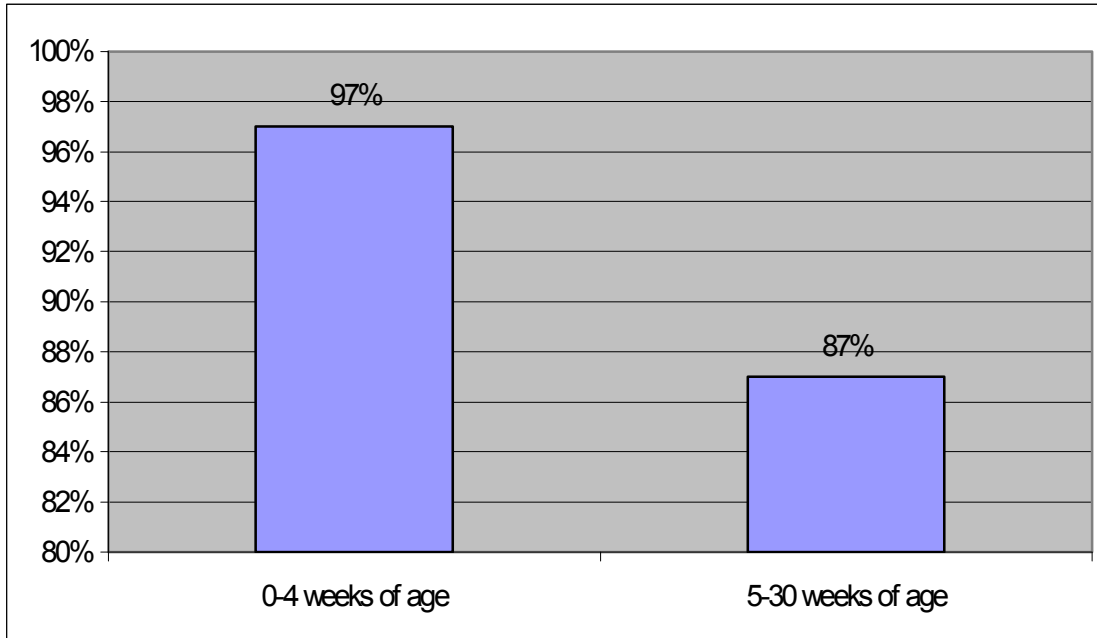


Figure 4.9 AABR screening pass rates for ears in the current study (n=78)

Figure 4.9 indicates that AABR screening was performed on 78 ears of subjects in the current study (80% of all ears). The pass rate for neonates aged 0-4 weeks was 97% for all ears and 87% for those of infants aged 5-30 weeks. The AABR screening results are similar to the immittance measurements and AOA screening that indicate a decreased incidence of pass results in older infants and may point to a possible increased incidence of MEE in the older subjects.

Van Straaten et al. (2003:335) reported an initial AABR referral rate of 8% for subjects' ears after AABR screening for NICU infants. This referral rate for a developed country corresponds with what was recorded in a developing country during the current study (8% of subjects' ears referred). Table 4.9 summarises the AABR screening results.

Table 4.9 Results of AABR screening recorded for both ears (n=37)

Category	Number of subjects*	Percentage of sample
Pass both ears	28	76%
Refer both ears	3	8%
Refer left ear	3	8%
Refer right ear	3	8%

*Subjects with results for both ears

Table 4.9 indicates that 76% of the sample evidenced a bilateral pass result and 8% a bilateral refer result. In the sample, 24% exhibited a unilateral referral result after screening. Swanepoel (2004b:239) reports that irritability and restlessness in infants older than three months of age minimises the use of AABR as an effective technique for hearing screening. When infants are restless, poor AABR results are expected, which will lead to more failures and referral results. In the current study, 80% of subjects were in the group aged from 5-30 weeks and the referral rate for this age group was 13%. The large number of infants who were older than three months in the current study may have increased the unilateral referral rate because of increased incidence of MEE, restlessness and irritability.

According to Van Straaten et al. (2003:335) it is possible to incorporate a two-stage AABR in a NHS programme for NICU graduates, with a participation rate of 98%. They report that a neonate should be tested as late as possible so as to avoid false-positive screening results due to an immature brain. On the other hand, it is argued neonates should be screened as early as possible before they are transferred into the general healthcare system (Van Straaten et al., 2003:335).

4.4.3 Comparison between AOAЕ and AABR screening results

The pass rates for AOAЕ and AABR were considered individually in the previous sections. The unilateral AOAЕ pass rate was 93% for subjects with results for both ears and the unilateral AABR pass rate was 84% for subjects with results for both ears. In the current study, 76% of the AOAЕ pass results correlated with the

AABR pass results. Only a small number (7%) of the subjects evidenced both an AOAE refer and an AABR refer result, while 17% of the sample exhibited no correspondence between AOAE and AABR results. A comparison of the AOAE and AABR results follows and is illustrated in Figure 4.10.

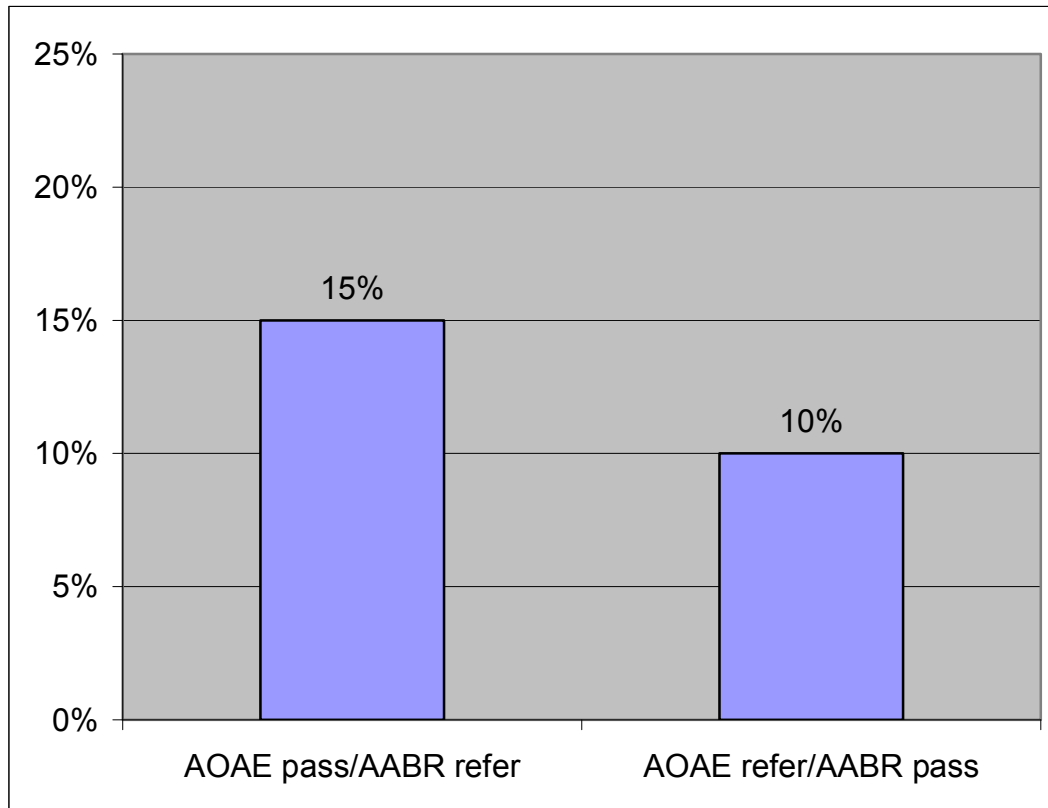


Figure 4.10 Comparison of AOAE and AABR results

Figure 4.10 indicates that 15% of the hearing screening results presented with an AOAE pass and AABR refer result while 10% of the results presented with an AOAE refer and AABR pass. The combination of AOAE and AABR results may point to different pathologies of the auditory pathway.

AOAE's and AABR's constitute fast and efficient measurements of the sensory and neural components of hearing sensitivity. However, effectiveness may be reduced owing to contamination by ambient noise in the nursery, vernix in the ear canal or any other middle-ear pathology (De Michele & Ruth, 2005:7). In the

study, 10% of the AOAE refer/AABR pass results could represent a mild conductive problem that did not obliterate the AABR measurement.

Absent OAE's may be due to a middle-ear pathology, but results must be interpreted with caution in order to differentiate between a true sensory problem and a transient middle-ear pathology (Campbell & Mullin 2006:3). Some examples of such pathologies which may cause transient middle-ear problems that in turn may lead to absent OAE results include cerumen and debris in the ear canal, vernix immediately after the birth of the neonate and abnormal middle-ear pressure (Campbell & Mullin, 2006:4). Even in the presence of normal cochlear function, OAE's may be absent in the presence of MEE. Reliable OAE results are obtained only after MEE has cleared (Campbell & Mullin, 2006:5). Any cochlear pathology that may cause a hearing loss can affect the ABR result, but in general, ABR abnormalities cannot offer a diagnosis of specific cochlear pathology (Don & Kwong, 2002:289). The pathologies that do not usually affect OAE's comprise auditory nerve pathology, central auditory disorders and auditory neuropathy /auditory dys-synchrony (AN/AD) (Campbell & Mullin, 2006:5). ABR testing could assist in differentiating between conductive loss and sensorineural loss (De Michele & Ruth, 2005:7). In the current study, 15% of the results indicated an AOAE pass/AABR refer result, indicating a possible auditory-nerve pathology.

A type of pathology of the auditory nerve that has received increasing attention in recent years is AN/AD. Classic AN/AD presents with the occurrence of OAE's and abnormal ABR findings (Ngo et al, 2006:1123; Campbell & Mullin, 2006:5; Don & Kwong, 2002:289). AN/AD is characterised by normal outer-hair cell function and abnormal neural function at the level of the cranial nerve VIII (Ngo et al., 2006:1123; D'Agostino & Austin, 2004:344). In the current study, 15% of the results indicated an AOAE pass/AABR refer and one infant was diagnosed with AN/AD.

However, AABR's and AOAE's are best recorded from a quiet infant in a resting state, because excessive movement by the infant will affect the screening results (Campbell, & Mullin, 2006:3; Diefendorf, 2002:471). The AABR was the last of the hearing assessments in these studies, making infants more prone to restlessness. In the current study, some subjects were restless at the time of AABR testing. Their restlessness and irritability may also have contributed to the 15% of results that indicated an AOAE pass/AABR refer result.

AOAE's may effectively be used to identify neural hearing loss in all neonates. However, if OAE is used as the solitary screening measurement to detect hearing loss, auditory pathology beyond the cochlea may go undetected. Testing of the sensorineural function of the auditory nerve is consequently necessary to detect retrocochlear hearing loss and auditory neuropathy. Measures to evaluate the auditory nerve are especially important for the NICU population because of the risk factors for hearing loss that characterise this population.

4.4.4 Summary of results and discussion: sub-aim #3

The results and description of hearing screening in neonates in terms of AOAE and AABR screening are summarised in Table 4.10.

Table 4.10 Summary of results and discussion for sub-aim #3

AOAE screening

- An analysis of the neonatal ears revealed a 99% unilateral pass rate compared to a pass rate of 92% in infants aged 5-52 weeks. The lower pass rate for older infants is similar to results reported for conventional and high-frequency tympanometry and may be indicative of a higher incidence of MEE in the older age group (Swanepoel et al., 2006a:1241). The number of subjects that had either one or both ears referred was 7% in the current study. The unilateral AOAE refer rate in the current study was within range of the reported values for initial screening at discharge from the NICU (8-20%) (Khairi et al., 2005:678; Chiong et al., 2003:216; Meyer et al., 1999:902);

AABR screening

- The pass rates for neonates aged 0-4 weeks were 97% for all ears and 87% for infants aged 5-30 weeks. For subjects with results for both ears, 76% of the sample evidenced a bilateral pass result and 24% a unilateral refer result. The high unilateral referral rate in the current study may be attributed to irritability and restlessness in patients and to the fact that AABR testing was the last screening method used. It has been shown that irritability and restlessness in infants older than three months of age minimise the use of AABR as an effective technique for hearing screening (Swanepoel (2004b:239).

Comparison of AOAE and AABR results

- During the comparison of AOAE and AABR results, 15% of the infants presented with an AOAE pass and AABR refer result and 10% presented with an AOAE refer and AABR pass. Middle-ear pathologies and ambient noise in the nursery during screening could have affected the screening results. Absent AOAE's may be recorded for normal-hearing infants in the presence of middle-ear pathology, without obliterating the AABR results. Middle-ear problems may have contributed to the 10% of subjects that exhibited an AOAE refer/AABR pass result. Auditory nerve pathologies may be present even with an AOAE pass result. In the current study, 15% of subjects evidenced an AOAE pass/AABR refer result. AN/AD was diagnosed in one of the subjects in the present study. However, irritability in the subjects could have increased the AOAE pass/AABR refer results in the current study (Campbell & Mullin, 2006:3; Diefendorf, 2002:471).
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4.5 DESCRIPTION AND DISCUSSION OF RESULTS: SUB-AIM #4

To describe the follow-up screening results

The follow-up screening results were divided into three groups. Firstly, the subjects who were scheduled for a routine follow-up hearing screen at three-month intervals. Secondly, subjects who were referred for further testing of hearing sensitivity after screening. Finally, infants who were referred for diagnostic testing (10% of the sample) were given a follow-up appointment for diagnostic ABR testing, usually within one week. A successful follow-up return rate as regards a NHS programme is a challenge faced by hospital-based hearing screening (Mukari, Tan & Abdullah, 2006:848).

4.5.1 Three-month interval screening

Table 4.11 indicates the number of subjects that returned for hearing screening at three-month intervals during the period of data collection in the current study. The research endeavour, of which this study constituted part, continued after the data collection in the current study had ended. The subjects that were included in the research project after data collection in the current study were also scheduled for hearing screening at three-month intervals. The return rates discussed in the following sections represent the return rates for the first two years of the research project and for 49 subjects; these rates are summarised in Table 4.11.

Table 4.11 Return rates for three-month screening

Visit	N	Percentage
2 nd Visit (3-month follow-up)	31	63%
3 rd Visit (6-month follow-up)	21	43%
4 th Visit (12-month follow-up)	16	33%
5 th Visit (15-month follow-up)	8	16%
6 th Visit (18-month follow-up)	2	4%

Table 4.11 indicates that a large number of subjects returned for a second visit (63%). The three-month interval visits became progressively fewer so that only two subjects returned for a sixth visit and both of them were referred for further testing of their hearing sensitivity. However, the data collection in the current study ended before the subjects returned for such further testing. The percentages of subjects who passed the AOA screening bilaterally at the different screening intervals in the current study are represented in Figure 4.11.

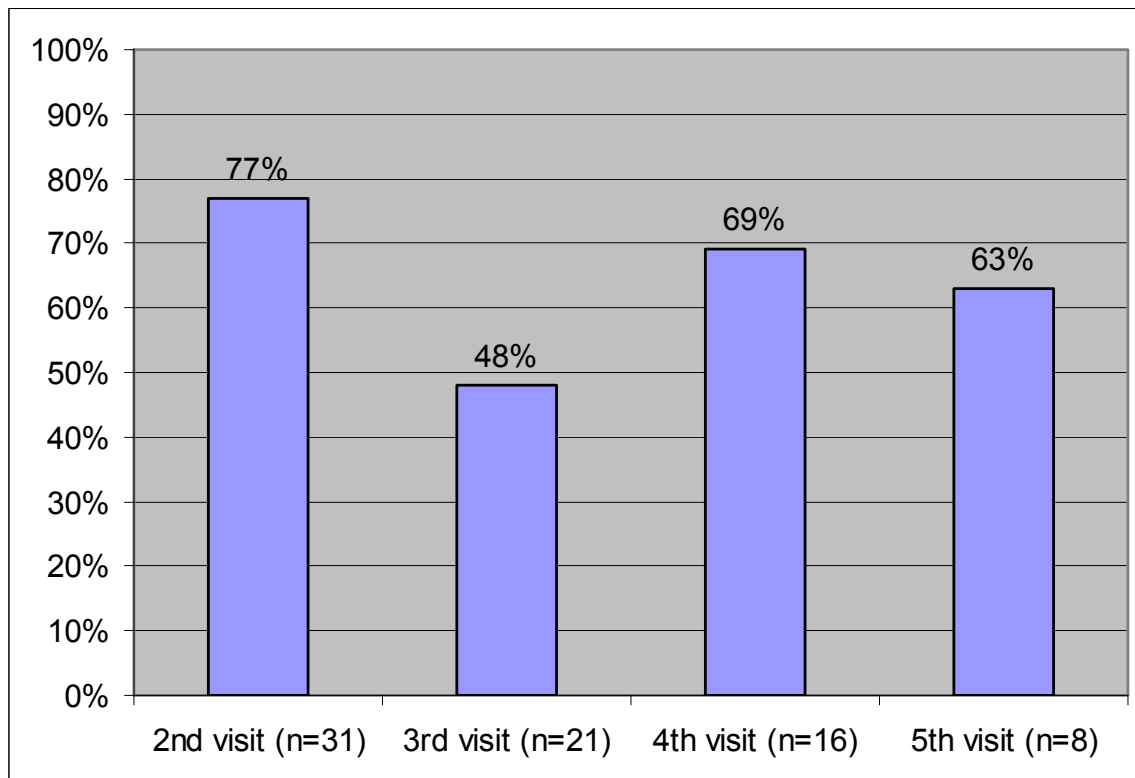


Figure 4.11 Number of subjects that passed AOA screening bilaterally at three-month screening intervals

Figure 4.11 indicates that the highest numbers of subjects that passed the screening were those at the second visit (77%) and the lowest at the third visit (48%). Reasons for the poor return rate are considered in the following section.

Mukari et al. (2006:849) investigated the return rates in a hearing screening programme and reported on various factors that contribute to a low return rate in

a NHS programme: firstly, the lack of communication between the hearing healthcare worker and mothers regarding the need for screening and follow-up. Screening results and the necessity for follow-up must be communicated clearly to parents. Secondly, the programme must ensure that a constant effort is made to confirm that all screening failures are given a follow-up appointment. Thirdly, lack of public awareness, with respect to childhood hearing loss and the importance of early intervention, decrease the return rate in a programme. Appropriate knowledge of these matters should be disseminated to enhance compliance with follow-up and intervention. Fourthly, the geographical distance from the hospital and resulting transportation problems reduce subjects' access to audiological services especially in rural areas where such services are limited. Compliance with follow-up could be bettered by including NHS and diagnostic follow-up in the total package of infant care (Mukari et al., 2006:849).

4.5.2. Subjects referred for further testing

The percentages of subjects who were referred for further testing after AOAE screening during the period of data collection in the current study are illustrated in Figure 4.12. These figures apply only to the first two years of the research project.

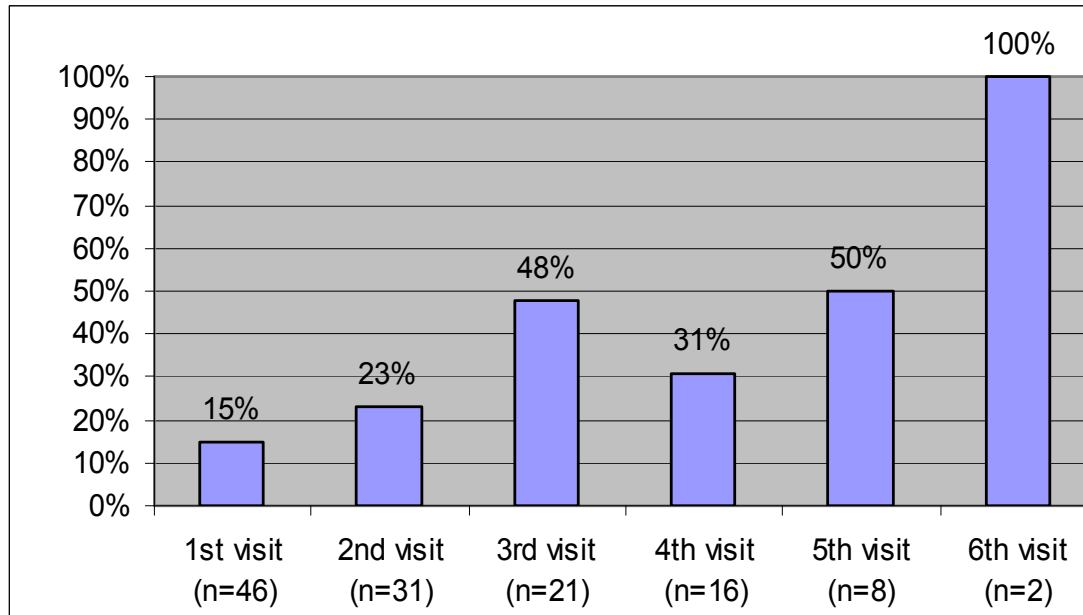


Figure 4.12 Subjects who were referred for further testing during data collection

Figure 4.12 shows that the numbers of subjects referred for further testing after AOA screening increased progressively during the collection of data. The higher number of referrals at the third screening interval may be attributed to the presence of middle-ear pathology in older infants (Engel et al., 2001:138; Klein, 2001:S4). However, the numbers of infants who returned for screening also dropped dramatically from the third to the sixth visit. The majority of subjects who were referred for further testing after the initial screen (86%) returned for a follow-up screen after referral.

The referral rate as regards further testing reported by Korres et al. (2005:242) was 3% in a group of healthy infants investigated over two years. Mukari et al. (2006:846) observe that 12% of their NICU sample failed the screening in either one or both ears at follow-up. No particular trend suggested a higher referral rate for the NICU population compared to healthy neonates (Mukari et al., 2006:843). The referral rate after the first screen in the current study (15%) is significantly higher than the rate reported by Korres et al. (2005:242) (3%); however, the

subjects included in their study were healthy neonates. The referral rate after the first visit in the current study (15%) is in line with that reported by Mukari et al. (2006:346) (12%).

4.5.3 Diagnostic testing results

In the current study, follow-up appointments were made for subjects if they failed the follow-up screening. Only 10% of the sample was referred for diagnostic ABR testing. During the data collection in the current study, five subjects were referred for diagnostic ABR testing; however, such results were obtained only from three subjects. One subject was diagnosed with AN/AD after such testing.

The majority of subjects referred for diagnostic testing evidenced normal hearing bilaterally. In the current study only one subject was diagnosed with a profound bilateral hearing loss. In the study by Mukari et al. (2006:847), 53% of the sample possessed bilateral normal hearing while 38% of the sample with a hearing loss stemmed from the NICU group and had such a loss in at least one ear. In the current study 1 in nearly 50 subjects was identified with hearing loss. The difference in the number of infants thus diagnosed from those in similar studies internationally may be attributed to various factors.

Firstly, the sample in the current study was small in size compared with those of the other studies. Secondly, the current study was the first of its kind in South Africa and the results report only on the first two years of the project. Many aspects (e.g. follow-up rates and diagnostic testing) need to be improved to make a NHS programme more effective, but screening is only the first step to rehabilitation (Mukari et al., 2006:847; Weichbold et al., 2006:235). In developing countries, like South Africa, funding and resources are limited and screening programmes must aim to be extremely accurate and cost-effective (Mencher & DeVoe, 2001:21).

4.5.4 Summary of results and discussion: sub-aim #4

In Table 4. 12 the results and description of the follow-up screening are summarised. .

Table 4.12 Summary of results and discussion for sub-aim #4

Three-month interval screening

- The return rates for the three-month interval screening were the highest at the second visit (63%) and lowest at the fifth visit (16%). The main factors that influence the return rates in a study are communication between parents and hearing healthcare workers, confirmation of the follow-up appointment, public awareness of hearing and hearing loss and geographical distance (Mukari et al., 2006:847);

Subjects who were referred for further testing (first two years of the study)

- The highest referral rates in the current study were recorded during the first (15%), second (23%) and third (48%) visit. The higher referral rates may be attributed to the presence of middle-ear pathology in older infants (Engel et al., 2001:138; Klein, 2001:S4) The majority of subjects referred for further testing after the initial screen (86%) returned for a follow-up second screen;

Diagnostic testing

- In the current study, 10% of the sample was referred for diagnostic testing and the majority (80%) arrived for this testing. One subject was diagnosed with a profound bilateral sensorineural hearing loss. The limited number of subjects diagnosed with hearing loss may be attributed to the small sample sizes and the fact that the study was in its first two years of implementation.
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4.6 DESCRIPTION AND DISCUSSION OF RESULTS: SUB-AIM #5

To compare the middle ear functioning and hearing screening results

Only the results of high-frequency tympanometry, AOAE and AABR at the first screening are presented and discussed in this sub-aim, as well as the routine follow-up screening results at three-month intervals and follow-ups after referral from AOAE and AABR screening. The age range of subjects at the first screen was between 4 and 210 days. These screening procedures were selected because they provide results for the entire auditory pathway, from the middle ear and cochlea to the auditory brainstem.

4.6.1 Comparison of normal screening results

The conventional, high-frequency tympanometry, AOAE screening and AABR screening results are compared in the following section. Figure 4.13 compares the initial results of the four test procedures indicative of normal functioning, which comprise a peak in both probe tone tympanograms, and an AOAE and AABR pass result. These results are compared for all the ears of subjects in the sample and for all subjects with bilateral pass results.

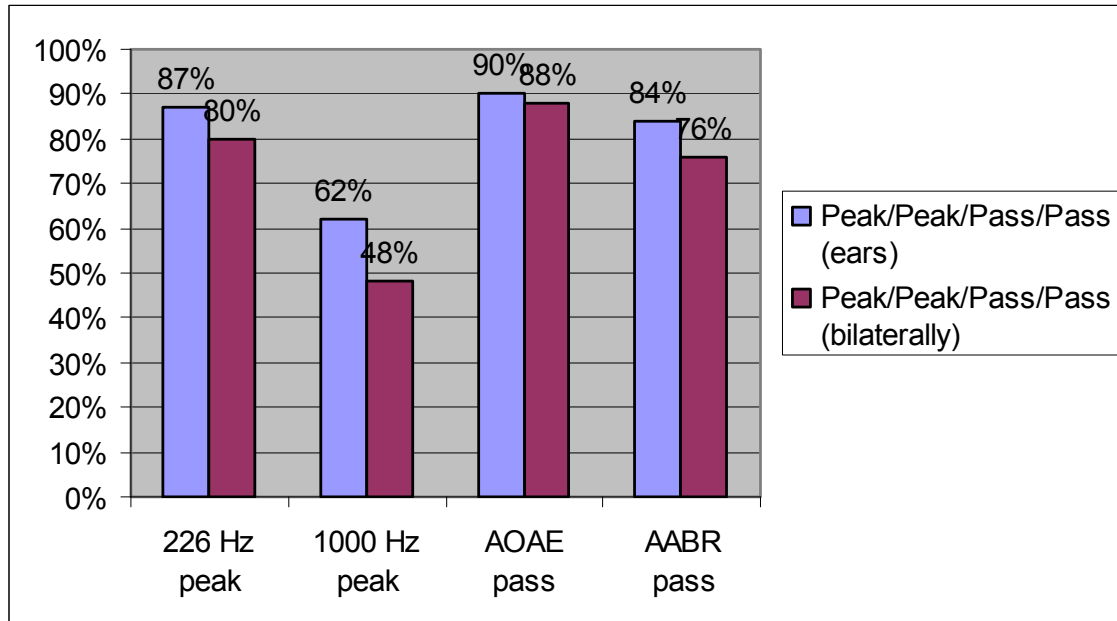


Figure 4.13 Comparison of tympanogram peaks, and AOAЕ and AABR pass results

Figure 4.13 indicates that the AOAЕ screening furnished the highest percentage of positive results suggestive of normal or near-normal middle-ear functioning and cochlear integrity (Taylor & Brooks, 2000:53). This was followed by 226 Hz probe tone tympanometry, then AABR screening and lastly 1000 Hz probe tone tympanometry. However, a proportion of 226 Hz probe tone tympanograms is unreliable because of their poor sensitivity regarding middle-ear disorders in the neonatal population (Kei et al., 2003:21).

The positive results (peak for both probe tone tympanograms and an AOAЕ and AABR pass) for all procedures decreased once a bilateral positive criterion was employed. Results decreased from 87% to 80% for 226 Hz tympanometry, 62% to 47% for 1000 Hz tympanometry, 90% to 88% for AOAЕ screens and for AABR screening from 84% to 76%. This suggests better bilateral results when using AOAЕ than the other procedures.

4.6.2 Comparison of referral screening results

Although the presence of OAE's does not offer a perfect gold standard for the absence of middle-ear pathology OAE measurement relies on an intact, uncompromised middle-ear system (Kei et al., 2003:24; Sutton et al., 1996:13). Figure 4.14 illustrates the percentages of subjects with an AOAE refer result and no peak using conventional and high-frequency tympanometry.

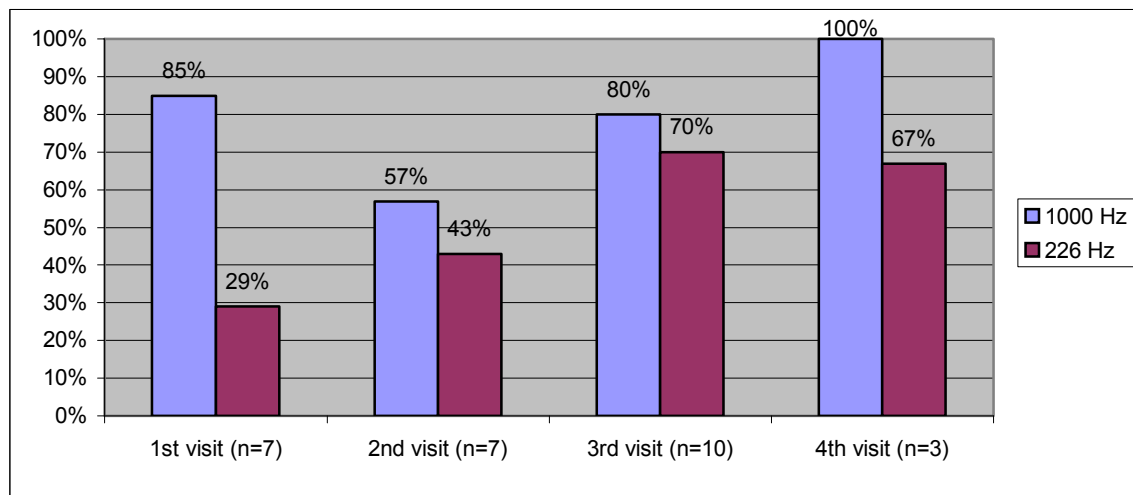


Figure 4.14 Percentages of subjects with an AOAE refer result and no peak conventional and high-frequency tympanometry

Figure 4.14 assesses the number of AOAE referrals and failed tympanometry results and indicates that the accuracy of tympanometry improves with increasing age, because the correspondence between AOAE and high-frequency tympanometry also increased from the first to the sixth visit. As Swanepoel et al. (2006:1241) observe, a significant association exists between OAE and high-frequency tympanometry.

Figure 4.14 indicates that a smaller number of AOAE referrals presented with a no-peak using 226 Hz tympanometry, a result in line with literature which recommends that conventional tympanometry is not the best suitable immittance measure for neonates (Kei et al., 2003:21; Purdy & Williams, 2000:9).

Conventional 226 Hz tympanometry displays a poor sensitivity (i.e. false negative results) to middle-ear disease in young infants who could present with Type A tympanograms despite the presence of MEE, diagnosed otoscopically or surgically (Purdy & Williams, 2000:9; Hunter & Margolis, 1992:33). A higher frequency probe tone is more consistent with the diagnosis of MEE (Purdy & Williams, 2000:9; Hunter & Williams, 1992:42).

Figure 4.14 also shows that the accuracy of tympanometry improves with increasing age especially with a high-frequency probe tone because the correspondence of AOAE and high-frequency tympanometry is greater at successive screening intervals. A recent study confirms that high-frequency tympanometry demonstrates promise in clarifying middle-ear status in infants, but that age and gender-specific norms should be taken into account (Swanepoel et al., 2006b:1). The high-frequency tympanometry and AOAE results in the current study support research which indicates that such tympanometry could be used to determine middle-ear status in infants. Such tympanometry can be employed to clarify false-positive screening results due to MEE, which is a common occurrence in NHS programmes (Swanepoel et al., 2006b:1). The timely and correct identification of MEE could guide referrals to medical and audiological staff and may contribute to the overall efficiency of the programme (Swanepoel et al., 2006b:1).

- ***AOAE refer / no-peak 1000 Hz tympanogram / AABR refer***

The various screening procedures used on subjects provide different site-of-lesion results. An AOAE refer, high-frequency no-peak tympanogram and AABR refer results that presented in subjects during the first and follow-up screens are illustrated in Figure 4.15.

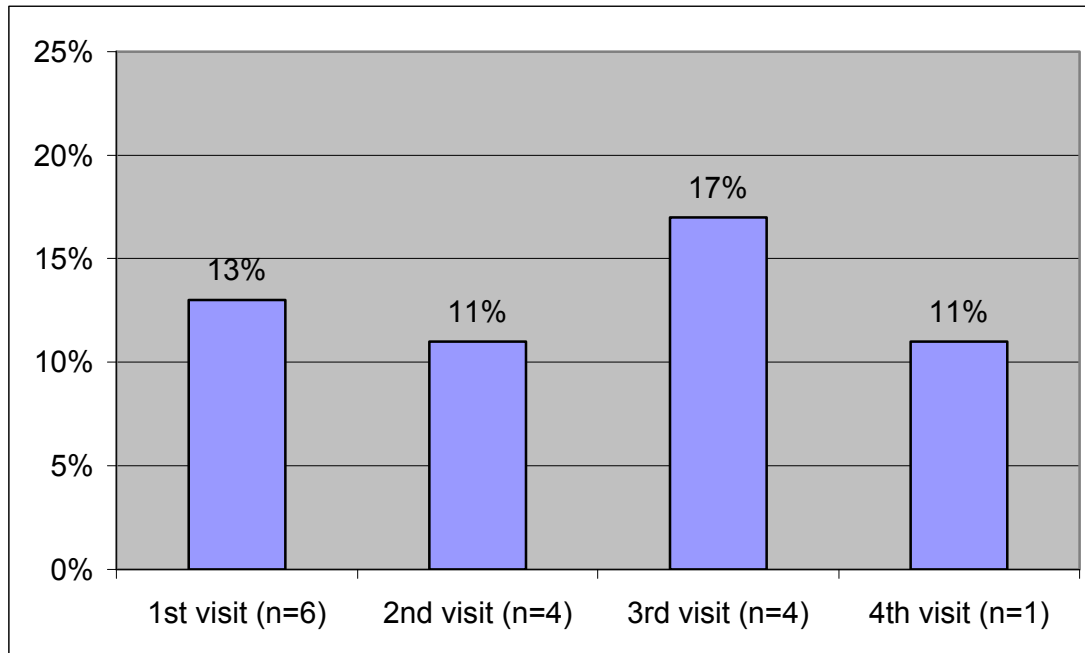


Figure 4.15 AOE refer / no-peak 1000 Hz tympanogram / AABR refer

Figure 4.15 shows that the referral rates for all measurements at the first, second and fourth visit were respectively 13%, 11% and 11%. A higher referral rate of 17% was recorded at the third visit. This may be due to the higher incidence of MEE in infants older than 28 days and could indicate a more severe conductive hearing loss. Different pathologies of the ear are summarised in Table 4.13 as they present during different screening measures.

Table 4.13 Site of lesion screening (DeMichele, 2006:7; D’Agostino & Austin, 2004:344; Hunter & Margolis, 1992:42)

Site of lesion	High frequency tympanograms (middle ear)	AOAE (cochlea)	AABR (auditory nerve)
Mild conductive pathology	No-peak	Refer	Pass
Severe conductive pathology	No-peak	Refer	Refer
Sensorineural hearing loss	Pass	Refer	Refer
AN/AD	Pass	Pass	Refer

As Table 4.13 suggests, infants may have varying degrees of risk for different hearing pathologies. AABR screening does not effectively distinguish between a mild sensorineural and a conductive loss (Hunter & Margolis, 1992:42). AOAE

may be more strongly affected by middle-ear pathology because the transmission of the AOAEE is disrupted even in minor cases of middle-ear pathology (Hunter & Margolis, 1992:42). Investigation of the middle and inner ear is necessary to effectively distinguish between infants that fail NHS because of MEE and those that fail due to sensorineural hearing loss (Kei et al., 2003:20; Hunter & Margolis, 1992:42). Correct identification of middle-ear pathology in the neonatal period could guide timely and correct referrals to medical and audiological personnel that may increase the efficacy of NHS programmes (Swanepoel et al., 2006b:16).

4.6.3 Summary of results and discussion: sub-aim #5

The results and description of a comparison between screening results are summarised in Table 4.14.

Table 4.14 Summary of results and discussion as regards sub-aim #5

Comparison of results

Normal results

- AOAE screening demonstrated the highest percentage of positive results suggestive of normal or near normal middle-ear functioning and cochlear integrity, followed by 226 Hz probe tone tympanometry, then AABR screening and lastly 1000 Hz probe tone tympanometry (Taylor & Brooks, 2000:53). However, a percentage of 226 Hz probe tone tympanograms is unreliable because of their poor sensitivity for middle-ear disorders in the neonatal population (Kei et al., 2003:21). The positive results (peak for both probe tone tympanograms and an AOAE and AABR pass) for all procedures decreased once a bilateral positive criterion was used. This suggests better bilateral results when using AOAE than the other procedures. The AABR referrals in the current study were significantly higher than the AOAE referrals due to the irritability and restlessness of subjects and because the AABR was the last screening measure used;

AOAE referral compared with tympanometry

- The results indicated that the accuracy of tympanometry increases with increasing age, especially with high-frequency tympanometry. The correspondence between AOAE and high-frequency tympanometry became greater from the initial to the last visit. A smaller number of AOAE referrals presented with a no-peak with 226 Hz tympanometry, in line with literature which recommends that conventional tympanometry is not the best suitable immittance measure for neonates (Kei et al., 2003:21; Purdy & Williams, 2000:9). A higher-frequency probe tone is more consistent with the diagnosis of MEE (Purdy & Williams, 2000:9; Hunter & Williams, 1992:42). High-frequency tympanometry could be used to determine middle-ear status in infants;

AOAE refer / no-peak 1000 Hz tympanogram / AABR refer

- The referral rates for all measurements were the highest at the first and third visit. This may be due to the higher incidence of MEE in infants older than 28 days and could be indicative of a more severe conductive hearing loss. Investigation of the middle and inner ear is necessary to effectively distinguish between infants that fail NHS because of MEE and sensorineural hearing loss respectively (Kei et al., 2003:20; Hunter & Margolis, 1992:42).
-

4.7 DESCRIPTION AND DISCUSSION OF RESULTS: SUB-AIM #6

To describe the perceptions of mothers and caregivers regarding neonatal hearing screening

The perceptions of mothers/caregivers were recorded on their first visit, after the immittance and hearing screening measurements were conducted. These views and feelings were recorded on a separate data collection sheet (see Appendix) and are discussed in the following section.

4.7.1 Perceptions of mothers/caregivers in the current study

All the mothers/caregivers in the current study expressed the view that it is necessary to screen neonates for hearing loss. All of them considered that they should know more about hearing loss and all were satisfied with the results obtained. The other perceptions are discussed in the following paragraphs.

- ***Exposure to a community/family member with hearing loss***

Figure 4.16 demonstrates the number of mothers/caregivers that had a family member, or knew someone with a hearing loss, in their community.

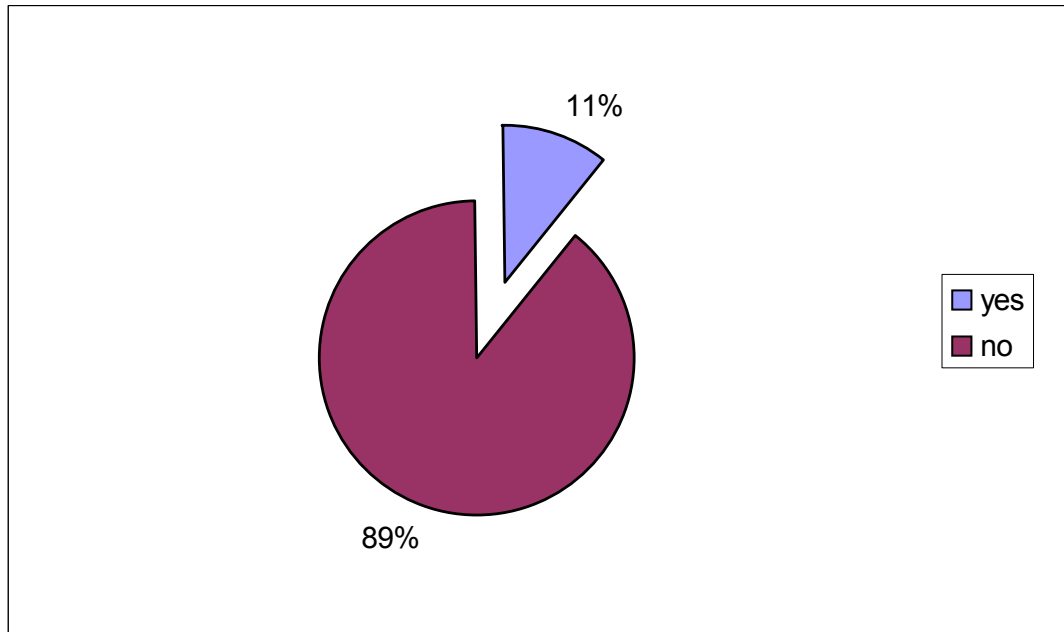


Figure 4.16 Exposure to hearing loss in the family or community (n=38)

As Figure 4.16 indicates, the majority (89%) of mother/caregivers had no exposure to a person with hearing loss; a small number (11%) knew someone in their community or a family member with a hearing loss.

Watkin et al. (1998:31) report that 44% of mothers had personal contact with a person with a hearing loss, and two-thirds possessed some knowledge of deafness which had been gained through the media. The 11% of mothers in the current study who acknowledged such contact is significantly lower than what was reported for reports in developed countries. Public awareness and attitudes towards early childhood disabilities in a developing community are poor and often exacerbated by unfavourable superstitious beliefs and customs (Olusanya et al., 2006:623; Swanepoel et al., 2005:14).

- ***Mothers/caregivers who are familiar with NHS***

Figure 4.17 illustrates the mothers/caregivers that had heard about NHS previously.

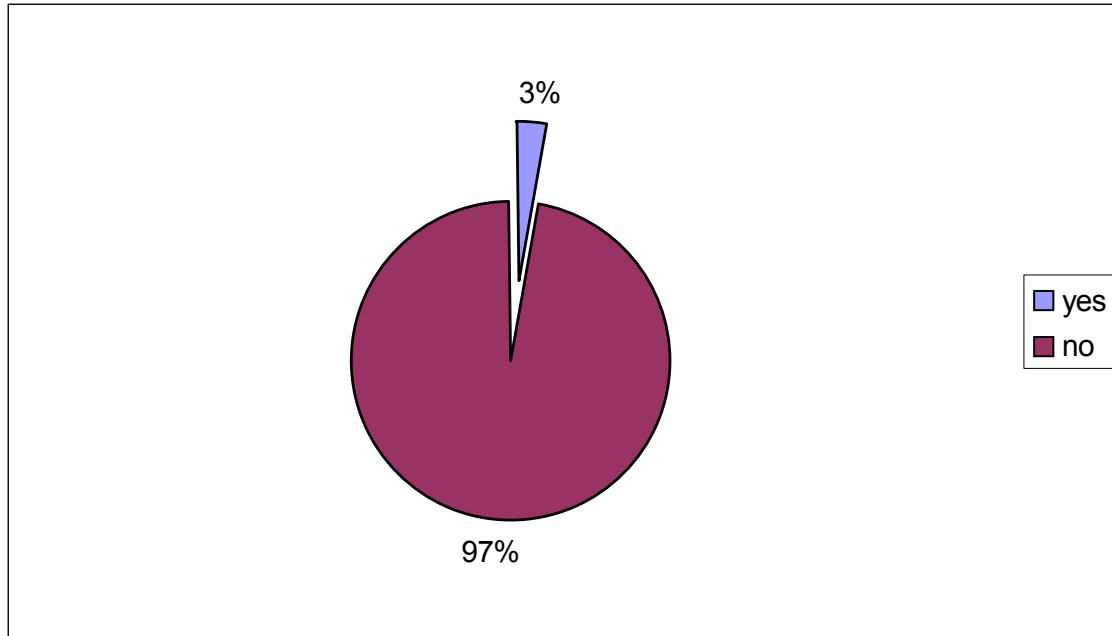


Figure 4.17 Previous exposure to NHS (n=38)

Figure 4.17 indicates that a very small number (3%) of mothers/caregivers in the current study had been exposed to NHS before. The initial hearing screening in the current study represented their first encounter with NHS for the great majority of mothers/caregivers (97%).

Vohr et al. (2001:17) studied maternal worry about NHS and observed that 29% of mothers had learned of NHS before hospitalisation and 67% during hospitalisation in the first year of the study. The majority of mothers in the current study were informed about the screening programme during hospitalisation, but only 3% had learned about hearing screening previously. Vohr et al. (2001:19) suggest that a secondary benefit of NHS and the investigation into the feelings of mothers is the raised awareness of hearing loss and hearing screening in the neonatal population. Weichbold et al. (2001:59) further consider that providing information about the hearing test will positively affect maternal attitudes towards NHS.

- **Mothers/caregivers who felt the neonate was uncomfortable during testing**

The mothers and caregivers were asked if they felt their infants were uncomfortable at any stage of the hearing screening. Figure 4.18 demonstrates the number of mothers/caregivers that felt that their infant was uncomfortable at any stage during the hearing screening.

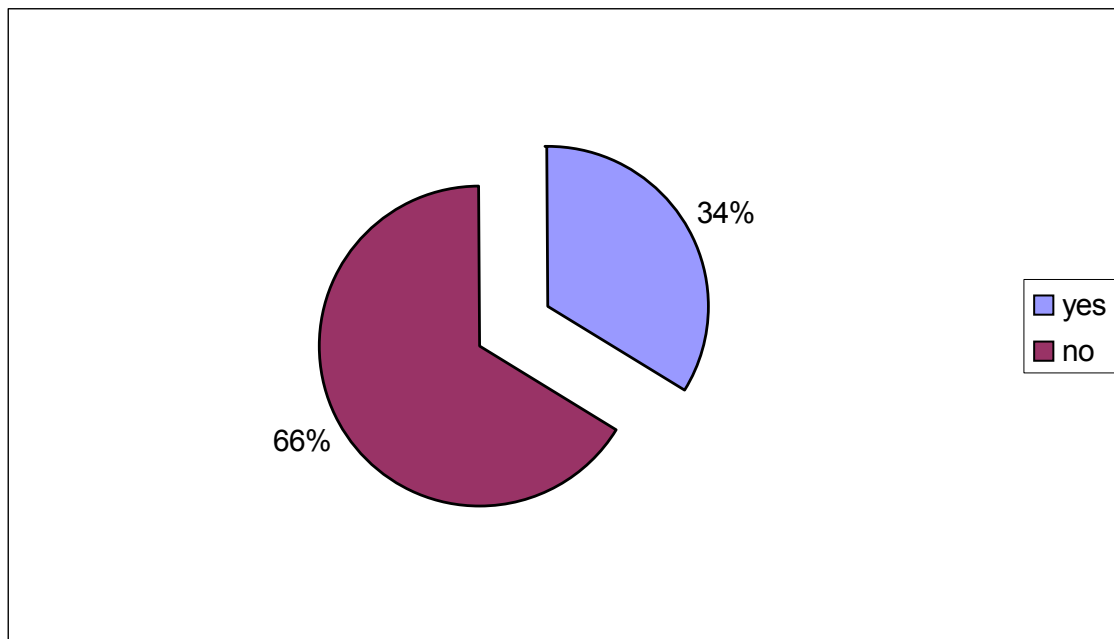


Figure 4.18 Feelings that neonate was uncomfortable during testing (n=38)

Figure 4.18 indicate that most mothers/caregivers (66%) were not uncomfortable as regards the children at any stage during the hearing screening. However, some mothers/caregivers (34%) did feel uncomfortable during this screening.

The study by Magnuson & Hergils (1999:55) suggests that the presence of mothers/caregivers during the testing promotes an attitude of reassurance and interest, in part because they can see how the test is performed and in part because of the explanation by the audiologist. The explanation provides the mothers with information concerning the aim of the programme and the benefits

of NHS. Better information and support before and during testing could reduce the feelings that the neonate was uncomfortable during the testing.

Mothers and caregivers generally know very little about hearing loss and hearing screening and evidence no knowledge of or need for audiological assessment (Magnuson & Hergils, 1999:55). Continuous access to professional information during screening is consequently needed to support mothers and to reduce anxiety (Weichbold et al., 2001:64; Magnuson & Hergils, 1999:55). The research protocol used included a number of different test procedures which may have added to some mothers' perceptions that the neonates were uncomfortable – if only one test (e.g. AABR or AOAЕ) had been carried out it could have been speculated that their comments would have been different and more favourable.

- ***Mothers/caregivers who were anxious during testing***

Previous studies demonstrate that some mothers/caregivers could feel anxious during hearing screening (Magnuson & Hergils, 1999:49). The percentage of those who felt anxious in the current study is indicated in Figure 4.19.

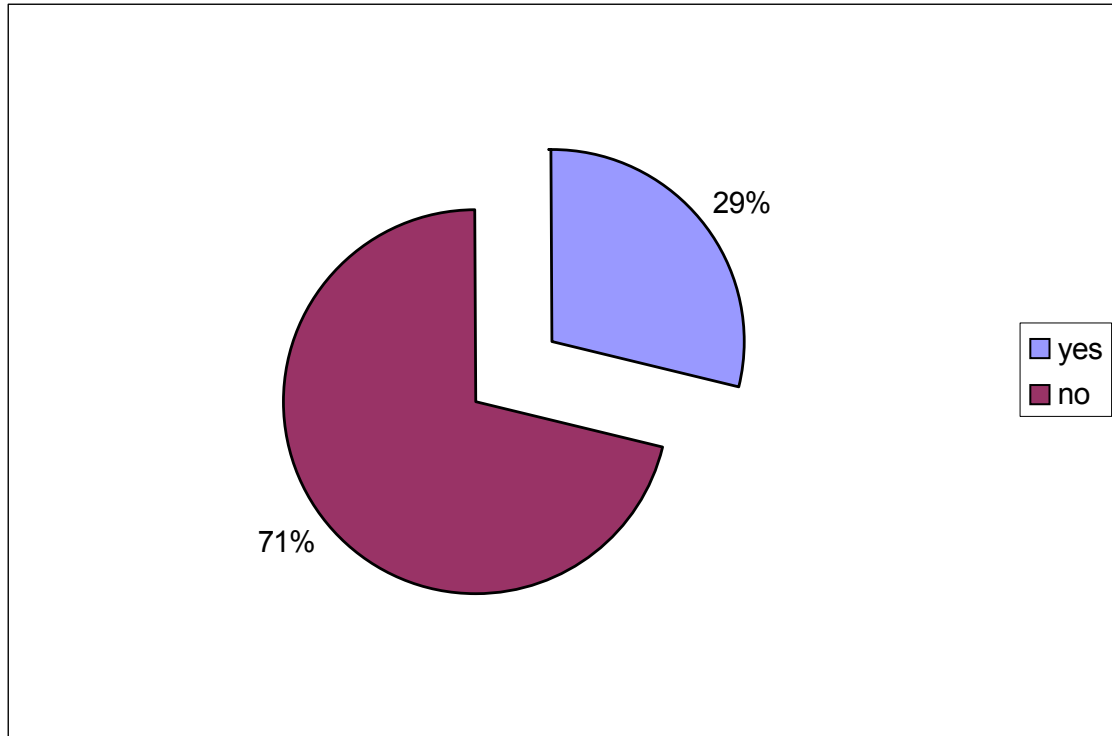


Figure 4.19 Mothers/caregivers who felt anxious during the screening (n=38)

From Figure 4.19 it is evident that a number of mothers/caregivers (29%) did feel anxious during the testing. A significant number (71%), however, did not. However, all the mothers who felt anxious during the testing nevertheless stated that it was necessary to screen the hearing of their neonate.

Magnuson & Hergils (1999:52) report that in their study the hearing screening caused very little anxiety and that if the information given to mothers had been more complete this could have reduced the anxiety even more. Vohr et al. (2001:18) similarly indicated that the majority of mothers (89%) felt no or very mild worry during screening and only 1, 3% - 2, 5% were very worried.

In the present study the higher number of mothers who felt anxious (29%) might be attributed to certain contributing factors:

- The subjects in the current study were NICU graduates and evidenced a confirmed risk for hearing loss;
- Socio-economic factors, including lower socio-economic status, poorer maternal education, bilingual status, being single, and non-White, may increase maternal worry (Vohr et al., 2001:20);
- If mothers are not familiar with NHS, the chance of maternal worry and anxiety increases (Vohr et al., 2001:20).

Olusanya et al. (2006:619) investigated maternal views on infant hearing loss in a developing country and reported that the attitudes towards NHS were positive in the majority (92%) of mothers. A high degree of acceptance of hearing aids (84%) was evident as an early intervention option in their study. Table 4.15 provides a summary of feelings that occurred together in the current study.

Table 4.15 The feelings of mothers/caregivers recorded in the current study (n=38)

Feelings reported	Subjects	Percentage of sample
Anxious	11	29%
Anxious and uncomfortable	2	5%
Anxious and knows someone with a hearing loss	2	5%
Anxious, uncomfortable and knows someone with hearing loss	1	3%

Table 4.15 indicates that 29% of mothers and caregivers felt anxious during the study. A small number (5%) were anxious and uncomfortable, or were not only anxious but also knew someone with a hearing loss. Only one mother (3%) was anxious, uncomfortable and knew someone with a hearing loss. A minority of mothers in the current study were very worried (3-5%), but all the mothers expressed the view that it is necessary to screen for hearing loss.

The current study aimed to minimise anxiety by not separating the mothers and subjects for the hearing screening. The mothers/caregivers held the subject in their arms during screening, because stress levels are increased if a neonate is

separated from their mother for the screening (Watkin et al., 1998:34). The study further aimed to reduce anxiety since information on the screening programme was provided by the interpreter and researcher. This positively affects mothers' attitudes towards screening (Weichbold, et al., 2001:59). The researchers in the current study therefore aimed to provide all the necessary information about the screening process and the procedures that would follow, not only to inform the mother/caregivers but also to improve their attitudes towards screening and to increase awareness regarding hearing and hearing loss.

4.7.2 Summary of results and discussion: sub-aim #6

The results and description of the perceptions of mother/caregivers are summarised in Table 4.16.

Table 4.16 Summary of results and discussion for sub-aim #6

Perceptions of mothers/caregivers

Community/family member with hearing loss

- In the current study, 11% of mothers/caregivers knew someone with a hearing loss. This is significantly lower than the figure reported in developed countries (44%) (Watkin et al., 1998:31);

Mothers/caregivers familiar with NHS

- In the sample, 3% of mothers were familiar with NHS. This is significantly lower than the 29% of mothers who learned of NHS before hospitalisation, as reported for developed countries (Vohr et al., 2001:17);
- Providing information about the hearing test will positively affect maternal attitudes towards NHS (Weichbold et al., 2001:59)

Mothers/caregivers who felt subjects were uncomfortable during screening

- The results indicate that 34% of mothers felt that the subjects were uncomfortable during testing. However, the presence of mothers/caregivers during the testing promotes an attitude of reassurance and interest (Magnuson & Hergils, 1999:55);

Mothers/caregivers who were anxious during screening

- The mothers/caregivers were anxious in 29% of the sample. This incidence is higher than that reported for developed nations (10%). (Vohr et al., 2001:17).
-

4.8 SUMMARY

This chapter presented, described, and discussed the results of the study as they related to its main aim: to critically describe a hearing screening programme at a neonatal intensive care unit in a provincial hospital in South Africa. The results were discussed in terms of the six sub-aims specified in chapter 3. The conclusions and implications of the research and results are considered in Chapter 5.

Chapter 5

CONCLUSION

The intention of this chapter is to discuss the conclusions and practical implications drawn from the empirical and theoretical research as described in the previous chapters, to critically evaluate the study and to make recommendations for future research.

5.1 INTRODUCTION

Summarising the empirical and theoretical data gathered is essential in research (Babbie, 2004:490). It is also necessary to review the significant findings, to point out their clinical implications and to highlight the shortcomings of the research (Babbie, 2004:490). Lastly, any research report should conclude with suggestions for future research (Babbie, 2004:490).

The Hearing Screening Position Statement of 2002 recommends investigation of the NICU as a hearing screening platform in South Africa, and in the current study the researcher aimed to concentrate on this recommendation by providing research-based evidence on a screening programme in this screening context (HPCSA, 2002:5). The present study may therefore serve as an impetus for further research and clinical implementation of successful Early Hearing Detection and Intervention (EHDI) programmes which will serve the general population of South Africa in an accountable manner.

5.2 CONCLUSIONS AND IMPLICATIONS

The empirical research was conducted according to the six sub-aims specified in chapter 3 and the conclusions reached are summarised in the following paragraphs.

Sub-aim #1: Description of inherited and acquired risk factors for hearing loss

The subject group in the current study was greatly at risk for hearing loss because of the presence of the established risk factors. The high incidence of pulmonary hypertension, ototoxic medication, exposure to Human Immunodeficiency Virus (HIV) and Neonatal Intensive Care Unit (NICU) admission, as noted previously, may increase the risk for developing a hearing loss during or after birth. The high incidence of risk factors recorded in the current study is even higher than that reported for developed countries (Wroblewska-Seniuk et al., 2005:1353; Polinski, 2003:99; Yoon et al., 2003:356; Van Straaten et al., 2003:333; Robertson et al., 2002:355). Infants in developing countries face a higher risk for developing a hearing loss when compared to infants in developed countries because of the higher proportion of risk factors present in third-world countries (Olusanya, 2000:167), which highlights the importance of screening this population for congenital and late-onset or progressive hearing loss. The NICU provides a starting point for hearing screening for infants at risk in this respect despite the prevailing contextual barriers that characterise developing countries. A significant problem in developing countries is that a considerable number of births take place at homes and clinics instead of in hospitals (Swanepoel et al., 2006:1243). This could pose a significant difficulty in accurately recording and monitoring risk factors for hearing loss in South Africa. Undertaking targeted neonatal hearing screening for NICU neonates and infants in a community with limited resources is an intermediate step towards universal neonatal hearing screening (HPCSA, 2002:5).

In this situation collaboration between hearing healthcare professionals and other medical practitioners is crucial in order to increase the awareness of established risk factors for hearing loss and early detection of hearing loss in the neonatal period. Medical practitioners are vital members of EHDl programmes, because they could encourage parents to comply with recommendations for follow-up services after hearing screening (Danhauer et al., 2006:33).

Sub-aim #2 Description of middle-ear functioning in terms of immittance measurements

High-frequency tympanometry yielded results indicative of normal middle-ear transmission in the majority of subjects' ears tested in the current study. The 226 Hz tympanometry also demonstrated that a high incidence of tympanometric results suggestive of normal middle-ear function was recorded. However, the results in the current study support the findings of the literature that 226 Hz tympanometry is not adequate to identify Middle Ear Effusion (MEE) effectively in neonates and infants (Kei et al., 2003:21; Margolis et al., 2003:384; Palmu et al., 1999:207; McKinley et al., 1997:218; Sutton et al., 1996:10). High-frequency tympanometry proves to be more accurate for this purpose in this population (Kei et al., 2003:21). The use of such tympanometry is therefore recommended to diagnose MEE effectively and accurately in a Neonatal Hearing Screening (NHS) programme (Swanepoel et al., 2006b:11; Kei et al., 2003:22; Margolis et al., 2003:384). The current study supports research which indicates that peaked tympanometric results increase with age in infants but that a higher incidence of MEE is present in infants older than five weeks of age (Swanepoel et al., 2006a:1247). Acoustic reflexes were present in a small number of subjects' ears, and may be attributed to the fact that the acoustic reflex testing followed the tympanometry testing and that a low probe tone was used to elicit such reflexes. The current study is in line with other research which establishes that high-frequency immittance measurements (tympanometric and acoustic reflex

measurements) are the most effective for accurately detecting MEE in neonates and infants (Swanepoel, 2006a:1247; Kei et al., 2003:21; Margolis et al., 2003:384; Palmu et al., 1999:207; McKinley et al., 1997:218; Sutton et al., 1996:10).

Sub-aim #3 Description of AOA and AABR screening results

Results in the current study indicate that screening of neonates younger than five weeks of age is more effective than screening infants older than five weeks of age, since a lower pass rate was recorded for Automated Otoacoustic Emission (AOAE) and Automated Auditory Brainstem Response (AABR) testing in infants older than five weeks than for neonates younger than four weeks of age. Accurate identification of sensorineural hearing loss in infants older than five weeks of age is limited because of the influence of MEE on older infants. The unilateral AOA referral rate in the current study was within range of the reported values for initial screening at discharge from the NICU (Khairi et al., 2005:678; Chiong et al., 2003:216; Meyer et al., 1999:902). However, a high unilateral referral rate was recorded for AABR in the current study. This may be attributed to irritability and restlessness in the subjects because AABR testing was the last measure used to screen them. These responses in infants older than three months of age reduce the use of AABR as an effective technique for hearing screening (Swanepoel, 2004b:239). The results in the current study are congruent with other findings which report that AABR referrals could increase with age because restlessness and irritability increases with age in infants (Palmu et al., 1999:2141).

Sub-aim #4 Description of the follow-up screening results

The highest percentage of subjects who returned for their three-month-interval screening was recorded at the second visit in the current study. The majority of subjects who were referred for further testing comprised infants older than five weeks of age. The higher referral rate in the latter may be indicative of the higher

incidence of MEE in such infants. The presence of MEE in them plays a major role in the referral rate regarding follow-up visits. Effective diagnoses of MEE are needed to accurately distinguish between a severe conductive hearing loss and/or a sensorineural hearing loss, especially in high-risk infants. Hearing screening at an immunisation clinic in South Africa also reported a poor follow-up rate after referral from screening (Swanepoel et al., 2006:1247). This low rate was reported because the screening programme was in its initial years of implementation and was also due to the fatalistic cultural perception of African communities toward disability (Swanepoel et al., 2006:1248). The poor follow-up results in the current study therefore confirm reports on a low follow-up rate in the initial years of a screening programme and the passive acceptance and integration of disability in South Africa (Swanepoel et al., 2006:1248; Louw & Avenant, 2002:145).

Follow-up rates should improve over time if a consistent service is rendered to parents and if parents realise the importance of detecting a hearing loss at a young age, as long as a continuous service is in place (Lieu, Karzon, Mange, 2006:66; Mehl & Thomson, 2002:688). Compliance with follow-up could be improved by making NHS programmes an integral part of the total package of a healthcare system (Mukari et al., 2006:84; Swanepoel et al., 2006:1248). Ensuring a high follow-up return rate in a NHS programme could address the cultural perceptions of a community towards hearing loss and lead to the implementation of an efficient tracking system that improves over time with sustained exertion and diligence (Swanepoel et al., 2006:1248). A continuous hearing screening service and awareness regarding the importance of hearing and hearing loss should also encourage higher follow-up return rates over time.

Sub-aim #5 Comparison of the immittance measurements and hearing screening results

Investigation of the middle and inner ear is necessary to effectively distinguish between neonates and infants that fail NHS because of MEE and those that fail owing to the presence of a sensorineural hearing loss (Kei et al., 2003:20; Hunter & Margolis, 1992:42). Tympanometric measurement, AOAЕ screening and AABR screening results indicated a higher incidence of positive results in infants younger than five weeks of age. This may point to the more frequent incidence of MEE in older infants which, as remarked, influences effective AOAЕ and AABR measurements in this age group. The significant association reported between AOAЕ measurement and high-frequency tympanometry in the current study is in line with other studies that report on this association (Swanepoel et al., 2006:1241). High-frequency tympanometry could therefore be used to classify the type of hearing loss and to distinguish between sensorineural hearing loss and MEE in infants younger than seven months of age (Kei et al., 2003:21; Margolis et al., 2003:384; Purdy & Williams, 2000:9). Differential diagnosis between transient MEE and external ear canal obstruction is possible with the use of a high-frequency probe tone. The effective identification of MEE, as suggested, could assist timely medical or audiological referral, save unnecessary referrals and increase the follow-up rates of a screening programme (Margolis et al., 2003:384). In the current study AOAЕ testing led to the highest percentage of positive screening results. These decreased once a bilateral screening criterion was used with all screening measures, which presented the best positive screening results in the current study and is in line with similar reports in South Africa (Swanepoel, 2004b:241). Screening with AOAЕ is recommended because few disposables are used, and the measurement is cost-effective and simple to use. These benefits of AOAЕ cause the measure to constitute the best screening option in a country with limited resources. AOAЕ should be employed in a protocol to detect bilateral hearing loss. A bilateral referral protocol is consequently recommended in a country with limited resources where healthcare priorities are skewed toward more life-threatening diseases and where it is

expensive to detect unilateral hearing loss (Davis et al., 1997:73). Effective early identification of hearing loss should lead to earlier intervention with regard to the infant and family (Yoshinaga-Itano, 2003:2000).

Sub-aim #6 Description of perceptions of mothers and caregivers regarding neonatal hearing screening

The current study was the first of its kind to investigate the perceptions of mothers and caregivers regarding neonatal hearing screening in South Africa. A small number of mothers in the current study were familiar with NHS. This is significantly less than the reported numbers of mothers in developed countries who learned of NHS before hospitalisation (Vohr et al., 2001:17). The results in the present study indicate that mothers/caregivers were anxious in a third of the sample, an incidence higher than what is reported for developed nations (Magnuson & Hergils, 1999:52; Vohr et al., 2001:18). In the current study, their lower socio-economic status, lower maternal education, bilingual status, single, and being non-White may have increased maternal worry (Vohr et al., 2001:20). Including parents/caregivers as informed stakeholders in screening programmes may decrease such levels of worry and increase active participation over time (Swanepoel et al., 2006;1248; Vohr et al., 2001:19; Weichbold et al., 2001:59).

5.3 CRITICAL EVALUATION OF STUDY

A critical evaluation of any study is necessary to reflect on the strengths and limitations of the results. The following section offers this perspective.

Strengths

The quantitative approach allowed the researcher to collect data on a topic and context in an exploratory manner, where only limited data had existed before (Neuman, 2003:30). The descriptive and exploratory research approaches

functioned together to provide a detailed picture of the NICU context investigated (Neuman, 2003:30).

The screening protocol and data collection consisted of immittance measurements, AOAIE and AABR screening and data on the perceptions of mothers and caregivers regarding hearing loss. The protocol followed in the current study investigated the target population in-depth across various parameters to provide a comprehensive profile of the subjects.

The results in the current study are congruent with other reports of hearing screening for NICU neonates and infants. The high incidence of risk factors in the current study is greater than has been reported for developed countries. This phenomenon highlights the importance of hearing screening in the at-risk population for a developing country with limited resources. The results confirmed research which establishes that 226 Hz probe tone tympanometry produces erroneous responses in young infants. The relationship between high-frequency tympanometry and AOAIE testing underlines the need for differential diagnosis so as to accurately detect MEE and/or sensorineural hearing loss in neonates and infants. The perceptions of mothers/caregivers emphasised the lack of awareness regarding hearing and hearing loss in South Africa; the results in the current study could therefore provide a starting-point to empower and include parents as important stakeholders in a successful hearing screening programme with a low referral and high return rate.

The interpreter in the current study acted as the link between the researcher and mothers. Her role contributed significantly to the study because of the language barrier between the researcher and some mothers and caregivers. The active participation of the Head of Paediatrics at the hospital promoted the successful carrying-out of the screening programme, demonstrating that collaboration with medical practitioners is vital for the successful implementation of such a programme.

Limitations

The small sample size in the current study limited the generalization of the results since it only provided a small representation of the NICU population in one public hospital in South Africa. The size of this sample was significantly smaller than those in other studies reporting on NICU neonates and infants, as a result of the shortage of hearing screening programmes in South Africa. This shortage may be attributed to limited funding, manpower shortages and lack of governmental and legislative support in South Africa.

The hearing screening programme in the current study was the first of its kind conducted for NICU neonates and infants in South Africa and merely reported on the first two years of the programme. The results and conclusions drawn in the study are therefore representative of a newly-implemented programme and are not the results of an existing screening programme. The follow-up return rate is directly affected by the current study because improved follow-up rates with increasingly lengthy programmes are reported (Lieu et al., 2006:66; White, 2003:85; Mehl & Thomson, 2002:1).

During the two years of data collection in the current study it was not possible to screen neonates and infants every day. Therefore not all neonates and infants discharged from the NICU were necessarily screened for hearing loss. An established programme, however, provides a more consistent service to screen neonates and infants every day of the week and offers follow-up and diagnostic testing (Shoup et al., 2005:67). The lack of a consistent service in the current study may have contributed to the poor three-month return rate and follow-up screening rate here.

A further difficulty was that the prenatal and perinatal history of some subjects was not thoroughly documented in the patient's files. Closer collaboration between nursing staff and medical practitioners is needed to accurately record risk factors for hearing loss, especially in the high-risk population. The acute

medical problems that neonates and infants experience when admitted to the NICU, combined with socio-economic challenges in a developing country, increase the risk for developing hearing loss.

5.4 RECOMMENDATIONS FOR FUTURE RESEARCH

The current exploratory research provided some answers, but also gave rise to new questions that have not been answered; in so doing the researcher hopes to awaken more interest and research in the field of early detection of congenital hearing loss in South Africa. The results obtained and conclusions drawn from the research indicated several significant aspects that require further investigation. Suggestions and guidelines for future research projects are discussed in the following section.

- Large-scale longitudinal studies at well-baby nurseries, NICU's and six-week immunisation clinics are necessary to gather data on the prevalence of hearing loss and to establish which platform is the better option for hearing screening in South Africa (HPCSA, 2002:5). Nurses and/or lay volunteers should be trained to conduct hearing screening and audiologists should manage the screening programme (HPCSA, 2002:4);
- HIV-exposure is a reality, reaching pandemic figures in South Africa and other developing countries. The effects of such exposure in the prenatal phase need to be investigated to determine the effect on the incidence of congenital, delayed-onset, and progressive hearing losses (Matkin et al., 1998:152). The high prevalence of HIV-infection in pregnant women in South Africa provides a platform to investigate its effect on the auditory development of a neonate and infant (Swanepoel et al., 2004a:634). HIV-infection must be investigated to determine if it should be added as an established risk for hearing loss;
- It is recommended that nurses and lay volunteers comprise the personnel who should conduct hearing screening (HPCSA, 2002:4). Investigation of the

attitudes and awareness of nurses and volunteers should guide the training of these personnel, and is essential for the successful implementation of a screening programme. An increased awareness amongst medical personnel, parents/caregivers and the general community is crucial for the long-term feasibility of such a programme;

- Parents/caregivers should be included as informed stakeholders in screening programmes because active participation could decrease their levels of worry and increase participation over time (Swanepoel et al., 2006:1248; Vohr et al., 2001:19; Weichbold et al., 2001:59). An investigation of parents/caregivers' perceptions regarding follow-up screening should provide vital information about the challenges that a screening programme must overcome to achieve a high return rate and to render a continuous service to infants and families.

5.5 FINAL COMMENT

The current investigation of the NICU as a hearing screening context provided empirical evidence on an EHDI programme in South Africa, a field which is characterised by a dearth of research in the field of neonatal hearing screening. However, “this is a first step in a process toward ensuring that South African infants with hearing loss, especially those in previously disadvantaged communities, are afforded the best opportunities for optimal development and societal integration through accountable early hearing detection and intervention services.” (Swanepoel, Hugo & Louw, 2006:1248). It is hoped that other studies will follow.

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