A hearing profile of persons infected with Acquired Immune Deficiency Syndrome (AIDS)

by

Maria de Lange

Submitted in fulfillment of part of the requirements for the degree of Master in Communication Pathology

in the

Department of Communication Pathology,

Faculty of Humanities

University of Pretoria

Pretoria

April 2007

ACKNOWLEDGEMENTS

With much appreciation, I thank:

- Dr Soer and Dr van Dijk, for hours of support with competence and aptitude, patience and compassion;
- Johan, my husband and companion, for your unconditional love, support and incessant understanding during the completion of this research project and for always being there and believing in me;
- Mary-Anne Theunissen, my loving mother and best friend, for your endless prayers, never-ending love, pride, endless encouragement, motivation and always being there through the years;
- Susan Strauss and all the staff members from HASS SA involved in this research project, for support and assistance with the equipment and the establishments of norms for the equipment;
- Klerksdorp Hospital, in particular the hospital management, for the opportunity granted to conduct this research and the research assistants (medical doctors and nurses) for their continuous assistance and referrals;
- Aldine Oosthuyzen for the statistical analysis, your patience, promptness and continuous availability;
- Mrs Denise Kocks for the language editing, your willingness to assist, promptness, professionalism and the precision of your work;
- Dad and Mom de Lange, for support, love and encouragement;
- Family and friends, for support and encouragement;
- My earthly father, Wilhelm Theunissen, for the 13 years you were part of my life, bringing me up to the best of your ability, being an example I will live by forever.
- My Heavenly Father, without You, Lord, I am nothing. To You all the glory.

SUMMARY

TITLE: A hearing profile of persons infected with Acquired Immune Deficiency Syndrome (AIDS)

NAME: Maria de Lange

PROMOTERS: Dr M Soer and Dr C van Dijk

DEPARTMENT: Communication Pathology, University of Pretoria

DEGREE: M. Communication Pathology

With the worldwide increase in numbers of individuals infected with the human-immune deficiency virus (HIV) and acquired immune deficiency syndrome (AIDS), the need for more information became essential. The devastating influences and fatal outcome of this disease is inevitable. These individuals are confronted with mortality and various disabling conditions. One of these disabling conditions is the possible development of a hearing loss. Loss of hearing sensitivity related to HIV/AIDS is only one of numerous effects the virus may have on humans and their quality of life. Therefore increased awareness of HIV/AIDS and the influences of this disease is inevitable for the modern audiologist. The precise nature and the extent of the influence that HIV/AIDS and antiretroviral therapy (ART) has on the hearing ability of a person are unknown to date. Even though a relationship between hearing loss, HIV/AIDS and the administration of relevant medication is expected, no clear explanation is available to provide the public or clinicians with the necessary information on assessments, interventions and aural rehabilitation techniques. Without being able to identify the specific cause, symptoms and place of lesion of the hearing loss, it will be difficult to ensure appropriate monitoring and treatment. Information regarding the influences of HIV/AIDS and ART on hearing sensitivity had to be established to ensure appropriate intervention and rehabilitation options.

The first part of this research project reviews the evidence available regarding the possible influences of HIV/AIDS on hearing. Throughout the research a cross-sectional design with quantitative and qualitative approaches were followed comprising of a structured interview, basic and specialized audiometric battery to obtain the necessary case history, as well as

results for these different audiological tests that were conducted. The specialised tests included immittance measurements, distortion-product otoacoustic emission (DPOAE) and auditory brainstem response (ABR).

The results of this study were discussed in terms of the three sub aims in accordance with the different audiological tests that were conducted. The results indicated that those participants with ART exposure had a significantly higher incidence of hearing loss. The pure tone averages were mainly found within normal limits but decreased with the progression of the final stages of HIV/AIDS. The high and low frequencies of the audiogram were often affected with loss of hearing sensitivity suggesting the presence of a high and low frequency slope. The final three stages of HIV/AIDS had a significantly higher incidence of bilateral hearing loss. ART exposure were associated with more severe degrees of hearing loss. The DPOAE and ABR indicated that cochlear and retro-cochlear damage existed often among these participants. Only 20% participants had abnormal tympanograms suggestive of conductive pathology. The results revealed that the type of pathology varied across the stages of HIV/AIDS.

The conclusions and implications of this study are discussed. Recommendations incorporate the development of HIV/AIDS awareness campaigns that includes audiological information on the possible influences, where to refer or where to seek assistance; issues regarding the improvement of the modern audiologists' knowledge in terms of the management of the audiological needs of individuals with HIV/AIDS and the application of these results in the industrial setting to utilize when they consider granting compensation claims.

Key words:, Antiretroviral therapy (ART), audiology, audiologist, audiometry, CD4+ cells, Human Immune Deficiency Syndorme (AIDS), Human immune virus (HIV), hearing loss, ototoxic, ototoxicity, pathology, stages.

OPSOMMING

TITEL: 'n Gehoorprofiel van persone met verworwe immuniteitsgebrek-sindroom (VIGS)

NAAM: Maria de Lange

STUDIELEIER: Dr. M. Soer en Dr. C. van Dijk

DEPARTEMENT: Kommunikasie Patologie

GRAAD: M. Kommunikasie Patologie

Met die toename in persone wat wêreldwyd geïnfekteer word met die menslike immuniteitsvirus (MIV) en verworwe immuniteitsgebreksindroom (VIGS), is die behoefte aan meer inligting noodsaaklik. Die ingrypende invloed en fatale uitkoms van die virus is onvermydelik. Hierdie persone word gekonfronteer met die dood, verganklikheid and verskeie stremmende toestande. Gehoorverlies is een van hierdie vele stremmende toestande wat by die mens deur MIV/VIGS veroorsaak kan word, dus is die toename in bewustheid rakende die invloed van die virus op die gehoorsisteem onvermydelik vir die hedendaagse oudioloog. Gehoorverlies kan verreikende gevolge op die kwaliteit van 'n persoon se lewe hê. Die presiese aard van die invloed wat MIV/VIGS en antiretrovirale terapie (ART) op 'n persoon se gehoor het, is nog tot dusver onbekend. Die verwagting is dat 'n korrelasie tussen gehoorverlies, MIV/VIGS en die administrasie van ART bestaan, maar geen duidelike verklaring is beskikbaar om die publiek en klinici van inligting te voorsien om die evaluasie, intervensie en ourale rehabilitasie- tegnieke aan te pas nie. Die besluitnemingsproses rakende die hantering van 'n persoon met MIV/VIGS word bemoeilik omdat daar geen definitiewe antwoord is oor wat die oorsaak kan wees van die onverklaarbare gehoorsimptome waarmee 'n individu presenteer nie. Sonder om die oorsaak van die gehoorverlies te identifiseer en dus die plek van die letsel op te spoor, is toepaslike monitering en behandeling nie moontlik nie. Inligting aangaande die invloed van MIV/VIGS en ART op die gehoorsensitiwiteit van 'n persoon moet ontwikkel word om toepaslike intervensie en rehabilitasie-opsies te verseker.

Die eerste deel van die navorsingsprojek fokus op die beskikbare literatuur aangaande die moontlike invloed van MIV/VIGS op 'n persoon se gehoor. Met die verloop van die

navorsingsprojek is 'n dwarsprofiel-ontwerp gebruik met kwantitatiewe en kwalitatiewe benaderings wat bestaan uit 'n gestruktueerde onderhoud, basiese oudiometrie en gespesialiseerde oudiometrie. Hierdie metings is gebruik om die nodige gevalsgeskiedenis-inligting asook oudiometriese resultate te verkry. Die gespesialiseerde toetse sluit in immittansie metings, distorsie produk otoakoestiese emissies (DPOAE) en ouditiewe breinstam response (OBR).

Die resultate van die navorsing word bespreek in terme van die drie subdoelwitte met betrekking tot al die oudiologiese prosedures wat uitgevoer is. Die resultate toon dat 'n gehoorverlies in sommige persone teenwoordig was, maar nie in al die individue nie. Die resultate het daarop gewys dat individue met ART blootstelling 'n noemenswaardige hoër insidensie van gehoorverlies het. Die gemiddelde suiwertoondrempels wat hoofsaaklik binne normale intensiteitsvlakke verkry is, het verswak met die vordering van die virus na die finale fase van MIV. Die hoë en die lae frekwensies van die oudiogram is meestal geaffekteer deur 'n gehoorverlies wat dus aanduidend is van hoë en lae frekwensie aantasting. Die finale drie fases van MIV/VIGS het 'n hoër insidensie van bilaterale gehoorverlies gehad terwyl blootstelling aan ART geassosieer kon word met meer ernstige grade van gehoorverlies. DPOAE en OBR resultate het aangedui dat kogleêre patologie en retro-kogleêre patologie algemeen gevind is onder die individue. Slegs 20% individue het abnormale timpanogramme gehad wat gedui het op konduktiewe patologie. Die resultate dui ook aan dat die tipe patologieë wat geïdentifiseer is, gevariëer het tussen die verskeie individue veral ten opsigte van die stadia van MIV/VIGS en die blootstelling aan ART.

Die gevolgtrekkings en implikasies van die navorsing word dan bespreek. Aanbevelings ten opsigte van die ontwikkeling van MIV/VIGS-bewustheidsveldtogte wat die oudiologiese aspekte van MIV/VIGS insluit, waarheen om pasiënte te verwys en waar om hulp te soek, word ingesluit; aspekte rakende die verbetering van kennis van die hedendaagse oudioloog in terme van die hantering van oudiologiese behoeftes in persone met MIV/VIGS word ook bespreek, asook die toepassing van die inligting in die industriële sektor ten opsigte van die oorweging om kompensasie-eise toe te staan.

Kernwoorde: Antiretrovirale terapie (ART), CD4+ selle, fases, gehoorverlies, menslike immuniteitsvirus (MIV), ototoksies, ototoksisiteit, oudiologie, oudioloog, oudiometrie, patologie, verworwe immuniteits-gebreksindroom (VIGS).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ABR	Auditory brainstem response
AIDS	Acquired immune-deficiency syndrome
ART	Antiretroviral therapy
AZT	Zidovudine
dB	Decibel
DNA	Deoxyribonucleic acid
DPOAE	Distortion product otoacoustic emissions
FM	Frequency Modulated
HAART	Highly Active Antiretroviral Therapy
HIV	Human immune-deficiency virus
HL	Hearing level
HPCSA	Health Professions Council of South Africa
Hz	Hertz
IC	Inferior Colliculus
LL	Lateral Lemniskus
MGB	Medial geniculate body
n	number
NIHL	Noise-induced hearing loss
NNRTI	Non-nucleoside reverse transcriptase inhibitor
NRTI	Nucleoside/nucleotide reverse transcriptase inhibitor

OI	Opportunistic infections
PI	Protease inhibitors
PTA	Pure tone average
SOC	Superior olivary complex
SRT	Speech reception threshold
RF	Reticular Formation
RNA	Ribonucleic acid
TB	Tuberculosis
UNAIDS	Joint United Nations programme on HIV/AIDS
WHO	World Health Organisation

CHAPTER ONE

INTRODUCTION AND ORIENTATION TO THE RESEARCH PROBLEM

"There must be no barriers to freedom of inquiry. There is no place for dogma in science. The scientist is free, and must be free to ask any questions, to doubt any assertion, to seek for any evidence, to correct any errors"

(J. Robert Oppenheimer, 1904-1967)

1.1 INTRODUCTION

"The images and descriptions of AIDS are often morbid and extremely bleak, and while we should never underestimate the seriousness and the potential devastation of this disease, we must also not forget the human side" (Evian, 2000: vii).

In our modern society, the Human Immune-deficiency Virus [HIV], which causes the Acquired Immune-deficiency Syndrome (AIDS), is becoming an increasing dilemma. Based on the statistics made available by the UNAIDS/World Health Organisation during November 2005 on this growing pandemic, it is clear that Sub-Saharan Africa contains the largest percentage of humans infected with this fatal disease (Advert.org, 2006, retrieved February 22, 2006 from http://www.advert.org). An estimated 10,8 percent of the South African population older than two years were living with HIV/AIDS during 2005 (Advert.org, 2006, retrieved February 22, 2006 from http://www.advert.org). Only two percent of the world's population live in Southern Africa and yet this part of the world has up to 30 percent of the world's HIV population (Lubbe, 2004:250). Although Sub-Saharan Africa, including South Africa, has the highest infection rate and the largest percentage of humans infected with HIV/AIDS, the AIDS crisis is also a growing concern to the majority of countries in the world. The devastating influences and fatal outcome of this disease could be catastrophic to the human race, since all human beings are at risk of contracting this disease (South Africa. info, 2005,

retrieved 22 February, 2006 from http://www.southafrica.info) and the reality today is that more and more people are becoming infected with HIV/AIDS. The disease can be contracted when a person comes into contact with body fluid that contains infected cells or plasma, such as blood, semen, vaginal secretions, breast milk or saliva (MSD, 1992:72). This disease can be considered as one of the most devastating diseases of modern times, since a cure has not been found or developed yet, leading to an extremely high mortality rate (Matkin, Diefendorf and Erenberg, 1998:143).

In the past, individuals infected with HIV/AIDS were more concerned to cope with the fatality of the illness, rather than with the human side and the improvement of the qualify of life. "*Throughout most of the epidemic, the concern of most people was to stay alive by preserving the immune system and fighting off primary, life-threatening infections; however this fundamental distress was often simultaneously accompanied with concerns of ignorance and prejudice*" (Friedman and Noffsinger, 1998:211). Once this virus is contracted, it has distressing effects on a person's life, not only in terms of the medical conditions, but the person also has to cope with various disabling conditions associated with HIV/AIDS (Friedman and Noffsinger, 1998:211). The individuals infected with HIV will experience an enormous impact on their biomedical, psychosocial and spiritual well-being (Mngadi, 2003:259). Extreme emotional issues concerning sexuality, reproduction, guilt, loss of vitality, loss of productivity and death are disabling conditions that overwhelm individuals after being diagnosed with HIV (Mngadi, 2003:259). Karnofsky's Performance Status Scale suggests that in the final stages of the HIV disease, an individual is unable to attend work, to care for him/ herself and requires institutionalisation or hospitalisation (Mngadi, 2003:260). Yet, very little research has been done to obtain more information regarding the specific nature of these disabilities in order to improve the quality of the person's life (Bankaitis, 1998:123).

Loss of hearing sensitivity related to HIV/AIDS is only one of numerous effects the virus may have on humans. The nature and consequences of a hearing loss could have far-reaching influences on

the quality of life of a person. *"Many people have inferred that adults with acquired hearing loss do not suffer significant shock, disappointment, anger, sadness, or other emotions, because they more or less expect the diagnosis they hear…. this is far from true in many cases, and adults may be much more emotionally fragile than had been supposed"* (Martin, Krall, and O'Neal (1989) in Martin and Clark, 2006:413). The need for information regarding HIV/AIDS related to hearing loss started to exist among the public as well as professionals ever since a definite association was identified between impaired hearing and HIV/AIDS (Friedman and Noffsinger, 1998:211).

1.2 RATIONALE AND PERSPECTIVES

The precise nature and the extent of the influence that HIV/AIDS and antiretroviral therapy [ART] has on the hearing ability of a person are unknown to date. Even though a relationship between hearing loss, HIV/AIDS and the administration of relevant medication is expected, no clear explanation is available to provide the public and clinicians with the necessary information to adjust assessments, interventions and aural rehabilitation techniques. What is said is that the assessment of hearing in individuals with HIV/AIDS should include a comprehensive audiological examination, which includes that auditory brain stem response testing and aural rehabilitation should be included in HIV-infected individuals without any specific reason for the presence of hearing loss (Gold and Tami, 1998:167). Much of the literature discloses the side-effects of the drugs taken to suppress the progress of HIV, as well as the direct effect HIV has on hearing (Friedman and Noffsinger, 1998:211; Bankaitis and Shountz, 1998:155 and Gold and Tami, 1998:167). Information regarding the influence of HIV/AIDS and the medication on hearing sensitivity should be established to ensure appropriate intervention and awareness campaigns.

HIV/AIDS is most prevalent in certain cultural groups with certain beliefs, living in certain areas in South Africa. Lower socio-economical areas and countries, like South Africa, have a greater

prevalence of HIV/AIDS-infected people (Evian, 2000:21). The South African Government has even gone so far as to state that *"HIV thrives in an environment of poverty..."* (Department of Labour, 2000:1). It is speculated that this is mostly due to the superiority men have over women in these low socio-economical conditions, as well as to the high levels of unemployed people in South Africa. This leads to migrant work and family disruption, forced prostitution, poor education and poor literacy levels, alcohol and drug abuse, crime, violence, as well as the breakdown of cultural beliefs, traditions, customs and practices in the community (Evian, 2000:21). These social behaviour patterns, phenomena and standards lead to a higher risk for sexually transmitted diseases and especially to a higher susceptibility for HIV (Stein and Steinberg, 1995:24-42).

The reality today is that this high-risk HIV/AIDS phenomenon raises many unusual and unique problems for humans, especially in terms of medical conditions related to this viral infection. The HIV/AIDS virus has devastating effects on the immune system of the human being. Even though very little research has been done on the nature of disabilities caused by HIV/AIDS, its influence on the immune system and its characteristics have been examined in depth (Spencer, 2005:6-7; Maartens, 2005:126 and Bankaitis, 1998:123). Evolution has ensured that all vertebrae have a sophisticated system that operates in a complex manner to remove all strange and harmful agents from the body (Weinhold, 1993 in Schountz and Bankaitis, 1998:131), but HIV disables the immune system and makes it incompetent to perform the task of defence for which it is responsible. This retrovirus (Evian, 2000:5) *"slowly damages the immune system and the appearance and manifestations of disease (HIV-defined illnesses) are usually related to the degree of immune-deficiency and the HIV viral load in the body"* (Evian, 2000:25). The progress of this disease is subtle and insidious in nature, meaning that the infection is initially "*visibly undetectable*", but with the progress of the disease many symptomatic fatal illnesses related to the infection may occur (Bankaitis, 1998:122-123).

According to Evian (2000:25), a person infected with HIV will go through four clinical stages that will occur over a long period of time, usually five to twelve years. The incubation period of this disease varies from person to person, but the average time it takes to develop into the full extent of the viral infection, AIDS, is approximately eight to ten years (Fan et al., 1991 in Bankaitis (1998:123). The progress of this viral infection, in other words the state of the immune system, can be measured by the CD4+ cell (helper T cells) count and this can predict the individual's risk of developing a symptomatic disease (Evian, 2000:25). Therefore CD4+ cell count is not only used to measure the progress of the individual, but is also used to monitor the individual's immune status. The classification of the stage of HIV infection is linked to the CD4+ cell count, the Lymphocyte count and the presence of symptomatic diseases a person has (Evian, 2000:26). Blood test results indicating the presence of more than 500 to 600 CD4+ cells and more than 2500 lymphocyte cells per cubic millimetres suggests stage one, when the person is healthy with no medical condition related to HIV infection. As soon as a person presents with minor to major clinical symptoms, it means the CD4+ cell count and the lymphocyte count has dropped to either 350 to 500 and 1000 to 2500 cells per cubic millimetres or 200 to 350 and 500 to 1000 cells per cubic millimetres respectively. It is as soon as the CD4+ cell count decreases to less than 200 and 500 to 1000 Lymphocyte cells per cubic millimetres that the virus has progressed to the advanced, late and final stage of the infection. This final stage of HIV infection is associated with severe immune-deficiency and is called AIDS (Evian, 2000:26). During all stages, but especially during the last stage, the person will present with numerous medical conditions due to the progressive immune suppression the person is experiencing. This is due to the vulnerability of the immune system to organisms and infections that would usually be no threat to a person with an optimal functioning immune system (Bankaitis and Schountz, 1998:155). These infections are called opportunistic infections [OIs].

"Nearly 100% of HIV related manifestations involve the anatomical areas of the head and neck" (Madriz and Herrara, 1995 in Bankaitis, 1998:117). Thus, the auditory system is most likely to be influenced by these HIV-related manifestations and these changes in the auditory system are due to the direct or indirect result of the HIV disease (Bankaitis and Schountz, 1998:155). Otitis externa, otitis media with effusion, Eustachian tube dysfunction, Kaposi's sarcoma, sensorineural hearing loss and Bell's palsy are described as most common hearing system manifestations due to HIV infection (Lubbe, 2004:251). Besides the direct result of HIV/AIDS, these associated chronic and recurrent infections caused by HIV/AIDS may lead to permanent damage to the middle ear structures, also resulting in a permanent decrease in hearing sensitivity. This includes sensory as well as conductive components (Gold and Tami, 1998:167), in other words, a mixed hearing loss.

One also has to take into consideration that the effect of the disease on hearing might increase with the progression of the virus, especially in terms of neural hearing loss or neuroauditory disorders. Neuroauditory disorders involve lesions in the auditory nerve, as well as auditory areas of the brainstem and the cerebrum (Musiek, Baran and Pinheiro, 1994:29). Kelly, Davis and Hegde (2001:187) explain that peripheral neural hearing loss occur due to involvement of the auditory branch of the Vestibular (VIIIth) cranial nerve. The prevalence of neural auditory disorders is comprehensible when all the types of symptomatic diseases and opportunistic infections [OIs] related to HIV/AIDS are inspected. As stated earlier, most of these late stage opportunistic infections in adults include illnesses such as HIV-related enchephalopathy, cryptococcosis meningitis, central nervous system toxoplasmosis, bacterial and viral meningitis, cytomegalovirus, herpes simplex- and herpes zoster virus (Gold and Tami, 1998:167). These infections could lead to central pathology. "*Central pathology associated with abnormal auditory evoked potentials represents one of the few audiological manifestations directly attributable to HIV infection*" (Lalwani and Sooy, 1992 in Bankaitis and Schountz, 1998:155). These illnesses and conditions are only a

few of many that are caused by HIV/AIDS related OIs, known to be present during the final stages of HIV/AIDS.

The majority of these opportunistic infections cause critical and fatal complications to human life and even though it is rarely curable, suppressive treatment is required for the rest of the individual's life in order to maintain life for as long as possible. Treatment for these OIs depends on a number of pharmacological interventions. The pharmaceutical regimens are generally described as antiretroviral drugs (ART) and often include ototoxic agents with potential ototoxic complications that have not yet been clearly recognized in literature (Bankaitis and Schountz, 1998:155). Even though the precise nature of the ototoxicity of the ART is not determined yet, these ototoxic agents may also influence hearing sensitivity. Consequently, in some cases hearing loss is not only the direct influence of the HIV/AIDS infection and the OIs that cause audiological changes, but also the side effects of the ototoxic agents in the ART which may potentially lead to a hearing loss (Bankaitis and Schountz, 1998:156). *"Aminoglycosides antibiotics, salicylates, quinine and its synthetic substitutes can be ototoxic*", affecting the auditory and vestibular parts of the hearing system, more specifically the organ of corti in the cochlea (MSD, 1992:2340). Idiopathic hearing loss (hearing loss of which the definite cause is unknown) in persons with HIV/AIDS was already associated with the use of ART and the ototoxic implications of these agents in the past (Lalwani and Sooy, 1992 in Gold and Tami, 1998:167).

The increasing number of individuals becoming infected with this disease (Kelly et al., 2001:186) and the lack of knowledge, interfere with our process of differential diagnosis especially when it comes to determining the cause of hearing loss in people with HIV/AIDS. *"With the expected increases in individuals who test positive for HIV, hearing loss related to viral and bacterial infections may increase dramatically over the next few years"* (Kelly et al., 2001:186). As a result, this is one of the most challenging medical situations of modern times, especially in South Africa

and in particular for the audiologist. The decision-making process regarding the management of an individual infected with HIV or who presents with AIDS is difficult, because there is no definite answer to what may be the precise cause of the various unexplained symptoms the individual may present with. Without being able to identify the specific cause, symptoms and place of lesion of the hearing loss, it will be difficult to ensure appropriate monitoring and treatment.

Although the audiologist is dealing with a fatal disease, it would be unethical to withhold an individual from audiological treatment. According to the Human Rights approach to AIDS prevention at work (Heywood, 2000:29), every employee with HIV/AIDS must be treated according to the policies that already govern sickness within the company and the active labour laws of South Africa. In this case, the role of the audiologist would be to provide the individual who experiences hearing problems and is infected with HIV/AIDS with optimal treatment, in order to improve the individual's ability to communicate, thus improving the quality of life of the person. The audiologist's role is also informative in nature, creating an awareness of possible audiological problems that may occur, informing the individual as well as other medical professions of these possible symptoms and providing them with information on how to manage these problems. Individuals should be aware of the possibilities of developing a hearing loss or otological manifestations and they should know where to find assistance. This will enable the individual infected with HIV to make an informed decision when giving permission to the audiologist to monitor the individual's hearing sensitivity and the progress of the ototoxicity. The audiologist should also be involved in prevention campaigns by informing the population of the lesser known direct effects of the disease and side-effects of the ART on the hearing mechanism. However, direct involvement in prevention and awareness campaigns specifically related to healthy hearing is not the only subject relevant to audiologists. "*The classification of any disease is useful for the management of patients, determination of appropriate medical intervention, determination of clinical*

trial eligibility, prognosis, and development of research protocols for new therapies, epidemiological, reporting and public health projections and determination of disability" (Stevens, 1993 in Gold and Tami, 123).

It might be possible that, when new information is obtained on the characteristics and origin of hearing loss associated with HIV/AIDS, aural rehabilitation and intervention programmes might be adjusted accordingly to offer the individual with HIV/AIDS the best possible assistance. This includes management in terms of hearing aid fittings, medical treatment, auditory rehabilitation and possible fitting of FM systems in cases where damage to the hearing system is detected. It is possible that it could in the end lessen the effect of the hearing loss and the indirect effect of HIV/AIDS on the daily communication of the person.

Knowledge on the effects HIV/AIDS has on hearing will provide more clarity in terms of otological, middle ear, cochlear and central nervous system conditions associated with HIV/AIDS so that diagnosis can take place and appropriate management can be initiated and established (Gold and Tami, 1998:165). It will lead to a better understanding of an individual's medical needs and required treatment. Information to be obtained from this research will give audiologists information on audiological changes in persons infected with HIV/AIDS. The ability to hear forms such an integral part of our existence and it is clear that HIV/AIDS and related factors may compromise this ability. For this reason, HIV/AIDS affects the quality of life, especially when addressing the communication needs of a person. Not being able to hear and being cut off from the rest of the world due to hearing loss may lead to additional social isolation problems and lack of optimal communication interaction. It has an enormous impact on the social life of a person…*"40% of patients have problems communicating with their partner and nearly one in four have to miss out on social events as a result of their hearing loss*" (Williamson, 2004:26). This and the fact that a person must still adjust to the idea of being HIV-positive could leave the individual in desolation and

despair. The effectiveness of audiological service is not guaranteed, since HIV/AIDS usually involves these social and cultural issues (Friedman and Noffsinger, 1998:205).

Individuals with a short life expectation are already confronted with loss at every level of life (Tanchel, 2003:250). The disease not only has a negative impact on the immune system of the human being, but it *"triggers a cascade of personal losses..."* (Evian, 2000:vi) and the inability to hear is one of these losses (Gold and Tami, 1998:165). Williamson (2004:26) suggests that if a hearing loss is left untreated, it may be an important cause of withdrawal from the community, leading to increased feelings of isolation and loneliness, lack of self-confidence, lack of poise and depression. Rehabilitation techniques can be adjusted to address these emotions of devastation and to provide the person with the most appropriate opportunity to improve hearing ability.

The Public Health Sector is compelled to provide rehabilitation services to people infected with HIV/AIDS (Department of Health, 2003, retrieved February 9, 2007, from http://www.doh.gov.za). During the Health Summit in 2001, the decision was made to follow a *"...holistic care approach to meeting the health, social, psychological and spiritual needs of those who need care"* (Department of Health, 2001:11). Therefore rehabilitation services to individuals with HIV/AIDS should include aural rehabilitation. The progressiveness of hearing loss due to the HIV infection, as well as the ototoxic implications of the drugs used to treat the OIs possibly suggest great difficulties when it comes to fitting these individuals with hearing aids. A progressive hearing loss implies that the hearing ability will worsen over a short period of time, which will influence the success of the amplification given to the individual. Over-amplification or under-amplification may occur, but by determining the average range of hearing loss at a certain stage of HIV/AIDS and the time frame in which progression takes place, will provide the audiologist with the necessary information to select a suitable and appropriate hearing aid. It will also ensure that other means of rehabilitation will be provided to people who do not comply with general selection criteria for hearing aid fittings. These

individuals may benefit more from FM systems or auditory processing therapy, depending on the diagnosis. Therefore, it might have a great economical and financial advantage for the Public Health Sector in South Africa to determine the influence of HIV/AIDS on the hearing profile of a subject. This, however, is only possible when the exact influence of HIV/AIDS on the hearing sensitivity of a person is determined.

Unfortunately, determining the hearing sensitivity of a person with HIV/AIDS is complicated, since there are so many factors which may influence a person's hearing ability. One of these factors is noise. "*Today's public, well informed about the dangers of sex and passive smoking, remain unaware that deafness needs to be the result of old age or infection. It is steadily rising among young people – and the cause is leisure noise*" (Copeland, 2005:64). Woodworking equipment, chain saws, internal combustion engines, heavy machinery, gunfire, aircrafts are things that may cause damage to the inner ear (MSD, 1992:2340). Thus, noise could be occupation-related as well. With extreme exposure to noise, the Organ of Corti loses hair cells, which leads to loss of sensitivity, especially in the high frequencies (MSD, 1992:2340). In occupation-related cases of noise-induced hearing loss (NIHL), compensation claims may be submitted. However, since HIV/AIDS can cause hearing loss and this disease is often found among individuals employed in the mining sector (Stein and Steinberg, 1995: i), determining the real cause of the hearing loss when such a claim is submitted, may be problematic.

Increased expenditures in mining industries in terms of granting compensation claims are a growing concern. One of the most common occupational diseases that could be encountered in the industrial setting is NIHL. Apart from NIHL in the mining sector, the NIHL in our modern society has also become a reality, because of the increase in environmental noise over these past few years. Discrimination between these high-risk causes of hearing loss is a relevant and emerging topic in especially the mining and industrial sector today. Current NIHL statistics serve as a clear indicator

of the increase and significance of this occupational disability in the mining sector (Franz & Phillips, 2001 in De Koker, Clark, Franz & Mackay, 2003:i-iii). The significance of these facts is that HIV/AIDS and NIHL could both be characterized by a decrease in hearing sensitivity. Hearing loss that might be caused by something other than noise, such as otitis media, barotrauma and the direct effect of HIV/AIDS or ototoxic complications of ART could be useful information for industries confronted with compensation claims submitted by individuals that may be HIV-positive. In 1998 NIHL was identified in 3175 employees (retrieved February 8, 2007, from http://www.hst.org.za). NIHL has grown since 1998 to become the occupational disease with the "*highest claims accounts of all reported claims"* (retrieved, February 8, 2007, from http://www.labour.gov.za). This increase in hearing loss might just be due to the increase in individuals who are infected with HIV/AIDS. However, there is a lack of information to make a definite conclusion of a possible correlation between the increase in HIV/AIDS and the increase in NIHL. This gap in information regarding the true cause of hearing loss among the mining employees should still be bridged in future.

This research can be considered as one of the first steps towards overcoming the lack of information. An in-depth assessment analysing the type of hearing loss will provide the researcher with information regarding the hearing sensitivity of a person and once a hearing profile has been determined, correlations can be drawn between the hearing profiles and particular characteristics, to attempt to determine the influence of HIV/AIDS on hearing. In this way it may be possible to discriminate between NIHL and HIV/AIDS-related hearing loss. Currently the assumption is that noise will lead to a significant decrease in cochlear functioning while a hearing loss due to HIV/AIDS may be characterized by a conductive hearing loss due to opportunistic ear infections, possible cochlear damage due to ototoxicity of the medical treatment and suspected neural damage to the auditory nerve (Lubbe, 2004:253, Fuzani, 1999:36 and Gold and Tami., 1998:167).

1.3 RESEARCH QUESTION AND DELIMITATION

It is indisputable that HIV/AIDS has definite influence on the hearing profile of a person, but to date the exact influence has not been clarified (Friedman & Noffsinger, 1998:205 and Gold & Tami, 1998; 165). Bankaitis (1998:123) states that classification systems had been developed in the past, but "*…research in the area of hearing involves vague descriptions of HIV-infected subjects…* " and "*Although HIV is directly and indirectly responsible for various changes to the ear and hearing, no clear relationship exists between disease progression and severity of auditory manifestations*" (Bankaitis (1996) in Matkin et al., 1998:148). More research is necessary to provide clinicians with more definite information and to improve their knowledge regarding this topic. Based on this knowledge and recent literature, it is still to be determined what the precise nature of HIV/AIDS-related hearing loss is, as well as the possibility of classifying the hearing profiles associated with the four clinical stages of HIV/AIDS.

It is clear that HIV/AIDS influences hearing sensitivity. The question is however, what the precise nature and the extent of the influence is that HIV/AIDS has on hearing, keeping in mind the CD4 count as well as the effects of the ototoxic medication, which can either be anti-tuberculosis drugs or ART. An average range of hearing loss should be determined for each clinical stage of HIV/AIDS. The literature states clearly that hearing loss could be conductive due to middle ear pathology or sensory (cochlear) due to cochlear hair cell damage, especially after the medication had been administered. The hearing loss could be neural (retro-cochlear) due the direct effect of the infection on the auditory nerve. Damage could be central, influencing the ability to make sense of auditory information. Conditions such as meningitis can influence the hearing system as a whole (Bankaitis, 1998:123; Bankaitis and Schountz, 1998:155; Lalwani and Sooy, 1992 in Gold and Tami, 1998:167). The literature also makes it clear that the progression of the viral infection may lead to changes in the medical condition of the individual. This implies that the type, nature and

degree of hearing loss for each clinical stage of HIV/AIDS may also change with the progression of this infectious disease (Bankaitis, 1996 in Matkin et al., 1998:148). All the above-mentioned information leads to the research question: What is the precise nature of the hearing loss in each clinical stage of HIV/AIDS?

1.4 CLARIFICATION OF TERMINOLOGY

The following terms need to be clarified in order to comprehend the research fully:

- **Human Immunodeficiency Virus [HIV]** is described as "…*one of several related retroviruses that become incorporated into host cell DNA and result in a wide range of clinical presentations varying from asymptomatic carrier states to severely debilitating and fatal disorders*" (MSD, 1992:77).
- **Acquired Immunodeficiency Syndrome [AIDS]** is a syndrome that is characterized by opportunistic infections, malignancies, dysfunction of the central nervous system and a variety of other medical conditions and syndromes that result secondary to HIV infection (MSD, 1992:77).
- **CD4+ cells** are one of the two categories of T-lymphocytes that develop in the bone marrow and undergo a two-stage developmental process in order to serve the function of interacting with peptide antigens and producing cytokines in reaction to the engagement with accessory cells to provide the necessary equivalent and soluble signals to ensure the production of antibodies. The CD4+ cell destroys extra cellular pathogens through the cell-mediated immunity. Upon recognition, the entire CD4+ cell binds to the foreign agent, releases cytokines and initiates the immune response (Schountz and Bankaitis, 1998:136-137).
- **Opportunistic infections [OIs]** result from the impaired immune system that becomes vulnerable to unthreatening organisms due to the HIV-infection. "*Opportunistic infections*

originate from commonplace, ubiquitous organisms that do not produce infection in individuals with intact immune systems, but take the opportunity to infect a body with a disabled immune system. OIs cause serious, life–threatening complications that are rarely curable, require life-long, suppressive therapy, and cause most of the illnesses and deaths among people infected with HIV" (Bankaitis and Schountz, 1998:155).

- **Antiretroviral therapy [ART]** is defined as the medical treatment of HIV/AIDS "to provide maximal viral suppression, restore immune function and improve the quality of life…ART has shown to reduce the incidence of opportunistic disease and to reduce short-term mortality from HIV infection (Spencer, 2005:4). It can also be explained as "*drugs specifically developed to combat HIV or other retroviruses...*" (Bankaitis and Schountz, 1998:155). These drugs are placed into groups according to their function in terms of their interference with retroviral reproduction (Bankaitis and Schountz., 1998:158).

- **Tuberculosis [TB]** is a pulmonary disease with symptoms such as coughing, night-sweats, weight loss and haemoptysis. TB is probably *"…the most important opportunistic infection and cause of death associated with HIV and probably accelerates HIV-disease, speeding up progression to AIDS and death"* (Conway and Bartlett, 2003:78-79).

- **Anti-tuberculosis drugs [anti-TB drugs]** are used to cure TB. These drugs consist of a combination of Rifampicin, Isoniazid, Pyrazinamide, Ethambutol and Streptomycin for a period of eight months. These drugs are given together with antiretroviral drugs in cases where a person with HIV/AIDS develops TB (Conway and Bartlett, 2003:79-80).

- **Ototoxic agents** refer to all drugs that cause damage to the ear due to the toxic effects of the various chemical agents such as gentamycin and streptomycin causing cochlear symptoms and Efavirenz known for its central nervous system toxicity. Most of these agents affect both the cochlear and vestibular parts of the inner ear. Cochlear hair cells and the strict vascularis

are affected by the ototoxic agents and lead to a hearing loss. Outer hair cells usually get affected before the inner hair cells, suggesting that the basal part of the cochlea usually gets damaged first (Gelfand, 2001:204).

- **Hearing profile** can be described as the average type, nature and degree of hearing loss a person may be experiencing, which may be determined by a complete diagnostic audiologic test battery. By using a battery of audiological tests, site of lesion (outer or middle ear structures, inner and outer cochlear hair cells and various parts of the auditory nervous system) as well as the degree of the damage in the auditory system, can be determined.
- **Conductive hearing loss** refers to as "*the loss of sound sensitivity produced by abnormalities of the outer ear and/or middle ear*" (Martin and Clark, 2006:443).
- **Sensory hearing loss** can be explained as "*the loss of hearing sensitivity produced by damage or alteration of the sensory mechanism of the cochlea...*" (Martin and Clark, 2006:452).
- **Neural hearing loss** suggests permanent hearing loss originating from eighth cranial nerve dysfunction (Debonis and Donohue, 2004:40) or a central brain dysfunction (Musiek et al., 1994: 29-275).
- **Mixed hearing loss** refers to a hearing loss caused by "*…dysfunction in both the conducting portion of the auditory system (outer and/ or middle ear) and the sensorineural portion of the auditory system (inner ear*)" (Debonis and Donohue, 2004:40).

1.5 OUTLINE OF CHAPTERS

The table below provides an outline of the chapters of this research project. The following topics will subsequently receive consideration:

Table 1.1: Outline of chapters

CHAPTER	TITLE	CONTENTS
ONE	**Introduction**	This chapter serves to introduce the research project by providing the rational and perspectives of the research and how they lead to the research question.
TWO	**HIV/AIDS and the influence on the human immune system and the hearing mechanism**	This chapter contains background information regarding the origin of HIV/AIDS, as well as the physiological and the medical aspects of this disease on the immune system of the human being. It also contains an in-depth discussion of the influence HIV/AIDS has on the hearing sensitivity and ability of a human being, based on existing theoretical knowledge and literature.
THREE	**Methodology**	The research design, sampling, material and apparatus used for measurement, research procedures including data collection, recording and analysis are discussed.
FOUR	**Results and discussion**	This chapter includes the analysed quantitative results obtained from each assessment that was conducted during the data collection and an in-depth discussion of the findings.
FIVE	**Conclusions**	This chapter serves as closure of the research, and general conclusions and implications arising from the research project are discussed. Limitations of this study and suggestions for further research are also discussed.

1.6 CONCLUSIONS

Currently South Africa is confronted with the HIV/AIDS pandemic in a far-reaching and comprehensive manner. Statistics show that during 2005, 10,8 percent of South Africans were infected with HIV/AIDS. *"This disease has taken a tremendous toll in human suffering..."* (Gold and Tami, 1998:165). Since HIV/AIDS causes extensive damage to the immune system of humans, it is evident that the disease is not only fatal, but also leads to significant losses in terms of social and emotional well-being. It is apparent from the literature that HIV/AIDS causes hearing loss, but no

specific and accurate information has been obtained on this topic through research projects yet: (Gold and Tami, 1998:167). If accurate data is not available on the precise type, nature and degree of hearing loss associated with each clinical stage of HIV/AIDS, it could indicate difficulties with possible future challenges and not provide the appropriate intervention that is in the best interest of the person infected. It is also not possible to provide support and counselling to the person if the progress of the disease is not known and if the clinician is not familiar with the extensive consequences the disease with related disabilities might have on the person infected with HIV/AIDS.

1.7 SUMMARY

HIV/AIDS is not only a life-threatening disease that has a severe impact on the immune system of human beings, but also has a devastating impact on the quality of life of the individual. One of the many influences that were identified in the past, even though little research has been done on it, was the impact of HIV/AIDS on the hearing sensitivity of an individual. HIV/AIDS can cause hearing loss. However, the precise nature of the hearing loss is yet to be determined. This chapter serves to introduce and substantiate the importance of the research project. The rational and perspectives of the research and how it leads to the research question are provided in this chapter. The next chapter contains an in-depth discussion of the human immune system and HIV/AIDS, to improve the understanding of how the disease influences the immune system and hearing mechanism of humans.

"No man really becomes a fool until he stops asking questions"

(Charles P. Steinmetz, 1865-1923)

CHAPTER TWO

THE INFLUENCE OF HIV/AIDS ON THE HUMAN IMMUNE SYSTEM AND THE HEARING MECHANISM

"Once a disease has entered the body, all parts which are healthy must fight it: not one alone, but all. Because a disease might mean their common death. Nature knows this; and nature attacks the disease with whatever help she can muster."
(Paracelsus, 1493-1541)

2.1 INTRODUCTION

"None of the cells of the immune system are capable of individually containing a pathogenic invasion. These cells work in concert with a sophisticated communication network of cognate interactions and soluble messages. The absence of any of these participants can have grave consequences for survival" (Schountz and Bankaitis, 1998:140).

Humans are constantly exposed to communicable bacteria, viruses and parasites in their daily environment. These infectious agents are forcefully tracking appropriate settings with the necessary resources to ensure growth and replication (Schountz and Bankaitis, 1998:131). In order to protect the body from these harmful particles, the immune system must act promptly to remove these harmful agents from the human body. The immune system defends the human body and removes all the harmful agents through a network of synchronized responses (Schountz and Bankaitis, 1998:131).

Immunity is a difficult concept to comprehend, mostly due to the sophisticated nature of the response processes involved to obtain either natural or adaptive immunity. "*To understand the immune system, one has to understand its individual components while recognizing that the system operates as a whole and that no one component operates autonomously*" (MSD, 1992:288).

However, immunity is not the only difficult concept to comprehend. In order to grasp the term AIDS fully, it is important that a person should understand how it breaks the immune system down and influences a person's immunity. Bankaitis (1998:119) states that the basic immune system and its associated concepts need to be fully comprehended in order to understand AIDS and the influence of AIDS on the auditory system. These phenomena will be explained in depth in this chapter.

2.2 THE IMMUNE SYSTEM

Upon infection, bacteria proliferate a variety of molecules interfering with the normal biochemical pathways of the human body. These molecules are usually protein and carbohydrate-based in order to serve as hosts for reproduction of the bacteria. These molecules are also known as antigens. Antigens can be detected and destroyed by the immune system through various processes and components working together (Schountz and Bankaitis, 1998:135). During any immune response, the components of the immune system function together as a group, as a pair, or in conflict to destroy and eliminate destructive micro-organisms, to remove "*worn out, damaged or dead cells*" and in general to defend the human body (Schountz and Bankaitis, 1998:131). To understand the immune response, it is important to understand the role and function of each individual component and how all these components function as a system. According to Schountz and Bankaitis (1998:131), the human immune system comprises of two systems: the natural immune system and the adaptive immune system.

2.2.1 The natural immune system

The natural immune system produces *"specific and non-specific immune responses"*. Natural immunity in humans is achieved by non-specific immune responses and serves as the first line of protection against infection (Abbas et al., 1993:131 in Schountz and Bankaitis, 1998:131). Physical

barriers, cellular components and soluble factors interact to form the first line of defence during the natural immune response.

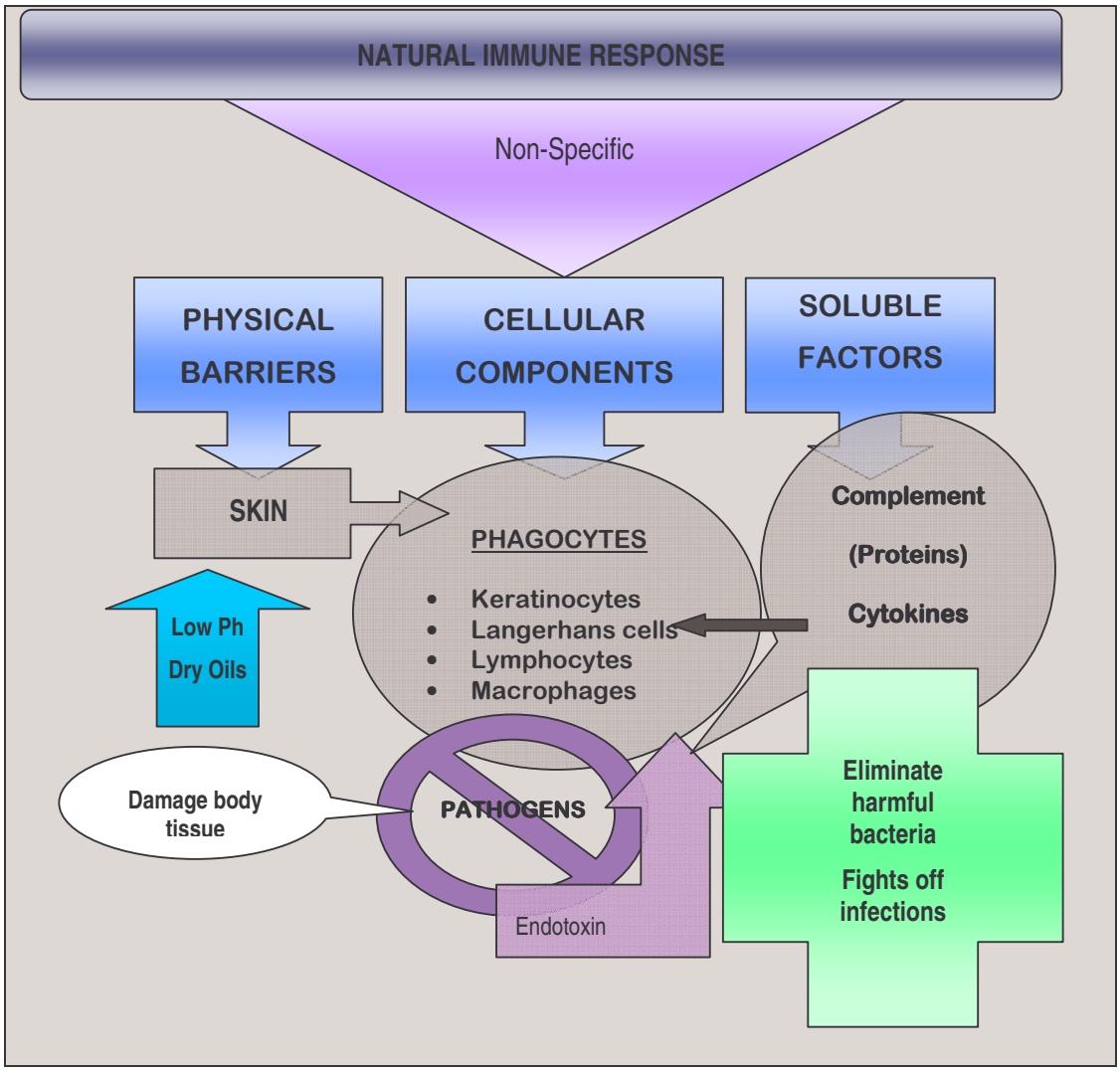


Figure 2.1: Explanation of the non-specific immune response of the human body (composed from Schountz and Bankaitis, 1998: 131-133).

In Figure 2.1, a depiction is provided of the various components of the natural immune system and how they interlink and work together in order to provide the human body with a non-specific, first line of defence against harmful bacteria. The non-specific immunity is innate to the immune system and involves similar reaction to all identified antigens, without bearing in mind the consistency of the antigen (MSD, 1992:279). In other words, non-specific immunity is obtained through wide-

ranging anti-microbial actions that react uniformly to all unknown components, with no consideration of the structural and chemical components the infectious agent consists of (Weinhold, 1993 in Schountz and Bankaitis, 1998:131). Bacteria, parasites and viruses consist of different infectious agents, but the natural immune system recognizes these agents as an unfamiliar entity and takes similar action to destroy all of these types of harmful entities. This first line of defence is achieved by interacting physical obstructions, cells and soluble factors.

2.2.1.1 Physical barriers

The most important physical barrier promoting natural immunity is the skin. Not only does the skin protect the human body by blocking foreign agents and avoiding them from entering the body, but it is also concerned with the production of anti-microbial activity. The low pH, dryness and secretion of oils protect the human body. Additionally, the skin also contains special immune cells, called cellular components, which form part of the natural immune system (Schountz and Bankaitis, 1998:131).

2.2.1.2 Cellular components

The human body contains special immune cells that are positioned in the dermal layers of the skin and which form part of the natural immune system. These cellular components are known as Keratinocytes, Langerhans cells, lymphocytes and macrophages (Kupper, 1990 in Schountz and Bankaitis, 1998:133). The role of these cells is to destroy infectious agents and subsequently produce cytokines, a protein-stimulating forceful resistance against pathogens. This facilitates microbial containment. The main cellular component of non-specific immunity is the phagocytic system. Phagocytes consist of neutrophils and monocytes in the blood and macrophages in the body tissue (MSD, 1992: 279). The phagocytes, macrophages, lymphocytes, sinophils and mast cells situated in the mucosa throughout the human body, can identify a wide range of bacteria.

These cells bind with infectious agents, internalize this destructive agent and deluge the contained bacterium with toxic compounds, destroying the infectious agent (Schountz and Bankaitis, 1998:132). However, infection is always accompanied by tissue trauma which in turn leads to another immune response (Shountz and Bankaitis, 1998:133).

2.2.1.3 Soluble factors

Bacteria damage body tissue. The damage of body tissue and body cells produces soluble molecules. The main soluble component is complement protein (MSD, 1992: 279). These molecules activate immune cells to respond by repairing the damaged tissue. In certain instances the bacteria produce endotoxin, in turn activating the immune system to produce cytokines. Cytokines encourage activation of various actions to provide resistance and destroy infectious agents with potential harm to the human body (Schountz and Bankaitis, 1998:133). The natural immune response is not always completely effective and complementary responses are often necessary in order to provide immunity. "*Nearly all micro-organisms have evolved evasionary mechanisms, such that natural immunity can provide protection for only a few days*" (Schountz and Bankaitis, 1998:133). In order to destroy these infectious agents, the body needs a more sophisticated system of immunity, such as the adaptive immune system.

2.2.2 The adaptive immune system

The adaptive immune system consists of more complex and interactive processes. The process of adaptive immunity is depicted in figure 2.2. This system is also known as specific immunity and it "*has the hallmarks of learning, adaptability and memory*" (MSD, 1992:280). Processes include detection of these antigens and the generation of specific immune responses. Organs and various

immune subsystems are responsible for these processes (Schountz and Bankaitis, 1998:133).

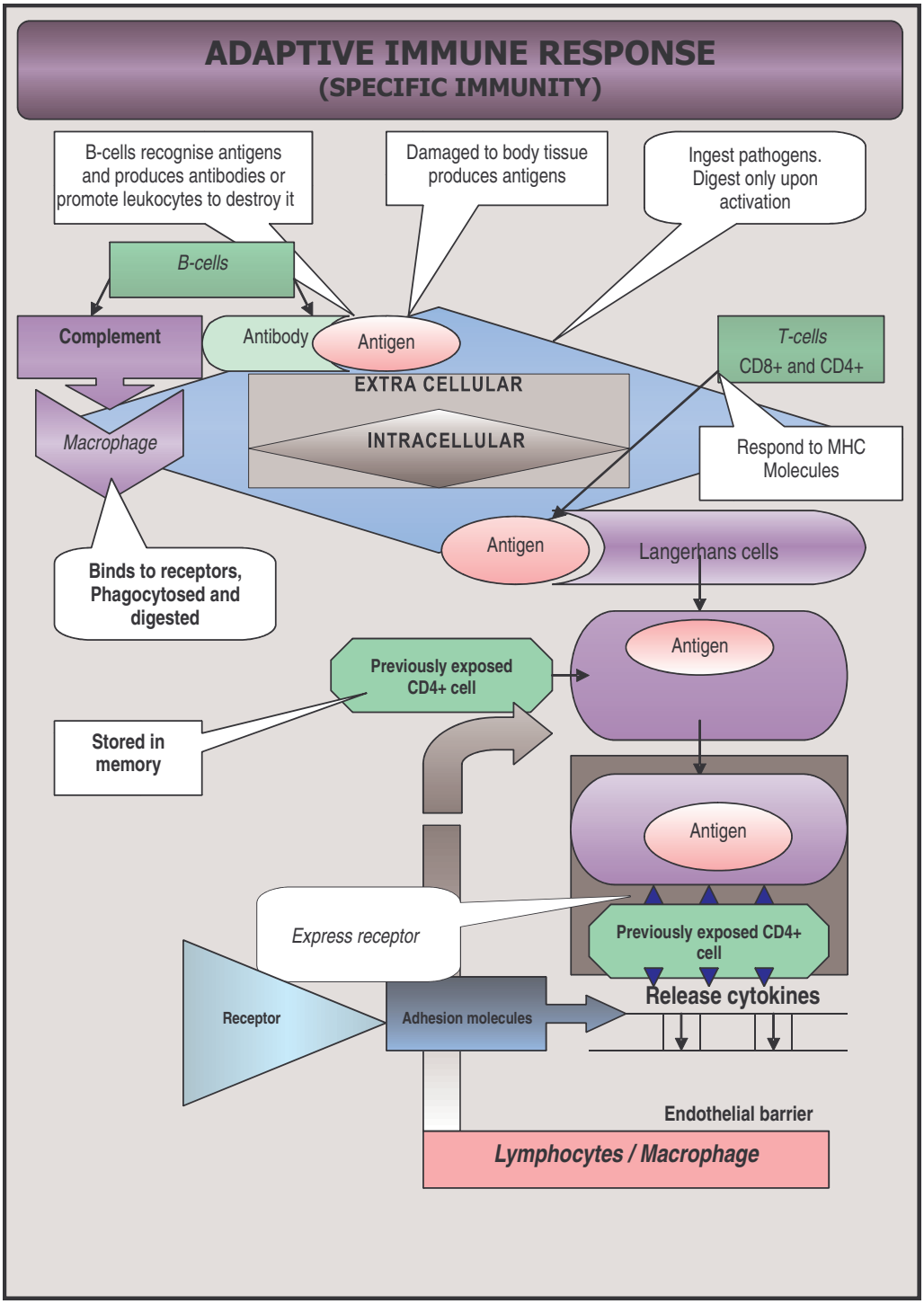


Figure 2.2: Explanation of the specific immune response of the human body (composed from Schountz and Bankaitis, 1998:133-137)

Figure 2.2 provides a schematic presentation on how the immune system generates a specific response to achieve immunity against foreign particles through adaptation and through storing the responses or recalling previously exposed CD4+ cells from the memory. A healthy individual will present with a CD4+ cell count of between 800 to 1200 cells per cubic millimetre (Bankaitis, 1998:123).

As suggested by Schountz and Bankaitis (1998:133-137) and indicated in Figure 2.2 above, upon infection, carbohydrates or protein-based molecules are produced by the infectious agent to serve as host for reproduction purposes. The adaptive immune system recognizes the foreign agents and activates various immune cells in the body to defend and protect the human body and to destroy unknown units. The system is also sensitive to derivatives produced by these antigens. The lymphocytes, better known as white blood cells, are the cellular components that detect and destroy infected cells. When the presence of an antigen is perceived by the immune system, it serves as activation signal for the production of antibodies. The B-cells produce an enormous number of antigen-specific antibodies, release it in the bloodstream, bind to the antigens, deactivate it and destroy it either directly or indirectly. The antigens are indirectly destroyed through the process of phagocytoses. These antigens are carried to the closest lymph nodes to expose the antigen to other lymphocytes. Each lymphocyte has an antigen-specific receptor. The immune system searches for the lymphocyte with the appropriate antigen-specific receptor. Once the lymphocyte and the antigen bind, the body is granted with specific immunity (Schountz and Bankaitis, 1998:134). T-cells depend on the major histocompatibility complex (MHC) for antigen recognition. Upon recognition of an antigen-peptide, the T-cell deactivates and kills it, or it releases cytokines to aid in the destruction of the antigen-peptide. Schountz and Bankaitis (1998:133) explain that the adaptive immune system consists of the following subsystems:

2.2.2.1 Structures of the immune system

The "*bone marrow, thymus, lymph nodes, spleen, tonsils, adenoids, appendix and clumps of tissue in the smaller intestines"* form part of the immune system (Schountz and Bankaitis, 1998:133). Immune cells develop and mature in the bone marrow and thymus. After maturation of these cells is completed, these cells accumulate in the lymph nodes of the neck, armpit, abdomen and groins, and motion through the lymphatic system and blood stream (Fan, et al., 1991 in Schountz and Bankaitis, 1998:134). The immune cells are developed by the different organs, but these cells still need to communicate with the various parts of the body through the lymphatic system and the bloodstream.

2.2.2.2 Lymphatic system

Lymph fluid is taken to all the lymph nodes through the endothelial venule (Weisman and Cooper, 1993 in Schountz and Bankaitis, 1998:134). The lymphnodes filter the lymph fluid and detect any unfamiliar or infectious agent and activate appropriate immune responses. The lymph fluid drains into the bloodstream. From here, the lymph fluid is reabsorbed by body tissue and is channelled to the lymphatic system. This immune response is therefore communicated through the entire body by means of the lymphatic system and blood (Fan et al., 1991 in Schountz and Bankaitis, 1998:134).

2.2.2.3 Blood

One of the most important functions of blood is to provide protection against infections. Blood consists of erythrocytes and leukocytes. Leukocytes lack haemoglobin, a red-coloured protein, and appear white in colour, therefore they are better known as white blood cells. White blood cells encompass various categories, but the category significant for the purpose of this research project, is the lymphocytes. Lymphocytes, as mentioned earlier, are the cellular components that detect

antigens in the body and upon detection, activate and manage immune responses (Schountz and Bankaitis, 1998:135). Whenever antigens are detected, the B-cells produce antigen-specific antibodies.

2.2.2.4 B-cells

Schountz and Bankaitis (1998:135) explain that B-cells mature in the bone marrow of the human body and play a significant role in protecting the body against infections. After maturation, the B-cells are stored in the lymph tissues. Upon identification of antigens, the B-cells produce large numbers of antigen-specific antibodies that bind to all the peptides of the antigens. These antigen-specific antibodies are released into the body fluids to bind to the antigens. Once these antibodies bind to the antigens, the antigens are neutralized and destroyed or leukocytes are promoted to target these antigens for destruction. This process is known as Type II immunity. Through this process, the B-cells stay dormant. Only when the B-cells receive an activation signal, the B-cells themselves start to separate through clonal expansion. During this process, antibodies are constantly produced, meaning that the amount of antibodies increases. This process only stops when the antigen is no longer present in the blood. B-cells are not the only type of lymphocytes produced by the human body. Another category of lymphocytes that needs consideration are the T-cells.

2.2.2.5 CD8+ T-cells and CD4+ T-cells

The function of the CD8+ T-cells is to *"interact with small antigen particles produced by intracellular agents*" which includes all viruses and some bacteria (Schountz and Bankaitis, 1998:137), whereas the CD4+ T-cells connect to small units containing antigens that originate from extracellular pathogens. Most bacteria, fungi and parasites have an extracellular origin. These extracellular pathogens mature and produce toxic substances extracellular, obliterating the immediate tissue.

Through the process called Type I immunity, these CD4+ T-cells bind to the detected antigens and destroy these extracellular pathogens. CD4+ T-cells are especially involved with the destruction of intracellular pathogens (Schountz and Bankaitis, 1998:137). However, the problem is that the natural and adaptive immune responses of the human body are usually unable to obtain immunity against HIV/AIDS since this disease disables the immune system, leading to an unproductive immune system. The human immune-deficiency virus and acquired immune deficiency syndrome are discussed in the following section.

2.3 HUMAN IMMUNE-DEFICIENCY VIRUS AND ACQUIRED IMMUNE DEFICIENCY SYNDROME

"Infectious diseases are a complex interplay between pathogen and host. Immune-compromised hosts are more susceptible to infection including those from organisms that are not normally pathogenic" (Maartens, 2005:126).

HIV/AIDS is a disease that compromises the functioning of the human immune system (Bankaitis, 1998:119). The HIV/AIDS pandemic is a universal dilemma that demands urgent consideration. The AIDS pandemic has become one of the leading public dilemmas of modern times (Sharma & Tami, 1995 in Gold and Tami, 1998:165). HIV and AIDS are often incorrectly used as one interchangeable concept. HIV is the actual infection that progresses to cause AIDS (Bankaitis, 1998:119). AIDS is characterized by the inability of the immune system to defend the human body against infections optimally and it develops as a result of HIV (Bankaitis and Schountz, 1998:155).

This HIV-infection primarily targets the immune cells containing the CD4+ cell marker (Bankaitis, 1998:123). In other words, HIV is a retrovirus that infects these CD4+ cells (MSD, 1992:77). All retroviruses use transcriptase, an enzyme, to convert viral RNA into proviral DNA. This copy of the DNA becomes integrated into the host cell DNA and during normal cell division this provirus is

duplicated. This means that these newly produced cells will all contain the HIV retrovirus (MSD, 1992:78). Due to the fact that the HIV virus targets the CD4+ markers in human cells, these CD4+ cell counts are used to determine the progress of the HIV infection in humans (Bankaitis, 1998:123). In other words, the HIV/AIDS status of a person can be determined by taking the CD4+ cell count and the presence of AIDS-defining illnesses into account. According to Evian (2000:25), a person infected with HIV will progress through four clinical stages that will occur over a long period of time, usually five to twelve years. Maartens (2005:126) also notes that the state of the immune system can be measured by the CD4 (helper T-cells) count and this can predict the patient's risk to develop a symptomatic disease. He furthermore indicates that the CD4+ lymphocyte count accurately reflects the level of the individual's immune suppression. Bankaitis (1998:127) states *"…HIV infection is associated with the eventual depletion of CD4+ T-lymphocytes…".* Table 2.1 depicts this CD4+ cell count depletion.

Table 2.1: The relationship between clinical condition, CD4+ cell count and immune status (Evian, 2000:26).

STAGES	CLINICAL CONDITION	CD4+ CELL COUNT
Stage I	Healthy with no symptoms	More than 500-600cells / mm^3
Stage II	Minor symptoms	350-500 cells / mm^3
Stage III	Major symptoms and opportunistic diseases	200-350 cells / mm^3
Stage IV	AIDS (increased symptoms and opportunistic diseases)	Less than 200 cells / mm^3

Table 2.1, as described by Evian (2000:26), outlines the development of various phases of HIV infection in relation to the immune status (CD4+ count). The advanced, late and final stages of HIV infection are associated with severe immune-deficiency and are called AIDS (Evian, 2000:26). The ultimate reduction of CD4+ cell counts induces the development of various disease manifestations, suggesting that the HIV-infection has progressed to its full extent: AIDS (Bankaitis, 1998:119). A person infected with the HIV-infection who presents with normal or near normal CD4+ cell counts

does not have AIDS. Usually a person infected with HIV will initially remain asymptomatic for long periods of time with a CD4+ cell count, allocating the person to either stage I or II of the infection (Bankaitis, 1998:119). AIDS is only diagnosed when a person presents with a very low CD4+ cell count (less than 200 cells / mm^3) and is diagnosed with asymptomatic diseases. In other words *"….while a HIV-infected individual may not necessarily have AIDS, a person with AIDS is always infected with HIV" (*Bankaitis, 1998:119). AIDS is suggestive of a CD4+ cell count below 200 mm^3 and the presence of asymptomatic diseases. These diseases are also better known as AIDS-defining diseases. Cryptococcosis, cytomegalovirus, enchephalopathy, kaposi's sarcoma, lymphoma, toxoplasmosis, and wasting syndrome, bacterial septicaemia, pneumonia, encephalitis, non-hodgkin lymphoma, herpes zoster, meningitis, neurosyphilis, myelopathy, sexually transmitted diseases, otological infections form part of AIDS-defining diseases (Spencer, 2005:35-215). Infections, acquired by immune-compromised individuals are due to the rapid progressive nature and the advanced insidious speed of the infection and leads to these diseases (Maartens, 2005:126). In order to understand the rapid progressive nature of this disease, it is necessary to understand the life cycle of HIV.

2.3.1 The life cycle of HIV

HIV-infection has a fatal impact on the lives of human beings. It damages the immune system of the human and leads to intense vulnerability to threatening and normally unthreatening organisms. Once infected with HIV, the health of the person gradually diminishes. Initially the viral load and the CD4+ count are relatively expectable, but with the progression of the virus, the CD4+ cell count finally decreases to less than 200mm^3, indicating that the person has AIDS. At this point in time, the viral load of the person will be extremely high. In order to comprehend the seriousness and rapid progress of this disease, as well as the importance of the CD4+ count, one must understand the life cycle of HIV. The life cycle of HIV is depicted in figure 2.3.

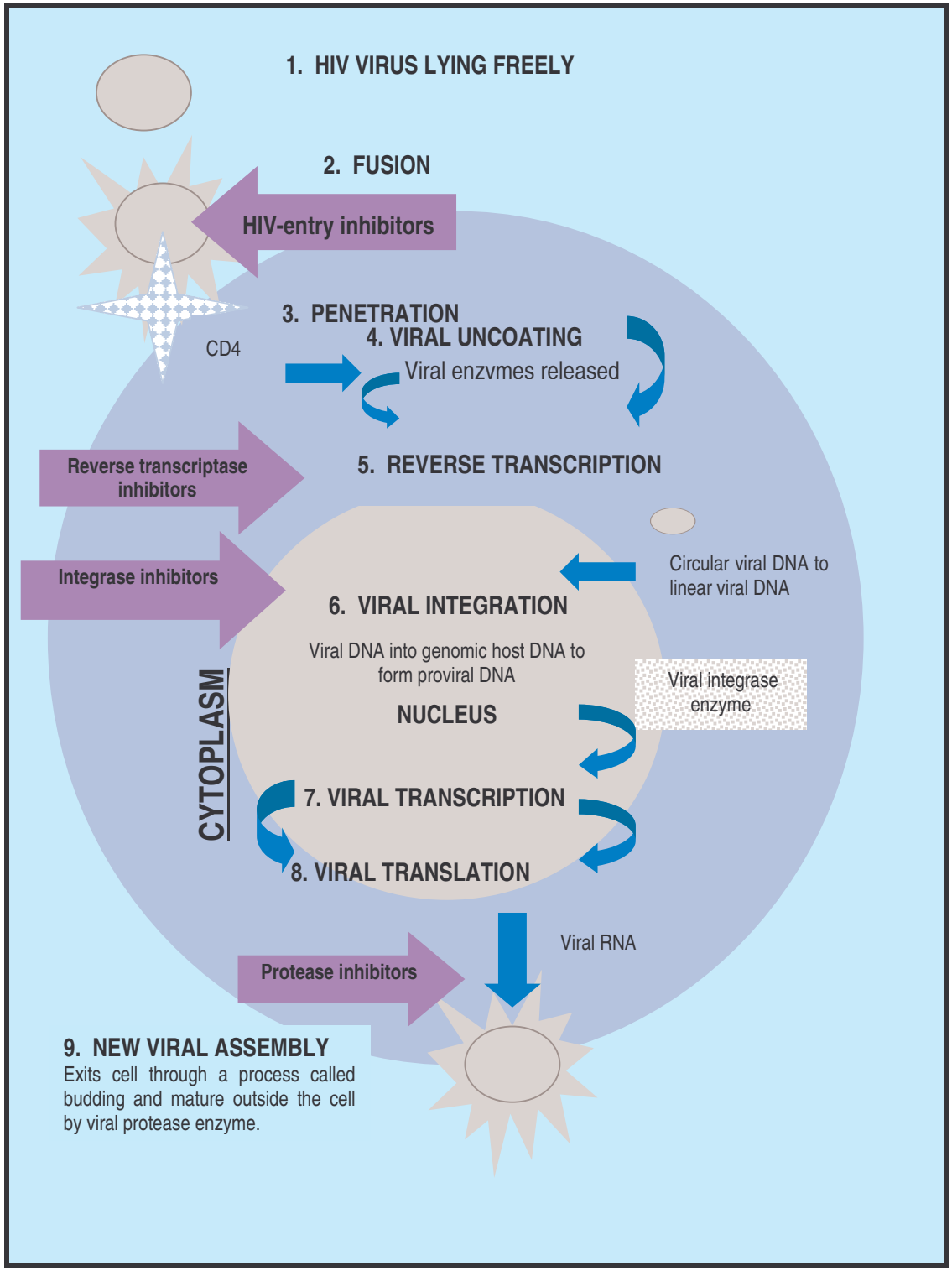


Figure 2.3: The life cycle of the Human Immune Virus (adapted from Spencer, 2005:6-7)

Figure 2.3 is a schematic presentation of the life cycle of the Human Immune Virus with all the different processes necessary to reproduce. It clearly explains how HIV enters the CD4+ cell and incorporates the HIV-DNA into the CD4+ cell-DNA. The presentation also includes the different ART, directed to restrain the further development and replication of the virus. This schematic presentation is adapted from Spencer (2005:6-7).

Spencer (2005:6-8) explains the life cycle of HIV/AIDS as follows: HIV-1 is a ribonucleic acid [RNA]. This free-lying ribonucleic acid binds to a CD4-receptor of a suitable target cell, typically the T-helper lymphocyte, a dendrite or macrophage. Fusion with CD4+ cell and cell membrane is aided by the chemokine receptors, a protein found on the surfaces of macrophage and dendrites. These proteins play a significant role in cell movement and the inflammatory reaction of the host. The HIV penetrates and enters the cytoplasm of the host cell. The HIV is "uncoated", in other words, released from the original coating through a process of *"viral uncoating*" and released into the host cell together with viral enzymes produced by this process. The viral RNA is then copied to viral DNA through a process called *"reverse transcription*". The viral enzymes that are released when HIV is "uncoated", aid the process of reverse transcription. The circular viral DNA penetrates the nucleus of the host cell and is then integrated into the DNA of the host cell, also called the genomic DNA. Through this process, proviral DNA is formed. Enzymes released during this "*viral integration"* process and activation of the CD4+ cells assist with the transcription of proviral DNA into the original viral (genomic) RNA and messenger [mRNA] through a process called "*viral transcription*". The viral RNA and the mRNA exit the nucleus to the cytoplasm of the host cell collectively. The genomic RNA (viral RNA) exits the cytoplasm of the host cell. The mRNA is decoded into viral proteins on the ribosomes of the endoplasmic reticulum through a process called "*translation*". These viral proteins are structural and enzymic in nature and are processed, accumulated and released in the form of a *"new viral assembly"* or a new infectious virus. This new

assembly exits the cell through a process called budding and matures outside the cell. V*iral protease enzyme* is responsible for the maturation process outside the cell. This means that with the increase in the new viral assembly, the CD4+ cell count decreases.

Therefore the CD4+ cell count is an essential measurement to manage HIV-infected persons. The viral load also plays an important role since there is a correlation between the viral load of the person and the CD4+ cell count. Usually, early after infection, both the viral load and the CD4+ count are fairly high. With progression of this disease, the CD4+ cell count decreases exceptionally and the viral load increases excessively. The HIV-infection usually takes an average of eight to ten years to develop and progress to AIDS, but in developing countries such as South Africa it often takes only five to eight years to progress to AIDS. Therefore, it must be taken into account that these time periods may vary in some individuals (Bankaitis, 1998:123). According to Conway and Bartlett (2003:3), the stages of HIV-infection include viral transmission and after two to three weeks it is followed by acute HIV-syndrome. The acute HIV-syndrome can be diagnosed by identifying if fever, adenopathy, pharyngitis, rash, diarrhoea, headache, nausea and vomiting as well as neurological symptoms such as Guillain-Barrè syndrome, encephalitis, aseptic meningitis and Bell's palsy are present. These illnesses are known as serconversion illnesses that are also the third stage of HIV-infection that takes place two to three weeks after acute HIV syndrome is diagnosed. These symptoms occur fifty to eighty percent of the time in a person diagnosed to be in the "acute HIV-infection syndrome" and "recovery and serconversion" stage.

The World Health Organisation [WHO] in Conway and Bartlett (2003:5) specifies that during stage I of the HIV-infection, the person is mainly asymptomatic with persistent generalised Lymphadenopathy and during stage II, weight loss occurs where a person can lose up to ten percent of body weight. Minor mucocutaneous manifestations such as seborrhoeic dermatitis, prurigo, fungal nail infections, recurrent oral ulcerations and angular cheilitis and recurrent upper

respiratory tract infections may also occur within the second stage of the HIV-infection. Herpes zoster occurs within the last five years of the second stage of the HIV-infection. Clinical stage III is characterized by more than ten percent of body weight lost; unexplained chronic diarrhoea for longer than one month; unexplained prolonged fever that can be intermittent or constant for longer than one month; oral candidiasis; oral hairy leukoplakia; pulmonary tuberculosis within the past year and severe bacterial infections such as pneumonia and pyomyositis (Conway and Bartlett, 2003:5).

Stage IV of the HIV-disease is also known as AIDS. Not only does a person who is diagnosed with AIDS present with a CD4+ cell count below 200mm^3, but various symptomatic conditions such as; cryptococcosis, cytomegalovirus, enchephalopathy, Kaposi's sarcoma, Non-Hodgkin's Lymphoma, toxoplasmosis and wasting syndrome may also be present (Bankaitis, 1998:125). Conway and Bartlett, (2003:7) specify that HIV-wasting syndrome; pneumocystis carninii pneumonia; toxoplasmosis of the brain; extra pulmonary cryptococcosis; cytomegalovirus disease of an organ other than the liver, lymph nodes and spleen; herpes simplex virus infection; progressive multifocal leukoenchephalopathy; any disseminated endemic mycosis; candidiasis of the oesophagus, trachea, bronchi or lungs; atypical mycobacteriosis; non-typhoid salmonella septicaemia; extra pulmonary tuberculosis; lymphoma; Kaposi's sarcoma and HIV enchephalopathy are diseases that may be present in a person who is diagnosed with AIDS, the fourth and final clinical stage of the HIV-infection.

A clear relationship exists between the clinical symptoms and the immune system in individuals with of HIV/AIDS. Table 2.2 provides a description of the clinical symptoms associated with each clinical stage of HIV/AIDS.

Table 2.2: The relationship between clinical symptoms and immune status (Conway and Bartlett, 2003:5)

STAGES	CLINICAL SYMPTOMS
Stage I	Asymptomatic Persisting generalised lymphadenopathy
Stage II	Weight loss < 10% of body weight Minor mucocutaneous manifestations (seborrhoeic dermatitis, prurigo, fungal nail infections, recurrent oral ulcerations, angular cheilitis) Herpes Zoster within the last five years Recurrent upper respiratory tract infections (i.e. bacterial sinusitis)
Stage III	Weight loss < 10% of body weight Unexplained chronic diarrhoea >1 month Unexplained prolonged fever (intermittent or constant) > 1 month Oral candidiasis (thrush) Oral hairy leukoplakia Pulmonary tuberculosis within the past year Severe bacterial infections (i.e. pneumonia, pyomyositis) Bedridden < 50% of the day during the last month
Stage IV	HIV wasting syndrome Pneumocystis carinni pneumonia Toxoplasmosis of the brain Cryptosporidiosis with diarrhoea > 1 month Cryptococcosis, extrapulmonary Cytomegalovirus disease of an organ other than liver, spleen or lymph nodes Herpes simplex virus infection, mucocutaneous > 1 month, or visceral any duration Progressive multifocal leukoencephalopathy Any disseminated endemic mycosis (histoplasmosis, cocidioidomycosis) Candidiasis of the oesophagus, trachea, bronchi or lungs Atypical mycobacteriosis, disseminated Non-typhoid Salmonella septicaemia Extrapulmonary tuberculosis Lymphoma Kaposi's sarcoma HIV encephalopathy Bedridden > 50% of the day during the last month

Table 2.2 explains the clinical symptoms that may be observed in the various stages of the HIV-infection. As the HIV-infection spreads and reproduces within an individual, the CD4+ cell count decreases and the probability to develop opportunistic infections increases.

During intervention, the viral load persists at the lowest point but the CD4+ cell count steadily diminishes yearly. *"Good anti-retroviral therapy and strict adherence are the only means currently available to ensure that patients control their viral infections, re-grow their immune system and improve their survival"* (Spencer, 2005:10). Venter, Ive and Mmbara (2005:238) state that ART must be used in correct combinations to control the virus successfully for years and in some cases decades. It is important, though, to ensure that the individual diagnosed with HIV/AIDS does not start with ART too early, since it raises the possibility of developing complications to the different drugs, as well as resistance to the virus. If this happens, it could lead to the transmission of a new viral DNA that is unresponsive to the currently available ART (Chisholm and Kredo, 2005:246). This means that commencing a person on ART should take enormous thought and deliberation.

2.3.2 Commencing antiretroviral therapy

"South Africa has a huge burden of HIV disease, with an estimated 5 million HIV-infected individuals, and more than 500 000 currently requiring ART" (Cohen, 2005:250). As explained above, the CD4+ cell count and the viral load are the two measurements that are used to monitor the health of a person infected with HIV/AIDS. Spencer (2005:10) explains that these measurements are conducted during the first visit and thereafter in four to six months' intervals. The protocol usually involves that a person who does not display symptoms of AIDS, in other words, an asymptomatic person, who is not on ART and whose CD4+ cell count is above 200mm^3 and viral load is below five to ten thousand replicas per millilitre blood, must be seen every six months. In South Africa the physicians mainly use the CD4+ cell count and the clinical stage of

the person to base the decisions on regarding the commencement of ART. This is mainly due to the expensive nature and the unavailability of the viral load test (Spencer, 2005:10).

According to research studies, there is no advantage in starting ART in asymptomatic persons with CD4+ cell counts below 350mm^3 according to recent studies (Spencer, 2005:10). Persons with symptomatic diseases, even though not AIDS-defining diseases, and whose CD4+ cell count is below 200mm^3 should consider starting with ART (Spencer, 2005:10). This is not a cure for the disease, but rather a suppressor for the progression of the disease. Different guidelines were established to determine whether or not a person should start with ART. These guidelines were adjusted (Appendix L) and made applicable to South Africa by the Southern African HIV Clinicians Society Clinical Guidelines (July 2002) and is stipulated in Spencer (2005:11). However, the success of ART not only depends on the time of commencement of treatment, but also on the adherence of the individual in terms of administration of the ART. Good adherence from the part of the infected individual and well-planned commencement of ART from the part of the medical doctor will assist in the achievement of the goals of ART (Chisholm and Kredo, 2005:246). The goal of ART is to suppress HIV-viraemia to a lesser visible level, thus preventing immune corrosion and avoiding HIV-related morbidity and mortality (Chisholm and Kredo, 2005:247).

Most individuals who participated in this research project were exposed to different types of ART. This signifies the importance of the inclusion of in-depth information on the different types of ART and the different ways of administering the ART. This information is discussed in the following section.

2.3.3 Suppressing the viral infection and restoring the immune system

Antiretroviral therapy, more specifically known as HAART (Highly Active Antiretroviral Therapy) serves to ensure maximal suppression of the virus and the progression of the viral infection,

restoration of the immune system and improving the quality of life of a person. Studies have proven that the foundation of good viral control is strict adherence to doctor's orders and prescriptions related to HAART (Spencer, 2005:4).

Antiretroviral therapy can be divided into four groups according to the function it serves to accomplish. These functions are directed towards the life cycle of the HIV-infection. Four main events were considered during the discussion of the viral life cycle (Spencer, 2005:6-25):

2.3.3.1 Fusion and penetration - HIV-entry inhibitors

The entry of HIV into the cytoplasm of body cells is known as the first event. This includes the processes of fusion and penetration. The drugs known to be involved in restraining these processes are known as *HIV-entry inhibitors* that directly interact with the free-lying virus, inhibit fusion with the CD4+ cell receptor and co-receptors such as the dendrites cells, macrophages and lymphocytes (Spencer, 2005:7,8,14).

2.3.3.2 Viral uncoating and reverse transcription - reverse- transcriptase inhibitors

The second phase of the progression of the virus is the viral uncoating and the transformation of viral RNA into viral DNA. This process is called reverse transcriptase and the drugs influencing the progression of the viral infection during this phase of the infection are called *Reverse- transcriptase inhibitors* and it includes nucleoside/nucleotide reverse transcriptase inhibitors (NRTIs) and non-nucleoside reverse transcriptase inhibitors (NNRTIs) (Spencer, 2005: 8,18).

2.3.3.3 Viral integration - integrase inhibitors

The third type of drug, *integrase inhibitors*, is directed towards inhibiting the virus from penetrating the nucleus of the cell. It also inhibits integration of viral DNA into the host viral DNA into the host

(genomic) DNA to form proviral DNA. The virus exits the cell and matures outside the cell by using viral protease enzymes (Spencer, 2005: 8, 20).

2.3.3.4 Viral replication external to the CD4+ cell - protease inhibitors

A fourth type of drug called *protease inhibitors* (PI) accomplishes the inhibition of this phase of viral replication. It presents the processing, accumulation, binding and release of the translated viral proteins and genomic viral RNA. The PI prevents the distribution of the newly formed infectious virus, in other words it avoids dissemination of the new viral assembly (Spencer, 2005: 8, 20).

Spencer (2005:14) suggests that HAART entails the use of no less than a combination of three diverse antiretroviral drugs. In the past, two nucleoside reverse transcriptase inhibitors (NRTIs) together with a protease inhibitor (PI) were used. Currently two NRTIs with a non-nucleoside reverse transcriptase inhibitor (NNRTI) are used in combination. The fact is that HAART does not suggest the use of three NRTIs. HAART proposes a combination of NRTIs with a PI.

The WHO (2002) suggested a first-line antiretroviral treatment regimen. Long-lasting clinical benefit and therapeutic success depend a great deal on the first ART regimen that was administered (Conway and Bartlett, 2003:34). The physician should carefully select a regimen that will be endurable for the person's general health condition, prone to be successful in having the relevant effects and easy to adhere to. WHO (2002) suggests that a twofold nucleoside constituent combined with a third drug in one of the subsequent manners will have a highly effective initial result on the CD4+ cell count and the viral load of the person:

- Two NRTIs together with an NNRTI.
- A less favourable option is a triple nucleoside where the third drug is Abacavir (ABC), because this combination is less durable.

- Dual Nucleoside with a PI.

These combinations of drugs contain at least two classes of strong drugs and spare at least one class to avoid side effects. If the person develops a resistance to the drugs, the fact that exposure was only to two of the NRTIs per regimen, suggests that the physician may have a larger quantity of drugs to select from in future, thus improving future options (Conway and Bartlett, 2003:34). "*These three approaches use one or two classes and spare at least one class to avoid side-effects and improve future options if resistance develops*" (Conway and Bartlett, 2003:34). However, a successful response to therapy suggests improvement in general health condition, weight gain, no further HIV-related events and symptoms, constant improvement in CD4+ cell count after three months of ART, decrease in the viral load to less than thousand replicas per millilitre after only four weeks of treatment and after twenty-four weeks of treatment, the viral load remains at more or less four hundred replicas per millilitre.

There is no definite answer as to which is the best combination of drugs to start with when treating a person with HIV. Southern Africa has adapted the following from the WHO (2002) in Cohen (2005:254) and Conway et al. (2003:35) and recommended the use of one of these regimens in the public sector as first-line ART:

- two nucleosides reverse transcriptase and one non-nucleoside reverse transcriptase inhibitors such as AZT (Zidovudine), 3TC and EFZ *or* AZT (Zidovudine), 3TC and NVP *or* AZT(Zidovudine), 3TC and NVP; or

- three nucleosides reverse transcriptase inhibitors such as AZT (Zidovudine), 3TC and ABC; or

- two nucleosides reverse transcriptase inhibitors and one Protease inhibitor such as AZT (Zidovudine), 3TC and RTV-PI or AZT (Zidovudine), 3TC and NFV.

Even though administration of these drugs (Appendix M) in the correct manner prolongs the life of the person infected with HIV, the fact remains that HAART consists of drugs with serious side effects including ototoxicity. It is extremely important to understand that the "*risk of side-effects from HAART is outweighed by the benefits of viral suppression*" (Orrel & Wilson, 2003:312). Therefore, even though side-effects may be present, the person cannot discontinue with the therapy. Drugs may be altered, but the fact remains that all the drugs that form part of ART have serious side-effects that the person has to cope with. *"The potential for a drug–induced hearing loss in an HIV-infected individual at any stage of the disease is relatively high. With all the medications the HIV-infected individual is taking and the continual developments in HIV-therapies, it is challenging to acquire and maintain a comprehensive knowledge base of HIV-related drugs and associated ototoxicity"* (Bankaitis and Schountz, 1998:156).

2.4 AIDS AND THE HEARING MECHANISM

AIDS has far-reaching consequences. It is not just a disease which should be managed medically, it is a disabling condition which influences every aspect of a person's daily living, leaving the individual feeling hopeless and fearful (Friedman and Noffsinger, 1998:207). Gold and Tami (1998:165) state that HIV/AIDS has an inevitable negative impact on the lives of those who contracted the virus, but also on the lives of their families and caregivers who have to endure the suffering with the infected individual. They also mention that, from the emotional perspective, this disease has an overwhelming socio-economical impact on the health care systems across the world (Gold and Tami, 1998:165). Once the virus has penetrated the CD4+ cell and becomes permanently integrated into the cell, the HIV kills all the CD4+ cells it comes into contact with, leaving the human body with no adaptive mechanism to fight off infectious agents. The immune system becomes susceptible to organisms that are usually unthreatening, leading to the development of opportunistic infections (Bankaitis and Schountz, 1998:155).

Up till now, no cure has been found, but antiretroviral therapy was developed and adjusted on a regular basis to suppress the progress of this disease, reducing the risk of HIV-related illnesses (Orrel and Wilson, 2003:308). Unfortunately, as with any other drugs, ART consists of drugs that may have serious side-effects, leading to other problems the person has to cope with (Venter, Ive and Mmbara, 2005:238). Bankaitis and Schountz (1998:155) clearly state that changes in the auditory system may occur as a direct or indirect result of HIV, suggesting that HIV is not necessarily the only cause of loss of hearing sensitivity, but ART may raise the risk of permanent ototoxicity considerably. Although this disease is liable for different alternations to the ear and hearing, no clear correlation exists involving the progress of the disease and the severity of auditory symptoms (Matkin et al., 1998:148). In order to understand the influence of HIV/AIDS and ART on hearing, one has to understand the hearing mechanism and the basic concept of the process of hearing.

2.4.1 The hearing mechanism

"Hearing and its disorders are intimately intertwined with the anatomy and physiology of the auditory system which is composed of the ear and its associated neurological pathways" (Gelfand, 2001:37). Knowledge of the normal anatomy and physiology of the complete hearing mechanism forms the foundation of an audiologist's clinical work. Knowledge of the complete auditory system and the function of the separate components provides a better understanding of pathological conditions that may exist (Debonis and Donohue, 2004:224). The hearing mechanism comprises of several parts: The external ear, also called the outer ear, the middle ear, the inner ear and the auditory neurological pathways (Gold and Tami, 1998:165 Martin, 1997: 214-218 and 327-330; Debonis and Donohue, 2004: 225-232).

2.4.1.1 The external ear

The external ear consists of the auricle, also known as the pinna and the external auditory meatus, better known as the ear canal (Martin, 1997: 214-218). "The pinna and the external auditory canal are susceptible to infectious and dermatological conditions associated with HIV" (Gold and Tami, 1998:165).

2.4.1.2 The middle ear

The *tympanic cavity*, also known as the *middle ear* is the air-filled cavity behind the tympanic membrane (eardrum). The middle ear contains three small ossicles called the *ossicular chain*, connected to one another and at the lateral end they are connected to the *tympanic membrane* and the medial end to the entrance of the inner ear, better known as the *oval window*. These three ossicles are known as the malleus, incus and stapes. The Eustachian tube connects the middle ear and the pharynx (Martin, 1997: 214-218). Problems in the middle ear may lead to a conductive hearing loss that may be identified through immittance measurements.

2.4.1.3 The inner ear

The inner ear is a vestibule that lies medial to the middle ear, more specifically the oval window. It contains sensory organs responsible for hearing and balance. Anterior to the vestibule lies the snail-shaped cochlea and the semicircular canals lie posterior to the vestibule. These semicircular canals are filled with fluid and are situated in the temporal bone. Problems in the cochlea or semicircular canals may lead to cochlear hearing loss or vestibular pathology suggesting complaints of dizziness, episodes of vertigo or menière's disease.

2.4.1.4 Auditory neurological pathways

These areas responsible for the sense of hearing are tremendously complex. Stimulation from one ear to both sides of the brain is obtained by the afferent system. The efferent system is responsible for the detection of auditory stimuli in the presence of background noise. These systems comprise of the auditory nerve as well as central pathways, which include higher centres such as the reticular formation, the lateral lemniskus, the inferior colliculus, superior olivary complex and the medial geniculate body (Martin, 1997: 330).

2.4.1.5 The auditory nerve and the cochlear nucleus

The nerve fibres exist in the cochlea at the modiolus and pass through the internal auditory canal. The internal ear canal starts at the base of the modiolus and ends at the base of the brain. The vestibular portion of the vestibulo-cochlear nerve (VIIIth cranial nerve) runs through the internal auditory canal. The VIIIth cranial nerve's fibres innervate the urtricle, saccule and the semicircular canals. The internal ear canal carries up to 50 000 nerve fibres. These fibres are arranged orderly in a cylindrical bundle and connected to the fibres that arise from the basal turn of the cochlea, forming a nerve trunk. The outer portion is formed by the basal part of the cochlea and the centre originates from the atypical part of the cochlea. Each part is responsible for the processing of a particular frequency range. The outer portion of the nerve trunk carries high-frequency sounds and the inner portion is responsible for low-frequency sounds. The internal ear is approximately 10mm in adults and is the keeper of facial nerve fibres and the internal auditory artery. The auditory nerve attaches to the brainstem 17 to 19 mm beyond the internal auditory canal. Here, the cerebellum, medulla oblongata and pons unite to form the cerebellopontine angle, but the vestibular and auditory portions of the VIIIth cranial nerve divide into two, ascending and descending to the dorsal cochlear nucleus and the ventral cochlear nucleus. The cochlear nucleus is thought to preserve

information obtained from the auditory nerve. Various decussations (crossover points) exist, connecting one symmetrical half of the brain to the other symmetrical half to ensure bilateral representation of the auditory stimuli. The first crossover point beyond the level of the cochlear nucleus is the trapezoid body of the pons. Some nerve fibres also proceed to the superior olivary complex, the inferior colliculus, the lateral lemniskus or the reticular formation (Martin, 1997:327). ABR potentials that are observed relatively early reflect the functioning of the cochlea and the distal end of the vestibule-cochlear nerve and the wave forms that are observed a few milliseconds later echo the functioning of the proximal end of the vestibulo-cochlear nerve, the caudal brainstem near the trapezoid body and superior olivary complex, as well as the lateral lemniskus and the inferior colliculus (Hall and Mueller, 1998:328).

2.4.1.5.1 The reticular formation (RF)

Fibres from the cochlear nucleus proceed to the RF. The RF is found in the centre of the brainstem. It serves as communication means to all areas of the brain. The function of the RF is to provide auditory alertness, reflexes and training. It is also known as the reticular activating system. It is presumed that the RF's primary function is to control the central nervous system (Martin, 1997:328).

2.4.1.5.2 The superior olivary complex (SOC)

A large number of fibres from the cochlear nucleus continue to the superior olivary complex. The SOC analyses the "*small difference in time or intensity of sounds arriving at the two ears*", therefore enabling humans to localize. The tensor tympani reflex and the stapedius muscles of the middle ear are mediated by the SOC. Decussations at this level ensure that contralateral reflexes can be elicited. The motor nerve fibres of the facial nerve innervate the stapedial branch of the auditory nerve. Therefore the stapedial reflex of both ears can be elicited when a loud sound is actually

produced into one ear only. This can be explained as contralateral reflexes (Martin, 1997:328). Ipsilateral and contralateral reflexes provide the researcher with objective information regarding the integrity of the hearing system at various levels including the SOC. The wave III of the auditory brainstem response also reflects the functioning of the SOC.

2.4.1.5.3 The lateral lemniskus (LL)

The precise function of the lateral lemniskus is unknown. However, it does serve as communication pathway for impulses from the lower brainstem. Decussations exist at this level in such a way that the nerve fibres proceed to the contralateral lemniskus. Some fibres terminate at the level of the LL or continue to the inferior colliculus (Martin, 1997:328).

2.4.1.5.4 The inferior colliculus (IC)

Most nerve fibres from the LL reach the higher centres by passing through the inferior colliculus. From here they proceed to the medial geniculate body. Some fibres proceed past the IC directly to the medial geniculate body. Both superior olivary complexes send afferent information to the IC. For each nerve fibre entering the IC, one nerve fibre is exits the IC (Martin, 1997:328).

2.4.1.5.5 The medial geniculate body (MGB)

The MGB is located in the thalamus. This is the last transmitting station for auditory impulses. The ventral region of the MGB is the only region responsible for auditory information. Most fibres reach the MGB from the IC and only a few reach the MGB from the LL. All fibres radiate from here and ascend to the auditory cortex. This is called the auditory radiations. No crossover points exist at the level of the auditory radiations (Martin, 1997:328-329).

2.4.1.5.6 The auditory cortex

The bilateral temporal lobes are responsible for auditory reception. Auditory processing also takes place in the auditory cortex, in other words makes sense of what a person is hearing (Martin, 1997:329).

Problems in these above-mentioned parts of the hearing mechanism may lead to auditory neuropathy, poor speech discrimination or neurological deafness, poor localisation, the absence of acoustic reflexes as well as abnormal auditory brainstem response (ABR) findings. The influence of HIV/AIDS on these structures are still unknown, but might be determined with thorough, in-depth basic and specialised audiometry.

2.4.2 The influence of HIV/AIDS on hearing

"Although HIV is directly and indirectly responsible for various changes to the ear and hearing, no clear relationship exists between disease progression and severity of auditory manifestations. As such, the effects of HIV on the auditory system differ greatly from one individual to the next" (Matkin et al., 1998:148).

People diagnosed with HIV/AIDS usually present less frequently with ear manifestations than oral cavity manifestations, sinonasal manifestations and neck manifestations (Lubbe, 2004:253). However, Lubbe (2004:253) states that sensorineural hearing loss occurs in the individual infected with HIV/AIDS. The risk to develop a hearing loss when diagnosed with HIV/AIDS has become an increasing predicament, but also a reality for all audiologists in terms of diagnoses and treatment. Various auditory manifestations can be observed during the progression of this viral infection (Friedman and Noffsinger, 1998:205) and accurate identification of these conditions is of absolute importance in order to ensure optimal treatment. Since the manifestations differ from individual to individual, it is necessary to know the types of auditory conditions that may be present in a person

infected with HIV/AIDS. Literature regarding these auditory manifestations is limited, but it is clear from existing literature that otological manifestations, neuropathology and resulting auditory neuropathy and central pathology associated with HIV/AIDS and ART may lead to the loss of hearing sensitivity. Many OIs are associated with the presence of a sensorineural or conductive hearing loss, regardless of the stage of HIV/AIDS (Bankaitis and Schountz, 1998:155).

2.4.2.1 Medical conditions of the auditory system

Fuzani (1999:36) found that conductive hearing loss had a high incidence throughout all clinical stages of HIV/AIDS. Persons with HIV/AIDS are prone to develop middle ear conditions. These conditions may explain the conductive hearing loss that is often found in persons with HIV/AIDS (Fuzani, 1999:36).

Infectious and dermatological conditions of the pinna and the ear canal (external ear) are frequently found in individuals infected with HIV/AIDS (Gold and Tami, 1998:165). *Candida albicans,* also known as thrush, is a non-dangerous organism usually found in the oral cavity, but in individuals with HIV/AIDS this might become an opportunistic infection and it may be found in the external ear (Scully, 2004:94 and Matkin et al., 1998:148). Scully (2004:94) further notes that thrush and nonalbicans species are identified progressively more frequently. The current situation with HIV/AIDS can be considered as the basis for this increase and the reason for the resistance to the antifungals that are administered as treatment. Even though this may not cause a hearing loss, the identification of this dermatological condition in the ear canal is important.

Pseudomonas aeruginosa is the pathogen responsible for otitis externa. *Otitis externa* is the infection of the cartilaginous section of the external ear (Gold and Tami, 1998:165), in other words the pinna and the outer portion of the ear canal (Martin and Clark, 2006:225). Individuals infected with HIV/AIDS do not have a higher incidence of otitis externa or necrotising otitis extern when

compared with individuals with other types of immuno-compromised conditions (Lubbe, 2004:253). In individuals with HIV/AIDS, otitis externa may lead to *skull base osteomyelitis* also known as *malignant otitis externa*. This condition is generally also caused by *pseudomonas*. However, *aspergillus fumigatus,* a fungal infection, has also been identified in the past as the cause of this condition (Gold and Tami, 1998:166). Although uncommon in the population with an intact immune system, *Aspergillus* can be found worldwide, but especially in immuno-compromised individuals, such as HIV-positive persons. In HIV-positive individuals, this pathogen can inhabit the respiratory tract and lead to invasive aspergillosis primarily affecting the lungs, but it may extend to the brain (Scully, 2004:83-84). *Polyps* in the ear canal may therefore be caused by *pneumocystis* and *tuberculous infections*. The incidence of extra pulmonary pneumocystis infection, diagnosed as *pneumocystis otitis*, is intensified by the increased use of prophylaxis against pneumocystis (Gold and Tami, 1998:166). *Pneumocystis carinii* may cause *subcutaneous cysts* in the ear canal that may enlarge and completely block the ear canal (Gold and Tami, 1998:166).

Aural polyps may be present in the middle ear, but also extend into the ear canal due to *Mycobacterium tuberculosis* infections. With such a condition, clear otorrhea will be observed and a conductive hearing loss will be present (Gold and Tami, 1998:166). *Otitis Media* is often found in adults infected with HIV. Compared to the general population, a higher incidence is present in individuals diagnosed with HIV/AIDS (Lubbe, 2004:253). Lubbe (2004:253) strongly suggests that the presence of otitis media with middle ear effusion in an adult may indicate that the person may possibly be infected with HIV/AIDS. *Serous otitis media* and *recurrent acute otitis media* occur mainly due to *Eustachian tube dysfunction* caused by either "… *diminished cell-mediated immunity, recurrent viral infections, benign lymphoid, hyperplasia of the adenoids, nasopharyngeal neoplasm's, sinusitis, allergies"* (Gold and Tami, 1998:166). Another cause of Eustachian tube

dysfunction could be due to a post nasal lesion obstructing the Eustachian tubes (Lubbe, 2004:253).

Individuals with AIDS often presents with nasal obstruction, hearing loss and otitis media with effusion due to benign nasopharyngeal lymphoid. Otitis media can result in *Mastoiditis* due to S.pneumoniae. However, less common pathogens in individuals with AIDS, leading to mastoiditis, are Aspergillus or M.tuberculosis (Gold and Tami, 1998:166). Nevertheless, certainty regarding the incidence of these conditions in the AIDS population is not completely obvious since evidence is required in terms of the frequency of chronic otitis media, cholesteatoma, intracranial complications and suppurative complications relevant to otitis media in persons with AIDS in relation to persons without this disease.

2.4.2.2 Neuropathology and central pathology of the auditory system

Sensorineural hearing loss in individuals infected with HIV is caused by the direct effect of the virus on the cochlear nerve, syphilis and Cryptococcus meningitis (Lubbe, 2004:253). Sensorineural hearing loss in HIV-infected patients ranges from 20 to 50%" (Bankaitis and Keith, 1995, Lalwani and Sooy, 1992 and Tami and Lee in Gold and Tami, 1998:166). The nature and degree of this type of hearing loss in the AIDS population is typically sloping to a moderate loss in the high frequencies with normal speech discrimination. A recent study indicated that *"…the prevalent type and degree of hearing loss in HIV positive black female patients, at various clinical stages of infections in South African population… was slight to mild sensorineural hearing loss in both low and high frequencies"* (Fuzani, 1999:36). A slight to mild low frequency conductive component was also often found, but it was less prevalent than the sensorineural loss (Fuzani, 1999:36). It is speculated that the effect of HIV/AIDS on hearing is either due to opportunistic infections, neoplasias in the central nervous system, the direct effect of the disease on the central nervous

system or the peripheral auditory nerve or the ototoxic complications related to the administration of ototoxic drugs (Gold and Tami, 1998:167).

One third of individuals infected with HIV/AIDS and who display a sensorineural hearing loss usually have a record of a recent viral infection. Certain viruses especially may attack the spiral ganglion and acoustic part of the N.VIII, resulting in a temporary or permanent hearing loss (Matkin et al., 1998:149). Central auditory pathology may originate from the direct influence of HIV/AIDS on the central nervous system, especially considering illnesses such as AIDS enchephalopathy and sub acute encephalitis. Other OIs associated with HIV/AIDS, namely cryptococcal meningitis, central nervous system toxoplasmosis, tuberculosis meningitis, as well as bacterial and viral meningitis may lead to a sensorineural hearing loss due to the damage it causes to the central nervous system and the hearing mechanism (Kohan et al., 1988 in Gold and Tami, 1998: 167 and Matkin et al., 1998:149). A 27% incidence of sensorineural hearing loss has been reported as being caused by cryptococcal meningitis (Matkin et al., 1998:150). These illnesses are not only significant because they are the most common neurological syndromes seen in AIDS patients, but also because they may result in a central hearing loss (Lalwani and Sooy, 1992 in Gold and Tami, 1998:167).

Furthermore, it has been verified that hearing loss can arise from viral central nervous system pathogens in AIDS. Cytomegalovirus, herpes simplex virus and herpes zoster virus and syphilis are some of these harmful pathogens. There is also a higher prevalence of otosyphilis in Individuals infected with otological complaints, infected with HIV/AIDS (Gold and Tami, 1998: 167). These speculations have been confirmed by the increased absolute latencies and interpeak latencies obtained when conducting auditory brainstem response tests and it can be explained by the evidence of demyelination of glial cells and neurons in the brainstem that was found in the AIDS

population. These effects increase with the progression of the disease (Lalwani and Sooy, 1992: 167).

In order to restrain the progress of the HIV-infection, antiretroviral drugs have been developed and are currently used to prolong the life of the infected person. November 19, 2003, the South African Cabinet decided on the establishment and implementation of an operational plan for comprehensive care and treatment of people living with HIV and AIDS. An estimated 230 000 individuals infected with HIV/AIDS were receiving ART by November 2006 (Government communication and information system. (retrieved on February 9, 2007, from http://www.doh.gov.za).

2.4.2.3 Ototoxic influences of ART

"Approximately 53 million individuals worldwide have been infected with the HI virus. More than 34 million are still alive today" (Orrel & Blockman, 2005:220). This suggests that millions of individuals worldwide are living with this disease today. South Africa alone has an estimated five million individuals infected with HIV/AIDS and more than 500 000 are at an advanced stage of the disease and require treatment (Farham, 2005:217 and Cohen, 2005:250).

Antiretrovirals is a relatively recent development in HIV/AIDS. Practically the whole world is committed to finding a cure for this fatal disease, but no success has been achieved yet. The drugs that have been developed and that are improved on a regular basis due to the need to ensure "*…improved tolerability and activity against resistant HIV strains…"* are known as antiretroviral treatment (Wood, 2005:255). It is given to individuals infected with HIV/AIDS to inhibit the progression of the disease. Vincristine, an antineoplastic drug, as well as antifungals such as amphotericin-B, immune modulators, aminoglycocides antibiotics, erythromycin and azidotymidine/zidovidune (AZT) are commonly used to treat HIV/AIDS and the opportunistic

infections. These drugs are known to be significantly ototoxic and are known to cause decreased hearing. *"Additionally, the use of experimental medications with relatively unknown toxicity as well as the use of ototoxic drugs in combination adds to the overall effect on hearing"* (Gold and Tami, 1998:167).

These drugs slow the progression of HIV/AIDS and increase the lifetime of the individual diagnosed with this fatal disease. Even though the primary goal is reached, namely a prolonged life for an individual infected with HIV/AIDS, it is important to realise that the well-being of these individuals do not only depend on the prolonged life given to him/her. The well-being of a person is subjective to the entirety of the ecological, social and cultural interactions experienced by the individual (Winkelstein, 1993 in Friedman et al., 1998:205).

2.5 THE QUALITY OF LIFE OF A PERSON WITH HIV/AIDS

"HIV is a terminal disease…This makes it a life-altering diagnosis, impacting on the biomedical, psychosocial and spiritual well-being of the patient" (Mngadi, 2003:259). As already confirmed, individuals with HIV/AIDS are faced with many challenges. These challenges are linked together in terms of cause and effect relationships, leading to a challenging cycle. Negative changes in the chemical, anatomical and physiological aspects of the human body together with the social and cultural responses of the individual's immediate environment can contribute to the general presentation and overall effects of any disease an individual may have (De Andrade and Ross, 2005:490). Winkelstein (1993) in Friedman et al. (1998:205), states clearly that the totality of the environment, social en cultural interactions that a human is experiencing, is probably the most important factor that influences a human's health status. HIV/AIDS may influence the person's physical health, leading to poor emotional and social well-being. However, HIV/AIDS may also have an influence on the social-cultural environment of this individual. Many individuals with

HIV/AIDS struggle with discrimination, prejudice, stereotypical thinking and judgemental issues (Friedman et al., 1998:210-211 and Johnsen, 1998:222). Housing, employment, social support and financial assistance may be challenging. The required professional assistance may be problematic too. *"During the initial recognition of the HIV/AIDS epidemic, health-care providers expressed concern for treating the HIV-infected population for various reasons, including personal fears of working with HIV/AIDS patients and attitudes that, given its terminal nature, the disease could not be efficiently or effectively treated... many people infected with HIV still cannot obtain adequate health care for a variety of reasons"* (Johnsen, 1998:216). These social-cultural and professional effects may aggravate the general impact on the social, emotional and physical health of the infected individual.

Nowadays diseases are viewed more holistically, especially when it comes to HIV/AIDS (Department of Health, 2001:11 retrieved on 9 February 2007 from http://www.doh.gov.za). Besides the medical treatment of the disease and the physical health of the person, other aspects such as social inclusion, psychological and emotional well-being as well as family and cultural facets must be considered. Individuals with HIV/AIDS are daily confronted by these medical, social and cultural aspects. These aspects will influence the quality of life of a person infected with this fatal disease. The person may easily become socially isolated or emotionally unstable due to the stigma surrounding HIV/AIDS or the lack of acceptance within the cultural group. Therefore, HIV/AIDS may even be disabling. Not only do some infected individuals have to fight for inclusion in their daily environment, but they also have to cope with medical complications (Johnsen, 1998:215).

One of these conditions that may have disabling effects is the decrease in hearing sensitivity. Hearing loss may lead to poor communication as well as reduced psychological, sociological, vocational and educational well-being (Gelfand, 2001:488). It may even lead to social isolation if

the necessary rehabilitation does not occur. "*AIDS has provided a challenge to the medical fraternity at large, calling for closer collaboration between curative and palliative care, demanding that curative medicine adopts higher levels of care, and that palliative medicine adopt a reasonable measure of cure*" (Mngadi, 2003:266).

Mngadi (2003:266) states that a holistic approach to dealing with HIV/AIDS should be the ultimate aim in terms of palliative care. This suggests that the response should start from the day of diagnosis, not just at the end of a person's life and that the patient care should be multidisciplinary in nature. Since a team approach is evidently necessary, audiologists must also be included and become part of the treatment of these patients. A team approach to treatment should be encouraged because apart from the fact that HIV/AIDS, with no intervention, is characterized by progressive deterioration of the underlying immune system, progress of this disease is also characterized by other factors including the person's social status (Mngadi, 2003:259).

When the CD4+cell count has reached less than 200 cells/mm^3 80% of the individuals dies within two years. ART administration can improve the life of an individual *"to a potential quality of 15 years"* should adherence to the ART be appropriate (Orrell and Blockman, 2005:220). However, the quality of life does not only depend on an individual's health status, but also his emotional well-being, considering the devastating fact that the disease is still fatal and that several personal losses may occur. It is a well known fact that poor communication and the inability to hear may lead to social isolation, thus to poor social status. Since investigations for hearing impairment in individuals with HIV/AIDS includes a complete audiological work-up (Lubbe, 2004:253), an audiologist should be part of this multidisciplinary team, to optimize communication in those persons with hearing impairment due to the disease.

2.6 THE INFLUENCE OF HEARING LOSS ON THE WELLBEING OF A PERSON

Efficient and successful communication is a major problem for patients with hearing loss (Williamson, 2004:26). Approximately 40% of individuals with a hearing loss, experience great difficulties to communicate with their partner and one in four individuals tend to avoid social events as a result of the hearing loss (Williamson, 2004:26). Social isolation becomes inevitable. *"Hearing loss can be a significant psychological cause of social withdrawal leading to increased feelings of isolation, lack of self-confidence and depression"* (Williamson, 2004:26).

An individual, already suffering from the thought of being infected with HIV, might therefore even more so, experience social isolation and depression. This advocates the involvement of the audiologist in the care and treatment plan of individuals infected with HIV/AIDS, even in terms of prevention of depression by early identification and treatment of a hearing loss.

2.7 SUMMARY

HIV/AIDS is probably the most challenging medical situation of modern times. The world has committed itself to developing a cure for this disease, but with no success to date. Antiretroviral drugs are currently the only medical treatment available to prolong the life of a person diagnosed with HIV. When the disease has progressed to an advanced stage, the individual will require ART to slow the progression of the disease. Unfortunately, the disease is still fatal and the ART has various side effects.

Apart from the ototoxic properties of ART that influence hearing, the disease itself also manifests in many disabling conditions which reduce the quality of life of a person. It often happens that a person infected with HIV/AIDS gets cut off from people when he/she looses his/her ability to hear and thus also to communicate optimally due to the hearing loss diminishing the individuals quality

of life. The literature regarding the influence of HIV/AIDS on the hearing mechanism and the number of research projects that have been done on this topic are limited.

"Our greatest happiness does not depend on the condition of life in which chance has placed us, but is always the result of a good conscience, good health, occupation, and freedom in all just pursuits"

(Thomas Jefferson, 1743-1826).

CHAPTER THREE

METHODOLOGY

"To answer some research questions, we cannot skim across the surface. We should dig deep to get a complete understanding of the phenomenon we are studying…We collect numerous forms of data and examine them from various angles to construct a rich and meaningful picture of a complex, multifaceted situation"

(Leedy, 2001: 147).

3.1 INTRODUCTION

Chapter three contains the main aim and sub-aims with a discussion of the applicable research design, subject selection, material (for subject selection and data collection), procedures (for subject selection, data-collection and data-recording), the pilot study, validity and reliability and ethical issues. The research focussed on determining a hearing profile of persons infected with AIDS. The research was based on the fact that more and more audiologists will be confronted with individuals who contracted HIV/AIDS and even though more is known about this disease, there is still a lack of knowledge and a need to know more (Bankaitis, 1998:117-118). The attempt to gain more specific information regarding the stages of HIV/AIDS and the type and degree of hearing loss are fundamental to this research. The research was carefully planned and documented to ensure repeatability and reliability and to ensure that the research question was answered.

3.2 RESEARCH AIMS

Various research objectives were identified to provide information regarding the influence of HIV/AIDS on the hearing ability of a participant, more specifically to establish a profile of hearing for persons infected with HIV/AIDS at different clinical stages of this disease. The following main aim will provide information to conduct the research project successfully:

3.2.1 Main aim

To determine the hearing profile of persons infected with HIV/AIDS at different stages of this disease and the participant's exposure to medicine with ototoxic components related to this disease.

3.2.2 Sub-aims

The following sub aims were identified in order to succeed in determining the answer to the main aim:

3.2.2.1 Sub-aim 1

To determine a hearing profile of persons who were diagnosed as being in any one of four different clinical stages of HIV/AIDS by considering the case history, otoscopic examination findings, pure tone air- and bone audiogram, speech discrimination results, immittance measurements, distortion product oto-acoustic emissions [DPOAEs], and auditory brainstem response of each participant with HIV/AIDS.

3.2.2.2 Sub-aim 2

To compare the hearing profile of the participants in the different clinical stages of HIV/AIDS (as mentioned above) and to identify if different hearing profile results were obtained for the four different clinical stages of HIV/AIDS with regard to the case history, otoscopic examination findings, pure tone air- and bone audiogram, speech discrimination results, immittance measurements, distortion product oto-acoustic emissions [DPOAEs], and auditory brainstem response of each participant with HIV/AIDS.

3.2.2.3 Sub aim 3

To compare the hearing profile of persons within each of the different clinical stages who did and who did not receive medication with ototoxic components (Antiretroviral therapy and anti-tuberculosis drugs containing streptomycin and amikacin) for treatment of HIV/AIDS and HIV/AIDS-related illnesses.

3.3 RESEARCH DESIGN

The research approach used for the purpose of this research project was a combination of a quantitative and quantitative research approach and various research designs were utilized for different phases of the study. The general organization and structure for the measures and procedures used during the collection and analysis of the data for the research can be described the research design (Leedy, 2001:91). "*The central aim of research design was to establish a relationship between the independent and dependent variable with a high degree of certainty*" (Bless and Higson-Smith, 1995:82). For the purpose of this research project, the research was divided into phases, since different research approaches and research designs were used.

3.3.1 Phase one: The structured interview and the otoscopic examination

To gain knowledge and insight into the medical history, otological complaints and observable landmarks in the external ear canal and tympanic membrane, the researcher followed a qualitative research approach. Analysing data through a qualitative research approach permitted the researcher to describe particular characteristics of a certain research population (Leedy and Ormrod, 2001: 101), in this case the external ear canal, tympanic membrane, medical conditions and otological complaints present in individuals with HIV/AIDS. The information obtained during phase one of the research project was difficult to quantify since the researcher cannot provide for all possible answers, especially considering that HIV/AIDS may affect each individual in an unique

way. Following a qualitative approach ensured that the unique characteristics were observed, collected, analysed and described. A descriptive survey analysis was utilized as research design during phase one of the research project. Quantification was used where possible to determine the characteristics of medical and otological complaints and conditions. Phase one of the research project was conducted through a structured interview, with the opportunity to provide more information where needed in order to collect the relevant data. By utilizing the descriptive survey design, the researcher was able to obtain information directly from the participants (Dane, 1990: 120). Descriptive research implies the study of a phenomenon in order to define the phenomenon more fully (Dane, 1990:6). Therefore, a descriptive approach enabled the researcher to define and describe the medical and otological complaints and observed characteristics of the external ear canal and tympanic membrane of a group of people in different clinical stages of HIV/AIDS in order to provide an accurate profile of this particular group (Neuman, 1997:20). Bless and Higson-Smith (1995:42) specifies that descriptive research needs to be conducted in order to gain insight into a situation, phenomenon or person. The structured interview is included in appendix F, discussed in section 3.5.1.1.1 and table 3.9 contains the design and purpose of the structured interview.

3.3.2 Phase two: Basic and specialized audiometry

Numerical values were obtained from the basic and specialized audiometry that was conducted on each participant. The results from the basic and specialized audiometry were recorded in terms of intensity and frequency on the pure tone audiogram and intensity and percentage of word discrimination on the speech audiogram, the number of oto-acoustic emissions present or absent, the wave latency values of the auditory brainstem response, as well as volume, compliance and pressure on the immittance results. These results were recorded as numerical values and were put into frequency tables referring to specific characteristics that could be described. Neuman (1997:30, 294) suggests that quantitative data is numerical in nature and is obtained from specific

measurements. Inferential statistical analysis, of these numerical values, was performed to gain more knowledge and insight on the characteristics of hearing loss in people with HIV/AIDS (Leedy, 2001: 103). Research results obtained from a quantitative research approach and the inferential statistical analysis enabled the researcher to compare the results with the normal values set in the literature for the different hearing assessments, but also to draw a comparison between the different groups (stages of HIV-infection) involved in the research. Quantitative analysis also allowed the researcher to identify possible correlations between the variables that were examined. Neuman (1997:107) states that variables are a central idea in quantitative research and are defined as a concept that varies. This suggests that all the different variables are recorded and analysed in order to be able to identify profiles of hearing and to be able to answer the research question finally.

The independent variable, according to Neuman (1997:107), can be seen as the cause variable, in other words the variable that "*identifies forces or conditions that act on something else*". HIV/AIDS status was identified as the independent variable, because HIV/AIDS is the condition that affects the hearing profile of the person. Neuman (1997:107) further concludes that the phenomenon that is the effect or the result of another variable is called the dependent variable. The hearing profile that was caused by HIV/AIDS is the dependent variable. This hearing profile was obtained by conducting an otoscopic examination, pure tone air-and-bone thresholds, immittance testing, DPOAE-testing and ABR-testing. Neuman (1997:107) also notes that the attribute is a value or category of the variable and it can be identified during the planning of the research. The attribute of the independent variable is the different clinical stages of the HIV/AIDS and the attributes of the dependant variable are the type of hearing loss and the different degrees into which the hearing loss are divided.

The unit of analysis refers to "*the objects about which the researcher would like to answer questions*" (Dane, 1990:176). The statistical group formed the unit of analysis for the purpose of

this research project, because the group of people with HIV/AIDS had a mutual characteristic that is central to the research question. Thus, in this study, a group of people with HIV/AIDS infection served as the unit of analysis. The unit of analysis is studied by measuring the units of observation and the information will be collected and interpreted (Dane 1990:176). The units of observation in this case are the results from the audiological test battery as well as the blood results (CD4+ cell count) of each person investigated. Data was collected on an individual level (information from the individual with HIV/AIDS), but the aggregate was interpreted for analytical purposes.

Combining two research approaches enabled the researcher to gain more knowledge about the influence of HIV/AIDS on hearing than when limited to one research approach (Leedy, 2001: 101). This assisted the researcher with the investigation and description of the hearing profile in participants with HIV/AIDS. The focus was specifically on determining and describing the otological complaints and conditions and the type, degree and nature of hearing loss based on the relationship between basic and specialized audiometry in terms of the stages of HIV/AIDS, the presence of medical conditions associated with HIV/AIDS and the history of exposure to ototoxic drugs related to the treatment of HIV/AIDS related illnesses. Therefore the research can be described as applied research, since it attempts to generate a theory that can be applied within a context. In this case, it must be used in the field of HIV/AIDS and hearing loss.

A cross-sectional design according to Dane (1990:110), *"involves one measurement of different groups that represent different time periods".* All the participants were not in the same clinical stage of HIV-infection. The participants were grouped into the various clinical stages of HIV-infection. The results for all the participants within a certain clinical stage were identified, analysed, described and compared to identify concurrent and general traits. This research design was applicable to both phases of the research since it investigated characteristics of different groups within a specified context and timeframe.

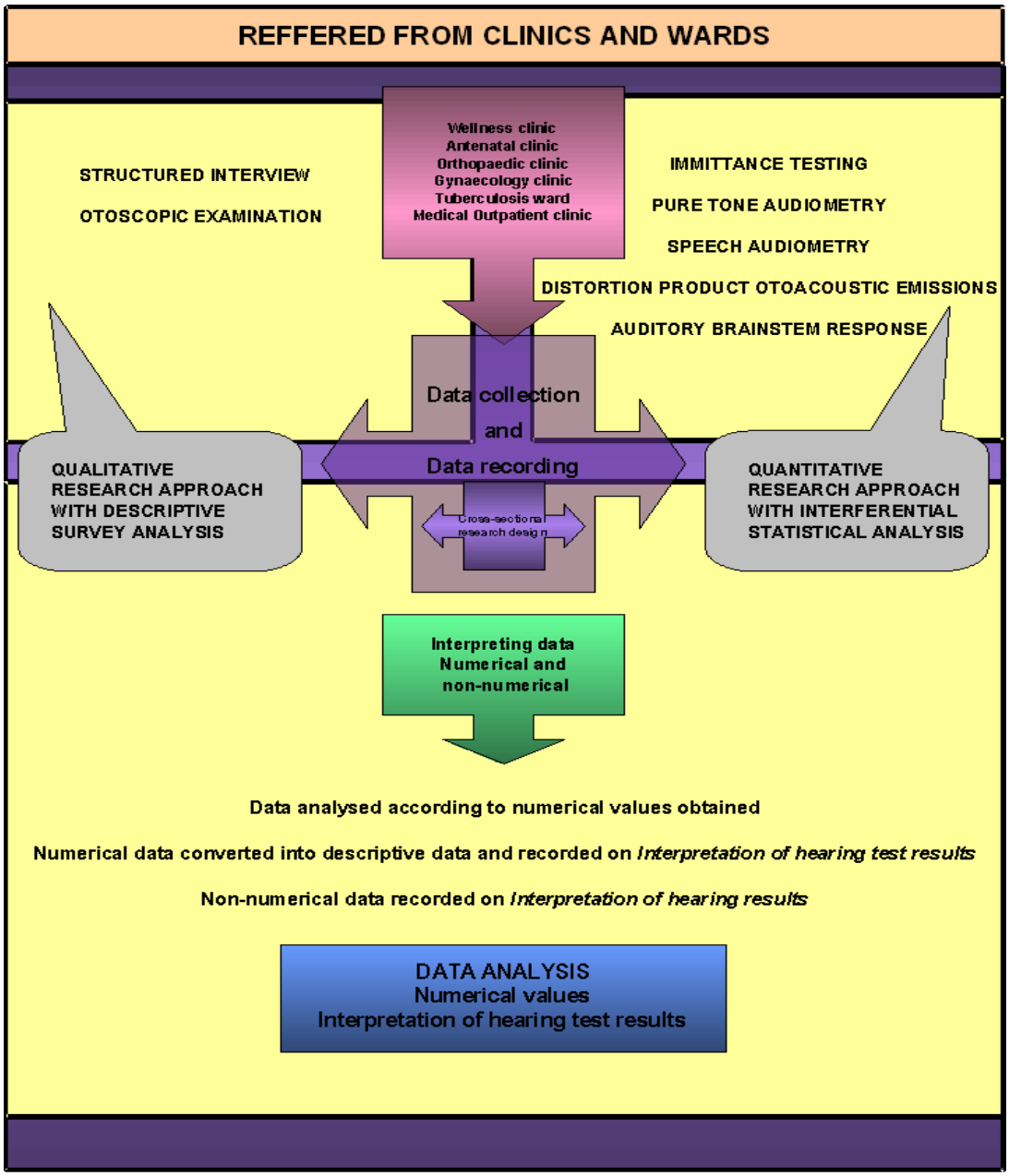


Figure 3.1: Phases of the research process

Figure 3.1 gives a classification of all the phases in the research process in the data collection of this research project. It is important to realise that different designs were used at different stages of the research. During the initial data collection, a qualitative research approach was followed for the completion of a structured interview and otoscopic examination, while for the gathering of basic and specialised audiometry values a quantitative research approach was used.

3.4 SAMPLE

"A sample is classified according to the way in which the items it comprises were chosen from the population" (Willemse, 1994:13). The sample consisted of individuals from the total collection of subjects the researcher wanted to investigate and draw conclusions from (Easton and McColl, retrieved from http://www.stats.gla.ac.uk on November 4, 2006). Thus, the data was collected from a subset of individuals that belonged to the larger group of individuals infected with HIV/AIDS.

3.4.1 Sampling

Reliable sampling methods implicate a well-defined population, a sufficiently selected sample and an estimation of the representation of the whole population (Neuman, 1997:201). Stratified random sampling and simple random sampling ensured a more representative research population. After the randomized sampling took place, the researcher determined if the sample complied with the following predetermined selection criteria.

3.4.2 Selection criteria

Participants had to adhere to the following requirements before their participation in this study was accepted:

3.4.2.1 Age

The participants had to be between the ages of 18 to 50 years. This age group was selected in order to ensure that presbycusis, hearing loss due to degenerative changes associated with ageing, did not influence the audiological results obtained, but also to ensure that the participants were old enough to give informed consent and did not need to have a parent or caregiver present. Williamson (2004:24) states that age-related hearing loss frequently commences at around 50 years of age. Debonis and Donohue (2004:78) described presbycusis as a hearing loss that affects

the high frequencies to a larger extent than the low frequencies. Presbycusis starts early in adulthood, but only becomes significant between the ages of 65 and 75 years of age (NIDCD, 2006 retrieved from http://www.nidcd.nih.gov on November 4, 2006). This explains why this particular age group was selected to participate in this study. This age group was also selected because HIV/AIDS is "*prevalent between 15 and 50 years of age, the most economically productive age group in most countries, and indeed HIV is now the most common cause of death in this age group in some parts of the world*" (Haslett et al., 1999:87).

3.4.2.2 HIV-status

The participants had to be diagnosed with HIV/AIDS with a recent, not older than 30 days, CD4+ cell count. The diagnosis had to be made by a qualified medical doctor. *"Viral infections may produce sensory hearing loss. With the expected increases in individuals who test positive for HIV, hearing loss related to viral and bacterial infections may increase dramatically over the next few years"* (Kelly et al., 1994:186)

3.4.2.3 History of exposure to noise

The participants had to have no history of practising an occupation or hobby that involved extreme noise exposure. Extreme noise exposure could cause a loss of hearing sensitivity and lead to unreliable research results. Hall and Mueller (1998:266) stated that the person *"should not have a history of exposure to high levels of any kind of sound (noise or music)".* According to Martin (1997:304) a typical configuration of hearing loss related to noise exposure has emerged that is characterized by a decrement of hearing thresholds at 3000Hz to 6000Hz with a recovery at 8000Hz. As a rule, the degree of NIHL is similar bilaterally (Martin, 1997:304). Therefore the subjects should not have been exposed to high noise levels which can contaminate test results.

3.4.2.4 Geographical area

For logistical purposes the potential participants had to be patients at Klerksdorp Hospital/Tshepong Hospital Complex in the North-Western Province. This institution has one of the best functioning wellness centres in South Africa and in order to improve the service, the institution and clinics were encouraged to take part in research.

3.4.2.5 No family history of hearing loss in terms of genetic conditions

The potential participants had to have no family history of hearing loss. If a genetic deviation formed part of the participant's history, the precise influence of HIV/AIDS and the ARVD therapy on the nature of the hearing loss would not be accurately determined, because the participant already had a predisposition for developing a hearing loss. The accuracy and reliability of the research would then be compromised.

3.4.2.6 History of administration of ototoxic drugs

The potential participants must have no history of exposure to ototoxic medication not related to the treatment of HIV/AIDS. *"Degenerative changes may occur in the inner ear as a result of the use of certain drugs that are ototoxic"* (Debonis and Donohue, 2004:237). Ototoxic drugs can have damaging effects on the cochlea and the vestibular system. These drugs include certain antibiotics, quinine, salicylates (aspirin), some diuretics, and chemotherapy agents such as gentamycin, amikacin, streptomycin, kanamycin, neomycin, tobramycin, ethacrynic acid, furosimide, and cisplatin (Debonis and Donohue, 2004:237). Debonis and Donohue (2004:237) also note that the effect of the various ototoxic drugs is not always consistent among individuals. Factors which influence the general ototoxic effect of the drugs on the auditory system of an individual are subject to the participant's health, the kidney functioning, the amount and duration of the exposure to the ototoxic agent and the participant's susceptibility to the drugs (Debonis and

Donohue, 2004:237). For the purpose of this research project, the duration of the exposure and the participant's current health status were taken into account. Therefore, participants who had a history of exposure to ototoxic drugs not related to treating HIV/AIDS were excluded in order to ensure that antiretrovirals were the only drugs that influenced the hearing ability of an individual.

3.4.2.7 Informed consent

Each person participating in this study had to give his/her full voluntary informed consent before the commencement of the research project. This implied that the participant had to make a voluntary decision to participate in the research based on the information that the researcher provided to him/her (Dane, 1990:40). Informed consent is a concept exercised by many internationally, especially regarding research on people. According to the International Guidelines on HIV/AIDS and Human Rights, *"informed consent is an ethical principle deeply embedded in the medical profession"* (Heywood, 2000:26). Based on the knowledge and information provided, the person should voluntarily decide whether or not to take part in the research project.

Furthermore these guidelines state that if a person should undergo any medical procedure, he/she should understand the procedure, the reasons for the procedures and the consequences of the procedures to be done to comply with prerequisites for research in the human sciences. Signed informed consent is one of these prerequisites when conducting research on individuals, consequently ethical clearance was obtained from the University of Pretoria's ethical committee (Appendix B). Therefore this was the most important criterion the potential participant had to comply with before commencement of the research. Information was provided to the researcher consisting of all the relevant issues that would influence the participant's choice regarding his/her agreement to participate.

3.4.3 Sample selection procedures

The stigma surrounding HIV/AIDS is a sensitive subject. The selection of a research population involved a system of goal-orientated steps and criteria for the identification of participants to participate in the research. These goal-orientated steps included obtaining informed consent from the hospital, research assistants and potential subjects, a randomized distribution of the patients' files among the doctors within the different clinics (including the research assistant), determining the compliance of the potential subject to the research criteria. Some of these goal-orientated steps, such as the structured interview, were also used as data-collection method. However, it is important to see the two sections of the structured interview (appendix F, discussed in section 3.5.1.1.1 and table 3.9), even though using the same tool, as separate procedures.

According to Bless and Higson-Smith (1995:87), it is of great importance that a sample is well defined and described with absolute accuracy in order to be analysed via an operational definition. This operational definition ensured that an accurate sample was selected from the population for this research project. The sample was a subset of the population and it had properties that made it representative of the whole (Bless and Higson-Smith, 1995:88). "Random samples are most likely to yield a sample that truly represents the population" (Neuman, 1997:208). For the purpose of this research project, a combination of stratified random sampling and simple random sampling were used to ensure that the subjects were randomly selected and to assure that *"every member of the population of the Klerksdorp/Tshepong Hospital complex had an equal opportunity to be included in the sample"* (Dane, 1990:238).

Willemse (1994:15) explained that stratified random sampling specifically ensures that various uniform groups within a particular population are completely representative of all types of items within the population. The researcher strived to compile groups of participants that represent each

clinical stage of HIV/AIDS by using "*random selection separately for each subgroup in the sampling frame"* (Dane, 1990:299). However, the intense ethical issues concerning this research project, the sensitive nature of the research, the various criteria that had to be met prior to granting participation, and most importantly, because full voluntary consent had to be obtained prior to commencing with the research, made it difficult for the researcher to estimate how many participants would be willing to participate. Thus, it was also difficult to ensure that the participants would be equally distributed across the four clinical stages of HIV/AIDS. Therefore random sampling took place prior to the commencement of the research, and then after the participant gave full voluntary consent, various selection steps were followed to determine if the potential participant complied with the selection criteria. As randomization was performed prior to the commencement of the research, all results were used to record and analyse data.

The following table provides a depiction of the procedure that was followed to select an appropriate sample for the research project. This sample selection process was complicated and to clarify the process followed, a schematic presentation of the various steps followed for sample selection purposes is depicted in figure 3.2. The following formed part of the sample selection procedures in this particular order:

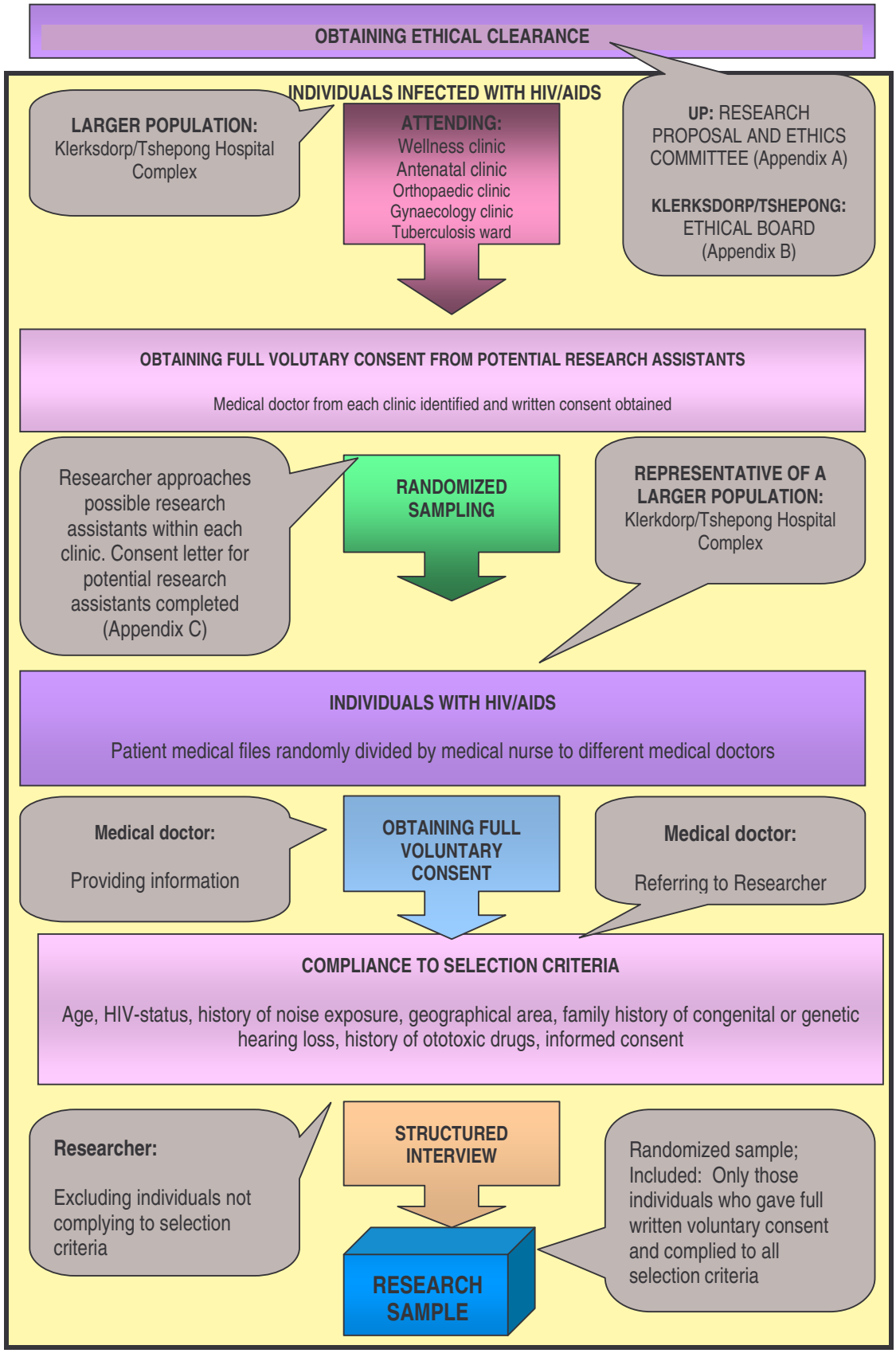


Figure 3.2: Procedures followed to select the appropriate sample for the research project

3.4.3.1 Obtaining ethical clearance (Appendix A and B)

The Ethical Board of Klerksdorp/Tshepong Hospital Complex within the Northwest Province was contacted. The research was presented to the Ethical Board to obtain ethical clearance for the conduction of this research project. This implied presenting the research proposal to the Ethical Board of the hospital and being available to answer queries that the ethical board had (Appendix A). Ethical clearance was also obtained from the Research Proposal and Ethics Committee of the Faculty of Humanities, University of Pretoria, before actual research and testing was commenced (Appendix B).

3.4.3.2 Obtaining informed consent from the Ethical Board of Klerksdorp/Tshepong Hospital Complex, hospital management and the potential research assistants (Appendix C)

The participation in the research project had to be voluntarily. Dane (1990:40-41) noted that it is important to provide the potential participants, in this case research assistants[1], with the necessary information regarding a research project and he defines the concept of "necessary information" as all information that could possibly affect the potential participant's choice to participate. The cover letter (Appendix C) was used to give the necessary information to the Ethical Board of Klerksdorp/Tshepong Hospital Complex. It also provided the needed information to the potential group one participants. In addition, this letter served to obtain voluntary written consent by signing the consent form attached to the cover letter (Appendix C), thus it served as a selection procedure. Information was given to the hospital management and participants from group one granting the application for the research at the hospital. This information was provided in the form of a letter

[1]The research assistants consisted of one medical doctor and one nurse in each identified clinic or ward. These research assistants are referred to as participants, since written consent had to be obtained from them in order to justify their participation in this research project. For the purpose of this research project and to prevent confusion, the medical doctors and medical nurses are referred to as participants from group one.

(Appendix C). Attached to the cover letter was a consent form (Appendix C) that served as an agreement that all information obtained from the patient in the presence of any participant from group was to be handled with the greatest care and confidentiality. Based on this principle and these guidelines that are given by Neuman (1997:450), the cover letter (Appendix C) was used to give the following information to the Ethical Board of Klerksdorp/Tshepong Hospital Complex:

- The identity of the researcher;
- The goal of the research study and relevant aspects that were to be researched;
- The assurance that confidentiality of every research assistant in this research project was to be kept, as well as an explanation on how the confidentiality would be kept;
- The assurance that participation in this study would not cause any disadvantages for the research assistants at work;
- A written agreement that the research assistant voluntarily made the decision to participate in the study and that at any given point in the study the participant could withdraw from the study;
- A written agreement that the research assistant agreed to keep all information obtained from the participant, strictly confidential.

Klerksdorp/Tshepong Hospital Complex already had an established HIV/AIDS health care clinic five days of the week. The Head of the Internal Medicine Department, the Medical Manager of Tshepong Hospital and the Medical Manager of Klerksdorp Hospital was contacted to determine their interest and willingness to participate in this study. The above-mentioned written consent letter was given to the Ethical Board of the Hospital Complex to sign (Appendix C).

3.4.3.3 Obtaining informed consent from the potential participants (Appendix D)

The right to make a free choice regarding participation in this study was recorded (from the patients[2]) by the researcher during the planning of this research project. Neuman (1997:450) notes that potential participants have the right to freedom of choice for participation in research projects, while Dane (1990:58-59) emphasizes freedom of choice without any pressure. *"A general common law protects the patient's rights at the time when medical procedures are conducted. Although no uniform federal statutory law states so, explicitly based on this common law, it is illegal for health-care workers to perform medical procedures without the patient's full, informed consent"* (Johnsen, 1998:220). Even though the research did not require direct and immediate medical procedures, it did involve the use of medical records and previous blood test results of patients, suggesting research in Humanities. Therefore, informed consent must be considered when conducting the research (Neuman, 1997:450), especially in the field of human sciences.

One medical doctor and one nurse working in a particular clinic, who agreed to participate in the research project, explained the research and the reason for the research to each potential participant to determine his/her willingness to participate. The nurse was used as an interpreter when a potential participant did not understand the information. The research and the reason for the research were explained to them (Neuman (1997:450). After the research had been explained to the potential participants, a covering letter (Appendix D) was handed to each participant who decided to participate in this research project. This letter included a consent form (Appendix D) that served to obtain full voluntary written consent for his/her voluntary participation in the research

---

[2]The group that were researched consisted of patients who were diagnosed with HIV/AIDS. These patients were potential participants and they had to give full voluntary written consent in order to be included in this research project. Since the doctors and nurses also had to sign consent and were also seen as participants in this research project, the researcher felt it necessary to refer to the patients who participated as participants from group two.

project. This consent letter clearly stated that the participant's participation in the research project would not affect him/her socially or occupationally because all information and results were to be handled confidentially. The participants were then referred to Klerksdorp Hospital's Audiology Department for a complete battery of hearing tests.

Also based on the principle and guidelines set by Neuman (1997:450), the covering letter was used to give the following information to the potential participants:

- The identity of the researcher.
- The goal of the research study and relevant aspects that were researched.
- The procedures that were to be conducted and the information that was to be used from the medical files.
- The assurance that confidentiality of every participant in this research project was to be kept.
- The assurance that participation in this study would not cause any disadvantages to the research assistants at work.
- A written agreement that the participant voluntarily made the decision to participate in the study and that at any given point in the study he/she could withdraw from the study.

3.4.3.4 Dividing the medical files of the patients: randomized sampling

The researcher identified a medical doctor and a medical nurse (group one participants) in seven different clinics. These clinics were the wellness clinic, medical outpatient clinic, orthopaedic clinic, gynaecology clinic, antenatal clinic, tuberculosis clinic / ward or Park Street Clinic. Each doctor and nurse working at a particular clinic or ward gave his/her full voluntary consent for participation in the research project (Appendix C). The doctor and nurse were informed again regarding various

issues of this study and their responsibility to be part of this research project. Within each clinic medical patient files were equally divided between the different doctors working in the particular clinic. Only one doctor for each clinic was identified to assist the researcher with the research project, and the staff nurse who also gave her full voluntary consent for participation in the research project, randomly assigned files to the doctors working in a certain clinic. This means that the medical doctor and the medical nurse were the first to make contact with the potential participants. By the time the medical doctor examined the patient, he received a randomized sample of the patients attending the clinic. Dane (1990:100) states clearly that random assignment of patients "*eliminates alternative explanations"* and is "*essential to true experiments*".

3.4.3.5 Completing the structured interview

The researcher conducted the interview with the participant after receiving the referral card (Appendix E) from the doctor. The researcher explained the research project to the potential participants again and the researcher again determined if they still wanted to participate in the research. If they wanted to terminate participation, the researcher still assisted them if they required assistance. If they did agree to participate, the researcher continued the interview with the participant to determine if the participant complied with the selection criteria. This structured interview (Appendix F) was only completed with the potential participants with HIV/AIDS who gave full voluntary consent to participate in this research project.

To obtain the information, a structured questionnaire (Appendix F) was used, but in the form of an interview to determine whether each participant complied with the necessary selection criteria. Information regarding the gender, age, race, referral clinic, medical condition and HIV/AIDS status, history of otological conditions before and after being diagnosed with HIV/AIDS, history of surgery to head and neck areas, history of trauma, occupational history, noise exposure and other relevant

issues were determined from this structured questionnaire. If they complied with all the selection criteria, they qualified to participate in the research. The structured interview was completed in the presence of an interpreter, if required by the participant or researcher. If a participant did not comply with all criteria, but wanted to have his or her hearing evaluated, pure tone air- and -bone conduction testing was performed, results were explained to the person and if the person qualified for a hearing aid, a hearing aid fitting was scheduled. If there were no hearing aids available due to exhaustion of funds, the patient was placed on the waiting list for hearing aids.

3.4.4 Sample size

Willemse (1994:12) explains that the number of participants or items a sample consists off *"should be large enough to minimize the influence of abnormal items on the average".* The law of inertia of large numbers explains that data collected from a larger group shows more reliability and constancy than data collected from smaller groups (Willemse, 1994:12).

The most important selection criterion was the provision of full voluntary consent to participate in the research project. Unfortunately this disease is "*surrounded by ignorance, prejudice, discrimination and stigma*" (Department of Labour, 2000:1), which explains why many potential subjects did not agree to participation in this research project.

The following table provides an explanation of the number of subjects who participated willingly in the research project and the number who complied with the selection criteria were qualified to participate in terms of the selection criteria.

Table 3.1: Description of potential sample (n=54)

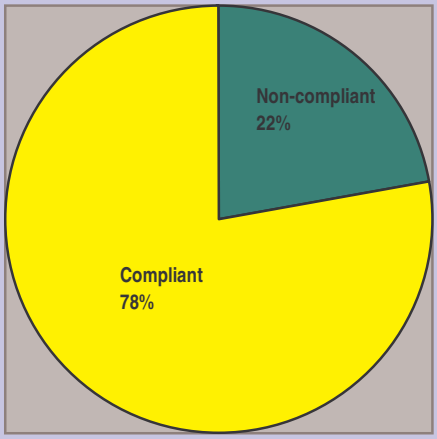
SAMPLE POPULATION	DIAGRAM SPECIFYING THE GENDER AND AGE OF THE PARTICIPANTS
Twelve of the 54 (22%) participants who provided their full voluntary consent could not be part of the research project because they either had a history of noise exposure or they had a history of trauma that was the cause of the hearing loss they experienced. Eleven (20%) of these participants were mining employees who were exposed underground in extreme noise levels and one (2%) participant was abused as a child and since then she experienced a hearing loss. Forty-two (78%) participants complied with all the selection criteria.	 **Figure 3.3: Demonstration of compliant against non-compliant participants contributing to sample (n=54)**

Figure 3.3 in table 3.1 provides a clear description of the participants who provided full voluntary consent to participate in the research project. The HIV status of 54 (22%) participants who provided full voluntary consent's hearing profiles were determined in order to provide the researcher with significant and reliable results. All these participants who provided their full voluntary consent then had to comply with the necessary requirements for this particular research project. Only 42 (78%) of the 54 persons who provided their full consent complied with the rest of the selection criteria.

3.4.5 Description of research population

The research population, as a result of all the above-mentioned selection criteria, consisted of all patients attending the wellness clinic, medical outpatient clinic and the orthopaedic outpatient clinic

at the Tshepong hospital, as well as the antenatal clinic, gynaecology clinic and the tuberculosis ward and clinic at Klerksdorp Hospital. The local public clinic, named Park Street Clinic, also formed part of the research project. Initially, the staff sister working in the same clinic as the medical doctor, who was assigned to the research project in advance, randomly assigned the patient medical files to a medical doctor working in a particular clinic. *"The law of statistical regularity holds that a reasonably large number of items selected at random from a large group of items will, on the average, have characteristics representative of the population"* (Willemse, 1994:12). The sample was distributed in the following categories, namely age, gender, CD4+ cell count and associated illnesses, exposure to ototoxic medication and referrals from identified clinics to determine the influence these variables had on the hearing profile of a person infected with HIV/AIDS:

3.4.5.1 Age

The participants were categorized into three different age groups in order to determine if the hearing sensitivity of participants in certain age groups is more susceptible to HIV/AIDS and the related ototoxic medication. The subsequent table provides a description of the participant age variation for this research project. Age group categories with the mean, standard deviation and age ranges are described.

Table 3.2: Participant's age variation according to three age group categories (n=42)

AGE GROUPS	MEAN	PERCENTAGE	STANDARD DEVIATION
18-30	7	17%	0.39
31-40	23	55%	0.51
41-50	12	28%	0.51

Table 3.2 portrays the age variation of the research population. The research population consisted of seven (17%) participants of 18-30 years, 23 (55%) participants of 31-40 ears and 12 (28%) participants of 41-50 years. The median age of the total population was 31 to 40 years.

3.4.5.2 Gender

The research population consisted of males and females. The next table provides a description of the distribution of males and females within the research project.

Table 3.3: Participant gender variation (n=42)

GENDER CATEGORY	MEAN	PERCENTAGE	STANDARD DEVIATION	RANGE
Male	19	45%	0.50	Male
Female	23	55%	0.50	Female

Table 3.3 indicates the categorization of participants into gender, male and female, in order to determine if the gender of a participant influences the susceptibility to either the HIV-infection or ototoxic medication. In total, 19 (45%) of the participants were male with a standard deviation of 0.5, while 23 (55%) were female with a standard deviation of 0.5. Overall, 10% more females were involved in the research project compared to male participants. The following table provides a description of the population into the gender and age groups to determine the number of female participants in each different age group, as well as the number of male participants in each different age group.

Table 3.4: Description of research population into gender and age groups (n=42)

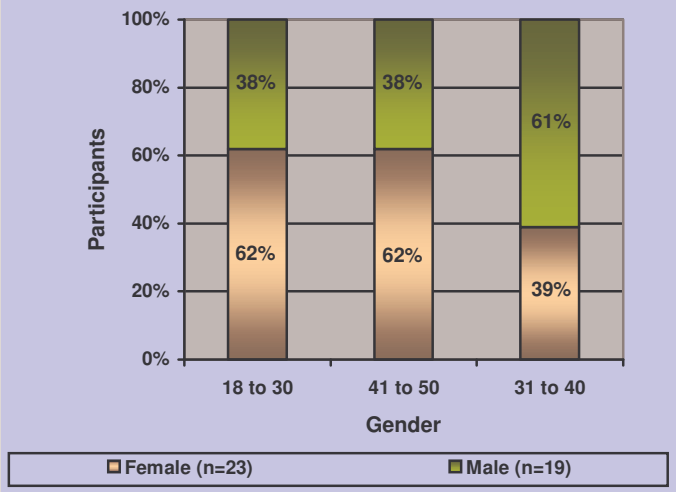
RESEARCH POPULATION	DIAGRAM SPECIFYING PARTICIPANT GENDER AND AGE
In the age group 18-30 years, five (62%) females and three (38%) males participated. The age group 31-40 years consisted of 13 (62%) females and eight (38%) males while, the age group 41-50 years consisted of five (39%) females and 8 (61%) males.	

Figure 3.4: Description of the gender and age of participants (n=42)

Table 3.4 specifies that female participants were mainly between 31 to 40 years. An equal number of male participants were between 18 to 30 and 41 to 50 years. The least number of male participants were between 18 to 30 years.

3.4.5.3 CD4+ cell count and associated clinical stage of HIV/AIDS

The participants were classified into the four different clinical stages of HIV/AIDS according to the classification model established by Evian (2000:26). The classification of the participants was based on the CD4+ cell count only. However, the presence of AIDS-defining illnesses in a particular patient was determined to establish associated hearing loss with certain conditions. The classification of the participants into the four clinical stages of HIV/AIDS according to the CD4+ cell count (Evian, 2000:26) is indicated in Table 3.5 below:

Table 3.5: The classification of participants into clinical stages of HIV/AIDS (n=42)

CLINICAL STAGE OF HIV INFECTION	NUMBER OF PARTICIPANTS	PERCENTAGE	STANDARD DEVIATION	RANGE
I	6	14%	0.35	More than 500-600 cells/mm^3
II	8	19%	0.40	350-500 cells/mm^3
III	8	19%	0.40	200-350 cells/mm^3
AIDS	20	48%	0.51	Less than 200 cells/mm^3

Table 3.5 indicates that most participants were in Stage IV of the HIV/AIDS disease, suggesting that the participants had AIDS. Six (14%) participants had a CD4+ cell count of more than 500-600 cells/mm^3 with no AIDS-defining illnesses present. These patients were classified to be in Stage I of this illness. Eight (19%) of the participants were classified to be in stage II of the illness, since the CD4+ cell count was between 350 and 500 cell/mm^3 and eight (19%) of the participants were classified to be in stage III, as the CD4+ cell count was between 200 and 350 cells/mm ^{3}. Twenty (48%) participants had AIDS (stage IV), given that the CD4+ cell count was less than 200 cells/mm^3 and the participant had at least two AIDS-defining illnesses.

3.4.5.4 Exposure to ART and ototoxic medication

The next table indicates the four categories of ototoxic drug exposure for the complete population that participated in the research project. The category division for exposure to ototoxic drugs was based on those participants who had not received any treatment yet and those who were exposed to only Anti-Tuberculosis-related drugs or antiretroviral therapy or both.

Table 3.6: Number of participants exposed to ototoxic medication (n=42)

EXPOSURE CATEGORY	MEAN	PERCENTAGE	STANDARD DEVIATION	RANGE
1	10	24%	0.43	No history of ototoxic exposure
2	19	45%	0.50	ART[3]
3	8	19%	0.39	Regime II/MDR[4]
4	5	12%	0.32	ART and Regime II/MDR

In total, thirty-two (76%) participants were exposed to ototoxic drugs. Ten (24%) of the participants had no exposure to ototoxic drugs and eight (19%) were exposed to Regime II/Multi-drug-resistant (MDR) treatment (containing ototoxic agents namely streptomycin and amikacin) for the treatment of Tuberculosis. Only five (12%) participants were exposed to both ARVD and Regime II / MDR treatment. Twenty (45%) participants received ARVD treatment.

It is important to keep in mind, though, that the health status of a person serves as a determining factor for the susceptibility to ototoxic drugs. Therefore the subsequent table provides an explanation of the types of ototoxic treatment which participants with HIV/AIDS received.

---

[3] For the purpose of the research project, ART is defined as anti-retroviral therapy used for the treatment of HIV/AIDS. ART aims to sustain long-lasting HIV viral load suppression, allowing the recuperation of the human immune system (Orrell and Wilson, 2003:308). Administering ART and good compliance to ART administration guidelines result in a reduced risk for the development of opportunistic infections (Orrell and Wilson, 2003:308). *"Antiretroviral drugs are categorized into groups according to how the drug interferes with retroviral reproduction....however, the primary mechanism typically involves interference with one or more of the enzymes required for retroviral reproduction"*(Bankaitis and Schountz, 1998:158). Therefore, for the purpose of the research project, the ART is seen in totality and not analysed according to each drug the ART consists off at a given time.

[4] For the purpose of the research project, Regime II/MDR stands for multi-drug resistant tuberculosis, which means that the individual with TB is at least resistant to two of the drugs used to treat tuberculosis, due to poor endurance and compliance to the treatment protocol. Streptomycin with ototoxic complications is part of the multi-drug-resistant protocol (Conway and Bartlett, 2003:43).

Table 3.7: Description of specific ototoxic drug exposure into the clinical stages of HIV/AIDS (n=42)

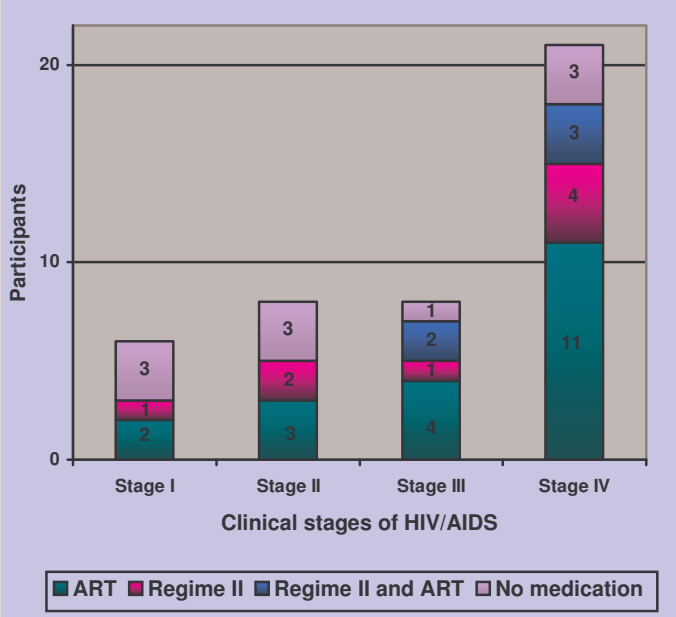
RESEARCH POPULATION	DIAGRAM SPECIFYING THE OTOTOXIC EXPOSURE AGAINST EACH CLINICAL STAGE OF HIV/AIDS
Eight (19%) participants already received anti-TB drugs, but had no exposure to ART. Nineteen (45%) participants were exposed to ART and five (12%) were exposed to a combination of Anti-TB drugs and ART. Ten (24%) participants had no history of ototoxic exposure.	

Figure 3.5: Description of the ototoxic drug exposure in each clinical stage of HIV/AIDS (n=42)

Figure 3.5 gives a clear description of the total participants in each clinical stage of HIV/AIDS who have received ototoxic Anti-TB drugs or ART since they were diagnosed with HIV/AIDS. Only regime II and multi-drug-resistant (MDR) participants were included in the anti-TB drug distribution, since these are the participants who received regimes that included ototoxic components namely streptomycin and amikacin. Participants in stages I, II received either ART, regime II or no medication. Participants in stage III and IV were characterized by all treatment groups, including no medication. Interestingly, 19 (45%) participants in total had already received ART, but only five (12%) participants received a combination of ART and Anti-TB drugs. A total of ten (24%)

participants received no medication at all. Eight (19%) participants were not on ART yet, but had received Anti-TB drugs since being diagnosed with HIV/AIDS.

3.4.5.5 Referrals from identified clinics

Since the researcher attempted to determine a profile of hearing for persons in all stages of the HIV infection, it was mandatory to ensure that participants should come from clinics other than the wellness clinic where only persons in stages III and IV of the infection were seen. Therefore Park Street Clinic and the antenatal care clinic were also identified as possible stations from which referrals might take place. Unfortunately, even though the medical doctor and medical nurse from Park Street Clinic gave their full voluntary consent to participate, no referrals were made to the researcher and the researcher had to include participants from other clinics in the research project in order to increase the number of referrals. Park Street Clinic was not included in the research project, but participants in group one were requested to refer patients from the tuberculosis clinic, the medical outpatient clinic, the gynaecology clinic as well as the urology and orthopaedic clinics who were included in the research project. The subsequent table illustrates the number of referrals from each clinic.

Table 3.8: Description of referrals from different clinics (n=42)

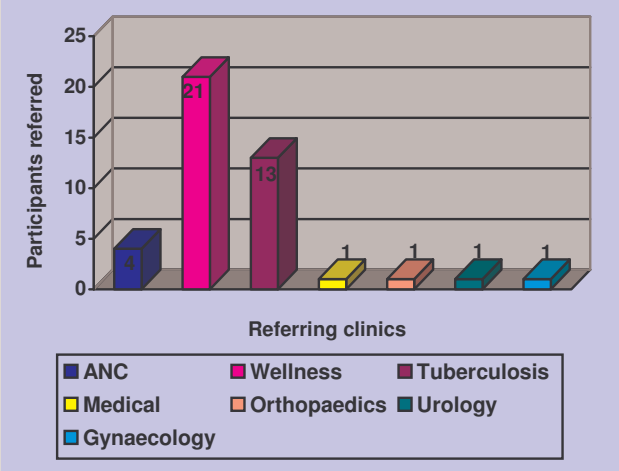
RESEARCH POPULATION	DIAGRAM SPECIFYING PARTICIPANT REFERRALS
Twenty-two (52%) of the participants were referred from the wellness clinic, indicating that most of the participants were diagnosed to be in the third or fourth stage of the HIV infection. The tuberculosis clinic referred 13 (31%) participants and the ANC clinic referred only four (10%) participants. The orthopaedic clinic, the medical outpatient clinic, the urology clinic and the gynaecology clinic referred one participant each.	 **Figure 3.6: Referrals of participants from clinics (n=42)**

Figure 3.6 provides a description of the distribution of referrals from the different stations identified by the researcher prior to the commencement of the research. Most of the participants were referred from the wellness clinic and the tuberculosis clinic and the fewest referrals (one participant from each) came from the orthopaedic clinic, urology clinic, medical outpatient clinic and gynaecology clinic.

3.5 APPARATUS AND MATERIAL

The following apparatus and material were used to gather the necessary data for the purpose of the research project.

3.5.1 Material

The following research material was used to assist the researcher with the selection of an appropriate sample and with the collection and recording of data.

3.5.1.1 Material used for the selection of participants, gathering, recording and analysis of data

The following material was used to obtain all the necessary information from the participants in a structured manner to provide the researcher with the means and motivation to exclude or include a participant in this research project and to collect the necessary information for statistical analysis.

3.5.1.1.1 Structured interview performed by using a questionnaire (Appendix F)

For the purpose of this research project, there was no information collected for administrative purposes in order to promote confidentiality of results. This means that the questionnaire did not contain any questions on personal information such as the subjects' residential addresses or telephone numbers. The introduction of the structured interview was done verbally by providing the potential participant with a short discussion about the importance of reliable information, the role of the participant, the insurance that all information and results would be kept confidential and that the research was necessary but participation not compulsory. This discussion ensured freedom of choice to participate and to orientate the participant to the goal of the research. A space was left where the participant had to sign, should the participant voluntarily agree to participate. This served as written informed consent (Appendix F) to participate in the research project.

The structured interview contained questions to determine if any factors other than HIV/AIDS that could lead to a hearing loss, were present in each participant's medical, occupational or family history. This assisted the researcher to exclude the willing participants, inappropriate for this research (not complying with the selection criteria), from this research project (table 3.9). Information regarding the family history of the hearing loss, genetic conditions, the period of noise exposure during work hours, history of operations to head and neck area, previous occupations, hobbies, previous diagnosis of hearing loss and health conditions were important information that

had to be obtained. This information served the purpose of selecting an appropriate sample. Only after the appropriate sample was selected, did this information serve the purpose of identifying existing correlations between these complaints, conditions and phenomena and the audiological results. In other words, after completing sample selection, the researcher obtained the necessary in-depth information from the structured interview (Appendix F) to complete the hearing-profile interpretation form (Appendix K). To ensure that the structured interview was reliable in its function, its construction had to be planned carefully in order to ensure optimal utilization.

This structured interview was assembled according to the guidelines given by Neuman (1997:233-236) and Bless and Higson-Smith (1995:115-124) for the development of a non-scheduled, structured interview. The structured interview was divided into categories to enhance the analysing of the research data. According to Dane (1990:128), categorization of data provides a more structural evaluation of the various issues involved. Neuman (1997:245-246) agrees that the order of the questions in the structured interview may influence the accuracy and response rates of the participants. Table 3.9 describes the design and purpose of the questions asked in the structured interview and it provides the literature supporting the relevance of the questions.

Questions were designed to collect appropriate and correct information. Willemse (1994:9) maintains that questions must be short and easily formulated, and misinterpretations and leading questions should be avoided at all cost. Therefore, closed questions were mainly used to obtain accurate and reliable answers. This also ensured that only the information appropriate in terms of what was needed, was obtained. The participants had to select one of the specified answers to a certain question asked. Mostly, the specified questions specifically involved “yes” or “no” answers. Questions with various possible answers relevant to the category and to the information that had to be collected were also included in the structured interview. The questionnaire contained questions concerning the symptoms the participant might experience as a result of HIV/AIDS. The participant

had to indicate which of these symptoms were applicable to his/her health, hearing status or occupational history.

Open-ended questions were also included in the questionnaire in order to provide the participant with the opportunity to add information when needed or applicable. According to Dane (1990:124), closed questions involved the selection of an answer from a specified category drawn up by the researcher, which ensured that the researcher obtained the appropriate information needed to complete the research project. However, at times a participant may not have experienced any of those symptoms of HIV/AIDS and therefore four open questions were included in the structured interview. This was to ensure that a participant could have the option of providing a relevant answer whenever the structured interview did not contain an option relevant to the particular participant. Table 3.9 provides an in-depth discussion of the questions that were included in the questionnaire in order to obtain the necessary information for sample selection and data collection purposes.

3.5.1.1.2 Spondaic wordlists (Appendix I)

Spondaic wordlists in Afrikaans (Laubscher and Tesner, 1966) and English were used to determine the speech reception threshold of each participant. CID Auditory Test W-1 was used to determine the speech reception threshold in English. This spondee wordlist was developed by Technisonic Studios and the Central institute for the Deaf (Martin, 1997:475).

3.5.1.1.3 Phonetically balanced wordlists (Appendix J)

Phonetically balanced wordlists, developed in English by Technisonic Studios and the Central Institute for the Deaf (Martin, 1997:476), were used to determine the speech discrimination threshold of each participant. This phonetically balanced wordlist are known as CID Auditory Test W-22. The Afrikaans wordlists (Laubscher and Tesner, 1966), even though not phonetically

balanced, but appropriate in terms of difficulty, were also used. This was to avoid inconsistency with pronunciation in terms of dialect when the researcher presented these words. The research would have been inappropriate and create even more bias when unfamiliar words had to be read by a speaker who does not know the language. However, the opposite is also true, the results would be extremely compromised if a speech discrimination test is done on a person in a language he/she does not know or speak. Fortunately, all participants were either a first language or a second language speaker in terms of the Afrikaans or English language.

Table 3.9: Design and purpose of the structured interview (*See Appendix F*)

DESIGN	TYPE OF QUESTIONS	RATIONALE FOR QUESTIONS	LITERATURE
SECTION A: Selection criteria	These questions aimed at obtaining information on any medical condition or predisposing factor a participant may be exposed to which could develop into a hearing loss.	The main purpose of these questions was to determine if the participant complied with the selection criteria.	For the purpose of the research project, the researcher had to determine if the participant had a history of infections, congenital disorders, otitis media, ossicular chain discontinuity, perforation due to trauma or acoustic trauma are (Martin and Clark, 2006:239, 276) prior to being diagnosed with HIV/AIDS. Debonis and Donohue (2004:225-240) states that multiple sclerosis, trauma to the head, noise, presbycusis, ototoxicity, ménière's disease, diabetes, facial nerve disorders, vestibular schwannomas, otitis media, tympanic membrane perforation, stenosis, atresia and microtia are all causes of hearing loss.
SECTION B: Demographic information	These questions are related to the features of each participant in terms of age, gender and racial group.	The researcher will attempt to identify if participants with HIV/AIDS of a certain gender, race and age are more prone to develop certain medical ear conditions.	This disease is most common in specific cultural groups with certain beliefs, living in specific areas in our country (Evian, 2000:21). The incidence of certain ear disorders differs in racial groups, gender and age. Martin and Clark (2006:248-364) clearly describe these differences: Otitis media is less common in females than males and differences between racial groups have been identified; Otosclerosis can lead to hearing loss and it occurs more often in women than in men; Ménière disease occurs more often in men than in women.
SECTION C: Medical history	These questions include matters regarding the participant's history of a medical condition that might have caused a hearing loss.	The questions serve as sample selection tool which provides clarification regarding the types of illnesses and medical conditions the participant might have experienced in the past. It serves to eliminate any other possible cause of hearing loss not related to HIV/AIDS and associated medical treatment procedures such as surgery or administration of ototoxic drugs.	The literature indicates that the following conditions may lead to hearing loss: *"Head injuries, acoustic trauma, diving accidents, or overexertion…"* may damage the structures of the ear (Martin and Clark, 2006:309). Loss of oxygen can also cause a hearing loss. Ototoxicity may lead to loss of hearing sensitivity, especially the side effects of streptomycin, viomycin, neomycin, gentamycin and kanamycin are cochleotoxic and vestibulotoxic (Martin and Clark, 2006:298). Tuberculosis can cause cochlear hearing loss especially when drugs are used for a long period of time. Quinine is an ototoxic drug, used to treat malaria. Recurrent episodes of otitis media can lead to a permanent hearing loss, it is important to include it in the structured interview (Martin and Clark, 2006: 276). It is also important to note that operative procedures might lead to permanent damage to the hearing (Martin and Clark, 2006:255-256). Therefore subjects with a history of any of the above conditions should not be included in the research project.

Table 3.9 : Design and purpose of the structured interview – continue *(See Appendix F)* (continued*)*

DESIGN	TYPE OF QUESTIONS	RATIONALE FOR QUESTIONS	LITERATURE
SECTION D: Occupational history **QUESTIONS:**	These questions involve the occupational history and leisure activities of the participant.	The questions in this section serve as selection procedure. It shows participants that should be excluded from this research project since the participant may be experiencing a noise-induced hearing loss and not a hearing loss due to HIV/AIDS.	Noise-induced hearing loss may be caused by repeated exposure to high intensity sounds causing damage to the cochlea. When the ear is exposed to high-impact sound of a sound pressure level that can rupture the organ of Corti from the basilar membrane, a hearing loss may result that is more commonly known as noise trauma or acoustic trauma (Debonis and Donohue, 2004:237). Baro trauma is also included in this section of the structured interview since it is known to occur in poorly pressurized circumstances (Debonis and Donohue 2004:233), such as those which mineworkers are exposed to when working underground.
SECTION E: Informed consent	These questions are concerned with the participant's willingness to participate in the research project.	Full voluntary consent is necessary before a potential participant can participate in the research project.	"A general common law protects a patient's rights at the time when medical procedures are conducted. Although no uniform federal statutory law states so explicitly, based on this common law, it is illegal for health-workers to perform medical procedures without the patient's full informed consent" (Johnsen, 1998:220).
SECTION F: Medical condition	These questions are concerned with the participant's current medical condition, complaints and HIV/AIDS status.	These questions served as data collection tool. It provided clarification regarding the types of illnesses and medical conditions the participant has experienced since being diagnosed with HIV/AIDS. It serves to identify possible cause for hearing loss related to HIV/AIDS, associated medical treatment procedures such as surgery or administration of ototoxic drugs. Despite all the medical conditions known to be present, as well as the ototoxic drug administration in persons with HIV/AIDS, the researcher included many questions related to the otological conditions of participants. The researcher attempted to identify any comparisons between the various otological conditions, neurological conditions and the presence of a hearing loss.	"The most common otologic problems reported in HIV-infected patients are serous otitis media and recurrent acute otitis media…" (Gold and Tami, 1998:166). "In patients infected with HIV, diminished cell-mediated immunity, recurrent viral infections, benign lymphoid hyperplasia of the adenoids, nasopharyngeal neoplasm's, sinusitis or allergies can all lead to poor eustachian tube function and middle ear effusions" (Lalwani and Sooy, 1992 in Gold and Tami, 1998:166). Recent literature indicated that HIV/AIDS directly infect the brain (Matkin et al., 1998:150), thus explaining why neurological diseases are common in persons with HIV/AIDS. Martin and Clark (2006:321) states that "lesions of the VIIIth nerve may occur as a result of disease, irritation, or pressure on the nerve trunk". Neurological diseases such as infectious diseases, toxic symbolic diseases and immune compromised diseases may lead to peripheral and cranial neuropathies (Sininger and Starr, 2001:37). Therefore it may suggest that persons with neurological conditions due to the HIV-infection may develop a central hearing loss (Matkin et al., 1998:150).

3.5.1.1.4 Otoscopic examination checklist (Appendix H)

This list was developed and used to record the findings of the observations of the external auditory meatus and tympanic membrane in a structured way. The structures and landmarks that were observed were identified in literature according to their possible influence on hearing (Debonis and Donohue, 2004: 225-232 and Martin, 1997:214-218). The checklist guided the researcher in the examination. Using a checklist also ensured that the researcher examined the same structures in all the participants and noted the same landmarks occurring in the different participants. The examination was done in a consistent manner. Information regarding any external or middle ear conditions that could have influenced the hearing profile of a participant was collected in this manner. This dependent variable (conditions of the external and the middle ear) was identified and appropriate comparisons were made between the presence of a hearing loss and the presence of either external or middle ear conditions. Table 3.10 depicts the design and purpose of the otoscopic examination checklist.

Table 3.10: Design and purpose of the otoscopic examination checklist (*Appendix H*) compiled from Martin, 1997:219, Gold and Tami, 1998:165 and Martin and Clark, 2006:260)

OBSERVATION	RELEVANCE	RATIONALE FOR INCLUSION	LITERATURE
SECTION 1: External auditory meatus [EAM]	These observations are related to the structures of the outer ear canal.	The otological conditions that may exist in the EAM in participants with HIV/AIDS that may lead to hearing loss, especially conductive hearing loss were observed.	"*When conditions occur that interfere or block the normal sound vibrations transmitted through the outer ear, conductive hearing loss results*" (Martin, 1997:219). This includes the presence of occluding wax or foreign objects in the ear canal. The outer ear canal and is vulnerable to "*infectious and dermatological conditions associated with HIV*" (Gold and Tami, 1998:165).
SECTION 2: Tympanic Membrane	These observations are related to all possible conditions of the tympanic membrane	Otological conditions that may exist in the participants with HIV/AIDS are observed.	Suppurative otitis media, tympanic membrane perforation and serous effusion are conditions that may be observed and may lead to conductive hearing loss in the middle ear (Martin and Clark (2006:260).

Table 3.10 portrays the design and purpose of his checklist. It contains phenomena and landmarks that may describe the external auditory meatus, as well as the tympanic membrane. Even though the middle ear was not observed directly, certain observations provided the researcher with important information regarding the condition of the middle ear.

3.5.1.1.5 Medical conditions referral card (Appendix E)

This referral card was compiled with the assistance of three medical doctors and was used to serve as a fast, effective way to evaluate the medical condition of the participant (See Appendix E). The CD4+ cell count and the presence of HIV/AIDS-defining diseases were noted on the referral card without using the term HIV/AIDS on the referral letter. The clinical stage of HIV/AIDS of the participant was also recorded on the referral letter. The referral card (Appendix E) was completed by the medical doctor. The referral card guided the doctor on the information needed by the researcher to perform the research project. Table 3.11 outlines the information regarding the design and purpose of the referral card and the rationale for including certain medical conditions, as well as literature supporting the relevance of each condition included in the referral card.

Table 3.11: Design and purpose of the referral card (*See Appendix E*)

MEDICAL INFORMATION	RELEVANCE	RATIONALE FOR INCLUSION	LITERATURE
QUESTION 1 Blood test results	These questions indicated the CD4+ cell count of a participant. For the purpose of the research project, the participants were classified into the four stages of HIV-infection by using the CD4+ cell count.	This was included in order to determine if the auditory system is affected differently through the various stages of the HIV infection. The blood results provided information regarding the HIV/ AIDS status of a patient and assisted with the classification of the patient into the four stages of the HIV/AIDS infection. Correlations were iden-tified between the presence of hearing loss and each clinical stage of HIV/AIDS.	According to Evian (2000:25), a person infected with HIV will go through four clinical stages that will occur over a long period of time, usually five to twelve years, but average 8 to 10 years. He also notes that the state of the immune system can be measured by the CD4+ (helper T cells) count and this can predict the patient's risk of developing a symptomatic disease. Therefore the CD4 + cell count was used to monitor the patient's immune status.
QUESTION 2 Medical symptoms	This involved all clinical symptoms that may be present in participants with HIV/AIDS.	The researcher attempted to identify correlations between the presence of hearing loss and some of the medical symptoms related to damage to the auditory system.	Persons with HIV/AIDS are also prone to develop bacterial meningitis, cryptococcosis infections, encephalitis, neurosyphilis, brain abscesses Toxoplasmosis and Tuberculosis which may all have an influence on the hearing system (Bankaitis, 1998:125).
QUESTION 3 TB-treatment	This involved the TB treatment the participant received in the past, as well as the duration of exposure to the drugs. It also entailed information regarding the resistance of the participant to treatment.	Tuberculosis is treated with two types of drug combinations, called regime I, regime II and MDR (Multi drug resistant). Regime II and MDR contain ototoxic drugs namely streptomycin and amikacin, which is suspected to lead to a sensory or neural hearing loss.	TB is usually more commonly found in tropical areas, but with HIV infections in the foreground, the prevalence and atypical presentations of TB have increased (MSD, 1992:82). *"In the presence of HIV infection, progression to clinical TB is much more common and rapid"* (MSD, 1992:133). Treatment of TB includes ototoxic agents such as streptomycin. *"Streptomycin is very affective..."* However …possible *toxic effects include… vestibular damage and ototoxicity". "Patients should be monitored with appropriate testing of balance, hearing, etc"* (MSD, 1992:143).
QUESTION 4 History of ART	With this question, information regarding the administration of ART and the duration of administration was obtained.	ART is suspected of causing a hearing loss in participants with HIV/AIDS due to ototoxic influences.	Treatment for opportunistic infections involves a number of pharmacological interventions. The pharmaceutical regimens are generally described as antiretroviral drugs [ARVD] and they often include ototoxic agents with potential ototoxic complications that have not yet been definitely recognized in literature (Bankaitis and Schountz, 1998:155).

3.5.1.1.6 Audiogram (Appendix G)

A standarized audiogram with the necessary space to record the pure tone air-and bone-conduction test results, speech reception and discrimination results and DPOAE results for each frequency (Appendix G).

3.5.1.1.7 Otoscopic examination checklist (Appendix H)

All observations of the external ear canal and tympanic membrane were recorded on the otoscopic examination checklist (Appendix H).

3.5.1.1.8 Medical conditions referral card (Appendix E)

The referral card (Appendix E) was completed by the medical doctor. The necessary information was indicated on the referral card itself.

3.5.1.1.9 Hearing interpretation recording form (Appendix K)

The hearing interpretation recording form (Appendix K) was used to compile a summary of all the relevant data obtained from the complete battery of tests. This form was developed by the researcher after the battery of tests was completed on all participants. This ensured that the final data given through to the statistician for data analysis purposes. This hearing interpretation recording form contained all necessary information in one document to make the data analysis easier and more reliable.

3.5.2 Apparatus

A complete test battery was conducted by using various audiometric apparatus to collect reliable information to determine the hearing profile of the participant.

3.5.2.1 Apparatus used for the gathering and recording of data

The following research equipment assisted the researcher with data-collection and recording:

3.5.2.1.1 Welsch Allen Otoscope with specula

A Welsch Allen Otoscope with specula was used to perform the otoscopic examination. The specula were sterilized with Milton immediately after use.

3.5.2.1.2 GSI 28-Tympstar version 2

A GSI Tympstar machine was used to conduct immittance measurements in both ears for the evaluation of middle ear function and the measurement of ipsilateral and contralateral acoustical reflexes (Martin, 1997:159-164). The immittance meter was calibrated in November 2005 (Appendix L), three months prior to the commencement of the data-collection and met the requirements of SANS 0154-2000 (South African National Standards, 2000). The immittance meter was the only equipment used for both data-collection and data-recording purposes.

3.5.2.1.3 GSI 61-Audiometer

The GSI 61-Audiometer was used for the hearing assessment of all participants. The audiometer was calibrated in November 2005 (Appendix L), three months prior to the commencement of the data-collection and met the requirements of the SANS 0154-2000 (South African National Standards, 2000). Pure tone thresholds for air-and bone-conduction, as well as speech reception thresholds and speech discrimination testing were performed to determine the type and degree of hearing loss of the participant.

3.5.2.1.4 GSI Audio screener (DPOAE)

The GSI Audio screener was used to conduct oto-acoustic emission (OAE) tests. This is an objective test procedure that was used to identify damage to the outer hair cells of the cochlea. This test identified possible damage to the outer hair cells due to ototoxic drug exposure. *Diagnostic OAE: Distortion product oto-acoustic emissions (DPOAE).* This equipment runs a self-test every time it is switched on and would not conduct the DPOAE-testing if the equipment was faulty. Therefore the equipment was not calibrated, but the researcher was informed that it should be sent back to the manufacturer if it gave problems. The researcher also conducted biological calibration by performing the test on herself prior to testing participants. The researcher cleaned the probe on a regular basis as suggested by the DPOAE manual.

3.5.2.1.5 Audera Auditory Brainstem Response prototype (ABR)

The Audera beta unit-prototype was utilized. The ABR instrument is an extremely expensive equipment and since Klerksdorp/Tshepong Hospital complex did not have it available, the researcher arranged with The Ear Institution in Queenswood, Pretoria, South Africa to borrow the ABR instrument from them. The only system that was available to borrow was the Audera beta unit. Prior to the commencement of the research, the equipment was serviced and tested in order to abide by the manufacturer standards. The ABR beta unit-prototype was the only ABR unit available to the researcher. Even though the stimulus rate on this unit could not be changed and the unit could not perform rarefaction, it ensured that the research procedures used for testing each participant were consistent. The Audera was used to measure auditory evoked potentials and to determine the nature of the hearing loss by identifying any delay or poor morphology in the different waveforms. Neural hearing losses (retro-cochlear damage), sensory (cochlear damage) or conductive hearing losses were also

identified through these results. Therefore this test served as cross check for the results obtained from other tests that were performed.

3.5.2.1.6 33-ER insert earphones and ear tips

Two insert earphones and ER3-14B disposable ear tips were used to serve as transducer for the ABR procedure.

3.5.2.1.7 Measuring tape

The researcher used the measuring tape to measure the circumference from the nasion to the inion of the participant's head in order to determine the centre position (Cz position) to ensure correct electrode placement during the conduction of the ABR procedure.

3.5.2.1.8 Electrodes

Three new electrodes were purchased. Two electrodes were placed on the earlobes of each ear and a third electrode was placed on the Cz (centre of the nasion and inion position) during the ABR procedure.

3.5.2.1.9 Soundproof booth

A two by two meter soundproof booth was used to ensure that the participant's responses were not influenced by environmental noise. The environment met the requirements of the SANS 0182-1998 (South African National Standards, 2000). This ensured more reliable audiometric test results.

3.5.2.1.10 Probe tips and Milton

Probe tips used during immittance testing and DPOAE measurements were sterilized immediately after use. These probes provided the necessary seal to ensure pressure build-up during immittance

measurements and the probe tip contained a miniature loudspeaker to present the evoking stimulus and a tiny microphone to pick up the emission during DPOAE testing.

3.5.2.1.11 Surgical gloves

The researcher used a new pair of surgical gloves when completing the test battery on each participant. This was done to avoid transmission of any infectious diseases to and from the participant. The participant infected with HIV's immune system is already compromised, therefore protection is of utmost importance (Kemp and Roeser, 1998:195). "*Everyone has the right to a healthy and safe environment that will ensure their physical and mental health or well-being, … as well as protection from all forms of environmental danger, such as pollution, ecological degradation or infection*" (HPCSA, 2002:116).

3.6 RESEARCH PROCEDURES

The researcher administered the following research procedures to enhance the research, obtain ethical clearance and to ensure excellence and promptness of the research project.

3.6.1 Obtaining ethical clearance

The researcher obtained ethical clearance from the ethical research committee of the University of Pretoria (Appendix B) as well as from the ethical committee of Klerksdorp/Tshepong Hospital complex (Appendix A) prior to commencement of the research project (See section 3.4.3.1 and figure 3.2).

3.6.2 Pilot study

A pilot study was conducted to ensure that all research material, research apparatus and research procedures that were used, were appropriate, reliable and valid. It was also conducted to identify and correct all possible deficiencies before starting the actual research therefore it assisted the researcher with valuable guidelines for the planning of the research. Pre-testing the research material and the

procedures involved "*administering research measures under special conditions, usually before full-scale administration to participants"* (Dane, 1990:127).

The sample participating in the pilot study consisted of three individuals attending three different clinics at Tshepong and Klerksdorp Hospital. The medical doctor who agreed to participate, obtained informed written consent from the participants and completed a referral card for each participant (Appendix D), identified the three individuals. These individuals were sent to the Audiology Department for the next phase of the research. This phase involved completing the structured interview (Appendix F) to determine the appropriateness of the candidacy of the participant. The researcher assessed the appropriateness of the structured interview, referral card, otoscopic examination checklist and hearing interpretation recording form and adjusted the material as needed.

During the pilot study, the researcher determined how well the instructions were understood. The researcher also determined if the questions conveyed the meaning intended and if appropriate answers from the participants were guaranteed. Furthermore, the researcher also identified if any misunderstandings existed. The researcher determined if smooth and efficient administration of the structured interview was possible and if responses were correctly and easily recorded. These results obtained during the pre-testing were used "to *investigate every aspect of the survey"* (Dane, 1990:128). During the pilot study, the researcher determined the duration of completing the battery of tests per participant. This ensured that the researcher could set aside the necessary time to test each participant.

3.6.2.1 Results of the pilot study

From the results of the pilot study indicated, it was clear that the researcher was able to complete a battery of tests on a participant within approximately 90 minutes. The researcher encountered a few difficulties with the administration of the material (questionnaire used for conducting a structured

interview). The questionnaire took an inappropriately long time to complete, because certain questions confused the medical doctors, other questions held no relevance to the particular research project and some questions were duplicated in the various forms, increasing the time needed to complete the forms. Therefore a few suggestions were made and the changes were brought about. Appropriateness of the questionnaire (for conducting a structured interview) had therefore been improved.

Table 3.12 provides a short description of the adjustments that were made to the material to improve the data collection procedure. Other suggestions were also made in order to improve the interpretation of the results after completion of the test battery.

Table 3.12: Adjustments to material based on suggestions from pilot study

GOAL	FINDINGS/SUGGESTIONS	ADJUSTMENTS
Referral card	• Changes regarding the outline of the referral card in order to make the completion less timely. • The questions regarding the administration of medication were confusing for most of the doctors.	• *All questions:* The options "absent"/"no" were eliminated. Doctors only have to mark the appropriate symptom. • *Questions 3 and 4:* An extra option was added for both TB treatment and ARVD.
Structured interview	• Changes regarding the outline of the structured interview in order to make the completion less timely. • The order of the questions is confusing when selecting the participants. • Level of education held no relevance to the particular research project. • It is unnecessary to ask questions related to the HIV/AIDS status and the treatment of the participant, since the referral card already contained all these information.	• *All questions:* The options "absent"/"no" were eliminated. The researcher only has to mark the appropriate symptom. • Questions for sample selection purposes were followed by the questions for data collection purposes. • The level of education was eliminated from the structured interview since it held no relevance to this particular research project. • Questions regarding the HIV/AIDS status and the administration of the ART were still included in the structured interview, but the questions were not discussed in-depth as on the referral card.
Hearing interpretation recording form	• The researcher thought it necessary to develop a new document in order to ensure that the precise characteristics of the hearing loss did not get lost when analysing the data.	• A new recording form was compiled and tested in order to indicate all the various characteristics that were present and that could be identified from the original test results (table 3.14).

3.6.3 Data collection

"The basic resource necessary for any statistical experiment is data" (Willemse, 1994:7). This research project required the collection of data related to the hearing ability and hearing sensitivity of participants with HIV/AIDS. "*The evaluation of hearing loss in the AIDS patient should be approached with a test battery. A complete audiogram with pure tone thresholds, speech audiometry, acoustic immittance, and acoustic reflexes should be performed. Otoacoustic emissions [OAE] and auditory brain stem responses [ABR] should be obtained to differentially diagnose cochlear from retro-cochlear involvement"* (Matkin et al., 1998:150).

The planning of the research ensured that the main aim of the research was reached. The following research procedures were therefore considered necessary and appropriate for determining the profile of hearing during the different clinical stages of the HIV/AIDS infection and to determine the influence of ototoxic drugs on the hearing profile of the participants:

- The staff nurse (a research assistant who gave her voluntary consent (Appendix C) to participate in the research project) who worked in a particular HIV/AIDS wellness clinic, antenatal clinic, orthopaedic clinic, gynaecology clinic, tuberculosis clinic, medical outpatient clinic or park street clinic did stratified random sampling by dividing the medical files in no particular order. After she completed this procedure, she handed medical files to the medical doctor who participated in the research.

- Voluntary consent was obtained from each participant prior to the commencement of the data-collection procedures. The participant had to sign a document (Appendix D) to give written consent for participation in the research project. The written consent implied that each participant was fully aware that he/she would undergo certain audiological test procedures, the researcher would be informed off his/her HIV/AIDS status, the test results would be handled strictly confidential, he/she

was under no pressure to participate and consent might be withdrawn at any stage during the research and, lastly, that the research results would be used to write a thesis and a research article.

- The researcher used the crosscheck principle as verification method for the results obtained during the audiology tests, prior to recording the results on the "Hearing interpretation recording form" (Appendix K). Pure tone air-and bone-conduction measures, as well as speech reception and discrimination measures were subjective and depended totally on the reliability of the participant's response and immittance measurements, ABR and OAE were objective and were used to confirm and cross-check these subjective test results. A complete in-depth test battery is extremely important when testing the hearing of an individual infected with HIV/AIDS, since auditory dysfunction may occur at different levels in the auditory system (Gold and Tami, 1998:167). In this way, the researcher ensured that all forms of auditory dysfunction were identified.

The following procedures were pursued in order to collect and interpret all the data (Table 13):

3.6.3.1 Completing the structured interview (Appendix F)

Sections B, C, D, E and F of the structured interview served to collect the data. This structured interview was administered verbally. Each question was asked by the researcher and the various options were provided. The participant had to choose the option applicable to him/her. If no option was applicable, the researcher would indicate none. In the case of another option that was not stated in the structured interview, the researcher would indicate "other" and would determine the information relevant to the particular participant. An interpreter was present when the participant did not understand the questions, due to a language barrier. When an interpreter had to be present, the researcher would complete the structured interview by asking the questions while maintaining eye contact with the participant. The interpreter would then interpret the question in the appropriate language and obtain the

appropriate answer from the participant. The interpreter would then provide the researcher with the information obtained from the participant.

3.6.3.2 Completing diagnostic test battery

The hearing ability of participants with HIV/AIDS was determined by conducting a full diagnostic test battery.

3.6.3.2.1 Otoscopic examination

The condition of the acoustic meatus and the tympanic membrane was evaluated via otoscopic examinations to identify any condition, such as inflammation, blood, discharge, otomycosis, foreign bodies, osteomas, perforations, myringitis, tympanoscleroses and other relevant conditions that may lead to a hearing loss. Table 3.13 indicate the protocol, relevance and the clinical application of the otoscopic examination that was conducted during the research procedure.

Table 3.13: Otoscopic examination procedure for data collection (According to Debonis and Donohue 2004:92)

RESEARCH PROCEDURE	PROTOCOL	RELEVANCE FOR INCLUSION	CLINICAL APPLICATION
Otoscopic examination	The external auditory meatus and the tympanic membrane of participants were examined by using a Welsch Allen Otoscope with specula. The pinna was gently pulled up and backwards to open the ear canal. The used speculum was immediately disinfected. The checklist containing the possible otological conditions that could be present was used to mark all appropriate conditions (Appendix H).	*"The pinna and the external auditory canal are susceptible to infectious conditions and dermatological conditions associated with HIV"* (Gold and Tami, 1998:165).	Visualizing the condition of ear canal and tympanic membrane for pathologies such as inflammation, myringitis, perforations, tympano-scleroses and landmarks such as the light reflex, the malleus and the colour of the ear canal and tympanic membrane.

Table 3.14 presents a description of the normative data and possible landmarks used to interpret the otoscopic observations made during the data-collection.

Table 3.14: Interpretation of the otoscopic examination (According to Martin and Clark, 2006: 260; Debonis and Donohue, 2004: 89; Martin, 1997:219, 228 and Gold and Tami, 1998:165).

RESEARCH PROCEDURE	NORMATIVE DATA FROM LITERATURE	INTERPRETATIONS	DESCRIPTION
Observation of the: External Auditory Meatus	The following characteristics are considered to be normal: ○ Healthy ear canal ○ Wax not occluding the ear canal The following characteristics are considered to be abnormal: ○ Red or inflamed ear canal ○ Blood ○ Wax occluding the ear canal ○ Discharge ○ Foreign objects ○ Cholesteatoma ○ Growths ○ Stenosis	*Conductive hearing loss may be due to any condition that occludes the ear canal and prevents normal sound vibrations to enter the ear canal or to transmit the sound waves successfully through the external ear (Martin, 1997:219).* *Infectious diseases and conditions of the skin associated with HIV/AIDS may affect the external ear canal (Gold and Tami, 1998:165).*	"Otoscopy… is a visual examination of the ear canal and the eardrum with an otoscope…in order to identify any obvious abnormality e.g. (blood in the ear canal, drainage, wax blockage)" (Debonis and Donohue, 2004:89).
Tympanic Membrane	The following characteristics are considered to be normal: ○ Pearl white tympanic membrane ○ Light reflex The following characteristics are considered to be abnormal: ○ Scarred tympanic membrane ○ Myringitis (red, inflamed) ○ Fluid behind tympanic membrane ○ Perforated tympanic membrane	*Sometimes the infection leads to infection of the middle ear system and the tympanic membrane may become scarred, thickened or perforated* (Martin, 1997:228). *Suppurative otitis media, tympanic membrane perforation and serous effusion are conditions that may cause conductive hearing loss in the middle ear* (Martin et al. (2006:260).	*Various medical conditions of the external and middle ear can be identified through the otoscopic examination.*

3.6.3.2.2 Immittance testing

A tympanogram was obtained for each ear and acoustic reflexes were elicited for each ear. These tests were conducted on each participant to determine middle ear pathology and to differentiate between cochlear and retro-cochlear pathology. These results were also used to crosscheck the results obtained from the pure tone audiometry and the oto-acoustic emission test in order to confirm or reject the initial results. The measurements serve as an objective measurement, because they did not require a voluntary response from the participant. The results were interpreted according to the middle ear pressure, ear canal volume and the compliance of the middle ear system to provide information regarding the health of the middle ear system. The information regarding the acoustic reflex measurements were described in terms of the presence, absence, decreased or elevated ipsilateral and contralateral reflexes. Even though these tests were not tests of hearing sensitivity, they serve as a crosscheck for the pure tone measurements (Hall and Mueller, 1998:192-230). Table 3.15 provides an in-depth discussion of the protocol that was used during the immittance procedure and table 3.16 provided the normative data and how the researcher applied the interpretation of the tympanogram and the acoustic reflexes.

Table 3.15: Immittance procedure for data collection (As suggested by Debonis and Donohue, 2004: 168-169; 183-184 and Martin and Clark, 2006:159)

RESEARCH PROCEDURE	PROTOCOL	RELEVANCE FOR INCLUSION	CLINICAL APPLICATION
Immittance Tympanometry	- The Callibrated GSI Tympstar version 2 was used. - The participant was instructed not to move, swallow, talk, yawn or cough and not to be scared of any loud noises that were heard. The researcher ensured the participant that the procedure is painless. The test was discontinued if pain or discomfort was experienced. - An appropriate clean probe-tip was selected. It was placed on the probe assembly to seal the participant's ear canal. The researcher pulled the pinna up and backwards to insert the probe tip, twisting it slightly to obtain a seal. Trouble-shooting was done if researcher was unable to obtain a seal. - "Tymp" was selected. Ear: left / right was selected. - ← (Start) was pressed. Pressure was automatically increased to +200daPa and gradually decreased to negative 200daPa. The results were recorded automatically. "Stop": pressed to stop testing. - The test was repeated and the researcher determined if the tympanogram was normal or abnormal. - The same was done for the other ear. - Print: pressed to print results. Used probe-tip was disinfected. - The Tympanogram was classified according to types A, As, Ad, B or C. Pathologies were considered. - Results were reported on the "Hearing interpretation recording form" (Appendix K).	*"Immittance measurements are extremely sensitive to middle ear dysfunction"* (Hall and Mueller, 1998:234). *"…immittance measures guide the diagnostic audiologist in identifying abnormalities in the auditory system"* Martin (1997:153). *"The most common otologic problems reported in HIV-infected patients are serous otitis media and recurrent acute otitis media*"(Gold and Tami, 1998:166). *If all immittance measurements are normal, middle ear function is normal. There is no clinical value in carrying out bone conduction pure tone audiometry"* (Hall and Mueller, 1998:234).	Immittance measurements provide diagnostic information when used as component of complete audiological test battery. Tympanometry measures the efficiency of the middle ear to transform acoustical energy into mechanical energy, in other words to ensure that sound waves set the middle ear structures (tympanic membrane and ossicles) into vibration. The tympanogram provides information regarding the presence of any abnormalities in terms of ear canal volume, the middle ear compliance and the middle ear pressure. Hall and Mueller (1998:234*)* state that if a Type A tympanogram with normal compliance is obtained bilaterally, it suggests normal middle ear functioning.

Table 3.15: Immittance procedure for data collection (continue) (As suggested by Debonis and Donohue, 2004: 168-169; 183-184 and Martin and Clark, 2006:159) (continued)

RESEARCH PROCEDURE	PROTOCOL	RELEVANCE FOR INCLUSION	CLINICAL APPLICATION
Immittance (continue) Acoustic Reflex Thresholds	- The participant was instructed to swallow once tympanometry was completed. The probe-tip was left in the ear that was tested. A clean probe-tip was placed on the cord used for contralateral testing. The pinna was pulled up and backwards to insert the probe tip and to obtain a seal. - The immittance instrument adjusted ear canal pressure automatically to where the tympanogram peak was maximum. - "Reflexes" option was selected. Mode: Ipsilateral or contralateral were chosen. - Ear to be tested: left or right. - Press. → - Frequencies were adjusted to 500Hz and the intensity to 85 dB HL. - If a reflex was elicited, intensity was decreased with 5 dB and repeated. If a reflex was not elicited, intensity was increased with 5 dB and repeated. - Changes were visually inspected in admittance tracing immediately after a signal/tone was presented. Changes were compared to minimum criteria for an acoustic reflex. - Test was repeated for ipsilateral reflexes. Ipsilateral acoustic reflexes were elicited at 250Hz, 500Hz, 1000Hz, 2000Hz and 4000Hz. - Contralateral reflex mode was selected and acoustic reflexes were determined for 500Hz, 1000Hz, 2000Hz and 4000Hz. - The instrument plotted all acoustic reflex thresholds automatically. - The probe was inserted in the opposite ear and the procedure was repeated. - Record results on "Hearing interpretation recording form" (Appendix K). - Probe tip was disinfected immediately.	*"Sensorineural hearing loss associated with AIDS may be due to direct effects of HIV on the central nervous system of peripheral auditory nerve, idiopathic causes secondary to ototoxic medications, or opportunistic infections or neoplasias of the central nervous system"*(Gold and Tami; 1998:167).	Ipsilateral and contralateral acoustic reflex thresholds together with a compete battery of audiological tests provide the researcher with information and serve as cross-verification regarding the type of hearing loss and a possible place of lesion. There are three distinct results that the researcher identified during acoustic reflexes testing: normal, elevated or absent reflexes. Acoustic reflex thresholds elicited between 70 dB and 90 dB SPL (about 85 dB) under all conditions (at each pure tone threshold) for ipsilateral and contralateral testing (between 70dB and 95dB above the threshold), indicates normal middle ear functioning and normal hearing. Acoustic reflex thresholds can assist with the identification of retro-cochlear hearing loss and cochlear hearing loss as well (Hall and Mueller, 1998:216,225-227).

Table 3.16: Interpretation of the immittance results

RESEARCH PROCEDURE	NORMATIVE DATA FROM LITERATURE	INTERPRETATIONS	DESCRIPTIONS
Ear canal volume	0.9 to 2.0 ml for adults (Martin and Clark, 2006:154) 0.6 to 2.0 ml for adults (Debonis and Donohue, 2004:172) *For the purpose of the research project* 0.6 to 2.0ml was selected as being normal ear canal values since it included a larger spectrum of responses that could be observed as normal.	If wax is present in the ear canal or if the probe tip is pressed against the wall of the ear canal, it may lead to ear canal values smaller than 0.6ml (Debonis and Donohue, 2004:172). Values larger than 2.0ml suggest a perforation or open PE tube. Martin and Clark (2006:153) indicate that any clinician must take note that a normal ear canal volume value may be obtained with a perforation in the presence of a middle ear disease.	**Martin and Clark (2006:150-152) state the following concerning middle ear volume, compliance and pressure:** *"Once the seal is obtained, the pressure is increased to +200daPa. On most instruments, the intensity of the probe tone is automatically adjusted until the desired sound-pressure level is obtained, usually 85 to 90dB soundpressure of the probe-tone. The clinician can then determine the* ***equivalent volume*** *in cubic centimetres"*
Static acoustic compliance	0.3 to 1.7mm³ for adults (Martin and Clark, 2006:154 and Debonis and Donohue, 2004:172) *For the purpose of the research project* 0.3 to 1.7 mm³ was selected as being normal static compliance. If the compliance exceeds the 1.7mm³, the tympanogram will be called a type Ad if the compliance is below 0.3mm³ the tympanogram is called a type As. When the maximum compliance curve cannot be found, the tympanogram is called type B (Martin and Clark, 2006:156).	Middle ear compliance values smaller than 0.3mm³ is indicative of stiffness of the middle ear whereas values higher than 1.7mm³ suggest too little stiffness (Debonis and Donohue, 2004:172). Ossicle chain dislocation may lead to values above 1.7mm³. Changes in the mass, resistance or stiffness of the middle caused by fluid accumulation in the middle ear space, previous perforations which healed or poor mobility of the ossicle chain less than normal mobility of the middle ear system may lead to results below 0.3mm³ (Martin and Clark, 2006:154).	***Static acoustic compliance****…* suggests the mobility of the tympanic membrane in reaction to a specified value of air pressure in the external ear canal (Martin and Clark, 2006:150-152 and Martin, 1997:154).
Tympanometric peak pressure	-100 to +50 daPa for adults (Debonis and Donohue, 2004:172) *For the purpose of the research project* negative pressures of –100 to +50 daPa were selected as being within the normal range. If the maximum tympanic membrane compliance is at –100daPa or below the tympanogram will be called a type C tympanogram (Martin and Clark, 2006:158).	*"Negative pressures more negative than –100daPa are generally associated with Eustachian tube dysfunction. Positive pressures greater than +50 may be due to crying or nose blowing"* (Debonis and Donohue, 2004:172).	*"…The* ***middle ear pressure*** *is determined by the mobility of the membrane as a function of the various amounts of positive and negative air pressure in the external ear canal"* (Martin and Clark, 2006:150-152)

Table 3.16: Interpretation of the immittance results (continue)

RESEARCH PROCEDURE	NORMATIVE DATA FROM LITERATURE	INTERPRETATIONS	DESCRIPTIONS
Ipsilateral and Contralateral Acoustic reflexes	*"Most normal hearing individuals will elicit a bilateral intra-aural muscle reflex when pure tones are introduced to either ear at 85 to 100dB SPL"* (Gelfand, 2002 in Martin and Clark, 2006:158 and Hall and Mueller, 1998::234). *For the purpose of the research project the interpretation of the ART and PTT was done according to the suggestions made by Martin and Clark (2006:161):* Ipsilateral acoustic reflex thresholds should be elicited at 70 to 90 (median reponse level of 85dB) above the pure tone threshold (PTT) of the particular frequency. Contralateral acoustic reflex thresholds should be elicited between 70 to 95 dB above the PTT of the particular frequency. Acoustic reflex thresholds elicited between 70 to 90dB (ipsilateral) and 70 to 95dB (Contralateral) above PTT is indicative of normal hearing. Acoustic reflex thresholds elicited below 60dB above PTT is indicative of cochlear damage. Absent acoustic reflex thresholds or acoustic reflex thresholds elicited above 90dB (ipsilateral) and 95dB (contralateral) above PTT is indicative of either conductive pathology or retro-cochlear pathology.	**According to Martin and Clark, 2006:161:** ○ Acoustic reflex thresholds will be elicited at about 70 to 90dB (average 85dBSL) in individuals with normal hearing. ○ The acoustic reflex thresholds will be absent if the stimuli that are presented to the cochlea are not loud enough. ○ Acoustic reflex thresholds might appear in an ear with a hearing loss if the stimulus is presented at a relatively low sensation level (a 50 dB hearing loss may show a reflex at 95dBHL (45dBSL). This is associated with cochlear pathology. ○ When presenting a stimulus to an ear with a severe cochlear hearing loss, no response at the limit of the equipment may often be indicated. This might be due to the fact that the intensity of the signal reaching the brainstem is insufficient to produce a reflex. (>60dB) ○ Auditory nerve damage leads to absent acoustic reflex thresholds or acoustic reflex thresholds at increased intensity levels. ○ Abnormal facial nerve functioning may lead to abnormal or absent reflexes in the probe ear. ○ Damage to the brainstem at areas housing the contralateral reflex portions, normal ipsilateral acoustic reflexes might be obtained with absent contralateral reflexes. ○ Lesions in the auditory cortex produce no abnormal acoustic reflex thresholds. ○ With middle ear pathology, acoustic reflexes are absent.	*"Contraction of the middle ear muscles, known as the **acoustic reflex**, in response to intense sounds, which has the effect of stiffening the middle-ear system and decreasing its static acoustic compliance"* (Martin and Clark, 2006:150-152).

3.6.3.2.3 Pure tone air-and-bone audiometry

Pure tone air-and bone-conduction threshold testing of each participant was determined after the immittance procedure. The results were recorded on an audiogram and interpreted to identify the nature, degree and configuration of the hearing loss (Hall and Mueller, 1998:104-112). The results were classified according to type and nature of hearing loss, which will be indicated as conductive, sensory, neural or mixed hearing loss. The degree of the hearing loss was classified into normal, mild, moderate, moderate-severe, severe and profound hearing loss as described by Goodman (1965) in Mueller and Hall (1998:104). Table 3.17 gives a clear description of the protocol used during the pure tone air-and bone-conduction test.

Table 3.17: Pure tone air- and-bone conduction procedure for data collection

RESEARCH PROCEDURE	PROTOCOL	RELEVANCE FOR INCLUSION	CLINICAL APPLICATION
Pure tone audiometry Pure tone air- and bone-conduction test (As suggested by Debonis et al., 2004:93).	- ***Pure tone thresholds:*** The participant was situated in a soundproof booth, slightly facing away from the researcher and informed that the earphones were to be placed on his/her ears. A very soft sound was to be heard. The participant was instructed to press the indicated button whenever the sound was heard. The participant was told that he / she can talk to the researcher at all times. - ***Air conduction:*** Earphones were placed on the participant's ears. The booth door was closed. - **GSI 60 Audiometer:** Phone, tone and the ear to be tested were selected on the audiometer. The tone was presented 1-2 seconds in duration, at a comfortable intensity at a selected frequency above the expected threshold of the participant, mostly 30dB. - The threshold was determined for 125Hz, 250Hz, 500Hz, 1000Hz, 2000Hz, 4000Hz and 8000Hz. - If the air conduction minus 40dB was greater than the bone conduction, masking was necessary in the non-test ear (NTE). - **Masking:** The stimulus (narrow-band noise), the transducer (phone) and the routing (NTE) were selected. - The intensity of the air conduction threshold of NTE at a specific frequency plus 10dB was the masking intensity. "Interrupt" was selected. The TE stimulus stayed on tone, the transducer was selected as phone. The tone was presented in test ear (TE) and the masking was increased in 10 dB steps if the participant did hear the stimulus in the TE. It the participant did not hear the sound, the tone was increased and a new threshold was obtained. The masking noise was elevated until the threshold stayed the same. Masking was increased twice in 10 dB steps.	*"Although HIV is directly and indirectly responsible for various changes to the ear and hearing, no clear relationship exists between disease progression and severity of auditory manifestations"* (Bankaitis, 1996 in Matkin et al., 1998:148). *"While opportunistic infections may potentially induce varying types and degrees of hearing loss, audiologists and health care workers must be cognizant of the fact that in the absence of a vaccine the medical management of HIV relies on numerous pharmacological interventions"* Bankaitis and Schountz, 1998:155).	Pure tone air- and bone- results allow the researcher to classify audiogram results in terms of degree and type of hearing loss.

Table 3.17: Pure tone air- and bone conduction procedure for data collection (continued)

RESEARCH PROCEDURE	PROTOCOL	RELEVANCE FOR INCLUSION	CLINICAL APPLICATION
Pure tone air- and bone-conduction test (continued) (As suggested by Debonis et al., 2004:93).	- ***Bone conduction:*** Bone conductor was placed on the mastoid. No hair was underneath the bone conductor and it did not touch the pinna. The headphone was placed on the NTE and the other side of the headphone was situated on the participant's cheek. Air conduction instructions were repeated. - **GSI 60 Audiometer:** Tone, bone and left or right ear were selected, depending on the TE. Thresholds were determined for 250Hz to 4000Hz. The intensity selected 10/20dB above the air threshold. No response: the stimulus intensity was increased with 10dB steps until response was obtained. Then the intensity was decreased with 10 dB increments until the participant did not respond anymore. Intensity was increased with 5dB steps until participant responded. Ascending-descending approach continued until the threshold was identified. Thresholds were recorded immediately if they differed less than 5dB from air threshold. - ***Masking***: A difference of 10 dB or more between air conduction and bone conduction thresholds in the same ear suggested compulsory masking. Masking input: audio-meter automatically selected narrow-band noise. Masking intensity: NTE threshold plus 10dB. Interrupt was selected and tone presented in TE. Masking was increased twice in 10 dB steps. No response from participant: masking was increased in 5 dB steps in the TE until a response was recorded. (Appendix G)	*"The evaluation of hearing loss in the AIDS patient should be approached with a test battery. A complete audiogram with pure tone thresholds …"* (Matkin et al., 1998:150). *"Frequent otologic manifestations of HIV infection include otitis externa, otitis media, sensorineural hearing loss, conductive hearing loss, mastoiditis, tympanic membrane perforation, and cholesteatoma"* (Kohan, Rothstein and Cohen, 1988 in Gold and Tami, 1998:165).	An air-bone gap of 10dB or more is indicative of the presence of a conductive pathology (Martin, 1997:90)

The results obtained during the pure tone testing were interpreted according to the normative data in the literature. Table 3.18 gives a clear description of the interpretation of the pure tone

results obtained during the collection of the data. The interpretation is based on the normative data found in the literature.

Table 3.18: Interpretation of pure tone results

<table>
<tr><th>RESEARCH PROCEDURE</th><th>NORMATIVE DATA FROM LITERATURE</th><th>INTERPRETATIONS</th><th>DESCRIPTION</th></tr>
<tr>
<td>Pure tone audiometry:
Pure tone air thresholds and
pure tone bone thresholds</td>
<td>Degree of hearing loss determined as average at 500Hz, 1000Hz and 2000Hz (Goodman (1965) in Hall and Mueller (1998:104), Martin et al. (2006:83) and Gelfand (2001:157):
<table>
<tr><th>PTA</th><th>DEGREE</th></tr>
<tr><td>-10 to 25 dB</td><td>Normal</td></tr>
<tr><td>26 to 40 dB</td><td>Mild</td></tr>
<tr><td>41 to 55 dB</td><td>Moderate</td></tr>
<tr><td>56 to 70 dB</td><td>Moderate to Severe</td></tr>
<tr><td>71 to 90 dB</td><td>Severe</td></tr>
<tr><td>> 91dB</td><td>Profound</td></tr>
</table>
Arlinger (1991:58) indicates, “…when air-and bone-conduction curves coincide it is an indication of the lesion being sensorineural”. In other words, if the air-bone gap is no more than 10 dB, the lesion is in the inner ear or higher. “If, however, the air-bone gap is significant, i.e. 15 dB or more, this indicates a disturbed middle ear function – a conductive loss”. Gelfand (2001:155) suggests that “…the air-bone-gap should be at least 10dB wide before it is considered significant.”

The statistical distribution between air conduction and bone conduction indicates, “…air-and bone conduction thresholds are within ±10dB of each other” (Frank et al. (1983) in Gelfand (2001:155). For the purpose of this research project, a conductive component will be present if the AC and BC differ with more than 10dB.</td>
<td>For the purpose of the research project:

The researcher determined a pure tone average for each category. The types of hearing loss as described by Martin et al. (1997:6) are used: A conductive hearing loss suggest that the air conduction thresholds are impaired, but the bone conduction thresholds are within normal limits. When the air conduction and bone conduction thresholds are impaired with the same amount, it means that the conductive mechanism is not involved and the hearing loss can be described as sensorineural hearing loss. Mixed hearing loss suggest that both air- and bone conduction thresholds fall outside the normal range with the presence of an air-bone gap. Thus, the bone conduction thresholds are impaired, but the air conduction thresholds are even more impaired. Gelfand (2001:154) provides a formula, [AC-BC=ABG ≥ 10dB], to determine if a conductive component is present. Gelfand (2001:154) also states that when the bone conduction thresholds are determined at 0dB, it suggests normal bone conduction and thus no sensorineural lesions.</td>
<td>“Pure tones are defined as signals consisting of only one frequency of vibrations” (Debonis et al., 2004:77).

Pure tone air conduction provides information regarding the degree of the hearing loss (Martin and Clark, 2006:78).

Pure tone bone conduction thresholds indicate the participant’s sensorineural sensitivity for pure tones (Martin and Clark, 2006:87). to enable the researcher with the identification of the type of hearing loss (sensorineural, conductive or mixed). “The combined term sensorineural is used to highlight the fact that we cannot distinguish between cochlear (sensorineural and eighth nerve neural disorders from the audiogram” (Gelfand, 2001:154).</td>
</tr>
</table>

Table 3.18: Interpretation of pure tone results (continued)

<table>
<tr><th>RESEARCH PROCEDURE</th><th>NORMATIVE DATA FROM LITERATURE</th><th>INTERPRETATIONS</th><th>DESCRIPTION</th></tr>
<tr><td>Pure tone audiometry:
Pure tone air thresholds and
Pure tone bone thresholds</td><td>Configurations were determined by the guidelines set by Roeser, Valente and Hosford-Dunn (2000).

<table><tr><th>Configuration</th><th>DEGREE</th></tr><tr><td>Flat</td><td>No change or little change in thresholds across all frequencies</td></tr><tr><td>Sloping</td><td>As frequency increased, degree of hearing loss increased</td></tr><tr><td>Low frequency</td><td>As frequency increased, degree of hearing loss decreased</td></tr><tr><td>Ski-slope</td><td>Very sharp increase in the hearing loss between octaves</td></tr><tr><td>High frequency</td><td>Thresholds is limited below normal levels at 2-3kHz</td></tr><tr><td>Notch</td><td>Notched shaped loss at 1-3kHz</td></tr></table>
Added to these configurations was an irregular configuration with no particular pattern, but a definite variance of thresholds across all frequencies. “Other” configurations were also added to the list to describe those configurations which did not fit into the above-mentioned spectrums</td><td>(as above)</td><td>(as above)</td></tr>
</table>

3.6.3.2.4 Speech audiometry

Speech reception thresholds served as a cross-check principle for the average pure tone audiometry threshold that was obtained, whereas the speech discrimination configurations were used to confirm cochlear or retro-cochlear damage. The step-by-step protocol that was followed during this procedure is depicted in table 3.19.

Table 3.19: Description of procedures used during speech audiometry

RESEARCH PROCEDURE	PROTOCOL	RELEVANCE FOR INCLUSION	CLINICAL APPLICATION
STEP 4 Speech reception test (As suggested by Martin and Clark, 2006:117-140)	- ***Speech reception [SRT]:*** The researcher presented either the English or Afrikaans word lists, depending on the need of the participant. The participant was instructed to listen to the words that the researcher was about to read and not to look at the researcher's mouth while reading. If the participant was unable to identify the word, he/she should guess what the researcher was saying. - **GSI 60 Audiometer:** Microphone, phone and the ear were selected. The best ear was tested first. The test started at 30dB HL. Interrupt was selected and the VU meter had to reside on 0dB.Words were read in groups of 6 spondaic words through micro-phone. If three consecutive words were repeated correctly, the intensity was decreased with 10dB. If not, the intensity was increased with 5dB. The SRT was where the participant repeated at least 3/6 words correctly (Martin and Clark, 2006: 119). - ***Speech discrimination test:*** The native language of the patient was determined. Phonetically balanced word lists were administered (Martin and Clark, 2006:128 and 129). - The researcher read the words. The participant was instructed to listen to the words that the researcher was about to read and not to look at the reader's mouth while reading. - If the participant was unable to identify the word, he/she should guess what the researcher was saying. The interpreter was only used to clarify instructions, not to present the words, since it would influence the consistency of the research.	SRT is used as a cross-check principle for pure tone results and should correlate with the pure tone test. The purpose of the speech discrimination test is to determine the maximum speech under-standing of the participant and to rule out retro cochlear damage (Debonis and Donohue., 2004:137).	SRT may give the researcher information regarding the presence of central auditory nervous system pathology or it may confirm the presence of a sloping hearing loss either in the high or the low frequencies (Martin and Clark, 2006:120). The SRT and the PTA should correlate within plus 5dB minus 7dB. The accuracy of the pure tone thresholds is con-firmed by close agreement between the conventional PTA and the Speech Threshold measure (Hall and Mueller, 1999:129)

Table 3.19: Description of procedures used during speech audiometry (continued)

RESEARCH PROCEDURE	PROTOCOL	RELEVANCE FOR INCLUSION	CLINICAL APPLICATION
STEP 4 Speech discrimination test (continued) (As suggested by Martin and Clark, 2006:117-140)	- **GSI 60 Audiometer:** The researcher selected microphone, phone and the ear. The best ear was tested first. The researcher started 20dB above SRT. - "Interrupt" was selected and the VU meter adjusted so that it should reside on 0. - 25 words (phonetically balanced) were read. An introduction phrase or carrier phrase ("please say") was used. - Each word was marked as correct or incorrect response. The percentage of words repeated correctly was determined. - If any of the words were repeated incorrectly, the intensity was increased with 5dB. - To determine where the patient repeated 100 percent of the words correctly, the intensity was increased in 10dB steps. - Intensities were plotted as a function of the percentage of words repeated correctly on the speech audio-gram. - **Masking**: When the speech discrimination intensity in the TE minus 40dB was greater than the best bone conduction threshold in the NTE at 500Hz, 1000Hz or 2000Hz. - Speech noise was selected. The PBHL (intensity of the TE) minus 40dB plus the value of the biggest air-bone gap in the NTE was selected. - Maximum masking value was the average bone conduction threshold of the TE plus 40dB. - The results were plotted on the speech audiogram (Appendix G).	Speech discrimination, compared to pure tone-air- and bone conduction test is more representative of communication problems the participant may experience, compared to the pure tone air-and bone-conduction tests.	The researcher is able to cross verify between audiometry results by determining if results display certain characteristics. These characteristics confirm sensory, neural or conductive pathology as well as normal hearing sensitivity. This test procedure will also assist the researcher to confirm the retro cochlear or cochlear pathology that may exist. A roll-over index will be determined from the results obtained during this procedure. A roll-over index of more than 0.4 is associated with retro-cochlear auditory dysfunction (Hall and Mueller, 1998:147). *"Beyond ototoxicity, sudden-onset sensorineural hearing loss has been reported in the HIV/AIDS population and deserves special consideration, as this particular population is susceptible to numerous opportunistic infections. Viral agents are known to cause sudden sensorineural hearing loss and may represent the most frequent cause"* (Matkin et al., 1998:149).

Table 3.19: Description of procedures used during speech audiometry (continued)

RESEARCH PROCEDURE	PROTOCOL	RELEVANCE FOR INCLUSION	CLINICAL APPLICATION
STEP 4 Speech discrimination test (continue) (As suggested by Martin and Clark, 2006:117-140)	- **Interpretations**: The speech audiogram was interpreted by means of the rollover index (RI) to determine neurological pathology. An RI of 0 indicated normal hearing. A RI of less than 0.4 indicated the presence of a cochlear problem (sensory hearing loss) and when the RI was calculated to be 0.4 or more, it was indicative of a retro cochlear (nerve deafness).	(see above)	(see above)

The word lists used during the conduction of these tests were Afrikaans and English (Appendix I and J). The researcher presented the word lists to all participants in order to ensure consistency during presentation of these word lists, thus eliminating bias that can be caused by the accent, intonation and pronunciation of different speakers. These results were then interpreted according to the normative data in the literature.

The first part of table 3.20 gives a clear description for the interpretation of the speech reception results and the second part of table 3.20 depicts the interpretation of the speech discrimination results.

Table 3.20: Interpretation of the speech audiometry results

RESEARCH POCEDURE	NORMATIVE DATA FROM LITERATURE	INTERPRETATIONS	DESCRIPTION
Speech Audiometry: Speech reception thresholds (Threshold test)	*For the purpose of the research project,* the researcher determined the best threshold at frequencies 500-to 2000Hz in order to determine if a PTA/SRT discrepancy of –7 to +5 exists. If it does, it could indicate the presence of either a functional loss thus suggesting that the test reliability were poor during the pure tone audiometry procedure or it may be the results of a sloping audiogram configuration. The speech discrimination results were interpreted as follows: NORMAL 90 to 100% words correct at normal intensity levels 0 - 40 dB Configuration: S-curve CONDUCTIVE 90 to 100% words correct at increased intensities (More than 40 dB) Configuration: S- curve SENSORY Increase in word discrimination with increase in intensity up to maximum of 88% Configuration: Plateau NEURAL Roll-over; increase in intensity lead to decrease in percentage correct word discrimination Configuration: Roll-over	*"…Pure tone thresholds in the 500- to 2000Hz range are associated with the SRT. The SRT was originally compared to the PTA of 500- to 2000Hz, but soon it became apparent that this three-frequency PTA is not necessarily the combination of pure-tone thresholds that comes closest to the SRT"* (Gelfand, 2001:259). Sloping audiograms usually result in SRT-PTA discrepancy. Carhart and Porter (1971) in Gelfand (2001:259) found that the correlation between the PTA and the SRT was the best when the threshold at 1000Hz was used, unless the patient presented with a sloping loss. In such a case, it would be beneficial to use the best threshold at one frequency. The PTA-SRT discrepancy should not exceed 10dB, as indicated by Doyle (2004: 83). In order to determine if a participant experiences a neural hearing loss, the rollover index will be determined by the following formula (Jerger & Jerger (1971) in Gelfand, 2001:272): $RI = \frac{(PBmax-PBmin)}{PB\ min}$ If RI ≥0.40, retrochhlear pathology exists. For an individual with normal hearing the PBMax is 100% and will be obtained at 35 to 40dB above the SRT. Sensorineural hearing losses suggest a PBMax of below 100%, regardless of the intensity level (Martin and Clark, 2006:136)	*"…The SRT can be predicted from the pure-tone audiogram by averaging the thresholds at 500Hz and 1000Hz and subtracting 2dB"* (Carhart and Porter (1971) in Martin and Clark, 2006:120). The SRT can be obtained at a much better intensity level than the PTA, especially with sloping losses, whereas in patients with central auditory nervous system dys-function, the SRT may be poorer than the PTA (Martin and Clark, 2006:120). The purpose of the speech discrimination test is to "… determine the client's maximum speech understanding for one-syllable words. Ideally, the way to measure this maximum ability is to assess understanding of monosyllables at various intensity levels, in steps beginning near threshold and continuing to intensity levels that are well above threshold. This process is typically referred to as a per-formance-intensity function" (Debonis and Donohue, 2004:130-131). For the purpose of the research, these tests are called speech reception and speech discrimination tests.

3.6.3.2.5 Distortion product oto-acoustic emission

Distortion product oto-acoustic emission (DPOAE) testing was conducted after immittance to identify damage to outer hair cells of the cochlea objectively. This measurement, because it is objective and did not need a voluntary response from the participant, eliminated participant bias (functional hearing losses). Even though it served as an objective measurement, it assisted the researcher to confirm or reject pure tone air-and-bone results that have been obtained. It also served as a site of lesion test. Table 3.21 gives a clear description of the protocol used to obtain the DPOAE for each participant.

Table 3.21: Protocol used to elicit distortion product oto-acoustic emissions

RESEARCH PROCEDURE	PROTOCOL	RELEVANCE FOR INCLUSION	CLINICAL APPLICATION
STEP 5 Distortion Product Oto-Acoustic Emissions	1. GSI Audio Screener was used. 2. The symbol allocated to the patient was typed into the equipment. 3. DPOAE testing option was selected. 4. Ear to be tested was selected. 5. Test was conducted inside the soundproof booth and repeated. 6. The participant was instructed to sit still and keep quiet. No response was required from the participant. 7. The proper probe-tip size was selected to fit into the participant's ear. 8. "Test" was selected. 5 Frequencies were tested: 2000Hz, 3000Hz, 4000Hz, 5000Hz and 6000Hz. 9. The intensity parameters of L1 and L2 were 65dB and 55dB consecutively. 10. The data was immediately plotted on the DP-gram (Appendix G). 11. Each test frequency was indicated separately on the document. 12. If the participant had absent DPOAEs at one or more of the six frequencies, the test was repeated again.	Even though the researcher obtained information on the functioning of the different parts of the hearing mechanism (outer ear, middle ear and cochlea), the DPOAEs were included mainly to determine the status of the outer hair cells of the cochlear (Hall and Mueller, 1998:245, 252).	This procedure serves as method to reject results when the participant has a functional hearing loss, it enables the researcher to differentiate between cochlear and retro-cochlear auditory pathology, it can be used to monitor the ototoxicity and to identify a history of noise exposure and to determine the influence of noise exposure on the participant's hearing (Hall and Mueller, 1998: 265-266).

Table 3.21: Protocol used to elicit distortion product oto-acoustic emissions (continued)

RESEARCH PROCEDURE	PROTOCOL	RELEVANCE FOR INCLUSION	CLINICAL APPLICATION
STEP 5 Distortion Product Oto-Acoustic Emissions	13. The test results were replicated to improve reliability. 14. If noise levels were high, the test was repeated again. 15. If one or more frequency failed, cochlear damage was suspected and indicated on the Audiogram (Appendix G). 16. If the participant had absent DPOAEs at two or more frequencies, he/she failed the DPOAE assessment.	*"The drug regimen of the HIV-infected population often involves potentially ototoxic, government-approved antiretroviral medication along with experimental antiretroviral drugs with undocumented or unknown side effects"* (Bankaitis and Schountz, 1998:155)	(see above)

These DPOAE results had to be interpreted according to the information provided in the literature. Table 3.22 depicts this information and normative data as provided in the literature and explains how the were used by the researcher in order to interpret and cross-verify the results obtained.

Table 3.22: Interpretation of the distortion product oto-acoustic emissions

RESEARCH POCEDURE	NORMATIVE DATA FROM LITERATURE	INTERPRETATIONS	DESCRIPTION
Distortion product oto-acoustic emissions	*For the purpose of the research project*, GSI Audio screener was used. Five frequencies were tested and when a participant failed two or more, the participant's DPOAE failed.	Martin et al. (2006:167-168) suggests the following regarding the interpretation of OAEs: An OAE that is present, suggest normal middle ear functioning and therefore very little or no conductive hearing loss. The frequency response of the particular regions of the cochlea is normal or a mild hearing loss may be present. When outer hair cell functioning is intact, OAEs will be present in a sensorineural hearing loss, thus indicating retro-cochlear functioning. If OAEs are absent in the presence of a Sensori-neural hearing loss, it confirms outer hair cell damage, but does not always mean that retro cochlear pathology is not present.	*"Otoacoustic emissions reflect the activity of an intact cochlea…for any type of OAE to be observed, the conductive pathway must be normal, because the strength of a signal travelling from the inner ear to the outer ear canal may be attenuated by an abnormality of the middle ear in the same way as an externally generated signal travelling from the outer ear to the inner ear"* (Martin and Clark, 2006:168).

3.6.3.2.6 Auditory brainstem response (ABR)

The latencies of the different waveforms obtained by conducting an ABR-test was determined to differentiate between conductive, sensory and neural hearing losses. This procedure also served as a site of lesion test. The protocol used for conducting the ABR-test is described in table 3.23. The results obtained were then interpreted according to literature. Table 3.24 portrays an explanation from the literature regarding the interpretation of these results.

3.6.3.3 Comparing the results

- Physical audiological data were compared to the clinical symptoms of the participants to identify the nature, degree and configuration of hearing loss for each clinical stage of HIV/AIDS and then these physical audiological data were compared to the clinical symptoms of the participants in particular clinical stages of the infection (See Appendix K: Hearing profile interpretation form).

- Comparisons of the hearing profiles were established between those participants with a history of exposure to ototoxic drugs for treatment of HIV/AIDS and related illnesses and those participants who did not display a history of exposure to ototoxic drugs. In other words, the researcher determined an average hearing profile for each clinical stage of HIV/AIDS and compared the average hearing profiles of these participants. Furthermore the hearing profile of participants who had received ototoxic drugs was compared to those in the same clinical stage of the disease who did not receive ototoxic drugs yet.

Table 3.23: Protocol used to conduct the ABR

RESEARCH PROCEDURE	PROTOCOL	RELEVANCE FOR INCLUSION	CLINICAL APPLICATION
STEP 6 Auditory brainstem response	- The participant was informed that electrodes were to be placed on his forehead and behind the ears. It was clearly stated that it held no danger to the participant. It only involved "click" noises that would be heard. The participant was instructed to rest/sleep while lying for the completion of the test. - **Preparing the participant:** The vertex of the head and both earlobes of the participant were cleaned with alcohol and scour Nuprep, using gauze to reduce any resistance that was present. - **Electrode placement:** A small amount of ten20 conductive paste was placed on each of the electrodes. Electrodes were placed on the skin with conductive paste and plaster. - The **active electrode** was placed on the vertex [Cz-AIpsi] to record the maximum wave V amplitude. The length from the nasion to the inion, as well as the length of the left external ear to the right external ear was measured. This ensured the exact identification of Cz. The area where these two lines crossed was the exact Cz marker. - The Cz-A1 and Cz-A2 electrodes were placed on the earlobes of each ear. The reference electrode was the electrode placed on the TE and the ground electrode was placed on the earlobe of the NTE. - **Stimulus parameters:** The ER-3A inserts served as transducer. The foil-covered foam was connected to the insert and then to the acoustic tubing of the ER-3A transducer. The electrode wire with alligator clip was connected to the electrode box, which was in turn connected to the AER system. - Audera prototype was: One channel ABR thus obtaining monaural information only. - Click Stimuli was selected. - Duration of clicks was set at 0.1 ms and the stimulus rate was initiated at 11.0 clicks per second. - Stimulus rate was set at 2000 sweeps. - The test was started at 85 dB nHL and increased in 10 dB increments, if Wave I and V were not observed. 50 dB white noise was automatically introduced in the NTE ear when the stimulus was greater than 70 dB and the no wave I and a delayed latency for wave V was obtained. - To ensure consistency with test procedures, no adjustments were made to the sweeps or the click rate. The researcher only adjusted the intensity from 85dB to a maximum of 95dB.	*"The evaluation of hearing loss in AIDS should include a complete audiological examination, including auditory brainstem response testing"* (Gold and Tami, 1998:167) *"…delays in waves III and V have been consistently reported in AIDS patient, conflicting ABR findings have been reported in asymptomatic HIV-infected patients who have not yet developed AIDS"* (Bankaitis, Christensen, Murphy and Morehouse, 1998:181). *"The ABR has been effective in providing initial evidence of early neurological involvement in otherwise asymptomatic patients later diagnosed with various brainstem pathologies"* (Bankaitis et al., 1998:181). This protocol was used in order to obtain information regarding the status of the auditory neurological functioning of the participant. A slower stimulus rate and a higher intensity level were used to ensure a good wave I to V morphology (Hall and Mueller, 1998:344-345).	The ABR results enable the researcher to diagnose neurological dysfunction of the eighth cranial nerve or the auditory brainstem. The exact place of lesion can be determined by conducting the ABR and analysing the absolute wave latencies and the interpeak latencies, as well as the interaural latencies (Hall and Mueller, 1998:327).

Table 3.24: Interpreting the ABR results

<table>
<tr><th>RESEARCH PROCEDURE</th><th>PROTOCOL</th><th>RELEVANCE FOR INCLUSION</th><th>CLINICAL APPLICATION</th></tr>
<tr>
<td>Auditory brainstem response</td>
<td><u>For the purpose of the research project</u> the following data were used to interpret the ABR:
○ Absolute latencies
○ Interwave latency intervals
○ Interaural wave latencies
“Although adult latency values will vary with equipment, age and gender, in general, wave I is noted at latencies between 1,5 and 2,0 msec, wave III between 3,5 and 4,3 msec, and wave V between 5,0 and 6,1 msec. Based on normative data, audiologists determine if any of the waves occur outside of the norms” (Debonis and Donohue, 2004:198).</td>
<td>Martin and Clark. (2006:186) indicate the following:
<table>
<tr><th>Type of loss</th><th>ABR Characteristic</th></tr>
<tr><td>Normal hearing</td><td>Normal wave V and inter-wave latencies</td></tr>
<tr><td>Conductive loss</td><td>All wave latencies prolonged with normal interpeak latencies</td></tr>
<tr><td>Sensory loss</td><td>Slightly increased wave V and interpeak latencies</td></tr>
<tr><td>Neural loss</td><td>Very increased wave V and interpeak latencies</td></tr>
</table>
</td>
<td>“From the time the acoustic stimuli reach the inner ear, what is transmitted to the brain is not ‘sound’ but rather a series of neuro-electric events…when a signal is introduced to the ear, there are immediate electrical responses in the cochlea. As the signal is propagated along the auditory pathway, more time elapses before a response occurs, and thus the signal can be recorded at each subsequent nucleus in the pathway ” (Martin and Clark, 2006:168). “The term latency is used to define the time period that elapses between the introduction of a stimulus and the occurrence of the response. The term amplitude is used to define the strength or magnitude of the Auditory evoked response” (Martin and Clark, 2006:169).</td>
</tr>
</table>

Collecting the correct and appropriate data that are needed for the research is, according to Willemse (1994:9), one of the key principles of data collection. Another is to construct adequate verification to ensure that inaccuracies do not go unnoticed. The crosscheck principle for audiological testing was implemented here in order to confirm or reject results that do or do not correlate. Therefore it served as a verification method to ensure that errors were detected.

3.6.4 Procedure for data-recording

The following procedures were followed to record all data effectively.

- Each participant's test results were kept together.

- A symbol was allocated to the results of each participant in order to ensure confidentiality by not using the person's personal details.

- Blood results and medical information regarding the participant's health and exposure to ototoxic medication were recorded on the referral card (Appendix E).

- The otoscopic examinations and observations made by the researcher were recorded on the otoscopic examination checklist (Appendix H).

- Air-bone thresholds and speech reception thresholds and discrimination configurations were recorded on an Audiogram (Appendix G) by using the national standardized symbols.

- The immittance, DPOAE and ABR results were automatically recorded by the different machines.

- Coding of answers to questions was necessary for statistical analysis. The researcher recorded and coded all information on one document (Hearing interpretation recording form: Appendix K).

- The researcher used a crosscheck principle as verification method for the results obtained. Since pure tone air–and-bone conduction measures, as well as speech reception and discrimination measures are subjective measures and depend totally on the reliability of the participant's response, it is important to note that immittance measurements, ABR and OAE overrule these subjective tests.

- The researcher interpreted all the audiology results and recorded them on the Hearing interpretation recording form (Appendix K).

3.6.5 Data analysis

- The data obtained from the full diagnostic audiological test battery were analysed according to the nature, degree and type of hearing loss for the entire population with HIV/AIDS that was researched.

- The participants were grouped into four clinical stages of HIV/AIDS. A correlation between the clinical stages of HIV/AIDS and the nature, type and degree of hearing loss was determined. The nature, type and degree of hearing loss were categorized according to the clinical stage of HIV/AIDS of the participant. During this phase of the data analyses, the researcher determined the average range of hearing loss associated with a clinical stage of HIV/AIDS.

- The entire population with HIV/AIDS was then grouped into those who received ototoxic medication (Regime II and / or ART) and those who did not receive medication with ototoxic agents (Regime I and other medication). The hearing profile for these groups was analysed accordingly. A comparison was drawn between the average profile of hearing for participants with HIV/AIDS and the different groups (those who received ART and / or Regime II and those with no exposure to these drugs). This was done in order to determine if ototoxic medication influences the hearing profile of persons with HIV/AIDS. The hearing profile of the participants with HIVAIDS who received ART was compared with the average hearing profile of a person with HIV/AIDS with no exposure to ototoxic medication.

- Correlations between the relevant AIDS-defining illnesses and hearing profiles were identified.

- A professional statistician did statistical analysis of the data that were acquired. The data analysis was non-parametrical in nature, because the data were mainly categorical. Two-way frequency analysis was used. Statistical tests such as the Pearson Chi-square test, the M-L Chi-square test , the Mann-Whitney U test as well as the Kruskal Wallis test were used to determine and confirm significant differences within the categorical data.

3.7 RELIABILITY AND VALIDITY OF RESEARCH

"Poor measurements can invalidate any research project, because the researcher may be unable to show that the data accurately reflects the participant of the research" (Bless and Higson-Smith, 1995:130). Dane (1990:252-253) states that there are different techniques that are developed for the purpose of evaluating the measures that are used in the conduction of the research project. These techniques are based on the fact that the results of one measurement correlate with the results of another measurement. In the audiological profession this is known as the cross-check principle.

The researcher attempted to increase the reliability of the results by using objective measurements to verify the results obtained by subjective tests. This is known as the crosscheck principle. The audiological tests that were conducted by audiologists adhering to professional conduct were based on this principle. The hearing profile of the participant was not determined by an interview or single test that was performed, but a complete battery of tests were conducted in order to ensure the application of the crosscheck principle (Hall and Mueller, 1998:450). According to this principle, the test results were verified by conducting another test in order to confirm or reject the results of the initial test. The otoscopic examination and immittance testing are objective measures and were done to ensure that no voluntary response was required from the participants. The pure tone results and speech reception and discrimination results were crosschecked by the otoscopic results and the immittance results.

If these results did not correlate with the pure tone results, the pure tone results were rejected and the participant was retested. The DPOAE was used for a crosscheck measurement to exclude any functional hearing loss that might have existed. The audiologist was immediately aware of inconsistencies if the different results did not correlate and therefore the subjective tests could be repeated immediately. The application of this principle increased the test-retest reliability and the quality of the measurement. Reliability does not solely rely on the crosscheck principle. The researcher ensured that the equipment met the requirements of the manufacturers and the South African National Standards (SANS 0154-2000 and SANS 0182-1998, South African National Standards, 2000).

"Reliability deals with an indicator's dependability" (Neuman, 1997:138). Therefore ensuring that all equipment used to conduct the audiological test battery was calibrated or serviced prior to the commencement of the research increased the reliability. The ABR, the DPOAE and the insert earphones were serviced and tested prior to the commencement of the research in order to meet the requirements set by the manufacturer. The researcher also conducted biological calibration of the DPOAE by performing the test on herself prior to testing. Furthermore, the electrodes were cleaned after every ABR procedure that was conducted and a conduction test was performed prior to every ABR procedure to ensure that the electrodes were in operational condition. This suggested that the results obtained were exactly the same with the repetition of the test (Neuman, 1997:138).

The accuracy of the research results also depended on the validity of the instruments, especially the equipment that was used. Neuman (1997:141) said that the validity of the measurement instrument involves the extent to which an instrument measures what it is supposed to measure. The researcher identified the equipment needed to assess the different parts of the hearing system in order to identify any lesions that might be present. In this

research project the measurements were valid when the differences that were observed and measured in the hearing profiles of the participants reflected a true difference in characteristics of the participants.

Content validity and construct validity of all the material used for the purpose of the research project increased by the in-depth study of the literature concerning variants that influence the hearing profile of a participant with a HIV-related hearing loss. The literature regarding the conditions of the outer ear and the conduction of an otoscopic examination were used to establish a structured interview and a checklist containing the various observations that could be made and possible medical conditions that could lead to a hearing loss. The researcher developed the structured interview and the checklist based on her knowledge and experience and on the relevant literature that was studied. The literature was used to identify the structures and phenomena that could influence the hearing profile of the participants. These structures and phenomena were summarized in the checklist. This ensured a systematic evaluation and recording of observations.

The researcher also used a pilot study to determine if the apparatus and material were appropriate for obtaining the necessary results. The pilot study provided information regarding essential adjustments that had to be made in terms of the material used for collecting the data.

Lastly it must be kept in mind that perfect reliability and validity is almost impossible (Neuman, 1997:138). However, the researcher tried to maximise the reliability and validity by conducting a pilot study and ensuring that all the above-mentioned adjustments were made.

3.8 SUMMARY

The research aims, research design, material, apparatus and methods used in this research project were described in this chapter. Information regarding the complete research process is

also clearly discussed: the formulation of a research question, sample selection and description, material and apparatus that were used as data collection tools and the methods used for data collection and analysis. The results and a discussion of the results will be subsequently considered in the following chapters.

"What we have to learn to do, we learn by doing"

(Aristotle, B.C. 384-322)

CHAPTER FOUR

RESULTS AND DISCUSSION

Never regard study as a duty but as an enviable opportunity to learn to know the liberating influence of beauty in the realm of the spirit for your own personal joy and to the profit of the community to which your later works belong.

Einstein (1879-1955)

4.1 INTRODUCTION

The aim of this chapter is to present the results of the research project and to explicate the significance and implication of the results. The clarification of the influence of HIV on the hearing mechanism may assist the audiologist with comprehensive treatment in terms of the participants' hearing needs. The procedures used to collect the necessary data in order to obtain the required information to answer the main aim of the research project were enclosed in chapter three. The numerical results obtained during the data collection will assist in the description of the main aim: To determine the hearing profile of persons infected with HIV/AIDS at different stages of this disease, as well as the participants' exposure to medicine with ototoxic components related to this disease.

4.2 RESULTS OF SUB AIM ONE

To determine a hearing profile of persons who were diagnosed as being in any one of four different clinical stages of HIV/AIDS by considering the case history, the otoscopic examination, the pure tone air-and-bone audiogram, speech discrimination ability, the immittance measurements, distortion product oto-acoustic emissions [DPOAE's], and auditory brainstem response of each participant with HIV/AIDS.

The first sub aim of this research project was to determine the hearing profile of all participants without distinguishing between the four clinical stages of HIV/AIDS. The results were analysed and allocated as a group in order to determine the particular group's hearing profile. Sub aim one will be discussed in accordance with the areas of the hearing profile mentioned in section 4.2. Questions two to eight of the hearing interpretation recording form (Appendix K) revealed the various characteristics of the hearing profile for each participant. These results will be discussed and elucidated with the necessary figures.

4.2.1 Case history information

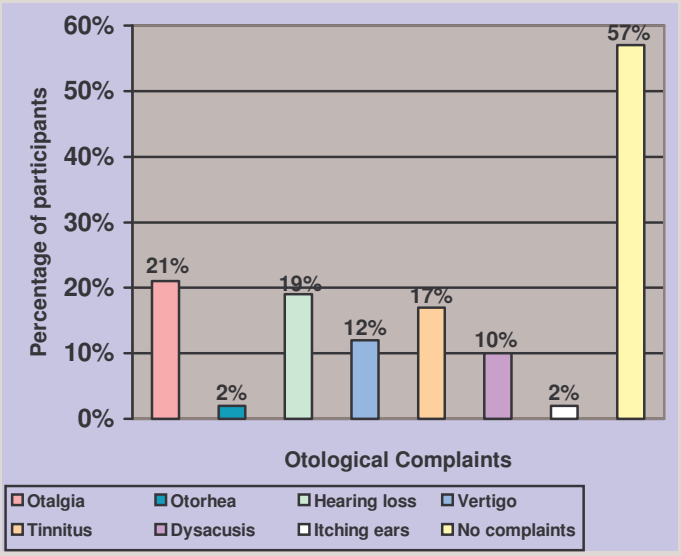
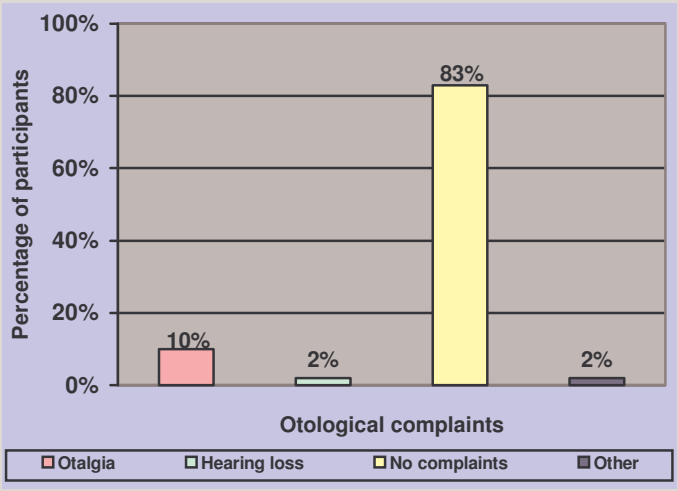
This category includes the otological complaints the participant may have experienced in the past and may currently be experiencing.

4.2.1.1 Previous and current otological complaints

Questions 2.1, 2.2 and 2.3 of the hearing interpretation recording form (Appendix K) provide the case history information regarding the otological complaints of the participants. These results were then divided into current complaints (complaints raised at the time of the data collection) and previous complaints (complaints raised prior to being infected or diagnosed with HIV/AIDS). Table 4.1 includes the current and previous complaints conveyed by each participant during the course of the data collection procedures.

Figures 4.1 and 4.2 supply information on the otological complaints of participants. Figure 4.1 indicates that, at the time of the data collection, participants had more otological complaints compared to the results in figure 4.2 which shows that the participants did not have as many otological complaints prior to being diagnosed with HIV/AIDS. The percentage of "no complaints" had the highest incidence. Fifty-seven percent of the participants revealed that they did not experience any otological complaints.

Table 4.1: Otological complaints of participants (n=42) [5]

RESEARCH POPULATION	DIAGRAM SPECIFYING OTOLOGICAL COMPLAINTS
Twenty-four (57%) participants had no otological complaints during the data collection procedure. Nine (21%) participants experienced otalgia and eight (19%) participants complained of hearing loss. Seven (17%) participants complained about tinnitus, while five (12%) participants complained of vertigo. Only one (2%) participant had problems with otorrhea and one (2%) complained of itching ears.	
	Figure 4.1: Current otological complaints of participants (n=42)
Thirty-five (83%) participants had no history of otological complaints. Four (10%) complained of otalgia in the past and only one (2 %) had a history of a hearing loss after being diagnosed with HIV/AIDS. Only one (2%) participant had another complaint not listed. None of the participants had previous symptoms of vertigo, tinnitus, dysacusis, itching ears and otorrhea.	
	Figure 4.2: Complaints of participants before diagnosed with HIV/AIDS (n=42)

5 At times more than one complaint was mentioned by one participant; therefore the percentages do not add up to 100%. For the purpose of discussing the prevalence of otological complaints, the researcher used n=42 as mean (and not the number of complaints as mean) to determine the percentage, because some of participants noted more than one otological complaint. In this way, the researcher was able to determine how many otological complaints were raised for the complete research population and to compare the results with the literature.

The complaints most often mentioned by the participants, were otalgia and loss of hearing. A well documented 70% to 90% of individuals infected with HIV presented at some point during the infection with ear; nose or throat manifestations, but external ear and middle ear pathology arises less frequently (Lubbe, 2004: 250,253). Even though otological symptoms in HIV-infected individuals are present less frequently than nose and throat complaints (Lubbe, 2004: 250,253), this research population presented with definite otological complaints. Complaints of otalgia had the highest incidence. A significant difference of p=0.002 was identified between males and females where females complained of otalgia more often. A significant difference (p=0.01) was also present between the oldest and the two youngest groups concerning the complaints of otalgia. The older individuals complained of otalgia more often. Gold and Tami (1998:166) mention that serous otitis media and recurrent acute otitis media are the most prevalent otological conditions. Otitis media is often associated with otalgia (Martin 1997, 243), therefore the presence of otalgia might suggest the presence of otitis media in these participants. However, this is still to be discussed in accordance with the immittance results.

Hearing loss had the second highest incidence. However, no significant difference existed between males and females regarding complaints of a hearing loss. Interestingly, Gold and Tami (1998:166) noted that a sensorineural hearing loss ranges from 20% to 50% in individuals infected with HIV/AIDS, while only 19% of this research population complained of hearing loss. However, since Gold and Tami (1998:166) state that more than 20% individuals may experience a hearing loss, these research findings (19% complained of hearing loss) correlate well with the literature. The literature also states that ear manifestations occur less frequently in HIV/AIDS compared to conditions from other areas of the head and neck (Lubbe, 2004:253). This statement is echoed in the large percentage that did not complain of any otological conditions, suggesting that no otological conditions were present. However, after participants had contracted HIV/AIDS, the number of otological complaints increased drastically. This may

be due to the direct effect of HIV, which compromises the functioning of the immune system, making the body more susceptible to contract harmful infections leading to otological infections and inevitably, to otological complaints.

Gold and Tami (1998:167) mention that vertigo can be prevalent in individuals with HIV/AIDS. The research results confirm this statement, since 12% of the participants complained of vertigo. Tinnitus was the third most prevalent complaint (17%). Stevenson (1993:22) found that individuals with HIV/AIDS can present with tinnitus, especially when AZT (Zidovudine) was administered. This signifies that the reason for the tinnitus may be the administration of ototoxic drugs. Dysacusis due to cochlear damage was also a complaint raised by 10% of the participants. Complaints of dysacusis revealed no significant difference between males and females.

Figure 4.2 shows that most of the participants had no history of otological problems prior to being diagnosed with HIV/AIDS, but otalgia and hearing loss were also complaints participants mentioned to have experienced in the past. However, complaints of otalgia and hearing loss were less recurrent before these participants were diagnosed with HIV/AIDS. Otalgia was present in only 10% of the participants and only 2% complained of hearing loss before being diagnosed with HIV/AIDS.

It is clear when comparing tables 4.1 and 4.2 that the participants experienced more otological complaints after they contracted HIV/AIDS, suggesting that the presence of otological complaints may have increased with the contraction of HIV/AIDS and the progression of HIV to AIDS. Before being infected with HIV/AIDS, participants did not have any otological complaints, but once they were infected, various otological conditions manifested themselves and participants started to complain. Bankaitis (1998:117) notes that almost "*…100% of HIV-related symptoms involve the area of the head and neck and audiological changes have been*

consistently documented". This suggests that otological manifestations may occur relatively often, thus leading to different otological complaints.

The assumption from these results can either be that these particular participants were less prone to experience otological problems before they contracted HIV/AIDS. After these participants had been infected with HIV/AIDS, the incidence of all types of otological complaints increased, especially in terms of otalgia and hearing loss. Vertigo and tinnitus was also a relatively common complaint after their being infected with HIV/AIDS. A possibility for the increase in otological complaints is that since the participants were diagnosed with HIV/AIDS, these participants became more aware of their health, as well as of signs and symptoms concerning HIV/AIDS. This may reflect the positive effects and appropriateness of post-test counselling (counselling after being diagnosed with HIV/AIDS), especially in terms of creating awareness.

Thus, while otological diseases are not, in general, life-threatening, they may be overlooked or neglected when the individual is examined by a health care worker. This means that not only audiologists, but also health care workers should include questions on ear discomfort in their interviews to ensure timely referral for these complaints. Liaison between the audiologists, general practitioners, specialists and other health care workers is extremely important. Audiologists cannot treat ear infections, but the phenomenon of hearing is the audiologist's field of expertise. This stresses the significance of a *team approach* in the treatment and rehabilitation of the individual with a hearing loss in order to address all aspects of this disease.

Awareness of probable ear conditions should increase among the public, including those infected with HIV/AIDS and their families, to ensure that they seek appropriate support and assistance to address these conditions. Audiologists should also be aware of otological conditions when making an ear mould or taking an ear mould from the patient with bare hands.

Bacteria and fungal infections may be present in the ear and when the procedures for *infection control* are not implemented, these infections may spread.

4.2.1.2 Distribution of spectrum of diseases

Apart from otological diseases, persons diagnosed with HIV/AIDS may also present with other types of diseases. Various diseases can be found among persons with HIV/AIDS. For the purpose of this research project, these diseases were classified into different spectrums, such as otolaryngological diseases, lung diseases, skin diseases, small bowel diseases and neurological diseases. According to Bankaitis (1998:123), the classification of diseases may be helpful in managing patients, deciding on proper medical management, developing research and establishing new treatment procedures. This does not only suggest medical treatment protocols, but may also include rehabilitation protocols, especially in terms of addressing hearing loss and associated problems. Considering the types of diseases present and comparing this to the presence of a hearing loss could lead to more prompt assessment and diagnoses of hearing loss. If a definite correlation exists between certain types of diseases and hearing loss, the clinician can recognise the disease and know that a proper and prompt referral should be made to an audiologist for a hearing assessment.

Questions 2.4 and 2.5 of the hearing interpretation recording form (Appendix K) provide the case history information regarding the spectrum of diseases present among the participants. In table 4.2, the typical spectrum of diseases found in the population who participated in this research was summarized. It encloses figure 4.3 which depicts the results obtained from the hearing interpretation recording form (Appendix K). Eight participants were diagnosed with more than one type of disease. Figure 4.3 provides the results in terms of the incidence of each type of disease among this research population.

Table 4.2: Spectrum of diseases diagnosed among participants (n=42)6

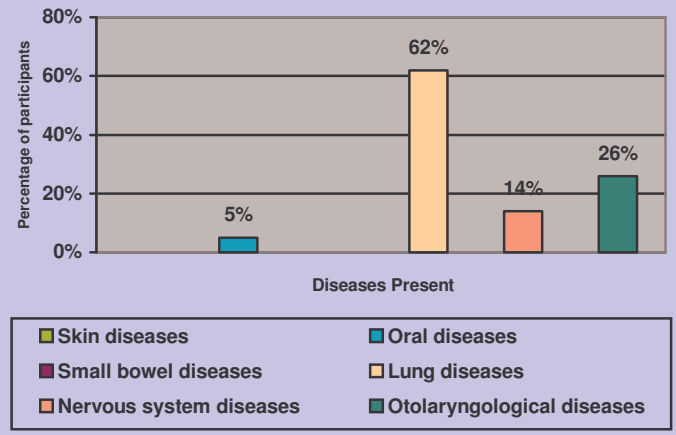
RESEARCH POPULATION	DIAGRAM SPECIFYING DISEASES PRESENT
Eight (19%) participants had more than one type of disease. Twenty-six (62%) participants were diagnosed with a lung condition such as Tuberculosis, while 11 (26%) participants were diagnosed with otolaryngological conditions. Six (14%) participants were diagnosed with a nervous system disease and only two (5%) presented with an oral disease.	

Figure 4.3: Diseases identified among participants (n=42)

As evident in figure 4.3, only four types of disease spectrums were found in the 42 participants infected with HIV/AIDS. Sixty-two percent of participants presented with more than one type of disease. Most of the participants presented with lung diseases, which were mainly pulmonary tuberculosis. No significant difference between males and females was identified in terms of the presence of this condition. The studied literature reveals that 72% of individuals with HIV/AIDS present with military tuberculosis that involves symptoms of the respiratory tract (Meintjies and Rebe, 2004:180). The high incidence of lung infections suggests that audiologists and health care workers should increase their infection control and go to great lengths to prevent contamination of other patients in the private or public sector.

Otolaryngological conditions, such as otalgia, otitis extern, otorhea and myringitis had the second highest incidence (26%) among the research population. However, this is not in line with the estimation made by Gold and Tami (1998:172), stating that approximately 40% to 60%

6 At times more than one condition was diagnosed in one participant, therefore these calculations do not add up to 100%.

and Lubbe (2004:250) suggesting that 70% to 90% of all HIV-infected individuals exhibit otolaryngological conditions involving head and neck manifestations. These head and neck manifestations, specifically those involving the auditory system, may suggest the loss of hearing sensitivity that may be cochlear or conductive in nature (Gold and Tami, 1998:165).

A significant relationship existed between those participants with otolaryngological diseases and those that complained of otalgia ($p=0.04$), those that complained of otorhea ($p=0.01$), those that complained of vertigo ($p=0.009$) and finally those that complained of tinnitus ($p=0.003$). existed between those participants with otolaryngological diseases and otorhea. This signifies the reliability of the results and the complaints of the participants. Furthermore, a significant relationship ($p=0.01$) existed between those participants with lung diseases and vertigo. This may be due to the vestibulotoxic effects of the TB medication.

Only 5% of the participants in this research project presented with oral diseases, with no significant difference between male and female participants. However, the literature states that oral ulcers and oral candidas are identified in 10% to 20% of HIV-infected individuals (Meintjes and Rebe, 2004:180). The reason for the difference between the incidence of these diseases in literature and in this research project may be that the diseases go undetected. The high incidence of HIV/AIDS in South Africa and the limited resources especially in the public sector could contribute to the inability to detect these diseases.

Audiologists and health care workers should also understand that part of the consequences of HIV/AIDS is the presence of otolaryngological infections, which should be considered during interviewing, evaluation and rehabilitation. Especially when a hearing aid fitting is planned, the audiologist should prepare the individual prior to the fitting of external ear conditions that may develop and thus influence the success of the hearing aid fitting. The audiologist should also educate this individual on the procedures to follow should an ear infection commence.

No participants presented with skin conditions and small bowel diseases, but 14% neurological diseases were observed among these participants. Neurological conditions, such as cryptococcus, cytomegalovirus, encephalopathy, kaposi sarcoma, lymphoma and toxoplasmosis are AIDS markers (Bankaitis, 1998:125). These conditions, especially AIDS-related encephalopathy and subacute encephalitis may lead to a neural hearing loss or a central hearing loss due to retro-cochlear damage (Gold and Tami, 1998:165,167). In these participants, a significant relationship (p=0.01) existed between those participants with nervous system diseases and those who presented with bilateral hearing loss. Those with nervous system diseases more often presented with a bilateral hearing loss. This shows that a strong relationship between a bilateral hearing loss and nervous system diseases existed, thus individuals with HIV/AIDS and nervous system manifestations will most probably present with a bilateral hearing loss. These results correlate with the literature stating that sensorineural hearing loss can be expected in approximately 27% of the individuals with a history of cryptococcal meningitis (Matkin et al.,1998:150). Therefore the probability is that the participants with HIV/AIDS and associated neurological conditions may present with either N.VIII pathology or facial nerve pathology.

4.2.2 Otoscopic examination

The researcher recorded the otoscopic observations on the hearing interpretation recording form (Appendix K). This category includes all landmarks and conditions that were observed by the researcher during the inspection of the ear canal and tympanic membrane, especially landmarks or possible conditions that may influence the participant's hearing.

Lubbe (2004:250) mention that 70% to 90% of the individuals with HIV/AIDS may present with ENT manifestations at some stage. Since ENT constitutes ear; nose and throat manifestations,

conditions of the ear canal, tympanic membrane and hearing are thus included as possible ENT manifestations.

The otoscopic examination revealed various otological conditions that may be the cause of a hearing loss. Kohan, Rothstein and Cohen (1988) in Gold and Tami (1998:165) suggest that otological manifestations such as otitis externa, otitis media, mastoiditis, tympanic membrane perforation and cholesteatoma are often associated with HIV/AIDS. Some of these conditions were in fact observed in this research population and are described in the following section.

4.2.2.1 Otoscopic examination findings

In table 4.3, the otoscopic findings obtained during data collection are specified. This table contains figures 4.4 and 4.5, which depicts prevalence of various observations made of the external ear canal in all the ears[7] for the total research population. In certain participants' ears, more than one pathology was observed, leading to a larger mean of observations than mean of ears. This suggests that the percentage of observations made will be higher than the supposed 100%.

7 At times, more than one condition or landmark was observed in one ear of a participant, therefore these calculations do not add up to 100%. For the purpose of this research project, the left and right ears were separated from this point onwards to increase the mean (n=84) for analytical purposes.

Table 4.3: Observations made for each ear during the otoscopic examination (n=84)

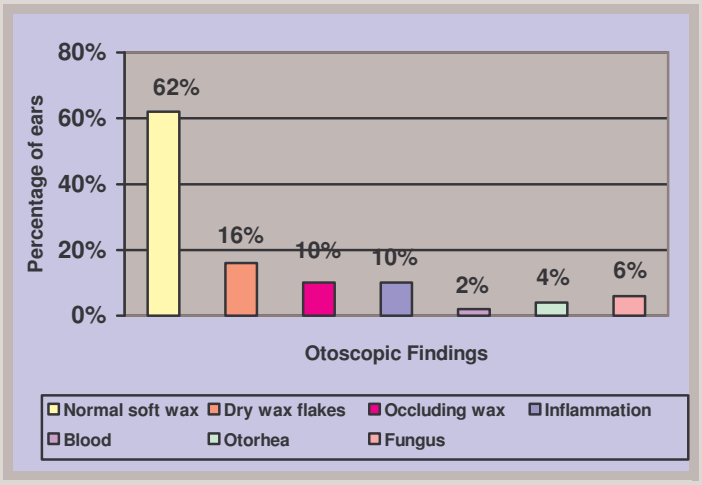
RESEARCH POPULATION	DIAGRAM SPECIFYING OTOSCOPIC FINDINGS
Seven (8%) ears had more than one abnormal landmark. The observations were as follows: Normal soft wax was present in a total of 52 ears (62%). Dry wax flakes were observed in thirteen (16%) ears. Wax occluding the ear canal was observed in eight ears (10%), and inflammation was observed in eight (10%) ears. Blood was observed in two (2%) ears; otorhea was identified in three (4%) ears and five (6%) ears had a fungal infection. No osteomas, hematomas or foreign bodies were observed.	

Figure 4.4: Otoscopic observations of the external ear canal for each ear (n=84)

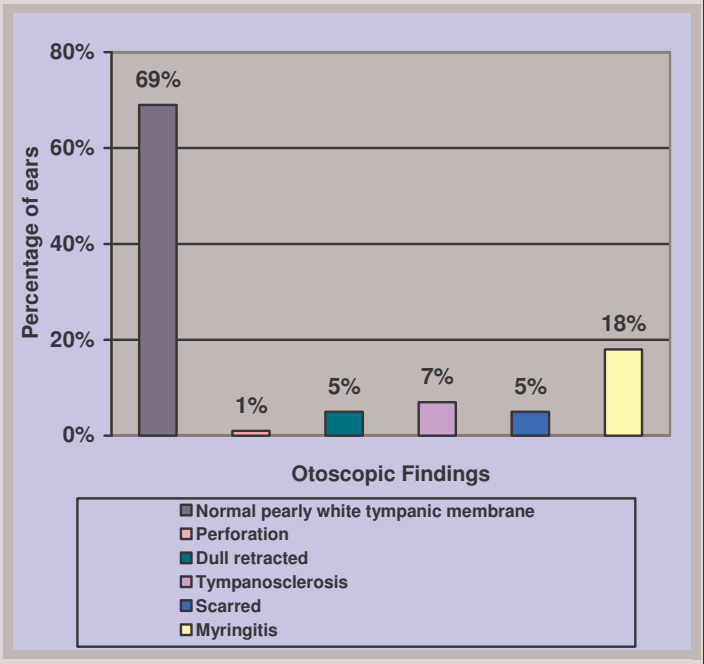
Four (5%) ears had more than one abnormal landmark. Normal pearly white tympanic membranes were observed in 58 (69%) ears and abnormal landmarks were observed in 26 (31%) ears. Inflamed tympanic membranes, suggestive of the presence of myringitis, were observed in 15 (18%) ears and four ears (5%) presented with dull retracted tympanic membranes. One (1%) had a perforated tympanic membrane.	

Figure 4.5: Otoscopic observations of the tympanic membrane for each ear (n=84)

Figure 4.4 depicts the otoscopic observations of the external ear canal made by the researcher during the data collection procedures. No foreign bodies, osteomas or hematomas were identified in any of the ears. The observation of normal soft wax had the highest incidence (62%) and dry flaky wax (16%) had the second highest incidence. Martin (1997:224) notes that glands situated in the external ear canal are often exceptionally active, leading to excessive production of cerumen and in a small ear canal it may result in occlusion leading to a hearing loss. Occluding wax, which may lead to a hearing loss, was observed in 10% of these participants.

The tympanic membrane becomes inflamed and red, usually in response to a viral infection producing otalgia (Martin, 1997:224), thus suggesting that the direct effect of HIV/AIDS might have led to myringitis or it could have developed in response to possible otitis extern. Inflammation and fungal infections, even otorhea, were observed in these participants, suggesting possible otitis extern. Since extreme pain together with redness and swollen skin, as well as discharge can often be associated with otitis externa (Martin, 1997:221), it confirms the results obtained from table 4.1, figures 4.1 and 4.2, which indicates that otalgia was a relatively common complaint among these participants, while itching ears and otorrhea were also experienced by some of the participants.

Figure 4.5 illustrates the otoscopic examinations of the tympanic membrane for each ear made by the researcher during the data collection, thus after the participant had been diagnosed with HIV/AIDS. A significant difference was identified between males and females, indicated by a p-value of 0.02. Males more often presented with normal otoscopic findings of the tympanic membrane.

A perforation was identified in one ear and according to Martin (1997:227), the tympanic membrane tends to perforate in response to infection, especially middle ear infection. With

perforations caused by infections such as otitis media, the healing process tends to be very slow (Martin, 1997:227). Since the incidence of otitis media with effusion is higher in individuals infected with HIV/AIDS (Lubbe, 2004:253), the researcher expected to observe otitis media and possible perforations more often. However, the perforation was observed in only 1% of the ears and dull retracted tympanic membranes, also suggestive of otitis media were observed in 5% ears (Martin, 1997:243). This is in line with the results to be discussed in section 4.2.5.1.1.

The assumption is that these conditions may lead to conductive non-permanent hearing loss, especially the dull retracted tympanic membrane, the perforations and tympanosclerosis. These conditions may affect the middle ear in such a way, leading to a conductive hearing loss. However, clinical diagnoses of middle ear conditions or conditions that may lead to a hearing loss are often difficult, due to lack of equipment and inexperience of the health care worker. In general, otoscopic examinations are not always as straightforward as they are made out to be. When the clinician does not know what to look for, conditions may go unnoticed.

Even though the presence of middle ear conditions is very probable in individuals with HIV/AIDS, there are still exceptions. Not all individuals will present middle ear conditions. This therefore suggests that even though audiologists and health care workers should take note of the different middle ear conditions and should constantly be aware of the possibility that these conditions may be present, the audiologist should not enter the assessment situation with preconceived ideas. Normal otoscopic findings can be found.

On the other hand, observations of normal external ear canals and normal tympanic membranes had the highest incidence, which may compose a problem in making the appropriate referrals, since normal otoscopic findings do not necessarily suggest normal hearing. Health care workers may not always make the appropriate referral to an audiologist to

conduct immittance measurements and an audiogram for the identification of these hidden conditions. This may be due to lack of awareness, lack of knowledge or just inability to obtain an appropriate case history and conduct the appropriate tests and management strategies. This also stresses the fact that all individuals with HIV/AIDS, as well as all individuals working with people infected with HIV/AIDS, should be aware of otological symptoms and complaints. Referral to an audiologist by a health care worker and a complete audiological assessment by an audiologist are essential when confronted with an individual with HIV/AIDS.

Other important factors are the need for equipment and the lack of skill, especially in the public sector. Otoscopes are not always available and those that are available are not always of good standard. The public sector should recognize the importance of high quality otoscopes for the identification of external and middle ear conditions as well as the training of the personnel to improve their skills and enable them to identify middle ear pathology through careful observation of the external ear canal and tympanic membrane. This will enhance appropriate referrals, early identification and even prevention of a hearing loss, which will in the end improve the quality of life of the individual infected with HIV/AIDS.

The high incidence of normal soft wax should also be considered when fitting a hearing aid, since excessive wax production may cause blocking of the hearing aid, preventing the amplified sounds from reaching the eardrum. Therefore audiologists should encourage patients to visit a health care worker on a regular basis to syringe their ears after being fitted with a hearing aid, prepare them for possible feedback that may be present due to the excessive wax production in the ear canal and educate them on the procedures that should be followed when it does happen.

Prevention of the spread of HIV/AIDS through wax is another important facet of infection control that should be considered when working with individuals infected with HIV/AIDS.

Research has shown that HIV/AIDS may spread through the wax, because wax is an infectious substance in individuals with HIV/AIDS (Kemp and Roeser, 1998: 199). Therefore the necessary measurements should be taken when the audiologist, for any reason, comes into contact with the wax of an infected individual. These infection control measures will prevent contamination and will protect the audiologist, as well as the other patients.

4.2.3 Characteristics of the pure tone audiogram

The characteristics of the audiogram, in terms of the type, nature and degree of the hearing loss are presented in this section. This section provides information on the number of ears affected by loss of hearing sensitivity, the type and the degree of hearing loss at the different frequency spectrums and lastly, the configuration of the audiogram.

Questions 4.1 to 4.11 of the hearing interpretation recording form (Appendix K) reveal information regarding the type, degree and configuration of hearing loss of the pure tone audiogram of the subjects. All thresholds at all frequencies for each participant were tabulated (Appendix N). This was used to establish the averages and standard deviations for each frequency in order to determine the audiogram that would mainly be found in this particular research population.

4.2.3.1 Unilateral or bilateral hearing loss[8]

When comparing the two ears, the researcher was able to determine whether both ears had been affected equally, suggesting the same incidence of hearing loss. Table 4.4 provides a discussion and a visual representation of how many participants' hearing was affected by a hearing loss or who experienced a bilateral or unilateral hearing loss. The information obtained from question 4.3 of the hearing interpretation recording form (Appendix K) provided the necessary information to discuss in this section.

Table 4.4: Prevalence of hearing loss (n=42)

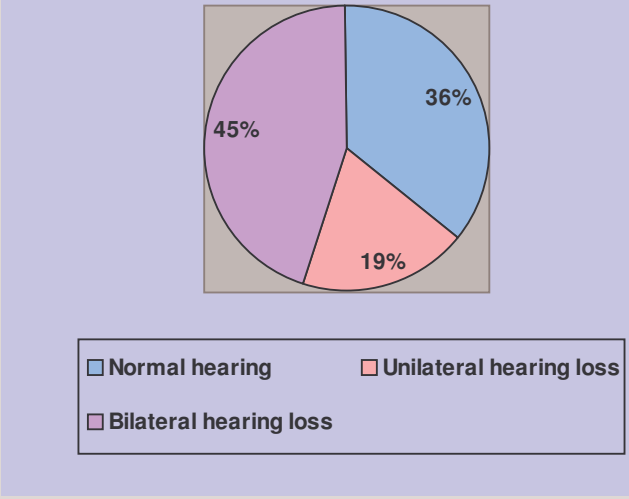
RESEARCH POPULATION	DIAGRAM SPECIFYING AMOUNT OF EARS AFFECTED
Fifteen (36%) participants experienced normal hearing, while eight (19%) had a unilateral loss. A bilateral hearing loss had the highest incidence of 19 (45%).	

Figure 4.6: Prevalence of unilateral or bilateral hearing loss (n=42)

8 For the purpose of discussing the prevalence of unilateral and bilateral hearing loss, and since a bilateral hearing loss is found per participant and not per ear, these results of section 4.2.3.1 will be analysed according to each participant and not according to each ear. The mean for section 4.2.3.1 is therefore n=42.

According to the results of this study, a bilateral hearing loss had the highest incidence, while a unilateral hearing loss had the lowest incidence. The results obtained from the study conducted by Stevenson (1993:27) suggest that unilateral hearing losses are found more frequently in the HIV/AIDS population. Therefore the results of this research project are not in line with the findings of Stevenson (1993:27).

It seems that when ears are affected by a hearing loss, it will most probably be bilateral in nature rather than unilateral. Another observation that can be made is that, more often than not, hearing sensitivity will be affected, irrespective of whether it is bilateral or unilateral especially when certain types of diseases were present. A significant relationship existed between those participants with otolaryngological diseases ($p=0.004$) and those who presented with bilateral hearing loss. Those with otolaryngological diseases more often presented with a bilateral hearing loss. This shows that a strong relationship between a bilateral hearing loss and otolaryngological diseases existed, thus individuals with HIV/AIDS and otolaryngological manifestations will most probably present with a bilateral hearing loss.

The current trend is to expect that individuals with HIV/AIDS present with a hearing loss most of the time. Audiologists should always remember that each individual is unique and this uniqueness should never be underestimated by entering an assessment situation with preconceived ideas. Not all patients will be susceptible to a hearing loss. It is probable that the hearing sensitivity may not be influenced at all. Literature sometimes leaves the impression that a hearing loss will almost always be present. Clearly this is not the case and audiologists should keep that in mind.

These results suggest that national awareness campaigns for HIV/AIDS should include facets such as the development of hearing loss, since it is clear that hearing loss does exist in some individuals. Individuals who contract this virus should be aware of the effects HIV may have on

their hearing ability. These individuals already have a life-threatening disease that may influence their quality of life and would therefore need all available resources to improve their quality of life. This explains why they need to be educated regarding their hearing health and where to find the necessary assistance.

Lastly, as it is important for each audiologist to protect the individual with HIV/AIDS, the audiologist needs to protect his/her employer. Increasingly,the mining sector of South Africa has become a problem (Department of Labour, 2005:21). Since HIV/AIDS is clearly associated with hearing loss, the industrial audiologists should be aware of the effects HIV/AIDS has on hearing, as mining and industrial sectors have increased their expenditure due to compensation claim payouts for NIHL without considering the effects that HIV/AIDS may have on hearing.

4.2.3.2 The prevalence of a hearing loss for the left and right ears[9]

In table 4.5 the left and right ears are separated and indicate the prevalence of hearing loss in each ear. Question 4.4 of the hearing interpretation recording form (Appendix K) reveals the information. Figure 4.7 is included in order to elucidate the results described in table 4.5.

9 For the purpose of this section, each ear was viewed as a separate entity in order to enable the researcher to identify differences in the number of left and right ears that were affected. Therefore the mean for section 4.2.3.2 is n=84. These results were also rounded off to the first decimal, since the left and right ears were affected equally. Therefore, the percentage of both ears had to be exactly the same and the sum of the ears affected and the ears not affected should be 100%. This explains why only figure 4.7 was rounded off to the first decimal.

Table 4.5: Prevalence of a hearing loss in the left and right ears separately (n=84)

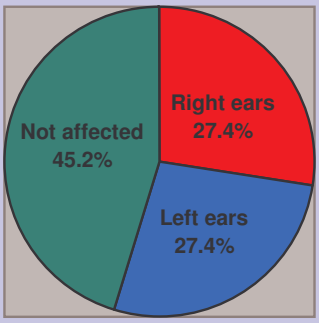
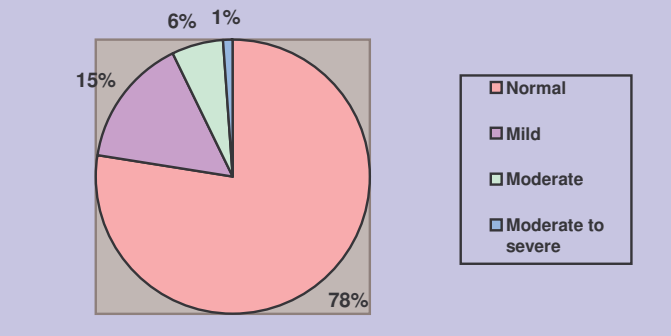
RESEARCH POPULATION	DIAGRAM SPECIFYING EARS AFFECTED
In terms of the number of ears affected, the results indicated that 23 (27.4%) left and 23 (27.4%) right ears were equally affected. Thus, in total 46 (55%) were affected while 38 (45.2%) displayed no decrease in hearing sensitivity.	 **Figure 4.7: Prevalence of hearing loss in the left and right ears (n=84)**

Figure 4.7 shows that both left and right ears were equally affected by a hearing loss. Therefore no significant difference existed between the degree of the hearing sensitivity in the left and the right ear of the subjects in this study. These results do not echo the findings of Stevenson (1993:27) who found in the HIV-infected population studied, that the left ears were more often affected by a hearing loss than the right ears. From this research, it is clear that even though unilateral hearing losses were present, both ears were affected equally. Thus one ear was not necessarily more prone to developing a hearing loss than the other ear. The results indicated in section 4.2.3.2 correlate with the results from section 4.2.3.1. According to section 4.2.3.1, eight participants experienced a unilateral hearing loss (suggesting that eight ears were affected) and 19 participants experienced a bilateral hearing loss (suggesting that 38 ears were affected). The sum of 38 and eight is 46.

4.2.3.3 The degree of hearing loss for each ear determined by the PTA[10]

Table 4.6 depicts the average degree of hearing loss through determining the PTA for 500Hz, 1000Hz and 2000Hz. Question 4.6 of the hearing interpretation recording form (Appendix K) supplies the information provided below.

Table 4.6: Degree of hearing loss determined by the PTA (n=84)

RESEARCH POPULATION	DIAGRAM SPECIFYING DEGREE OF HEARING LOSS
Sixty-five (78%) ears had (0-25dB) normal hearing sensitivity. Thirteen (15%) ears had a mild degree of hearing loss while 5 (6%) ears had a moderate hearing loss. A moderate to severe hearing loss was only found in one (1%) ear. None of the ears were diagnosed with a severe or profound hearing loss.	 **Figure 4.8: Degree of hearing loss according to the PTA (n=84)**

From figure 4.8 it is clear that hearing sensitivity calculated according to the PTA was mainly within normal limits. A significant difference (p=0.001) was identified between males and females in terms of the average thresholds at 125Hz and 250Hz and not in terms of the PTA. The females had a higher incidence of a low frequency hearing loss. Of those participants who did present with a hearing loss, a mild degree of hearing loss (PTA: 26-40dB) had the highest incidence. A significant relationship (p=0.004) existed between those participants with otolaryngological diseases and the different degrees of hearing loss. Apart from normal pure

10 The degree of hearing loss was interpreted according to Goodman (1965) in Hall and Mueller (1998:104). Normal hearing suggested a PTA between 0dB and 25dB, mild hearing loss suggested a PTA between 26dB and 40dB, moderate hearing loss suggested a PTA between 41dB and 55dB and lastly a moderate-to-severe hearing loss suggested a PTA between 56dB and 70dB.

tone averages that had the highest incidence in the groups with otolaryngological diseases, it was clear that mild, moderate and severe hearing losses were identified significantly less often. This confirms that the mid-frequencies were usually within normal limits, even with otolaryngological diseases present. Moderate and moderate-to-severe degrees of hearing loss had the lowest incidence. Gold and Tami (1998:167) suggest that *"…typically the hearing loss increases with frequency…".*

According to the results of this research project, the mid-frequencies were mainly within normal limits. Even though the degree of hearing loss was frequently recognized to be within normal limits (meaning better than 25dB), it was clear that the high and low frequencies were more often affected with a loss of hearing sensitivity than the mid-frequencies.

These observations suggest that some degree of loss of hearing sensitivity in the low and high frequencies, but with normal mid-frequencies, might most probably be present in individuals with HIV/AIDS. This also urges the audiologist not only to conduct a screening test that takes into account the degree of hearing loss at the mid-frequencies, but also to consider the loss of sensitivity at the high and low frequencies. These results also indicate that individuals with HIV/AIDS may not experience a total hearing loss and they might even think that their hearing is normal, since they still have excellent or relatively good hearing in the mid-frequencies. However, when obtaining more in-depth information in terms of case history and performance in hearing tests, a hearing loss which might influence their daily functioning to a great extent may be identified.

If appropriate questions are asked during the collection of case history information, one might obtain information that already suggests that a person may have difficulty with hearing in certain listening situations and then appropriate referrals can be made. Upon arrival at the audiology practice, the clinician should know and understand the importance of complete and

thorough pure tone testing across the complete frequency spectrum of the audiogram. This signifies the importance of awareness of hearing health, types of questions to be asked, appropriate referrals to be made and diagnostic testing to be done when consulting an individual with HIV/AIDS. More specific information regarding the configuration of the results in terms of high and low frequency hearing loss is discussed in the following section.

4.2.3.4 Configuration of audiograms

The results of the configuration of the audiograms, as well as the average thresholds elicited at various intensity levels as function of the different frequencies, are summarized in table 4.7. Question 4.9 of the hearing interpretation recording form provides the information supplied in table 4.7.

When the averages of all thresholds were calculated for each frequency of the audiogram, the average audiogram for individuals with HIV/AIDS seemed to have been slowly rising to the mid-frequencies and then falling to the high frequencies. This is indicated by figure 4.10. However, when each audiogram was analysed separately and the results indicated on the hearing interpretation recording form (appendix K), it was clear that flat configurations as well as regular configurations were also identified significantly often.

Table 4.7: Configuration of audiograms (n=84)

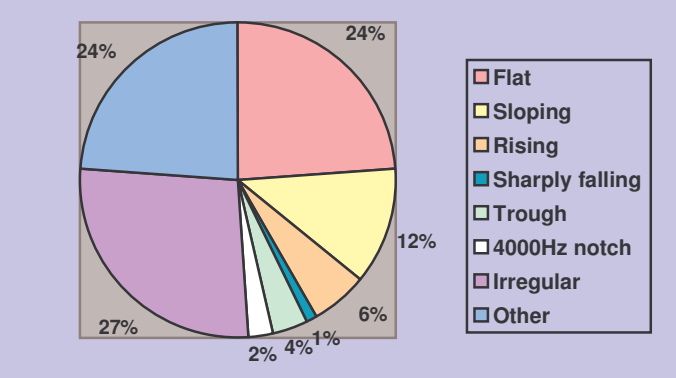
RESEARCH POPULATION	DIAGRAM SPECIFYING CONFIGURATION OF AUDIOGRAMS
A flat configuration was identified in 20 (24%) ears. An irregular configuration was identified in 23 (27%) ears. A sloping configuration was found in 10 (12%) ears and a rising configuration was found in five (6%) ears. A sharply falling configuration was found in only one (1%) ear, a trough configuration in three (4%) ears and a 4000Hz notch was found in two (2%) ears.	

Figure 4.9: Configuration of audiograms (n=84)

Air conduction thresholds for the ears of this research population were obtained at normal intensity levels for the low frequencies. An improvement in intensity with the progression to the mid-frequencies was noted, while with the progression to the high frequencies, the intensity levels deteriorated. Bone conduction thresholds had the same profile where a slight improvement from the low to the mid frequencies and then a decrease from the mid to the high frequencies were observed. Therefore this configuration can be described as a type of rising-falling configuration which is representative of the option "other" in table 4.13. However, the bone conduction thresholds in general were obtained within normal limits, with a significant air-bone gap in the low frequencies of the audiogram.

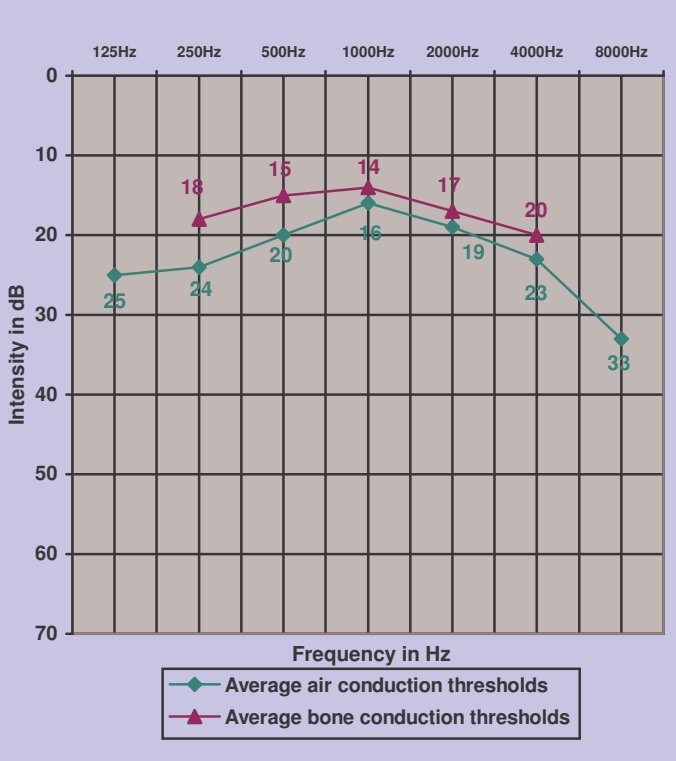


Figure 4.10: Average pure tone thresholds as a function of frequency (n=84)

Figure 4.9 suggests that an irregular audiogram configuration, thus configuration with no particular pattern or shape, has the highest incidence in this research population. Flat audiogram configurations (24%) suggest there is less than 5dB difference between two adjacent frequencies or according to Roeser, Valente and Hosford-Dunn (2000), little or no change in thresholds across all frequencies. Other configurations (24%), referring to configuration that rises slowly to the mid-frequencies, falls slowly from 1000Hz to 4000Hz, then falls relatively sharply from 4000Hz to 8000Hz, had the second highest incidence. A sloping hearing loss was found in 12% of the research population. These results echo the results obtained by Stevenson (1993:33) who mentioned that sensorineural hearing losses were characterized by sloping loss in the high frequencies, specifically in the 8000Hz frequency region. It also confirms the statement made by Gold and Tami (1998:167), stating that the degree of hearing loss becomes moderate at the high frequencies, thus suggesting a high frequency sloping hearing loss. This may suggest that in these individuals, prior to the low frequencies being affected, the high frequencies were probably first affected either by the direct effects of the disease or the administration of antiretroviral therapy [ART] [11]. The precise influence of the ART on the hearing of an individual has not been determined yet. However, a potential for HIV-infected individuals to develop a drug-induced hearing loss is relatively high (Bankaitis and Schountz, 1998:156), specifically in terms of a possible high frequency deafness (Bankaitis and Schountz, 1998:163). The influence of ART on hearing will be discussed in sub-aim three.

11"Drugs specifically developed to combat HIV or other retroviruses are known as antiretroviral drugs. The drug regimen of the HIV-infected population often involves potentially ototoxic, government-approved antiretroviral medication along with experimental antiretroviral drugs with undocumented or unknown side effects" (Bankaitis and Schountz, 1998:155). Therefore for the purpose of this research project, ART is the abbreviation used for antiretroviral therapy.

Figure 4.10 reveals that the mid-frequencies, specifically 1000Hz, had the best thresholds, while the low and high frequencies showed a slight decrease in hearing sensitivity compared to the mid-frequencies. This therefore suggests a type of configuration that rises or improves from the low frequencies to the mid frequencies and falls from the mid frequencies to the high frequencies. A sudden fall was observed from 4000Hz to 8000Hz. Figure 4.10 suggests that even though the PTA of these participant ears were obtained within normal limits, suggesting a normal degree of hearing, a decrease in the high and low frequencies were present at times. This is why the configuration of the audiogram provided the researcher with significant information regarding the integrity of hearing of each participant's hearing.

An interesting finding was also that a significant difference between males and females was found in terms of the types of configuration of hearing losses. A significant difference of $p=0.0006$ was identified between males and females where males presented with a flat audiogram configuration more often and females presented with a configuration that varies in the high and low frequencies more often. Furthermore a significant difference ($p=0.01$) existed between the types of configurations and the presence of otolaryngological diseases. Irregular, "other" configurations were found significantly more often than the sloping, trough, sharply falling and notching configurations. When otolaryngological diseases are present in individuals with HIV/AIDS they will most likely present with irregular configurations, or configurations that slowly rises from the low frequencies and drops in the low high frequencies. Consequently, it is essential to ask the type of questions which will promote the collection of appropriate information that may identify the loss of hearing sensitivity.

High frequency hearing loss is almost always present in individuals with HIV/AIDS, but the degree and configuration of hearing loss may clearly differ from individual to individual. This signifies why a thorough assessment should be completed when the hearing of a person with

HIV/AIDS is tested. It is extremely important to reflect upon all test results when the management of the hearing loss is planned and amplification is considered. In terms of fitting these individuals with hearing aids, the audiologist may consider a less sophisticated hearing aid for those with flat audiograms or a two-channel hearing aid for those with a slowly-rising-sharply-falling configuration. This suggests that the expenditure on hearing aids would be less, especially for the public sector, since free health care services are applicable to any individuals with a hearing loss. It also suggests that when the public sector plans and budgets for hearing aids, these facts should be considered in order to be able to assist these individuals with amplification. This also puts forward the issue of aural rehabilitation. Since individuals may experience a hearing loss across the complete frequency spectrum, they miss out on low and high frequency sounds, suggesting that aural rehabilitation should be more intensive.

4.2.3.5 The type of hearing loss

Table 4.8 contains a discussion on the type of hearing loss identified among this population. Figure 4.11 offers an illustration of the prevalence of the different types of hearing losses, as well as the prevalence of normal hearing sensitivity found in this research population.

The loss of hearing sensitivity was classified into four different types of hearing loss, namely, sensorineural hearing loss, conductive hearing loss, mixed hearing loss and normal hearing. Sensorineural hearing loss was viewed as loss of hearing sensitivity where the air-and bone-conduction thresholds are equally depressed with no air-bone gap (Martin, 1997:294). When the hearing sensitivity by air conduction is poorer than by bone conduction, especially with bone conduction still within normal limits, it is considered to be a conductive hearing loss (Martin, 1997:90). Mixed hearing loss also suggests the presence of an air-bone gap (10dB or greater), but both air- and bone thresholds are abnormal (Martin, 1997:90). Again, it is crucial to understand that these results may differ from the results in table 4.6. The 60% normal

hearing in table 4.8 and the 78% normal hearing in table 4.6 differ with 18% due to the fact that the type of hearing loss (table 4.8) was determined across the complete frequency spectrum, whereas only the PTA (average intensity thresholds at 500Hz, 1000Hz and 2000Hz) was considered when determining the degree of hearing loss (table 4.6).

Table 4.8: Type of hearing loss (n=84)

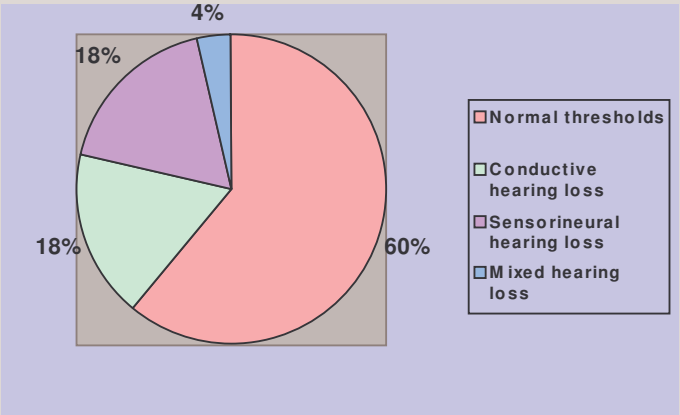
RESEARCH POPULATION	DIAGRAM SPECIFYING TYPE OF HEARING LOSS
Fifty-one (60%) of the total research population's ears had normal hearing thresholds in the low frequencies. Fifteen (18%) had a conductive hearing loss in the low frequencies, while fifteen (18%) ears were diagnosed with a sensorineural hearing loss in the low frequencies. Three (4%) had a mixed hearing loss in the low frequencies.	

Figure 4.11: Type of hearing loss (n=84)

Although 60% of the ears had normal hearing according to the pure tone average most ears had some type of sloping configuration (rising-falling, sloping, sharply falling configurations) in section 4.2.3.4. Figure 4.11 indicates that most participants were diagnosed with normal hearing thresholds. Apart from normal hearing that had the highest incidence in the groups with lung diseases, it was clear that conductive and mixed hearing losses were identified more often than sensorineural hearing losses. A significant difference (p=0.04) existed between those participants with lung diseases and other diseases in terms of the types of hearing loss. This was particularly applicable in the low frequencies. Apart from normal hearing that had the highest incidence in the groups with lung diseases, it was clear that conductive and mixed hearing losses were identified more often than sensorineural hearing losses. This was particularly applicable to the high frequencies.

It is clear that, in terms of hearing loss, the conductive hearing loss and sensorineural hearing loss had the highest incidence and were equally found in these ears. For this population, sensorineural hearing losses and conductive hearing losses occurred more often than mixed hearing losses. A significant difference (p=0.005) was identified between males and females in terms of the type of hearing loss. Males presented with normal hearing thresholds more often, whereas females had a higher incidence of conductive, sensorineural and mixed hearing losses, especially in the low frequency range of the audiogram. Gold and Tami (1998:166) maintain that a conductive hearing loss is present in individuals infected with HIV/AIDS, while Lubbe (2004:253) mentions that sensorineural hearing loss occurs in HIV-infected individuals. According to Gold and Tami (1998:166), a sensorineural hearing loss occurs in 20% to 50% of HIV-infected individuals. In these participants, a sensorineural hearing loss was found less often than suggested by Gold and Tami (1998:166). It is important to realise that even though the thresholds had been within normal limits, with a significant air-bone gap (10dB or greater), the researcher indicated that a conductive component was present (Martin, 1997:90).

A significant difference (p=0.005) existed between those participants with otolaryngological diseases and the types of hearing loss. Apart from normal hearing that had the highest incidence in the groups with otolaryngological diseases, it was clear that conductive and sensorineural hearing losses were identified more often than mixed hearing losses. This was particularly applicable to the low frequencies. A significant difference (p=0.003) existed between those participants with otolaryngological diseases and the types of hearing loss specifically in the higher frequencies.

According to these results, individuals with HIV/AIDS can present with a sensorineural, conductive or mixed hearing loss. The conclusion of this section is that one particular type of hearing loss is not necessarily associated with HIV/AIDS. Audiologists should understand that

individuals with HIV/AIDS should not be placed into a group with predetermined characteristics or expected features. Individuality should still be considered when evaluating the hearing of a person with HIV/AIDS. These individuals are also unique and the virus does not necessarily affect all individuals in the same way. In-depth, thorough audiological assessment is required as with any other individual. The fact that the type of hearing loss varies quite largely in the HIV population, suggests that under no circumstances should a hearing test include only air-conduction tests. There is no way to predict the type of hearing loss or pathology an individual may experience without conducting the necessary tests. The cross-check principle is essential when attempting to diagnose the type of hearing loss and pathology an individual may have. Different tests may display different pathologies. This means that objective measurements for cross-check purposes are necessary.

4.2.4 Characteristics of speech audiometry results

Speech audiometry is discussed in terms of speech thresholds and above threshold tests. This information was obtained from questions 5.1 to 5.4 of the hearing interpretation recording form (Appendix K).

4.2.4.1 Speech threshold tests

Table 4.9 provides information regarding the correlation between the SRT with the PTA. Question 5.1 and question 5.2 from the hearing interpretation recording form (Appendix K) reveal the answer to this question. Figure 4.12 provides a visual representation of the results described in table 4.9. SRT may give the researcher information regarding the reliability of the pure tone results. More specifically a poor SRT correlation may be present when a sloping hearing loss exists in either the high or the low frequencies (Martin and Clark, 2006:120).

Table 4.9: PTA and SRT correlation (n=84)

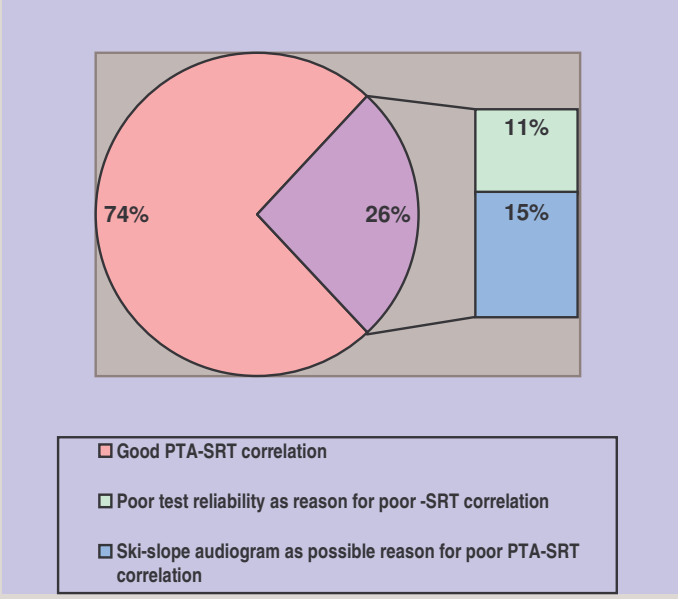
RESEARCH POPULATION	DIAGRAM SPECIFYING CORRELATION OF PTA WITH SRT
Good SRT-PTA correlation was obtained in 62 (74%) ears whereas a poor correlation was obtained in 22 (26%) ears. Of this 26% that presented a poor PTA-SRT correlation, nine (11%) were possibly due to poor test reliability or the possible presence of APD, while 13 (15%) were possibly due to the presence of a ski-slope audiogram.	

Figure 4.12: PTA-SRT correlation and possible reasons for poor correlation (n=84)

The SRT and the PTA should correlate within +5 -7dB (Hall and Mueller, 1998:129). The accuracy of the pure tone thresholds is confirmed by close agreement between the conventional PTA and the speech threshold measure (Hall and Mueller, 1999:129). Poor PTA-SRT correlation, in the absence of a sloping hearing loss, may be due to poor test reliability suggesting poor responses from the participant during the pure tone audiometry test.

Figure 4.12 illustrates the correlation between the PTA and the SRT for each ear. It shows that the PTA and SRT correlated more often (74%) than not (26%). The good PTA-SRT correlation suggests that in general the pure tone audiometry was done in a reliable manner. No significant difference was observed between males and females. Stevenson (1993:27) also obtained good SRT-PTA correlation in the study conducted on HIV-infected individuals. However, the poor PTA-SRT correlation suggested that in 26% of the ears the reliability of the

pure tone audiogram results was questionable. The reasons for poor SRT-PTA correlation could thus be due to poor responses of the participants during the test, possibly due to language barriers, the presence of a auditory processing disorder or a low or high frequency ski-slope (Martin and Clark, 2006:120). Only 11% of the ears did not present with a ski-slope audiogram, suggesting that the responses during the pure tone audiometry procedure were not reliable. According to figure 4.9, a ski-slope audiogram was obtained in 12% participants. This correlates well with the 15% poor PTA-SRT correlation that was identified due to the presence of a ski-slope audiogram in figure 4.12. Another interesting finding is that a significant difference existed between the PTA-SRT correlation of males and females. Females presented more often with a poor PTA-SRT correlation. However, this was mainly due to the presence of a ski-slope audiogram.

4.2.4.2 Above threshold tests

Table 4.10 indicates the configuration of the PI-function, in other words the speech discrimination results obtained during the data collection procedures. Question 5.4 presents the results of the hearing interpretation recording form (Appendix K). Figure 4.13 is included in this table in order to assist with the explanation of these results.

Table 4.10: Speech discrimination test results (n=84)

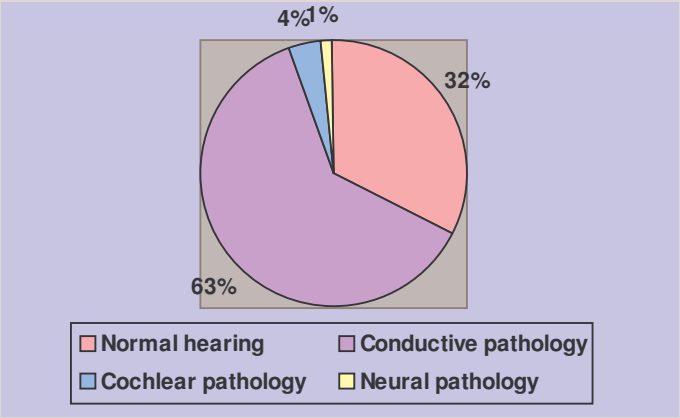
RESEARCH POPULATION	DIAGRAM SPECIFYING SPEECH DISCRIMINATION RESULTS
Speech discrimination results indicative of conductive pathology was found in 46 (63%) ears and 24 (32%) ears had normal hearing. Only three (4%) ears indicated a sensory hearing loss and one (1%) ear indicated a neural hearing loss.	 **Figure 4.13: Speech discrimination test results (n=84)**

Figure 4.13 reveals that 32% of the ears obtained 92% to 100% speech discrimination scores at intensity levels of 40dB or better. Most of the participant ears (63%) obtained 92% to 100% speech discrimination at intensity levels higher than 40dB. A maximum of 4% of the ears obtained a maximum of 92% word discrimination at increased intensity levels, while only 1% of the ears displayed a significant decrease in speech discrimination (according to the rollover index) with an increase in intensity.

Figure 4.13 indicates that normal hearing had the second highest incidence in participants while retro-cochlear pathology or neural pathology had the lowest incidence. Neural pathology suggests that these ears were not able to discriminate 100% words correctly and with the increase in intensity at which these words were presented, the discrimination ability was poorer, thus obtaining a rollover. A plateau indicating cochlear pathology was obtained in 4% of the ears, therefore indicating a plateau on the performance intensity graph. Conductive pathology had the highest incidence according to speech discrimination testing. This suggested that 63% of the ears were able to identify 100% correctly, but at increased

intensities. However these speech discrimination results did not correlate with the results discussed in section 4.2.3.5.

The researcher chose to use immittance measurements as the momentous standard for the identification of middle ear problems. However, it is important to note that even though these speech discrimination results did not correlate well with the type of hearing loss based on the audiogram, these speech discrimination results contradict the assertion made by Bankaitis and Schountz (1998:167) who note that speech discrimination results in HIV-infected individuals usually remain within normal limits, regardless of the moderate high frequency sensorineural hearing loss that is present. Speech audiometry results indicating a conductive hearing loss had by far the highest incidence according to these results. However, as mentioned above, the researcher utilized the information obtained from section 4.2.5 (the following section) as golden standard for the identification of middle ear dysfunction (conductive hearing components), since these measurements are most sensitive to middle ear dysfunction (Hall and Mueller, 1998:234).

The fact that the speech discrimination results were not as reliable, does not suggest that above-threshold tests should be left out of the test battery. Speech audiometry is still an indicator of central auditory pathology (Hall and Mueller, 1998:136). Individuals may often present with a normal audiogram, but complain of poor speech discrimination. Then central auditory pathology should be considered. These results imply a good candidates for hearing aids, since 100% word discrimination is reached at increased intensity levels. These results also suggest that the audiologist should include a APD assessment as part of the test battery when evaluating the hearing ability of individuals with HIV/AIDS. Upon diagnosis of APD, the audiologist can consider fitting a FM-system to improve the quality of life.

However, audiologists should always be aware of the possible factors that may influence the reliability of the speech audiometry results. Live voice stimuli versus tape-recorded stimuli, test material used, carrier phrases used, length of word lists for recognition and familiarity with material, especially in terms of the language of presentation in relation to the native language of the individual may influence the reliability of the speech reception and speech discrimination test results. Audiologists should be able to have insight in a situation and should know when to mark these results as unreliable or when to use these results to provide them with more information. It also stresses the importance of utilizing objective measures as crosscheck principle to confirm or reject these results. Again the possible unreliability of certain test results stress the importance of thorough and complete audiological assessments that include as many audiological tests as possible.

Since it has been indicated in the literature study that speech audiometry results are not always as reliable and accurate as place of lesion tests, it is important to note that "*immittance measurements are extremely sensitive to middle ear dysfunction"* (Hall and Mueller, 1998:234). In fact, Hall and Mueller (1998:177) also state that *"since the golden days of aural impedance measurement, newer audiological procedures, such as ABR and OAE, have worked their way into the audiological test battery. However, there is still no better, quicker, or less expensive audiological procedure for assessing the status of the middle ear, cochlea, eighth nerve and lower auditory brainstem than performing a complete immittance test battery".*

4.2.5 Characteristics of the immittance measurements

The immittance results include the tympanograms, the ipsilateral and contralateral acoustic reflexes. This information is provided in questions 6.1 to 6.5 of the hearing interpretation recording form (Appendix K).

4.2.5.1 Immittance results

Since immittance measurements are the most reliable and sensitive measurement for the identification of conductive pathology (as indicated in section 4.2.4.2), the researcher used the results obtained from this section to diagnose conductive pathology among the ears of this research population (Hall and Mueller, 1998:234). The immittance results are tabulated according to the values for compliance, ear canal volume and pressure, and in terms of acoustic reflex thresholds (Appendix O).

4.2.5.1.1 Tympanometry results

Table 4.11, including figure 4.14 provided below, indicates the types of tympanograms that were obtained from the total research population. Figure 4.14 indicates that Type-A tympanograms had the highest incidence in this particular research population, therefore indicating no middle ear pathology. Section 4.2.3.5 confirms these results, indicating normal hearing thresholds as having the highest incidence. According to the audiogram results in section 4.2.3.5, 18% of the ears (n=84) had a conductive hearing loss while, 4% of the ears (n=84) had a mixed hearing loss, suggesting the presence of a conductive component.

Table 4.11: Tympanometry results (n=84)

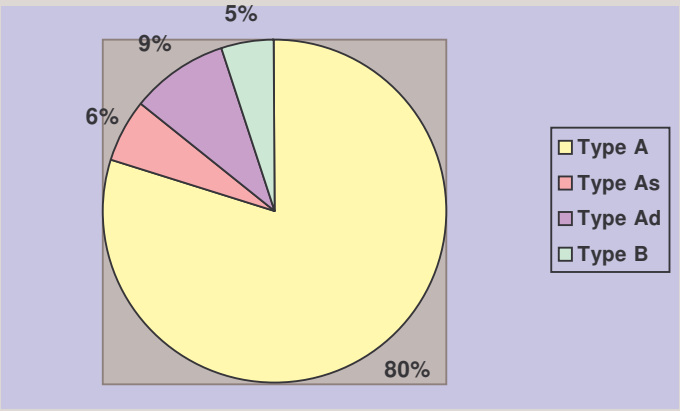
RESEARCH POPULATION	DIAGRAM SPECIFYING TYMPANOMETRY RESULTS
Type A-tympanograms were obtained in 67 (80%) ears, type As-tympanograms were obtained in five (6%) ears, while type Ad-tympanograms had been obtained in eight (9%) ears. Type B-tympanograms were obtained in four (5%) ears. No type C-tympanograms were obtained. Therefore, according to these results, a total of 17 (20%) ears had conductive pathology, while 67 (80%) had no pathology.	

Figure 4.14: Tympanometry results (n=84)

Therefore, 22% of the ears (n=84) displayed a hearing profile characterized by a conductive component. However, according to the immittance results, conductive pathology, indicative of a middle ear system functioning inadequately, was found in 20% of the ears (n=84). Therefore there is a good correlation between the pure tone air-and-bone audiometry in terms of the presence of air-bone gaps and the tympanometry results. This middle ear pathology was indicated by type As-tympanogram, type Ad-tympanogram and type B-tympanograms that were obtained during tympanometry testing.

This research population was expected to have a relatively high incidence of middle ear pathology given the fact that otitis media has a higher incidence in the HIV population (Lubbe, 2004:253). Therefore, type C- and type B-tympanogram were expected to have a high incidence in this population, since it is associated with otitis media. On the other hand, type-C tympanograms were not obtained in any of the ears and type B-tympanograms had the lowest incidence. Martin (1997:242) speculates that the rising epidemic of HIV/AIDS will raise the prevalence of otitis media. However, according to these findings otitis media did not have a high incidence. Ear manifestations occur less frequently than oral, sinonasal and neck

manifestations, according to Lubbe (2004:253), suggesting that these participants probably presented more often with nose and throat infections than with ear infections, thus confirming the small percentage of 5% of observations made in this research population suggestive of the presence of ear infections. Dull retracted tympanic membranes were observed in 5% of the ears as indicated in section 4.2.2.1, thus suggesting a good correlation between the ears that presented with a type B-tympanogram where one would also expect a dull retracted tympanic membrane. Type Ad- tympanograms were present in 9% of the population's ears, indicating a flaccid middle ear system, while type As-tympanograms were identified in 6% of the population's ears, suggesting a stiff middle ear system, suggestive of a middle ear dysfunction.

A good correlation existed between the 26% otolaryngological conditions in table 4.2 (figure 4.3), the total of 28% observations during the otoscopic examinations that may suggest the presence of a possible conductive hearing loss (occluding wax, perforations, dull retracted tympanic membranes, tympanosclerosis and scarred tympanic membranes in table 4.4), the 22% pure tone audiometry results indicative of a conductive hearing loss (table 4.8) and the 20% tympanometry results indicating conductive pathology (table 4.11). Immittance results are the most reliable measure when attempting to identify middle ear pathology (Hall and Mueller, 1998:177). Therefore 20% will be used as percentage for the presence of conductive pathology.

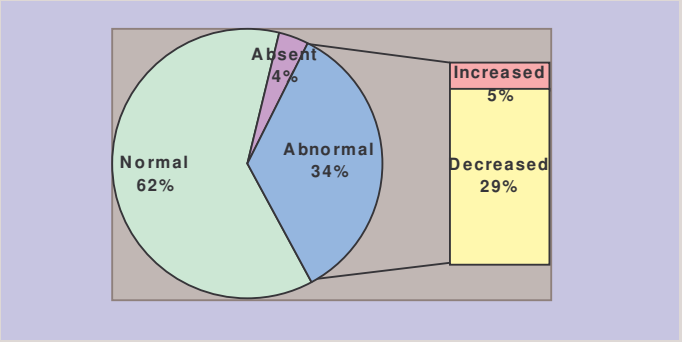
Because HIV/AIDS is a retrovirus that damages the immune system, the expectation was that otitis media or other middle ear conditions suggesting conductive pathology would have a higher incidence. However, only 20% of this research population had a hearing loss due to a conductive component as indicated by the tympanograms. Therefore, the audiologists must realise that HIV/AIDS does not always suggest the presence of a conductive pathology even though most literature sources state that conductive pathology has a high incidence in individuals with HIV/AIDS (Lubbe, 2004:253 and Martin, 1997:242). Compared to the presence

of a conductive component among the “normal” population, it is rather high, although lower than expected.

4.2.5.1.2 Acoustic reflex results for all participant ears

Table 4.12 specifies the ipsilateral and contralateral acoustic reflex results that were obtained from the total research population. Since table 4.12 provides the information regarding the integrity of the ipsilateral acoustic reflexes across the complete frequency spectrum, the mean was determined by multiplying the number of ears with the number of frequencies that were assessed. For the purpose of this section, the mean was therefore calculated as n=420. These percentages are therefore not discussed in terms of percentage of ears, but rather as percentage of ipsilateral acoustic reflexes. Therefore, at the end of section 4.2.5.2, the results will be discussed in terms of percentage pathology per ear in order to compare these results with the other results obtained during this research project. Figure 4.15 is included in this table to provide a visual representation that can elucidate the results. Martin (1997:356) states that acoustic reflex threshold testing provides valuable information on the functioning of the neurological crossover pathways in the trapezoid body situated in the brainstem. As illustrated in figure 4.15, normal ipsilateral reflexes, elicited at 70dBHL to 90dBHL with an average of 85dBSL (Martin, 1997:164), had the highest incidence of 62%.

Table 4.12: Ipsilateral acoustic reflexes (n=420)12

RESEARCH POPULATION	DIAGRAM SPECIFYING ACOUSTIC REFLEX RESULTS
Ipsilateral acoustic reflexes elicited at 70 to 90dBSL suggested normal reflexes and these reflexes were found 261 (62%) times while absent reflexes suggesting that there was no response during reflex testing were found 18 (4%) times. Abnormal reflexes suggest that reflexes were either elicited at increased or decreased intensity levels and were elicited in 141 (34%) times.	 **Figure 4.15: Ipsilateral acoustic reflexes (n=420)**

When interpreting the results in terms of number of ears, the tympanometry and ipsilateral acoustic reflex results indicated that cochlear pathology was identified in 55% of the ears; retro-cochlear pathology was identified in 14% of the ears through acoustic reflexes at increased sensation levels, as well as in 1% of the ears through absent acoustic reflexes not due to conductive pathology and conductive pathology was identified in 20% of the ears. This means that according to the ipsilateral acoustic reflex results and tympanometry results, no pathology was present in 10% of the ears.

These above-mentioned results as a whole were determined as follows: Ipsilateral reflexes elicited at normal intensity levels with no conductive pathology present were observed in eight (10%) ears (when n=84) and in four (10%) participants (when n=42). These results indicated a significant difference of p=0.04 between males and females regarding the ipsilateral reflexes at specifically 250Hz. These results suggest that males presented with normal ipsilateral reflexes

12 The mean for section 4.2.5.1.2 was determined as n=420 since five different frequencies were assessed for all 84 ears, suggesting that in total 420 reflexes were evaluated. This explains why the mean of this section is n=420.

at 250Hz more often than females did. Females presented with abnormal or absent reflexes more often. This corresponds with the findings of section 4.2.3.3 and 4.2.3.5, which suggest that low frequency thresholds are more often affected in females than in males.

Abnormal reflexes, indicative of cochlear pathology when elicited at decreased intensities or low sensation levels (sensation levels below 60dBHL) and retro-cochlear pathology when elicited at increased intensities or high sensation levels (sensation levels above 95dBHL to 100dBHL) had the second highest incidence of 34% (Martin, 1997:164). Of these abnormal reflexes, 5% were elicited at increased sensation levels and 29% were elicited at decreased sensation levels.

Absent reflexes, suggesting no response with the presentation of the stimulus at any intensity level, were only obtained from 4% of the ears which could be suggestive of conductive hearing loss, neural hearing loss or facial nerve dysfunction. As indicated in section 4.2.5.1, 5% of type B-tympanograms were obtained in this research population. Ipsilateral acoustic reflexes were absent across the complete frequency spectrum in a total of three ears (4%). According to these results, good correlation between the severe conductive pathology (type B-tympanogram) and the absent ipsilateral acoustic reflexes exists. All of these ears presented with a type B-tympanogram, suggesting the presence of fluid in the middle ear space, thus severe middle ear pathology.

Only one (1%) other ear presented with an absent ipsilateral reflex at 1000Hz only, but this was not due to middle ear pathology, since normal type A-tympanogram was associated with this particular ear. According to Martin (1997:166), this 1% of absent reflexes not associated with middle ear pathology might have been caused by cochlear damage (hearing loss greater than 60dB) at that particular frequency (1000Hz), N.VIII dysfunction. However, since the contralateral reflex at 1000Hz was not absent, it means the integrity of the contralateral ear's

facial nerve is intact. This particular participant ear did not have any absent DPOAEs at any frequency, suggesting that no cochlear damage was present. This suggests that 1% of the ears had vestibulo-cochlear nerve dysfunction. In this particular participant, the other ear also presented with N.VIII pathology indicated by the acoustic reflexes at increased intensities with normal tympanograms.

Gold and Tami (1998:168) mention that facial nerve palsy is more prevalent in individuals infected with HIV than in those not infected with this disease. Lalwani and Sooy, 1992 in Gold and Tami (1998:168) note that 7,2% individuals infected with HIV/AIDS presented with a unilateral or bilateral facial nerve palsy. According to Martin (1997:165-166), absent or elevated acoustic reflexes occur with damage to the vestibulo-cochlear nerve (VIIIth cranial nerve) or conductive pathology is present. Absent reflexes may also be due to brainstem dysfunction or facial nerve dysfunction (Martin, 1997:166). This damage is most likely due to the modifications in the communication of the stimulus from the cochlea to the brainstem. HIV/AIDS has proven to cause demyelisation of neurons in the brainstem and glial cells (Gold and Tami, 1998:167), but a cochlear hearing loss might also suggest that the intensity of the signal that reaches the brainstem is not sufficient enough to produce a reflex (Martin, 1997:165). This confirms that a conductive, cochlear or retro-cochlear hearing loss might be the possible reason for the elevated and absent ipsilateral acoustic reflexes. However, reflexes elicited at decreased intensity levels are mainly associated with cochlear damage, thus suggesting that the presence of decreased reflexes is indicative of cochlear damage (Martin, 1997:166).

Twenty-nine percent of the ipsilateral reflexes were elicited at low sensation levels which suggested the presence of cochlear pathology. In total, 30 (71%) participants when n=42, presented with ipsilateral reflexes at low sensation levels while forty-five (55%) ears when

n=84, presented with ipsilateral reflexes at low sensation levels, indicating the presence of cochlear pathology.

Since 5% ipsilateral reflexes were elicited at increased intensities, but not all of these reflexes were associated with an abnormal tympanogram, it suggests that neural damage may constitute as possible explanation for the reflexes being elicited at increased sensation levels. Therefore it is of great importance to determine how many participants and participant ears presented with elevated ipsilateral reflexes due to pathology other than conductive pathology. Ten (24%) participants (n=42) and 14 (17%) ears (n=84) presented with ipsilateral reflexes at higher sensation levels, with and without the presence of conductive pathology. Of the 5% reflexes elicited at high sensation levels, 4% were not due to conductive pathology but rather as a result of vestibulo-cochlear dysfunction because it was associated with a normal type A-tympanogram. Only 1% of these elevated reflexes were associated with an abnormal tympanogram, suggestive of middle ear pathology. This 4% of elevated ipsilateral reflexes were therefore due to vestibulo-cochlear nerve dysfunction. Since nine (21%) participants (n=42) in a total of twelve (14%) ears (n=84) presented with ipsilateral acoustic reflexes at increased sensation levels in the absence of conductive pathology, these results suggest that 21% of the participants and 14% of the ears had a vestibulo-cochlear nerve dysfunction, thus suggesting an auditory neural dysfunction.

Table 4.13 indicates the absent contralateral reflexes[13] with no response upon stimulation or abnormal contralateral reflexes elicited at intensities above 95dBHL and below 60dBHL. It also includes reflexes elicited at normal intensity levels, thus between 70dBHL and 95dBHL. Since table 4.13 provides the information regarding the integrity of the contralateral acoustic reflexes across the complete frequency spectrum, the mean was determined by multiplying the number of ears with the number of frequencies that were assessed. This enabled the researcher to determine the number of elevated, decreased and absent reflexes while one reflex served as one entity.

Table 4.13: Contralateral acoustic reflexes (n=336)

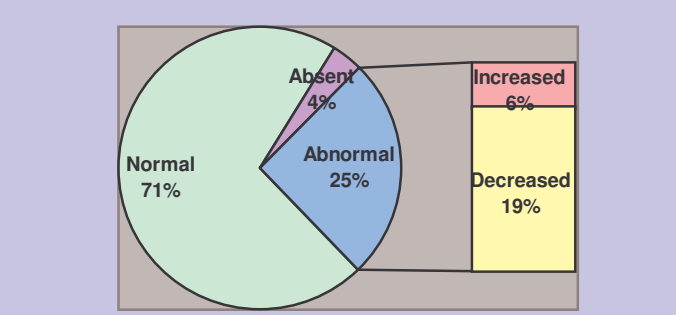
RESEARCH POPULATION	DIAGRAM SPECIFYING ACOUSTIC REFLEX RESULTS
Contralateral acoustic reflexes elicited at 70 to 90dBSL suggested normal reflexes and these reflexes were found in 239 (71%) ears while 12 (4%) ears presented with absent reflexes suggesting that there was no response during reflex testing. Abnormal reflexes suggest that reflexes were either elicited at increased or decreased intensity levels and were elicited in 85 (25%) ears.	

Figure 4.16: Contralateral acoustic reflexes (n=336)

As indicated in section 4.2.5.1, 5% of type B-tympanograms were obtained in this research population. Contralateral acoustic reflexes were absent across the complete frequency spectrum in a total of three ears (4%).

13 The mean for section 4.2.5.1.2 was determined as n=336 since four different frequencies were assessed for all 84 ears, suggesting that in total 336 reflexes were evaluated. This explains why the mean of this section is n=336. These percentages are therefore not discussed in terms of percentage of ears, but rather as percentage of contralateral acoustic reflexes. Therefore at the end of section 4.2.5.2, the results will be discussed in terms of percentage pathology per ear in order to compare these results to the other results obtained during this research project.

Figure 4.16 indicates that contralateral reflexes elicited between 70dBSL and 95dBSL, suggesting normal contralateral reflexes, had the highest incidence of 71%. Abnormal reflexes elicited either above 95dBSL or below 60dBSL, had the second highest incidence of 25%. Of these 25% reflexes, 6% were elicited at increased sensation levels and 19% were elicited at decreased sensation levels. In total, 19% of the contralateral acoustic reflexes at decreased intensities were elicited across the complete frequency spectrum. These 19% contralateral reflexes suggestive of cochlear pathology were elicited in 37 (44%) ears and in 25 (56%) participants. Therefore 44% ears presented with cochlear pathology.

When interpreting the results in terms of number of ears: the tympanometry and contralateral acoustic reflex results indicated that cochlear pathology was identified in 44% of the ears, retro-cochlear pathology was identified in 13% of the ears and conductive pathology was identified in 20% of the ears. This means that, according to the ipsilateral acoustic reflex results and tympanometry results, no pathology was identified in 23% of the ears. These results are mainly described in terms of the number of reflexes across the complete frequency spectrum and not always in terms of the pathology diagnosed in each ear. As indicated, these immittance results consisted of ipsilateral acoustic reflexes, contralateral acoustic reflexes and tympanometry results.

These above-mentioned results as a whole were determined as follows: Abnormal reflexes, when elicited at increased intensities, suggest the presence of conductive pathology or vestibulo-cochlear nerve dysfunction and when elicited at decreased sensation levels, it indicates the presence of a cochlear pathology (Hall and Mueller, 1998:223, 225 and Martin, 1997:166). According to Martin (1997:165), abnormal reflexes are indicative of cochlear pathology, indicating either the existence of early cochlear damage or the presence of a cochlear hearing loss. These research results suggest that three (1%) of these 6%

contralateral reflexes were elicited at increased intensity levels due to the presence of conductive pathology. These conductive pathologies were indicated by two type As-tympanograms and one type Ad-tympanogram. Seventeen (5%) of the 6% contralateral reflexes were also elicited at high sensation levels not due to conductive pathology, but due to vestibulo-cochlear nerve dysfunction. These contralateral reflexes at high sensation levels due to vestibulo-cochlear nerve involvement were distributed among eleven (13%) ears, while they were distributed across eight (19%) participants.

Twelve (4%) absent contralateral reflexes obtained in this research project could be indicative of conductive, neural, brainstem or facial nerve dysfunction according to Hall and Mueller (1998:223-228) and Martin (1997:166). However, 4% of these contralateral reflexes were all associated with an abnormal tympanogram, suggestive of conductive pathology. In terms of number of ears, three (4%) ears presented with absent contralateral reflexes in only two (5%) participants. In the case of this research project, type As-, Ad- and B-tympanograms were linked to the absent contralateral reflexes. This suggests that the absent contralateral reflexes in this population were only due to the presence of conductive pathology.

From these research results it was observed that when all contralateral and ipsilateral acoustic reflexes were absent, the tympanogram indicated the presence of conductive pathology in that ear. There is a good correlation between the percentage of absent (4%) ipsilateral and contralateral reflexes in the same ear and the type B-tympanograms (5%), confirming the reliability of the immittance results. Therefore in this research project, the absent acoustic reflexes (4%) are due to conductive components because they were obtained together with a type B-tympanogram.

The contralateral results were used to indicate the presence of facial nerve pathology. In this research population, facial nerve pathology was not present. Since no facial nerve pathology

was diagnosed in these participants and to enable the researcher to describe the pathology per ear, only the ipsilateral acoustic reflex results and tympanometry results were utilized in order to describe a correlation between the immittance results and the DPOAE results in the following section. The immittance results therefore indicated that 20% of the ears presented with conductive pathology (suggesting that abnormal tympanograms were obtained). Cochlear pathology was found in 55% of the ears and retro-cochlear pathology was identified in 15% of the ears. Therefore only 10% of the ears had no indication of any pathology.

These results signify the importance of obtaining ipsilateral and contralateral acoustic reflexes. The results indicate that various individuals with HIV/AIDS had retro-cochlear pathology with vestibulo-cochlear nerve involvement only and not facial nerve involvement. Since the management of an individual with retro-cochlear pathology differs excessively from those with cochlear pathology, the audiologist should always conduct a site of lesion test to locate the parts of the hearing mechanism that might be damaged. In this way, the success of the management in terms of amplification, the fitting of assistive devices, referrals and aural rehabilitation would improve. Management of these individuals have a higher success rate because it is based on appropriate, thorough assessments, thus improving the quality of life of the individual with HIV/AIDS.

Audiologists should not underestimate the value of immittance measurements, especially acoustic reflex measurement, since they assist with determining the place of lesion that may lead to the hearing loss. This serves as indication of cochlear integrity and reveals early cochlear damages which should be monitored regularly, but most importantly, the immittance measurements are definitely the most reliable measurement for the identification of middle ear pathology. Twenty percent of the participants had definite middle ear pathology and this was indicated by the immittance measurements.

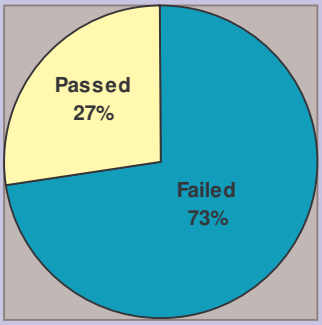
4.2.6 Characteristics of the distortion product oto-acoustic emission

Questions 7.1 to 7.4 of the hearing interpretation recording form (Appendix K) reveal the information regarding the presence or absence of the DPOAEs at the different frequencies. The DPOAE assessment failed when the DPOAEs were absent at two or more of the five frequencies.

4.2.6.1 DPOAE results

Questions 7.1 to 7.3 of the hearing interpretation recording form (Appendix K) reveal the information regarding the analysis of the DPOAE results. Table 4.14 contains figure 4.17 that specifies and illustrates the analysis of the DPOAE results and provides a clear description of these results.

Table 4.14: Absent DPOAEs in each ear (n=84)

RESEARCH POPULATION	DIAGRAM SPECIFYING THE ABSENCE OF DPOAEs
Sixty-one (73%) ears failed the DPOAE assessment while, 23 (27%) passed the DPOAE assessment.	 **Figure 4.17: Number of ears with absent DPOAEs (n=84)**

Oto-acoustic emissions reflect the functioning of a cochlea (Martin, 1997:181). Figure 4.19 indicates the absence of DPOAEs specifically at two or more frequencies. Absent DPOAEs suggesting the failure of the DPOAE assessment, had the highest incidence among this research population. However, in terms of the DPOAE response at particular frequencies, it

was clear that not all of the outer hair cells are damaged by HIV/AIDS, proposing that there will more often than not be outer hair cells of certain frequencies, especially 2000Hz and 3000Hz, which will respond to auditory stimulation, indicating a present DPOAE at that particular frequency. Interestingly enough, a significant relationship (p=0.008) existed between those participants with lung diseases and those who failed the DPOAE assessment. This is probably because lung diseases such as TB is managed with drugs containing ototoxic agents. These ototoxic drugs may lead to cochlear damage.

Cochlear damage in these participants with HIV/AIDS seemed to have a very high incidence. This could be due to the direct effects of HIV/AIDS or the administration of ART which contains ototoxic agents. These results are also site specific, providing the audiologist with information on the place of lesion and assisting with the decision-making process in terms of management of each individual with HIV/AIDS. When damage is present in the cochlea, assistive devices and amplification can still be considered as a management strategy, since damage to this structure suggests a sensory hearing loss which can be fitted with great success.

4.2.6.2 Absent DPOAEs at all frequencies

The DPOAE was tested at 6000Hz, 5000Hz, 4000Hz, 3000Hz and 2000Hz. Pass or fail results were obtained for each frequency. The information is obtained from question 7.3 of the Hearing interpretation form (Appendix K). Table 4.15 reveals the number of ears that had absent DPOAEs at all frequencies.

Table 4.15: Absent DPOAEs at all test frequencies (n=84)

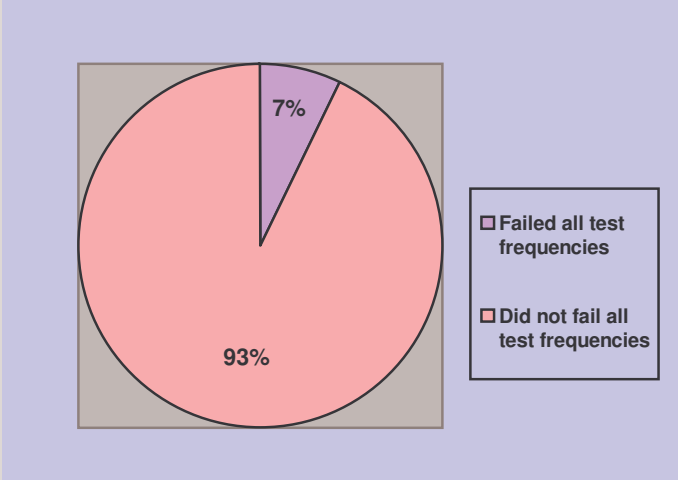
RESEARCH POPULATION	DIAGRAM SPECIFYING THE ABSENCE OF DPOAEs
Only six (7%) ears had absent DPOAEs at 2000Hz, 3000Hz, 4000Hz, 5000Hz and 6000Hz. Seventy-eight (93%) did not present with absent DPOAEs at all test frequencies.	 **Figure 4.18: Number of ears with absent DPOAEs at all test frequencies (n=84)**

Figure 4.18 suggests that the highest incidence of ears had absent DPOAEs at two or more test frequencies, but at less than five frequencies. Only 7% ears had absent DPOAEs at all five frequencies. These results differ from figure 4.17 because figure 4.17 reveals the number of ears with absent DPOAEs (due to absent DPOAEs at two or more test frequencies), whereas figure 4.18 indicates the percentage of ears that failed all test frequencies and did not fail all test frequencies. The majority of ears failed the DPOAE assessment because absent DPOAEs at two or more frequencies of the OAE indicated a fail result. This means that cochlear damage was quite common in this population with HIV/AIDS.

4.2.6.3 Absent DPOAEs at different frequencies

Each of the five frequencies was tested separately in order to determine where the specific problem was. Question 7.2 of the Hearing interpretation recording form (Appendix K) contains the answer to these questions. The results are discussed in table 4.16, and figure 4.19 is included in this table to elucidate the results.

Table 4.16: Absence of DPOAEs at each frequency (n=84)

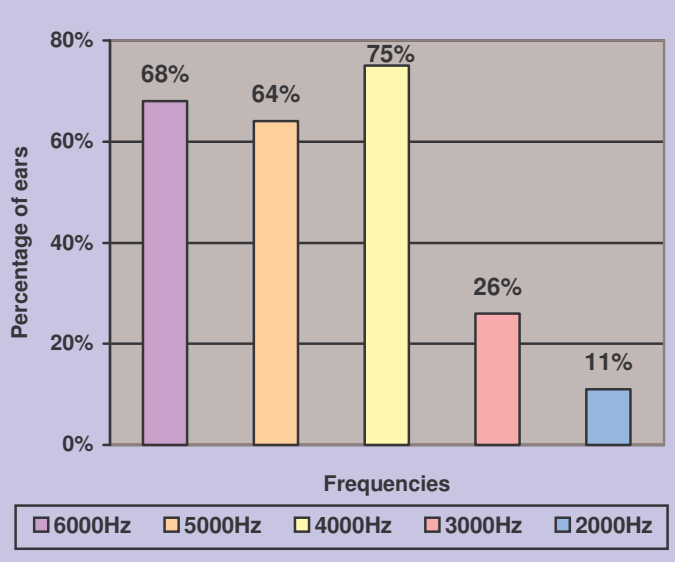
RESEARCH POPULATION	DIAGRAM SPECIFYING THE ABSENCE OF DPOAE
Fifty-seven (68%) of the 84 ears had absent DPOAEs at 6000Hz while at 5000Hz, 54 (64%) of the 84 ears had absent DPOAEs. Sixty-three (75%) of the 84 ears had absent DPOAEs at 4000Hz. At 3000Hz, 22 (26%) of the 84 ears had absent DPOAEs and at 2000Hz, nine (11%) ears had absent DPOAEs.	

Figure 4.19: Absence of DPOAEs at each frequency (n=84)

Figure 4.19 reveals cochlear damage existed more often at the higher frequencies, suggesting that cochlear damage was more often detected at outer cochlear hair cells responsible for processing the higher frequencies, 4000Hz to 6000Hz. Interestingly enough, the 4000Hz frequency had the highest incidence of absent DPOAEs that might be due to either cochlear pathology or conductive pathology. However, this is quite similar to the findings obtained by Clark (2004:112) that suggests that DPOAEs tends to be absent in the 4000Hz region when the participants had a history of excessive noise exposure. However, the fact that the researcher excluded all potential participants with a history of noise exposure from the research project, suggests that the absence is not due to excessive exposure to noise, but rather due to the direct effect of HIV/AIDS or the direct influence of ART. Clark (2004:112) also states that individuals with a history of noise exposure also exhibit a high incidence of absent DPOAEs at 5000Hz. On the other hand, the results of this research project differ, since the highest incidence of absent DPOAE's was found at 4000Hz, secondly at 6000Hz and only then at

5000Hz. Therefore it seems as if 4000Hz and 6000Hz had the higher tendency of absent DPOAEs in individuals with HIV/AIDS. However, it is important to note that frequencies 4000Hz, 6000Hz and 5000Hz, thus the higher frequency spectrum, more often presented with absent DPOAEs indicative of a failed DPOAE assessment in the participants with HIV/AIDS. These results suggest that a difference is expected between the OAE results of an individual with excessive noise exposure and the OAE results of an individual with HIV/AIDS.

4.2.6.4 The relationship between the immittance and DPOAE results

Question 7.4 of the Hearing interpretation recording form (Appendix K) provides information on the interpretation of the DPOAE results. Table 4.17 contains a discussion and a graph representing and elucidating these results.

Table 4.17: Pathology indicated by DPOAE and immittance results for each ear (n=84)

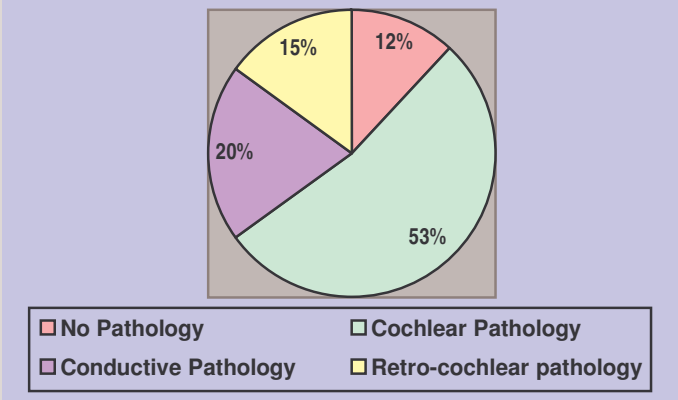
RESEARCH POPULATION	DIAGRAM SPECIFYING INTERPRETATION OF THE IMMITANCE AND DPOAE RESULTS
Only 13 (15%) ears presented with a retro-cochlear pathology, 17 (20%) ears had a conductive pathology, 44 (53%) ears had cochlear damage while ten (12%) ears had no pathology.	

Figure 4.22: Interpretation of the immittance results and DPOAE results for each ear (n=84)

According to section 4.2.6.1, 73% of the ears failed the DPOAE assessment suggestive of cochlear pathology. However, conductive pathology may lead to absent DPOAEs since OAEs

rely on a well functioning external ear and middle ear (Hall and Mueller, 1998:267). The tympanometry results indicate that conductive pathology accounts for 17 (20%) ears of these participants with HIV/AIDS. The expectation was that those participants with conductive pathology were part of these 61 (73%) participants who failed the DPOAE assessment. Thus the number of ears with conductive pathology was subtracted from those ears that failed the DPOAE assessment, indicating that 44 (53%) ears presented with cochlear pathology and 17 (20%) ears had conductive pathology. Since the DPOAEs are the most sensitive measurement for cochlear pathology, 53% of the ears displayed cochlear pathology (Hall and Mueller, 1998:265).

It is clear that the ears of these participants with HIV/AIDS had the highest incidence of absent DPOAEs due to cochlear involvement (Hall and Mueller, 1998:267). There is a close correlation between the immittance results obtained from section 4.2.5.2 which state that 46 (55%) ears presented with cochlear pathology and the results in this section which states that 44 (53%) ears presented with cochlear pathology. Therefore, figure 4.20 indicates that cochlear pathology had the highest prevalence of 53% in these participant ears. According to the immittance results in section 4.2.5.2, 12 (15%) ears had retro-cochlear pathology. DPOAE are site specific for cochlear auditory dysfunction (Hall and Mueller, 1998:265). Since the retro-cochlear pathology did not suggest absent DPOAEs, the percentage of ears with retro-cochlear pathology was included in those 27% ears that passed the DPOAE assessment (see section 4.2.6.1). Therefore of 27% of the ears with normal DPOAEs, 13 (15%) had retro-cochlear pathology (section 4.2.5.2) and therefore 10 (12%) had no pathology. Therefore when 15% of the ears that presented with retro-cochlear pathology (according to section 4.2.5.2) were deducted from 27% of the ears that passed the DPOAEs, the number of ears that presented with no pathology were determined at 12%. Since section 4.2.5.2 indicates that no pathology

was identified in 10% of the ears, it is clear that there is a close correlation between the immittance results and the DPOAE results.

Since potential participants with noise exposure were excluded from this research project, it is clear that the direct influence of HIV/AIDS may lead to cochlear damage. However, ototoxicity may also lead to cochlear pathology. The side effects of streptomycin, viomycin, neomycin, gentamycin and kanamycin are cochleotoxic and vestibulotoxic had ototoxic agents that might cause cochlear pathology (Martin and Clark, 2006:298). Known ototoxic medication is used to treat OIs, also indicating a possible explanation for the high incidence of cochlear pathology.

4.2.7 Characteristics of auditory brainstem response

The absolute wave latencies and interpeak latencies are described in section 4.2.7.1 in order to determine if neurological pathology is present in these ears and if it correlates with the results obtained from the acoustic reflexes that indicated retro-cochlear pathology.

4.2.7.1 ABR absolute latencies and interpeak latencies results

Table 4.18 contains a discussion and a graph representing and elucidating these results. These results are also tabulated according to the absolute wave latency values and interpeak latency values (Appendix P). ABR results are the most reliable measurement to identify neural pathology thus, serving as main indicator for retro-cochlear pathology.

Table 4.18: ABR interpeak and absolute wave latencies (n=84)

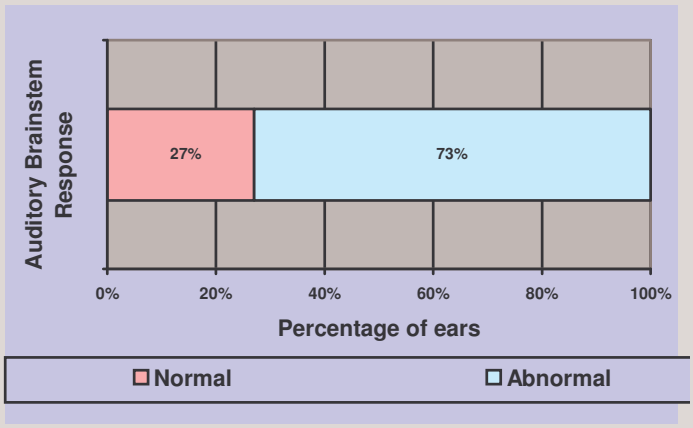
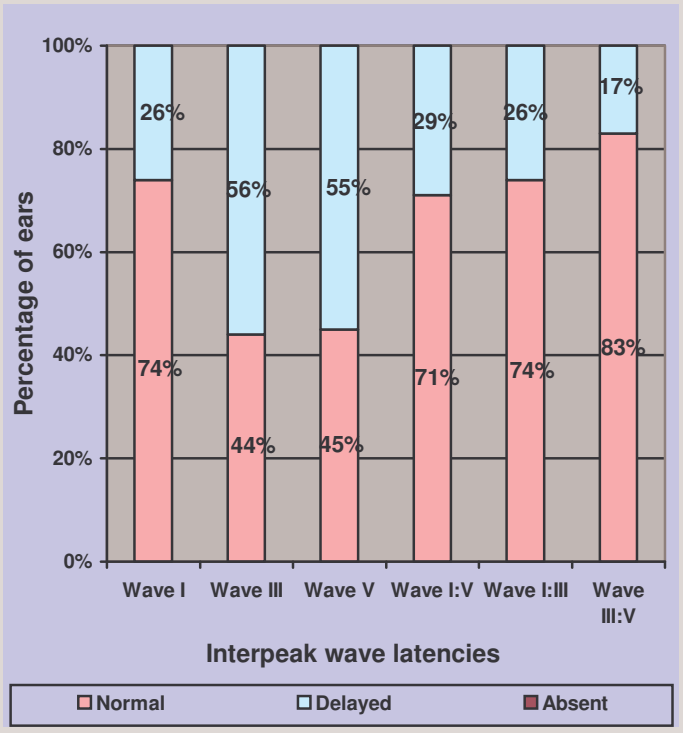
RESEARCH POPULATION	DIAGRAM SPECIFYING ABR RESULTS
Twenty-three (27%) participant ears presented with normal ABR results while 61 (73%) ears presented with abnormal ABR results.	
	Figure 4.21: Auditory brainstem response findings(n=84)
Wave I was delayed in 22 (26%) ears and normal in 62 (74%) ears. Wave III was delayed in 47 (56%) ears and normal in 37 (44%) ears. Wave V was delayed in 46 (55%) ears and normal in 38 (45%) ears. In terms of the interpeak latencies, 24 (29%) ears had a delayed wave I:V interpeak latency and 60 (71%) ears had a normal wave I:V interpeak latency. Twenty-two (26%) ears had a delayed wave I:III interpeak latency, while 62 (74%) had a normal wave I:III interpeak latency. Wave III:V showed a delayed interpeak latency in 14 (17%) ears and a normal interpeak latency in 70 (83%) ears.	
	Figure 4.22: ABR absolute wave latencies and interpeak wave latencies (n=84)

Figure 4.21 indicates that abnormal ABR findings had the highest incidence. Interestingly enough these ABR results concur to the exact percentages of normal and abnormal findings

indicated by the DPOAE results in figure 4.17. This suggests that the results are reliable and a close correlation exists between the general findings of the DPOAE and the ABR. The ABR results in figure 4.22 indicate that the absolute latencies of wave III and wave V had the highest incidence of abnormalities. This is in line with the finding by Bankaitis et al. (1998:178) that there is a general concurrence that the absolute latencies of wave III and / or wave V are delayed in individuals with HIV/AIDS. The research done by Welkborsky and Lowitzsch (1992) in Bankaitis et al. (1998:179) also indicates that wave III and V absolute wave latencies are prolonged the interpeak wave latencies of wave I:III and wave I:V were also delayed. Pragano (1992) in Bankaitis et al. (1998:179) found in his research that the interpeak latencies of wave III:V and I:V were delayed. However, the hearing status does play a significant role when analysing the ABR.

Since an ABR is sensitive for auditory thresholds in the 2000Hz to 4000Hz frequency range, it suggests that sloping hearing losses may influence the ABR results when a hearing loss is present in this frequency region of the audiogram (Martin, 1997:173). The abnormal wave III and V may be caused by this high frequency sloping hearing loss. According to the pure tone audiometry results in table 4.8, it is clear that 40% (18% conductive, 4% mixed and 18% sensorineural) of significant hearing losses were identified through pure tone audiometry. Table 4.7 suggests that 37% of the ears were especially affected in the high frequencies (24% had a rising-sloping configuration, 1% had a sharply falling configuration and 12% had a sloping configurations). This means that only 19% of absolute wave latencies of wave III and 18% of wave V were due to neural pathology. A close correlation exists between the DPOAE and immittance results in section 4.2.6.4 and the ABR results. The results in section 4.2.6.4 indicate that 15% of the ears presented with retro-cochlear pathology.

From these results, the place of lesion can be identified. According to the literature study, wave III is most likely to represent the caudal portion of the brainstem near the trapezoid body and

the superior olivary complex and wave V most likely represents the lateral lemniscus as it enters the inferior colliculus (Hall and Mueller, 1998:328). This proposes that these participants experience problems with the functioning of these structures, suggesting neurological pathology. Problems in these areas may suggest that these participants experience difficulty with the analysis of small differences in time or intensity of sounds arriving at both ears in order to localize the sound source (Martin, 1997: 328).

Furthermore it may lead to poor reflex activity of the tensor tympani, thus influencing the efficiency of the stapedial reflex leading to reflexes at increased sensation levels or absent reflexes. This explains why the results obtained from the immittance and DPOAE results also indicated retro-cochlear pathology (more specifically vestibulo-cochlear nerve dysfunction). The ABR is not as sensitive to early cochlear damage as the DPOAE. This suggests that even though 27% of the ears presented with a normal ABR, these ears may have presented with early cochlear pathology. This implies that 15% of the 27% of normal ABRs presented with early cochlear damage not indicated by the ABR. This means that 12% of the ears had normal auditory functioning.

4.3 RESULTS OF SUB AIM TWO

To compare the hearing profile of the participants and to identify if different hearing profile results were obtained for the four different clinical stages of HIV/AIDS with regard to the case history; otoscopic examination findings; the pure tone air-and-bone audiogram; speech discrimination ability; the immittance measurements; the distortion product oto-acoustic emissions [DPOAEs] and auditory brainstem response of each participant with HIV/AIDS.

The second sub aim of this research project was to determine the hearing profile of all participants diagnosed to be in a specific clinical stage of HIV/AIDS. Sub aim two will be

discussed in accordance with these areas of the hearing profile. Questions two to eight of the hearing interpretation recording form (Appendix K) revealed the various characteristics of the hearing profile for each participant. These results will be discussed and elucidated with the necessary figures.

4.3.1 Case history information in the different stages of HIV/AIDS

This category includes the otological complaints the participants experienced in the past and also at the time of data gathering. For the purpose of this research project, the researcher used only the CD4+ cell count to signify the stage of HIV/AIDS the participant was in (Evian, 2000:26). Table 2.1 provides a description of the CD4+ cell count and the associated stage of HIV/AIDS.

4.3.1.1 Previous and current otological complaints in the different stages of HIV/AIDS[14]

In table 4.19, the previous and current otological complaints of these research participants are summarized. These results are distributed across the stages of HIV/AIDS as determined by the CD4+ cell count and they contain graphs to elucidate the results.

[14] For the purpose of determining the number of otological complaints made by each participant in the different clinical stages of HIV/AIDS, the mean was established as n=42. Furthermore, each clinical stage had a separate mean since the number of participants identified to be in a specific clinical stage differed. The mean for stage I was determined as n=5, the mean for stage II was determined as n=7, the mean for stage III was determined as n=8 and lastly the mean for those participants with AIDS (stage IV) was determined as n=22.

Table 4.19: Otological complaints distributed across stages of HIV/AIDS

Otological complaints	Current complaints Incidence in stages of HIV				Before diagnosed with HIV/AIDS			
	I n=5	II n=7	III n=8	IV n=22	I n=5	II n=7	III n=8	IV n=22
Otalgia	-	14%	12%	32%	-	-	12%	14%
Otorhea	-	-	12%	-	-	-	-	-
Tinnitus	20%	14%	12%	18%	-	-	-	-
Dysacusis	-	-	25%	9%	-	-	-	-
Itching ears	-	-	-	5%	-	-	-	-
Fullness in ear	-	-	-	-	-	-	-	5%
No complaints	60%	71%	50%	55%	100%	86%	88%	81%
Hearing loss	20%	14%	25%	18%	-	14%	-	-
Vertigo	-	-	-	18%	-	-	-	-

Table 4.19 shows that of the participants in stage I of HIV, one (20%) complained of a hearing loss, one (20%) complained of tinnitus and three (60%) had no complaints. One (14%) participant in stage II of HIV complained of otalgia, one (14%) complained of a hearing loss, one (14%) complained of tinnitus and five (71%) had no complaints. Those participants in stage III of HIV, one (12%) complained of otalgia, one (12%) complained of otorrhea, two (25%) complained of a hearing loss, one (12%) complained of vertigo, one (12%) complained of tinnitus, while two (25%) complained of dysacusis and four (50%) had no complaints. In participants with AIDS, seven (32%) participants complained of otalgia, four (18%) complained of a hearing loss, four (18%) complained of vertigo and four (18%) experienced tinnitus. Two (9%) participants complained of dysacusis and one (5%) participant experienced itching ears. Twelve (55%) participants had no complaints.

In stage I, the number of complaints increased from 0% complaints to 40% complaints (20% complaints of tinnitus and 20% complaints of hearing loss) after contraction of HIV. After contracting HIV, participants in stage II and participants in stage III also presented with more otological complaints. Stage I and III had the highest incidence of complaints regarding loss of hearing sensitivity. Participants in stage IV presented with otalgia more often than those participants in other stages of HIV/AIDS. A well documented 70 to 90% of individuals infected with HIV present with ear; nose or throat manifestations at some point during the infection. However, ear manifestations arise less frequently (Lubbe, 2004:250,253). Gold and Tami (1998:166) mention that in HIV-infected individuals, the prevalence of a sensorineural hearing loss ranges from 20 to 50%.

The first symptoms to be experienced with the commencement of this disease were hearing loss and tinnitus, since these were the only symptoms these participants in stage I complained of and the fact that the research is cross-sectional in nature. As mentioned in section 4.2.5.2, Martin (1997:331) suggests that loss of hearing sensitivity in the high frequencies and the presence of tinnitus are the early symptoms often mentioned in individuals with auditory nerve disorders. Interestingly enough, the participants in stage I of HIV mainly complained of tinnitus and hearing loss, which may therefore suggest the presence of possible auditory nerve pathology. Already at stage II of HIV, these two symptoms were still present, but the participants started to complain of otalgia as well, indicating the possible presence or development of otitis extern or otitis media (Martin, 1997:221 and 243).

As expected, the number of complaints increased with the progression of the virus. From stage II to stage III of HIV, the otological complaints increased even more. Complaints of otorrhea, vertigo and dysacusis were new complaints that were raised by the participants in stage III. This might be directly related to the toxic effects of ART, since ART commenced in stage III for

almost all participants. A significant difference (p=0.03) existed between stage I,II and IV and stage III in terms of the complaints of otorhea. Dysacusis directly involves cochlear pathology (Martin, 1997:294) and some of the agents in ART are cochleotoxic and vestibulotoxic (Martin and Clark, 2006:298).

It is undeniable that ART might be the cause of the rise in these new symptoms. The interesting result noted in participants with AIDS was that the number of 'no complaints' decreased, suggesting that more participants experienced otological symptoms more often. In addition, the number of complaints regarding hearing loss, tinnitus, otalgia and vertigo increased.

The new complaint mentioned was itching ears and with no complaints of otorrhea. The same number of participants still experienced dysacusis in stage IV of the infection. Again the possible reason for the increase in the number of no complaints could be due to the fact that ART administration commenced in stage III, thus leading to a decrease in otological symptoms. However, this might also be the reason for the increase in the numbers of participants who complained of hearing loss, vertigo and tinnitus, suggesting the toxic effect of ART that might have influenced the cochlear and vestibular mechanisms even more.

Despite this fact, the direct effect of HIV/AIDS should not be underestimated. Persons with HIV/AIDS are also prone to develop bacterial meningitis, cryptococcosis infections and encephalitis, neurosyphilis, brain abscesses, toxoplasmosis and tuberculosis which may all have an influence on the hearing system, including the auditory nerve (Bankaitis, 1998:125). This, on the other hand, suggests that the increase in the cochlear and vestibular symptoms with the progression of the disease might be due to the direct effect of the virus on the various parts of the auditory system. Cochlear and vestibular complaints are not the only complaints that increased. Participants with AIDS also showed an increase in complaints of otalgia and

itching ears and this may be due to the presence of otitis media. Otitis media is one of the most commonly reported illnesses that are present in persons diagnosed with HIV/AIDS (Gold and Tami, 1998:166). One can argue that this may not be the reason, since ART is supposed to decrease the effects of opportunistic infections, but considering that the susceptibility of the individual to the drugs may fluctuate (Matkin et al., 1998:149), it should explain the reason why some participants still presented with otological complaints such as otalgia and itching ears (suggestive of otitis media and otitis extern). Matkin et al. (1998:149) state that the success and influence of ART on the auditory system, mainly depends on the susceptibility of the individual, dosage of the ototoxic drug and the duration of administration (Matkin et al., 1998:149).

According to the results of this research, there is a definite increase in the number of otological complaints and type of complaints with the progression of HIV to AIDS. This could possibly be explained by the administration of ART which treated the otological conditions but caused possible cochlear (noted in the increase of complaints of hearing loss, tinnitus and dysacusis) and vestibular damage (noted in the increase of vertigo). This may be due to a comforting effect the ART may have had on the participants by reducing the feeling of hopelessness and helplessness because they attempted to improve their health. The increase in the types of complaints might also have been due to the direct effect of HIV on the hearing mechanism. Table 4.19 reveals the previous complaints of these participants and it indicates in each stage the susceptibility to certain conditions prior to the contraction of the virus (previous complaints) and after contracting the virus (current complaints). Since the previous complaints represent the case history of the participants prior to their having HIV/AIDS, these results enabled the researcher to determine predisposition of these participants for certain otological complaints such as otitis media, otalgia or temporary hearing loss due to middle ear infections. These results suggested that some participants did have a predisposition to experience otalgia and

one participant mentioned that a hearing loss was experienced in the past, but it was temporary. Most participants did not complain of otological symptoms experienced prior to being diagnosed with HIV/AIDS.

This information on possible conditions may be included in national awareness campaigns on HIV/AIDS to attempt to explain to individuals who contracted the virus what may be expected in each stage of the disease. Audiologists should understand that with the progression of the virus, the hearing and ear conditions may increase and therefore the management of otological conditions should be adjusted accordingly.

4.3.1.2 Disease spectrum in the different stages of HIV/AIDS

Apart from otological diseases, persons diagnosed with HIV/AIDS may also present with other types of diseases. Various diseases can be found among persons with HIV/AIDS. For the purpose of this research project, these diseases were classified into different spectrums, such as otolaryngological diseases, lung diseases, skin diseases, small bowel diseases and neurological diseases.

Table 4.20 provides a description of the disease spectrums found among these participants. These disease spectrums are distributed across the stages of HIV/AIDS. Question 2.4 of the hearing interpretation recording form reveals the information discussed in this section. The mean was determined by calculating the number of participants for each clinical stage of HIV/AIDS. In this section the mean for stage I of HIV was n=5, the mean for stage II was n=7, the mean for stage III was n=8 and the mean for stage IV was n=22. At times, participants presented with more than one type of disease, thus suggesting that the percentages in some stages of HIV/AIDS do not add up to 100%.

Table 4.20: Disease spectrum distributed across stages of HIV/AIDS

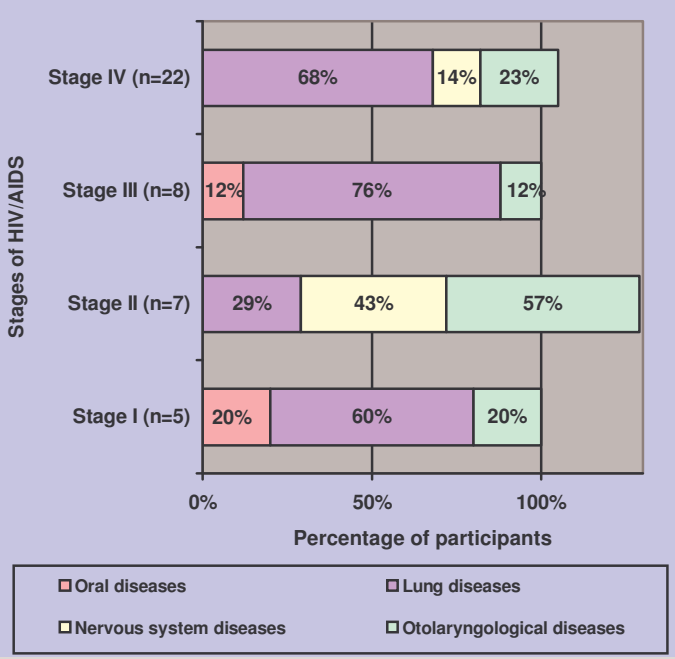
RESEARCH POPULATION	DIAGRAM SPECIFYING THE DISEASE SPECTRUMS
In stage I of HIV: Oral disease was found in one (20%) participant, lung diseases were found in three (60%) participants and an otolaryngological disease was found in one (20%) participant. *In stage II of HIV*, two (29%) participants had lung diseases, three (43%) participants had nervous system diseases and four (57%) had otolaryngological diseases. *In stage III of HIV,* one (12%) participant had an oral disease, six (76%) participants had lung diseases and one (12%) had an otolaryngological disease. *In participants with AIDS*, 15 (68%) had lung diseases, three (14%) had nervous system diseases and five (23%) participants had otolaryngological diseases.	

Figure 4.23: Disease spectrum in the different stages of HIV/AIDS (n=42).

Figure 4.23 reveals that in general, the disease spectrums that were diagnosed in these participants were lung diseases, otolaryngological diseases, nervous system diseases and oral diseases. Some participants in stage IV and Stage II presented with more than one disease. Lubbe (2004:253) states that ear manifestations in individuals with HIV/AIDS occur less frequently than neck manifestations and oral cavity manifestations. Otolaryngological diseases were present across all stages of HIV/AIDS. A definite increase in otolaryngological manifestations with the progression of HIV/AIDS was noted. Stage III of HIV showed a decrease in otolaryngological manifestations, which may be due to the administration of ART, since Lubbe (2004:250) states that recent studies have indicated that a decrease in conditions related to the buccal (part of the ear, nose and throat area) lesions are linked to the

administration of ART. From figure 4.23 it is clear that the number of lung diseases increased with the progression of HIV/AIDS.

Despite a person's HIV status, various OIs are associated with a sensorineural or conductive hearing loss and various degrees of hearing losses (Bankaitis and Schountz, 1998:155). The number of otological complaints, conditions and otological manifestations did not correlate and therefore it is important to realise that the results of table 4.19 are solely based on the perception of the participant and not on a diagnosis made by a medical doctor, as is the case with the results in table 4.20. This explains why the number of otological complaints in table 4.19 and the number of otolaryngological conditions did not correlate. The second reason is that table 4.19 only included otological complaints and not otolaryngological complaints which include conditions of the larynx, as with table 4.20. Lastly, otolaryngological conditions may go undetected because of a lack of equipment in the clinics, lack of awareness of the health workers regarding otological conditions associated with HIV/AIDS and lack of awareness of the public in terms of seeking assistance. Audiologists and health care workers should take note that otolaryngological conditions may be present at every stage of HIV/AIDS, but varying in degrees and symptoms.

4.3.2 Otoscopic examination in the different stages of HIV/AIDS

The otoscopic examination results are obtained from questions 3.1 and 3.2 of the Hearing interpretation recording form (Appendix K). These results are revealed in table 4.21.

4.3.2.1 Otoscopic examination of the external ear canal in the different stages of HIV/AIDS[15]

Table 4.21 reveals the information obtained from Question 3.1 of the Hearing interpretation recording form (Appendix K). Figure 4.24 reveal this information in the form of a visual graph which assists with the elucidation of these results.

Table 4.21: Otoscopic findings of the external ear canal in the different stages of HIV/AIDS

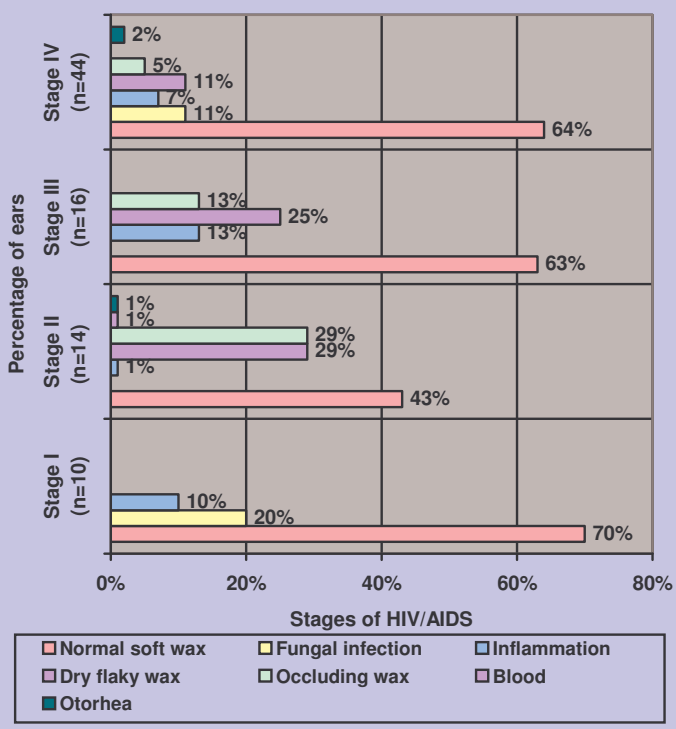
RESEARCH POPULATION	DIAGRAM SPECIFYING THE OTOSCOPIC FINDINGS
In stage I of HIV (n=10): one (10%) ear had inflammation, two (20%) had fungal infections, and seven (70%) ears had normal soft wax. *In stage II of HIV (n=14):* two (1%) ears had inflammation; two (1%) had otorrhea, two (1%) ears presented with blood, four (29%) had occluding wax, four (29%) had dry flaky wax, while six (43%) ears had normal soft wax. *In stage III of HIV (n=16):* two (13%) ears had inflammation and two (13%) had occluding wax. Four (25%) ears had dry flaky wax while ten (63%) had normal soft wax. *In stage VI (n=44):* one (2%) ear had otorrhea, two (5%) had occluding wax, three (7%) had inflammation, five (11%) had a fungal infection and five (11%) ears had dry flaky wax. Twenty-eight ears (64%) had soft wax.	

Figure 4.24: External ear canal observations in the different stages of HIV/AIDS

[15] These results are discussed in terms of ears per participant for each stage of HIV/AIDS. This means that the total mean was calculated as n=84, but the mean for stage I was n=10, for stage II was n=14, for stage III was n=16 and for those participants with AIDS was n=44. These calculations apply for section 4.3.2.1 and 4.3.2.2. The mean value is stated on the graph together with the particular stage of HIV/AIDS.

Figure 4.24 includes a discussion of all the landmarks and conditions that were observed by the researcher during the inspection of the ear canal and tympanic membrane. These observations include normal landmarks on the external ear canal as well as possible visible conditions that may influence the participant's hearing. Often, more than one abnormal landmark was observed in the ears of these participants, thus explaining why in some stages of HIV/AIDS the percentages do not add up to 100%.

Figure 4.24 reveals that the incidence of inflammation decreased and the presence of dry flaky wax increased with the progression of HIV to AIDS. This may relate to the administration of ART. No specific pattern of prevalence was observed for the other landmarks and conditions of the external ear canal. Normal soft wax had the highest incidence across all stages of HIV/AIDS. Wax may be considered as an infectious agent that may lead to the spread of HIV/AIDS (Kemp and Roeser, 1998:199). According to Kemp and Roeser (1998:199), cerumen, in other words, wax can contain bodily fluids that might be contaminated with infectious agents including HIV. The high incidence of soft wet wax in all stages of HIV/AIDS suggests that the infection control measures used by audiologists should be improved to prevent possible contamination or spread of the virus when getting in contact with the wax of an individual infected with HIV/AIDS. This is necessary to protect not only the clinician, but also future patients that may visit that particular audiology practice. Using specula tips for the otoscopic examination, without disinfecting these specula tips properly before using them on other patients, may lead to further spreading of the diseases or harmful bacteria. This may not only be harmful to patients, but even fatal, especially to a patient with HIV/AIDS, since these individuals' immunity has already been compromised to fend off most of these bacteria or viruses.

Otorhea was only found in stage IV, but inflammation was present in all stages of HIV/AIDS. The presence of inflammation and otorhea were expected to have a higher incidence. The literature study clearly indicates that individuals with HIV/AIDS have a higher incidence of otitis extern, especially characterized by inflammation (Matkin et al., 1998:148). These authors also state that inflammation is mainly observed in individuals with AIDS. However, in general, the findings were that inflammation was not present significantly often and the prevalence of inflammation in the ears of individuals with AIDS was only 11% compared to 18% of the ears in stage III that had inflammation of the external ear canal.

4.3.2.2 Otoscopic examination of the tympanic membrane in the different stages of HIV/AIDS

Table 4.22 specifies the otoscopic findings of the tympanic membrane. These results are obtained from Question 3.2 of the Hearing interpretation recording form (Appendix K).

Table 4.22: Otoscopic findings of the tympanic membrane distributed across stages of HIV/AIDS

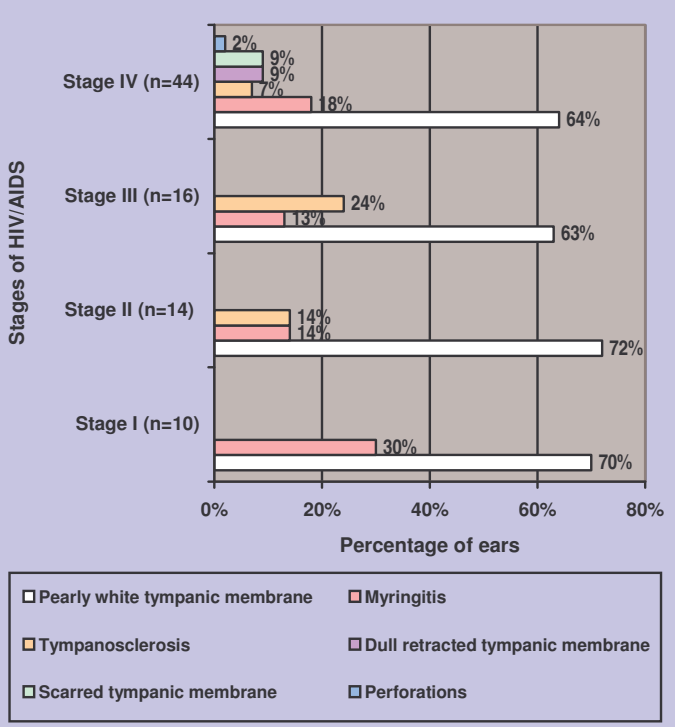
RESEARCH POPULATION	DIAGRAM SPECIFYING THE OTOSCOPIC FINDINGS
In stage I of HIV (n=10), three (30%) ears had myringitis and seven (70%) ears had a pearl white tympanic membrane. In stage II of HIV (n=14), two (14%) ears had tympanosclerosis and two (14%) had myringitis, while ten (72%) had normal pearl white tympanic membranes. In stage III of HIV (n=16), two (13%) ears had myringitis, four (25%) presented with tympanosclerosis and ten (63%) ears had normal pearly white tympanic membranes. The ears of participants with AIDS (n=44) presented with one (2%) perforated tympanic membrane, four (9%) were dull and retracted and scarred. Three (7%) had tympanosclerosis and seven (16%) had myringitis, while 28 (64%) had pearly white tympanic membranes	

Figure 4.25: Tympanic membrane observations in the different stages of HIV/AIDS

Figure 4.25 reveals that the incidence of pearly white tympanic membranes decreased with the progression of HIV to AIDS while the incidence of otological conditions increased from stage II to AIDS. Myringitis and tympanosclerosis together with normal pearly white tympanic membranes were the only phenomena and landmarks observed in the first three stages of the disease. Systemic viral infections (such as HIV/AIDS) can lead to the tympanic membrane becoming inflamed (Martin, 1997:224), thus presenting with myringitis. Therefore the direct effect of HIV/AIDS may largely be the reason for the increase in abnormal landmarks and the decrease in normal landmarks. Those participants with AIDS, in other words, stage IV of the HIV infection, presented with the most otological conditions that involved the tympanic

membrane including tympanic membrane perforation. Tympanic membrane perforation may be a result of chronic otitis media (Singh and Cohen, 2004:193) and Lubbe (2004:251) states that otitis media has a higher incidence in the HIV-infected population compared to the HIV-negative population. This suggests that otitis media as a result of HIV/AIDS may be the reason for the presence of dull retracted tympanic membranes, myringitis and perforated tympanic membranes. The tympanometry results from section 4.2.5.1.1 indicated that only 5% of the ears presented with otitis media with fluid in the middle ear, suggesting glue ears. These results suggest that myringitis was largely due to inflammation caused by the direct effect of the virus and not due to otitis media that was caused by the virus.

Otitis media is often characterized by a dull retracted tympanic membrane (Martin 1997:243). A dull retracted tympanic membrane was only found in stage IV of the HIV-infection with an incidence of 9%. This confirms the results obtained in section 4.3.5.1, suggesting that 9% of the ears in stage IV of the HIV-infection presented with type-B tympanograms, indicating the presence of otitis media and the need for medical or even surgical intervention.

Continuous infection may lead to a thickened scarred tympanic membrane and calcium plaques may even accumulate on the tympanic membrane causing tympanosclerosis (Martin, 1997:228). These research participants' scarred tympanic membranes, together with tympanosclerosis, were observed in 16% of the ears. In stage IV, these scarred tympanic membranes and tympanosclerosis, which may lead to a flaccid or stiff membrane, confirmed 16% type As- and Ad-tympanograms that were observed. This, however, is still to be discussed in section 4.3.5.1. These tympanograms suggest stiff or flaccid middle ear systems that may lead to a conductive hearing loss or a conductive component present in normal hearing sensitivity.

In summary, the types of otological conditions observed via the otoscopic examination, increased with the progression of the virus. This suggests that otoscopic examinations are extremely important and should always be included as part of a complete hearing assessment. Otoscopic findings vary across the different stages of HIV/AIDS and these conditions should therefore be regularly monitored and the audiological management, in terms of prompt referrals to health care workers such as general practitioners or ENT specialists, as well as the use of amplification, should be adjusted accordingly.

4.3.3 Characteristics of the pure tone audiogram in the different stages of HIV/AIDS

The qualities of the audiogram, in terms of the type, degree and configuration of the hearing loss are portrayed in this section. This section provides information on the number of ears affected, the type and the degree of hearing loss at the different frequency spectrums and lastly, the configuration of the audiogram at the different stages of HIV/AIDS. Questions 4.1 to 4.11 of the hearing interpretation recording form (Appendix K) reveal information regarding the type, nature, degree of hearing loss and configuration of the audiogram.

4.3.3.1 Unilateral or bilateral hearing loss in the different stages of HIV/AIDS

The presence of a hearing loss in one ear does not always imply a hearing loss present in the opposite ear of a particular participant. In table 4.23, the number of participants with hearing loss is indicated as well as whether it is a bilateral or unilateral hearing loss. The results are then distributed across the stages of HIV/AIDS in accordance with the CD4+ cell counts of the participants.

Table 4.23 also includes a graph which elucidates the information obtained from question 4.3 of the hearing interpretation recording form (Appendix K). This question divulges the information regarding the localisation of the hearing loss.

For the purpose of discussing the prevalence of unilateral and bilateral hearing loss and since a bilateral hearing loss is found per participant and not per ear, these results of section 4.3.3.1 will be analysed according to each participant and not according to each ear. The mean for section 4.3.3.1 is therefore n=42. This also suggests that the mean for each stage of HIV/AIDS is calculated according to the number of participants within each group. This means the mean of stage I is n=5, the mean for stage II is n=7, the mean for stage III is n=8 and the mean for stage IV is n=22. These mean values are stated on the graph with each specific clinical stage of HIV/AIDS.

Table 4.23: Bilateral, unilateral or no hearing loss distributed across stages of HIV/AIDS

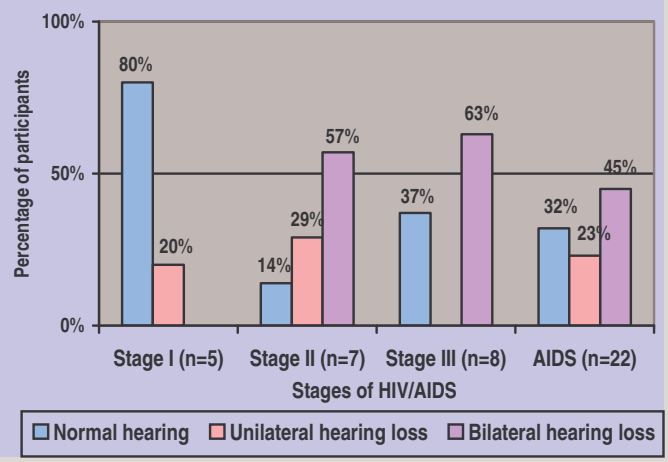
RESEARCH POPULATION	DIAGRAM SPECIFYING AMOUNT OF EARS AFFECTED
Four (80%) participants in stage I of HIV had no hearing loss and one (20%) had a unilateral hearing loss. One (14%) participant in stage II had no hearing loss, two (29%) had a unilateral loss and four (57%) participants had a bilateral hearing loss. Three (37%) participants in stage III had no hearing loss, while five (63%) participants had a bilateral hearing loss. Seven (32%) participant with AIDS had no hearing loss, five (23%) had a unilateral loss and ten (45%) participants had a bilateral hearing loss.	

Figure 4.26: Bilateral, unilateral or no hearing loss distributed across stages of HIV/AIDS

Figure 4.26 indicates that bilateral hearing loss had the highest prevalence in participants with AIDS. A significant difference (p=0.006) existed between all four stages of HIV/AIDS and the presence of a bilateral or unilateral hearing loss. Bilateral hearing loss was not diagnosed in stage I of HIV, but only started to develop from stage II. An increased incidence was observed in stage III and the incidence decreased in stage IV. According to the results of this study, the

incidence of hearing loss increased significantly with the development of the disease. The results suggest that a bilateral hearing loss could most probably be expected in stages II, III and IV while normal hearing was likely to be diagnosed in stage I of HIV/AIDS.

Hearing loss can already be present in the early stages of HIV/AIDS. This signifies that HIV-related hearing loss may easily be confused with NIHL in cases where individuals with HIV/AIDS might have been exposed to noise as well. These individuals would not necessarily present with diseases or conditions that may cause suspicions, but a definite hearing loss may be present, signifying that specifically for compensation claim purposes, a full diagnostic test battery is necessary.

4.3.3.2 The prevalence of a hearing loss in both ears distributed across stages of HIV/AIDS[16]

Table 4.24 separates the left and right ears and indicates the number of left ears and right ears were affected with a hearing loss. The ears affected are also distributed across the stages of HIV/AIDS in order to determine how many left ears and right ears were affected in each stage of HIV/AIDS. Question 4.4 of the hearing interpretation recording form (Appendix K) reveals the information regarding the ears that were affected.

---

[16] For the purpose of this section, each ear was viewed as a separate entity in order to enable the researcher to identify differences in the number of left and right ears that were affected. Therefore the mean for section 4.3.3.2 is n=84. Each stage was also divided into ears per stage, therefore the mean of stage I was n=10, the mean of stage II was n=14, the mean of stage III was n=16 and the mean of stage IV was n =44. These mean values are applicable in sections 4.3.3.2, 4.3.3.3 and 4.3.3.4.

Table 4.24: Left and right ears affected by the hearing loss in the different stages of HIV/AIDS

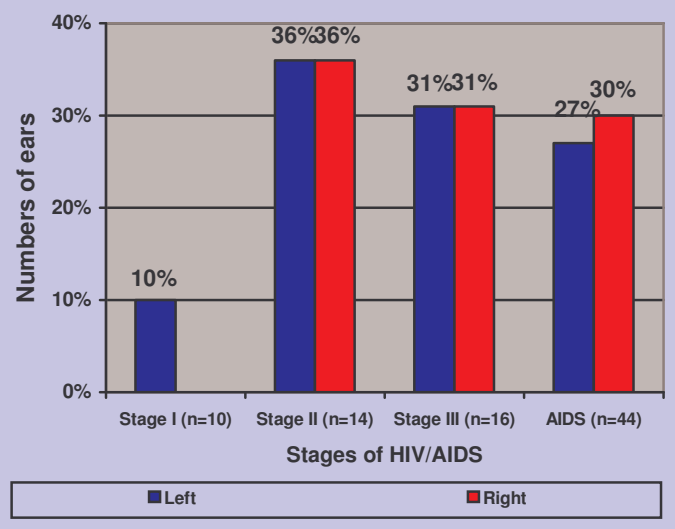
RESEARCH POPULATION	DIAGRAM SPECIFYING EARS AFFECTED
Participants in stage I of HIV (n=10) presented with a hearing loss in one (10%) left ear. Participants in stage II of HIV (n=14) presented with a hearing loss in five (36%) left and right ears. Participants in stage III of HIV (n=16) presented with a hearing loss in five (31%) left and right ears. Participants with AIDS (n=44) presented with a hearing loss in 12 (27%) left and 13 (30%) right ears.	

Figure 4.27: Ears affected by a hearing loss distributed across stages of HIV/AIDS

Figure 4.27 shows which ear was mainly affected by a hearing loss and these results are also distributed across the stages of HIV/AIDS. The results in figure 4.27 were determined by the complete audiogram (including the complete frequency spectrum of the pure tone audiogram and not just the PTA). The results indicated that the left and right ears in general were mainly equally affected with a hearing loss. No significant statistical difference was found between the left and the right ears, especially in the last three stages of HIV/AIDS. The left and right ears of participants in stage II and III were equally affected. Stage I only presented with 10% of affected ears, which were only left ears.

Again, it is clear that hearing loss may already be present in the early stages of HIV/AIDS. This may cause a great deal of difficulty when one attempts to distinguish between HIV-related hearing losses and noise-induced hearing losses. However, when a unilateral hearing loss is present, it could be due to the constant presence of a high intensity sound source on the side

of the affected ear. If it was not present in the working environment, the hearing loss could be due to the direct effects of HIV/AIDS.

4.3.3.3 The degree[17] of hearing loss distributed across stages of HIV/AIDS

Table 4.25 depicts the degree of hearing loss in terms of the pure tone average at 500Hz, 1000Hz and 2000Hz. Questions 4.6 to 4.8 of the hearing interpretation recording form (Appendix K) supply the information provided in the table and graph.

Table 4.25: Degree of hearing loss in the different stages of HIV

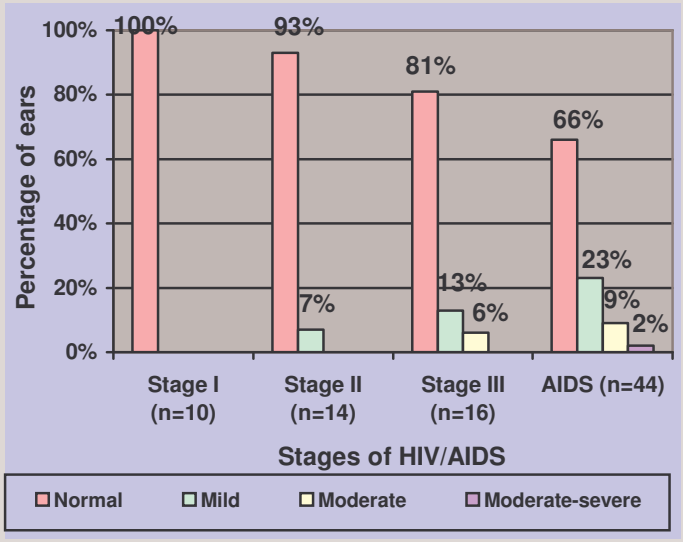
RESEARCH POPULATION	DIAGRAM SPECIFYING DEGREE OF HEARING LOSS
In participants with stage I HIV-infection, ten (100%) ears had normal hearing. In participants with stage II HIV-infection, 13 (93%) ears had normal hearing, while one (7%) ear had a mild hearing loss. In participants with stage III HIV-infection, 13 (81%) ears had normal hearing, two (13%) ears had a mild hearing loss and one (6%) ear had a moderate hearing loss. In participants with AIDS, 29 (66%) ears had normal hearing, ten (23%) ears had a mild hearing loss, and four (9%) ears had a moderate hearing loss, while one (2%) ear had a moderate to severe hearing loss.	

Figure 4.28: Degree of hearing loss according to the PTA in the different stages of HIV/AIDS

Table 4.25 indicates the degree of hearing loss for each ear in each clinical stage of HIV/AIDS. Figure 4.28, included in table 4.25, illustrates the pure tone average (average for 500Hz,

[17] The degree of hearing loss was interpreted according to Goodman (1965) in Hall and Mueller (1998:104). Normal hearing suggested a PTA between 0dB and 25dB, mild hearing loss suggested a PTA between 26dB and 40dB, moderate hearing loss suggested a PTA between 41dB and 55dB and lastly a moderate-to-severe hearing loss suggested a PTA between 56dB and 70dB.

1000Hz and 2000Hz) for each ear. A significant statistical difference (0.04) existed between all four stages of HIV/AIDS and the degree of hearing loss according to the PTA. No hearing loss was found in stage I of HIV according to the PTA (the high frequency and low frequency thresholds of the audiogram were not taken into account in this section). However, from stage II to stage IV, the hearing loss in terms of degree gradually increased to moderate-to-severe degrees of hearing loss. The incidence of normal hearing thresholds according to the PTA decreases with the progression of HIV to AIDS while the incidence of any degree of hearing loss increases with the progression of HIV to AIDS.

These results clearly suggest that audiologists should be aware that the hearing thresholds of individuals with HIV/AIDS are likely to worsen with the progression to the next stage of the disease. These findings hold a significant clinical implication when considering fitting individuals with HIV/AIDS with hearing aids and/or assistive devices. Audiologists should consider hearing aids with a relatively large fitting range when these individuals are fitted. The reason is that the hearing loss related to HIV/AIDS my be progressive in nature, which corresponds with the progressive nature of the disease. This also implies that after the hearing aid has been fitted, regular follow-up sessions should be scheduled to determine if the amplification still fits the hearing needs of these individuals with HIV/AIDS. If not, the hearing aid should be adjusted appropriately.

This last-mentioned aspect serves as motivation for a second, but highly significant implication of these findings. Regular follow-up sessions for hearing assessments and counselling should be conducted by the audiologist. The possible progressive nature of the hearing thresholds indicated by these results serve as justification for regular assessments. Since the degree of hearing loss tends to increase with the progression of HIV/AIDS, the audiologist or health care worker should counsel the infected individual on the possibility of the development of a hearing

loss, the progressive nature of the hearing loss and where to find assistance when a hearing loss does develop. Upon diagnosis, regular hearing assessments should be scheduled to determine when the hearing thresholds decrease, so that the necessary adjustments can be made to the assistive devices or amplification. Being proactive in this way may enhance the quality of life of an individual throughout the progression of the disease.

4.3.3.4 Configuration of hearing loss in the different stages of HIV/AIDS[18]

Table 4.26 portrays the configuration of the audiograms in left and right ears of the research participants distributed across the stages of HIV/AIDS. Question 4.9 of the hearing interpretation recording form provides the information supplied in the table below.

Table 4.26: Configuration of audiograms in the different stages of HIV/AIDS

CONFIGURATION	Incidence in stages of HIV				OBSERVATION
	I n=10	II n=14	III n=16	IV n=44	
Flat	50%	21%	19%	21%	Audiogram configuration found in all stages of HIV/AIDS, but with highest incidence in stage I of HIV.
Sloping	-	14%	25%	9%	Audiogram configuration found from stage II to stage IV.
Rising	-	7%	-	9%	Audiogram configuration with a relatively low incidence and only found in stage II and stage IV.
Sharply falling	-	-	-	2%	Audiogram configuration with a low incidence and only found in AIDS.
Trough	10%	7%	-	2%	Audiogram configuration with a low incidence and found in stage I, II and IV.
4000Hz notching	-	-	-	5%	Audiogram configuration only found in AIDS.
Irregular	20%	36%	25%	27%	Audiogram configuration with a relatively high incidence across all stages of HIV/AIDS.
Other[19]	20%	15%	31%	25%	Incidence across all stages of HIV/AIDS

[18] Each stage was also divided into ears per stage, thus the mean of stage I was n=10, the mean of stage II was n=14, the mean of stage III was n=16 and the mean of stage IV was n=44. In this way the researcher was able to compare the incidence of the different types of configurations in each stage.

It is important to take note that the means and percentages are difficult to compare since the mean for each stage of HIV/AIDS differs. Table 4.26 represents the configuration of audiograms found in the research population and these results are distributed across the stages of HIV/AIDS. According to the results discussed in section 4.2.5.1, 6% of type As-tympanograms were obtained from this research population. This is indicative of stiffness of the middle ear system (Martin, 1997:160,266) which may be due to the presence of otosclerosis. Carthart's notch configurations were not observed in any of the participants and since otosclerosis is characterized by a Carthart's notch audiogram configuration, it suggests that participants in this research population did not have otosclerosis (Martin, 1997:262). However, the audiogram did not confirm otosclerosis, therefore the stiff middle ear system was most probably not due to otosclerosis. The poor compliance of the middle ear system may be due to advanced otitis media which may include the presence of glue ears as well.

Three types of configurations, namely, flat, irregular and "other" configurations (configurations suggesting that the thresholds rise slowly to mid frequencies that are within normal limits and decrease slowly to the high frequencies with a sudden drop from 4000Hz to 8000Hz), were found across the various stages of HIV/AIDS. These types of configurations influence the choice of technology when the goal is to provide the individual with HIV/AIDS with amplification. Individuals with HIV/AIDS with a hearing loss characterized by a flat configuration usually need uncomplicated technology which tends to be less expensive. The sloping hearing loss or hearing loss that slowly rises to a mid frequency and drops at the high frequencies may need a two-channel hearing aid which may be slightly more expensive, but still less costly than state-of-the-art technology. These two last-mentioned configurations should be fitted with a hearing

---

19 "Other" refers to configurations that slowly rose from the low frequencies to 1000Hz or 2000Hz (the mid frequencies,) then slowly dropped from 1000Hz or 2000Hz to 4000Hz and sharply decreased from 4000Hz to 8000Hz.

aid where the knee point of the frequency range falls at the mid frequencies. With this technology, the audiologist will be able to adjust the amplification of the high and the low frequencies separately to provide the individual with HIV/AIDS with the best possible amplification for the cheapest price. This is very important, especially for the developing countries including South Africa, in view of the fact that these are the countries with the largest incidence of HIV/AIDS, but also with some of the poorest people in the world, who might not be able to purchase hearing aids containing state-of-the-art-technology. To elucidate these configurations even more, table 4.27 provides a visual presentation of the average configurations that were found in these participants with HIV/AIDS. These audiograms clearly show the decrease in the low and high frequencies, confirming the amplification options mentioned earlier in this section. These drops in thresholds in low and high frequencies are mainly visible in stages II, III and IV of HIV/AIDS (figure 4.35, figure 4.36 and figure 4.37).

Table 4.27a: Average audiogram configuration for stage I of HIV/AIDS

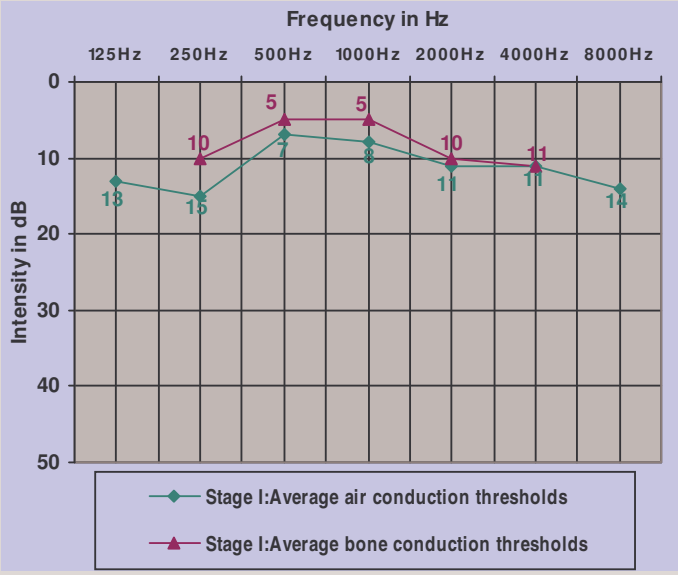
RESEARCH POPULATION	DIAGRAM SPECIFYING CONFIGURATION OF AUDIOGRAMS
Air conduction thresholds for the left and right ears of those participants in stage I of HIV were obtained at normal intensity levels across the complete frequency spectrum. The only significant air-bone gap was observed at 250dB, thus in the low frequencies.	

Figure 4.29: Average pure tone thresholds as a function of frequency for participants in stage I of HIV (n=10)

Figure 4.29 indicates that the average hearing thresholds for individuals in stage I of HIV were still obtained within normal limits. Significant air-bone gaps were mainly present at 250Hz. The air conduction thresholds were rising from the low frequencies and slowly falling to the high frequencies. However, air thresholds at 250Hz were worse than those in the high frequencies. The mid-frequencies (500Hz and 1000Hz) displayed the best air conduction threshold values.

Table 4.27b: Average audiogram configuration for stage II of HIV/AIDS

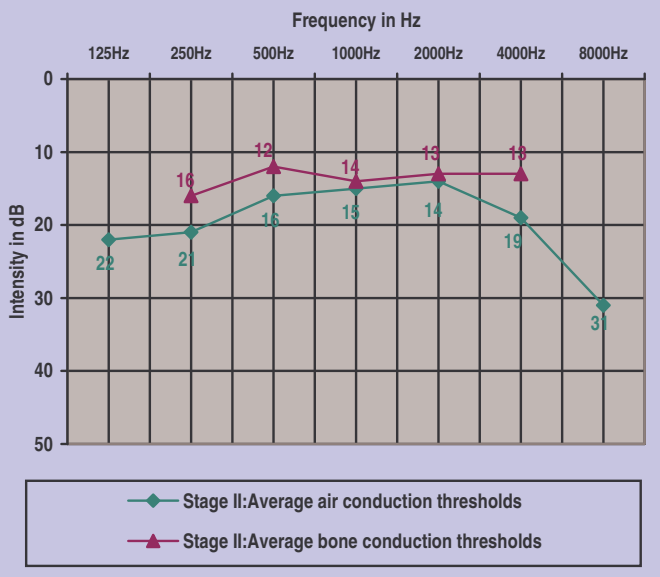
RESEARCH POPULATION	DIAGRAM SPECIFYING CONFIGURATION OF AUDIOGRAMS
Air conduction thresholds for the left and right ears of those participants in stage II of HIV were obtained at normal intensity levels across the complete frequency spectrum except at 8000Hz. The only significant air-bone gap was observed at 250dB and 4000Hz.	

Figure 4.30: Average pure tone thresholds as a function of frequency for participants in stage II of HIV (n=14)

Figure 4.30 shows that the average hearing thresholds for individuals in stage II of HIV were still obtained within normal limits except at 8000Hz. Significant air-bone gaps were mainly observed at 250Hz and 4000Hz and started to show at 500Hz. The air conduction thresholds were slowly rising from the low frequencies to the mid-frequencies where the best air conduction thresholds were obtained, and then slightly falling from 2000Hz to 4000Hz with a sudden fall from 4000Hz to 8000Hz.

Table 4.27c: Average audiogram configurations for stage III of HIV/AIDS

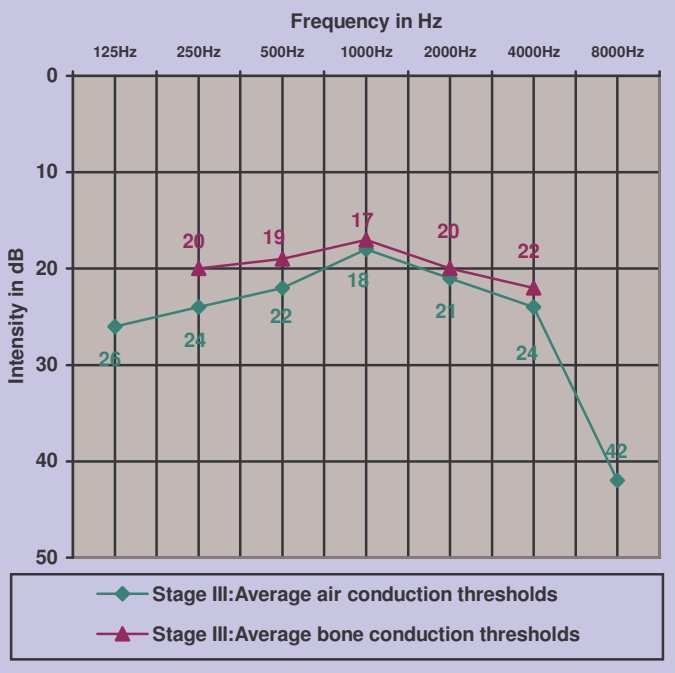
RESEARCH POPULATION	DIAGRAM SPECIFYING CONFIGURATION OF AUDIOGRAMS
Air conduction thresholds for the left and right ears of those participants in stage III of HIV were obtained at normal intensity levels across the complete frequency spectrum except at 125Hz and 8000Hz. No significant air-bone gap was observed.	

Figure 4.31: Average pure tone thresholds as a function of frequency for participants in stage III of HIV (n=16)

Figure 4.31 displays the average hearing thresholds for individuals in stage III of HIV. These thresholds were obtained within normal limits at 250Hz to 4000Hz. Air conduction thresholds at 125Hz indicated a mild decrease in hearing sensitivity and displayed a moderate hearing loss at 8000Hz. Insignificant air-bone gaps were mainly present at 250Hz, 500Hz and 4000Hz. The air-bone gap seems to be better in stage III of HIV. The air conduction thresholds seemed to rise slowly to the mid frequencies, which again had been obtained within normal limits and then a sudden fall from 4000Hz to 8000Hz.

Table 4.27d: Average audiogram configurations for stage IV of HIV/AIDS

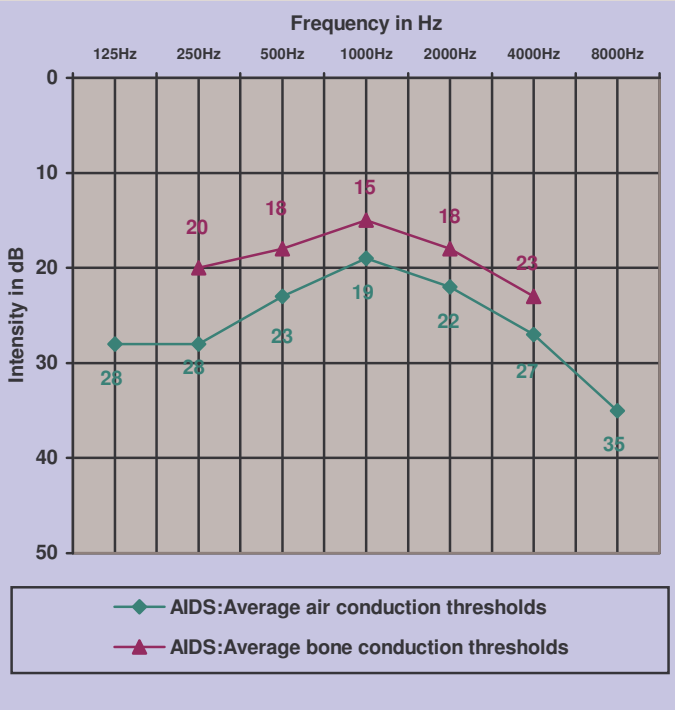
RESEARCH POPULATION	DIAGRAM SPECIFYING CONFIGURATION OF AUDIOGRAMS
Air conduction thresholds for the left and right ears of those participants with AIDS were obtained at normal intensity levels at the mid frequencies and decreased hearing sensitivity suggestive of a mild hearing loss at 125Hz to 250Hz and 4000Hz to 8000Hz. Air-bone gaps seemed to be present across the complete frequency spectrum of the audiogram, however it was significant at 250Hz and 500Hz.	

Figure 4.32: Average pure tone thresholds as a function of frequency for participants with AIDS (n=44)

Figure 4.32 reveals the average hearing thresholds for individuals with AIDS. These thresholds were obtained within normal limits at 500Hz to 2000Hz. This suggests that when calculating the degree of hearing loss in terms of the PTA, these individuals will present with normal hearing, even though the high and low frequencies are affected. The low frequencies (125Hz and 250Hz) and the high frequencies (4000Hz to 8000Hz) seemed to be affected to a mild degree. The air-bone gap was now present across the complete frequency spectrum, but it was found to be mainly significant at the low frequencies. Again the configuration displayed thresholds that slowly rise to the mid-frequencies, specifically 1000Hz, and then start to fall as they progress to the high frequencies.

Comparing figures 4.29 to 4.32, it is clear that the average thresholds worsen with the progression of HIV to AIDS. The mid-frequencies were mainly found within normal limits across all stages of HIV/AIDS, indicating that the PTA in any stage may display a normal degree of hearing, thus confirming the results obtained in section 4.3.3.3 in table 4.25.

The results clearly indicate that comprehensive pure tone air-and-bone audiometry assessments are necessary when the audiologist assesses the hearing of individuals infected with HIV/AIDS. The hearing may seem to be within normal limits at the mid-frequencies, but a drop is usually noticed at the high and low frequencies which may suggest a hearing loss, especially in stages II, III and IV. Another important fact is that the high frequencies may typically present like a NIHL, even though noise exposure was insignificant in this population. This signifies that conducting only baseline audiograms to determine the decrease in hearing is not sufficient for patients with HIV/AIDS, as noise-induced hearing loss is characterized by a drop in the high frequencies from 2 kHz to 8 kHz (Edwards, 1980:42).

4.3.3.5 The type of hearing loss distributed across stages of HIV/AIDS

Table 4.28 depicts the type of hearing loss obtained for each stage of HIV/AIDS. These results were analysed according to each individual's audiogram and indicated on the hearing interpretation recording form (Appendix K). Question 4.9 of this hearing interpretation recording form provides this information. The mean for each stage of HIV/AIDS is indicated in the following table.

Table 4.28: Type of hearing loss in the different stages of HIV/AIDS

Type of hearing	Incidence in stages of HIV			
	I n=10	II n=14	III n=16	IV n=44
Normal hearing	90%	57%	57%	57%
Conductive components	10%	36%	6%	18%
Sensorineural hearing loss	-	7%	31%	20%
Mixed hearing loss	-	-	6%	5%

Table 4.28 suggests that nine (90%) ears of the participants with HIV stage I had normal hearing, while one (10%) ear had a conductive hearing loss. Eight (57%) ears of the participants in stage II of HIV had normal hearing, while five (36%) ears had a conductive hearing loss and one (7%) ear had a sensorineural hearing loss. Nine (57%) ears of the participants in stage III of HIV had normal hearing, while one (6%) ear had a conductive hearing loss and five (31%) ears had a sensorineural hearing loss. Only one (6%) ear had a mixed hearing loss. Twenty-five (57%) ears of the participants with AIDS had normal hearing while eight (18%) ears had a conductive hearing loss and nine (20%) ears had a sensorineural hearing loss. Two (5%) ears had a mixed hearing loss. These results indicate the following:

- *Normal hearing*

When observing the results presented in table 4.27 and table 4.28, it is clear that stage I of HIV/AIDS had the highest incidence of normal hearing, while the ears of participants with AIDS had the lowest incidence of normal hearing in both the low and high frequencies. The trend seems to be that the incidence of normal hearing slowly decreases with the progress to each stage of HIV/AIDS. This is important for the audiologist because by the time the participants' health has regressed to stage II, III and / or AIDS, the presence of normal hearing will

decrease. In the case of this research project it decreased with at least 33%. This suggests that individuals with HIV/AIDS will probably present with a hearing loss which is progressive in nature.

- *Conductive hearing loss*

Conductive hearing losses are the consequence of middle ear disorders (Martin, 1997:241). A conductive hearing loss can be associated with HIV/AIDS, since middle ear disorders due to HIV/AIDS are relatively common (Gold and Tami, 1998:165-166). Conductive hearing loss was present with a varying incidence (10%, 36%, 6%, 18% in stages I, II, III and VI consecutively) throughout all the stages of HIV/AIDS. An increase in incidence was noted up to stage II, then a decrease in incidence took place in stage III where it increased again to stage IV. This could possibly be due to the administration of ART that is usually initiated in stage III (Cohen, 2005:250), thus clearing up the otological conditions that started to develop in stage I and were present in stage II.

Again, the protocol of administering ART suggests that ART should commence in the third stage of the HIV infection (Cohen, 2005:250). This could also elucidate why stage III had the lowest incidence of conductive hearing loss. With the progression to AIDS, the immunity of the participants is severely compromised and therefore, regardless of ART, they may be vulnerable to develop opportunistic infections, including otological infections. This possibly clarifies the increased prevalence of conductive hearing losses in the final stage of HIV. The results correlate well with the literature study which states that conductive hearing loss is frequently found in individuals with HIV/AIDS (Gold and Tami, 1998:165). However, these authors did not attempt to distinguish between the various stages of HIV/AIDS.

- *Sensorineural hearing loss*

The presence of a sensorineural hearing loss commenced in stage II (7%), progressed to a higher incidence in stage III (31%) and then decreased in terms of prevalence in the final stage of HIV (20%). Gold and Tami (1998:166) state that between 20% and 50% of the individuals infected with HIV/AIDS (in general, but not at a specific stage of the disease) present with a sensorineural hearing loss. The results from this research echo the statement made by Gold and Tami (1998:166), because more than 20% of sensorineural hearing losses were found in the last two stages of HIV/AIDS.

- *Mixed hearing loss*

Mixed hearing losses only commenced in stage III and the incidence decreased slightly with the progression of HIV stage III to AIDS. This probably suggests that cochlear pathology and conductive pathology increased with the progression of the virus. However, this is still to be discussed in the following sections.

The type, degree and configuration of hearing loss tend to differ in the different stages of the infection. This may suggest that the hearing loss may change with the progression of the virus. However, such longitudinal research should still be conducted. For now, audiologists should take note of these possible changes and ensure that the hearing of the patient should be monitored regularly, especially with progression to a different stage of HIV/AIDS. The management of amplification and hearing health should then be monitored accordingly.

4.3.4 Characteristics of speech audiometry in the different stages of HIV/AIDS

The speech audiometry results include information on the correlation between the speech reception threshold and the pure tone average, the possible reason for poor correlation, the

rollover index according to the appropriate formula, as well as the configuration of performance-intensity function during speech discrimination testing.

4.3.4.1 Speech threshold test results across the stages of HIV/AIDS[20]

Table 4.29 provides information regarding the correlation of the SRT with the PTA. A good PTA-SRT correlation suggests reliable pure tone audiometry results. Question 5.1 and 5.2 from the hearing interpretation recording form (Appendix K) reveal the answer to this question.

Table 4.29 reveals that seven (70%) ears of the participants in stage I of HIV (n=10) had a good PTA-SRT correlation, while three (30%) ears had a poor PTA-SRT correlation. Eleven (79%) ears of the participants in stage II of HIV (n=14) had a good SRT-PTA correlation, while three (21%) ears had a poor SRT-PTA correlation. Fourteen (88%) ears of the participants in stage III of HIV (n=16) had a good SRT-PTA correlation, while two (12%) ears had a poor SRT-PTA correlation. Thirty (68%) ears of the participants with AIDS (n=44) had a good SRT-PTA correlation, while 14 (32%) ears had a poor SRT-PTA correlation. The PTA-SRT correlation was mainly good across the four stages of HIV/AIDS, suggesting that in general the pure tone audiometry results were reliable.

[20] Each stage was also divided into ears per stage, therefore the mean of stage I was n=10, the mean of stage II was n=14, the mean of stage III was n=16 and the mean of stage IV was n =44. In this way the researcher was able to compare the incidence of the different types of configurations in each stage.

Table 4.29: PTA and SRT correlation distributed across stages of HIV/AIDS

CONFIGURATION AND REASONS	Incidence in stages of HIV				OBSERVATION
	I n=10	II n=14	III n=16	IV n=44	
Good PTA-SRT correlation	70%	79%	88%	68%	Audiogram configuration found in all stages of HIV/AIDS, but with highest incidence in stage I of HIV.
Poor PTA-SRT correlation	30%	21%	12%	32%	Audiogram configuration found from stage II to stage IV.

The correlation between the PTA and the SRT was increasingly poor with the progression of HIV/AIDS from stage II to stage IV of the disease and this was mainly due to the increase in ski-slope audiograms with declining thresholds. Since the reason for a poor PTA-SRT correlation is usually poor reliability of pure tone test audiometry or the presence of a ski-slope audiogram, this increasingly poor PTA-SRT correlation may be due any of these two phenomena or possibly APD but this had to be confirmed by other tests (Martin and Clark, 2006:120). One (1%) ear of the participants in stage II of HIV (n=14) had a ski-slope audiogram. Two (1%) ears of the participants in stage III (n=16) had a ski-slope audiogram. Ten (23%) ears of the participants with AIDS had a ski-slope audiogram. The degrees of the ski-slope differed for the different stages of HIV/AIDS, which explains why the number of sloping and sharply falling audiogram configurations in section 4.3.3.4 did not correlate with ski-slope results in this section.

It is clear from section 4.3.3.4 that an increasing incidence of a high frequency ski-slope audiogram configuration with the progression of HIV to AIDS was found in this research population. Therefore the ski-slope configuration may be the main reason for poor PTA-SRT correlation. Table 4.29 confirms this assumption, except when viewing the results of stage I of HIV. According to these results, participants in stage I did not present with a sloping hearing

loss, suggesting that the poor PTA-SRT correlation was due to poor test reliability during the pure tone audiometry procedure. Interestingly enough, table 4.29 also indicates that three (30%) ears had a poor SRT-PTA correlation, possibly due to poor test reliability, and stage IV (9%) was the only stage of HIV/AIDS that presented with poor test reliability of the pure tone audiogram. This may be due to the emotional adjustment and psychological issues these individuals go through to accept that they have HIV/AIDS. In stage I, they need to accept and adjust to the fact that they have contracted HIV/AIDS and in stage IV they probably need to accept and adjust to the fatality of the disease. These participants in stage I of HIV suggest that they are still in the early stages of HIV and that the diagnosis probably took place recently. It could therefore be that emotional and psychological well-being might have played a role when these audiometrical tests were conducted. Any person who contracts a life-threatening disease is confronted with a series of personal losses (Tanchel, 2003:249). Fear, a psychological reaction to the realization of the fact that they have a fatal disease, may lead to emotional responses overshadowing their complete well-being (Tanchel, 2003:249). These emotional and psychological phases might have influenced their emotional well-being, perceptions and therefore the reliability of their responses during behavioural testing.

Poor PTA-SRT correlations in stages II and III of HIV were due to the presence of a ski-slope audiogram. According to table 4.29, participants in stage IV of HIV, had the highest incidence of poor PTA-SRT correlations. The reasons for a poor PTA-SRT correlation was due to the audiogram that falls abruptly in the high frequencies and unreliable responses from the patient (Martin, 1997:121). These results correlate with the literature study suggesting that poor PTA-SRT correlation is usually associated with ski-slope audiogram configurations. A clear relationship was observed between the presence of a ski-slope audiogram configuration and a poor PTA-SRT configuration, especially in participants in stages II, III and IV of HIV/AIDS.

4.3.4.2 Above threshold tests in the different stages of HIV/AIDS

Table 4.30 indicates the speech discrimination results distributed across the stages of HIV/AIDS. The mean for each stage of HIV/AIDS is indicated in the graph below.

Table 4.30: Speech discrimination results in the different stages of HIV/AIDS

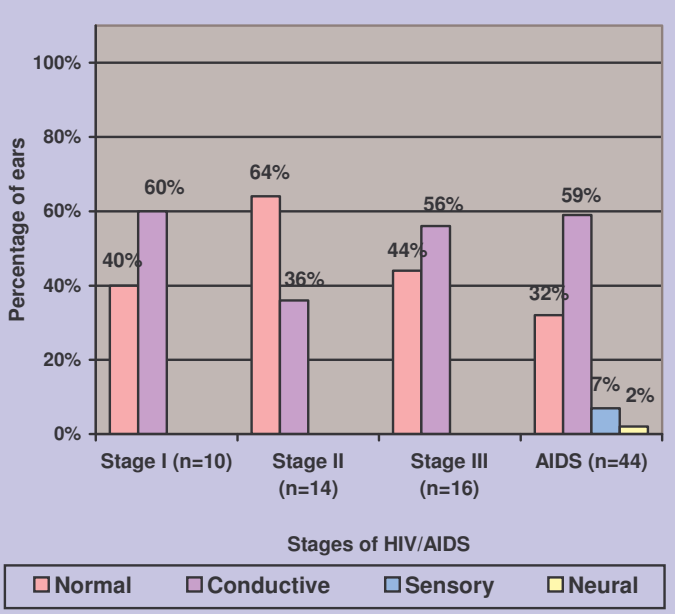
RESEARCH POPULATION	DIAGRAM SPECIFYING SPEECH DISCRIMINATION RESULTS
Participants in stage I of HIV presented with four (40%) ears with normal results and six (60%) ears with a conductive configuration. Nine (64%) ears of participants in stage II of HIV presented with normal results and five (36%) ears with a conductive configuration. Seven (44%) ears of participants in stage III of HIV presented with seven (44%) ears with normal results and nine (56%) ears with a conductive configuration. Fourteen (32%) ears of participant with AIDS presented normal results and 26 (59%) ears with a conductive configuration, three (7%) ears with a sensory configuration and one (2%) with a neural configuration.	

Figure 4.33: Speech discrimination results in the different stages of HIV/AIDS

Figure 4.33 reveals that 40% of the ears in stage I of HIV, 64% of the ears in stage II of HIV, 44% of the ears in stage III of HIV and 32% ears in stage IV of HIV obtained between 92% and 100% speech discrimination scores at intensity levels of 40dB or better. Speech discrimination results of 92% to 100% at intensity levels higher than 40dB were obtained in 60% of the ears in stage I of HIV, 36% of the ears in stage II of HIV, 56% of the ears in stage III of HIV and 59% of the ears in stage IV of HIV. A maximum word discrimination of 92% at increased intensity levels was obtained in 7% of the ears in stage IV only, while only 2% of the ears in stage IV

displayed a significant decrease in speech discrimination (according to the rollover index) with an increase in intensity.

Figure 4.33 indicates that only one (2%) neural configuration was identified, suggesting a decrease in discrimination ability with an increase in intensity, thus called a rollover. This was determined by subtracting the minimum percentage of word discrimination at the highest intensity level from the maximum percentage of word discrimination at the highest intensity level and dividing the result by the minimum percentage of word discrimination (Hall and Mueller, 1998:149). This is better known as a rollover index (RI). When this RI is more than 0.4, it is suggestive of a significant rollover, therefore retro-cochlear pathology (Hall and Mueller, 1998:147). Sensory (cochlear pathology suggesting inability to obtain 100% correct word discrimination even with an increase in intensity levels) and neural configuration (suggesting a rollover) were only obtained in participants who already had AIDS.

Any type of disease, especially neurological diseases, may result in disorders of the vestibulo-cochlear nerve (Martin, 1997:331). HIV should also be considered a disease that may affect the vestibulo-cochlear nerve, since it has been found that HIV tends to cause demyelization of the neurons of the brain and glial cells (Gold and Tami, 1998:167). This may serve to explain the presence of retro-cochlear pathology that was identified in 2% of the ears. However, the incidence was considerably low. Therefore the incidence of neural pathology among this population was not considered significant.

Speech discrimination results are more sensitive in the detection of retro-cochlear or central pathology. However, since it is clear that the incidence of retro-cochlear pathology was reasonably low and the possibility that outside factors such as language barriers and differences in dialect may have influenced the results, an additional objective measurement had to be performed to determine if retro-cochlear pathology, otherwise undetectable, may be

present in these individuals. Immittance results, specifically acoustic reflexes, also evaluate areas of the central pathways, specifically the functioning of the vestibulo-cochlear nerve and the facial nerve. The immittance results suggested that 26% of the total research population had retro-cochlear pathology (section 4.2.5.3). This may suggest that the audiologist might not be able to identify retro-cochlear loss through speech discrimination results in the participants with HIV/AIDS successfully and therefore the audiologists should not exclude objective specialized measurements from the audiological assessment. This is in line with the suggestion made by Gold and Tami (1998:167) recommending that an evaluation for the presence of a hearing loss in individuals with HIV/AIDS *"... should include a complete audiological examination, including auditory brainstem response testing".*

Conductive configurations according to the speech discrimination results had the highest incidence in stage I, III and IV, while normal configuration had the highest incidence in stage II. According to Gold and Tami (1998:167), *"speech discrimination usually remains within near normal".* Normal configurations were definitely found in all stages of HIV/AIDS, but conductive configurations had the highest incidence in three of the four stages.

Audiologists should realise that as from the diagnosis of HIV/AIDS, the complete hearing assessment battery should include APD (previously referred to as APD) testing and speech audiometry as part of the assessment battery, since APD may already be present in stage I of the disease. Audiologists should also take note that sensory and neural conditions indicated by speech audiometry are usually seen from the time the patient has AIDS. Stages I to III tend to reveal a speech audiogram that is indicative of 100% word discrimination at higher intensity levels.

4.3.5 Characteristics of the immittance measurements in the different stages of HIV/AIDS

The immittance results include the tympanograms, as well as the ipsilateral and contralateral acoustic reflexes. This information is provided by questions 6.1 to 6.5 of the Hearing interpretation recording form (Appendix K).

4.3.5.1 Tympanometry and acoustic reflex results in the different stages of HIV/AIDS

Since immittance results are the most reliable results in terms of determining a conductive, cochlear and retro-cochlear pathology, it is used to determine the presence of these pathologies and overrule the findings obtained by the speech discrimination results (Hall and Mueller, 1998:177).

4.3.5.1.1 Tympanometry results for all participant ears distributed across the stages of HIV/AIDS

Table 4.31 indicates the types of tympanograms that were obtained from the total research population. These results are distributed across the stages of HIV/AIDS. The mean for each stage is indicated in the graph below.

Table 4.31: Tympanometry results in the different stages of HIV/AIDS

TYMPANOGRAM	Incidence in stages of HIV				OBSERVATION
	I n=10	II n=14	III n=16	IV n=44	
Type A-tympanogram	80%	93%	81%	75%	Tympanogram found in all stages of HIV/AIDS, but with highest incidence in stage I of HIV.
Type As-tympanogram	10%	-	6%	7%	Tympanogram found from stage II to stage IV.
Type Ad-tympanogram	10%	7%	13%	9%	Tympanogram with a low incidence, only found in stage II and stage IV.
Type B-tympanogram	-	-	-	9%	Tympanogram with a low incidence and only found in AIDS.

It is important to note that the mean, thus percentages differ across the stages of HIV/AIDS. Eighty percent of the total research participants presented with normal type A-tympanograms, 6% presented with type As-tympanograms, 9% presented with type Ad-tympanograms and 5% presented with type B-tympanograms. Type-A tympanograms had the highest incidence in the particular research population and most participants also presented with normal hearing thresholds and normal speech discrimination results. Therefore, the results of the various audiometrical procedures correlated well. In terms of the tympanometry results distributed across the stages of HIV/AIDS, the following results were obtained and are discussed in table 4.31.

Table 4.31 indicates those participants in stage I of HIV (n=10) presented with eight (80%) type A-tympanograms, one (10%) type As-tympanograms and one (10%) type Ad-tympanograms. Participants in stage II of HIV (n=14) presented with 13 (93%) type A-tympanograms and one (7%) type Ad-tympanograms. Participants in stage III of HIV (n=16) presented with 13 (81%) type A-tympanograms, one (6%) type As-tympanograms and two (13%) type Ad-tympanograms. Participants with AIDS (n=44) presented with 33 (75%) type A-tympanograms, three (7%) type As-tympanograms and four (9%) type Ad-tympanograms. Four (9%) type B-tympanograms were also observed.

Therefore, type A-tympanograms had the highest incidence in this particular research population, more specifically stages I, II and III. Individuals with AIDS tend to show a decrease in normal type A-tympanograms. Type Ad- tympanograms, suggestive of a flaccid middle ear system or an ossicle chain dislocation, had the second highest incidence. Type As-tympanograms are indicative of a stiff middle ear system such as in the case of otosclerosis (Martin, 1997:266). Type B-tympanograms were only observed in the participants with AIDS. The incidence of type A-tympanograms, indicative of normal middle ear functioning, steadily

decreased with the progression of HIV to AIDS. Participants with AIDS had the highest incidence of abnormal tympanograms, indicating that 25% of the ears presented with middle ear pathology.

Twenty percent ears of participants in stage I of HIV, 7% in stage II and 19% in stage III had a conductive pathology. The highest incidence of conductive pathology was found in participant ears that had AIDS (25%). These results correlate with the other results in this research where section 4.3.2.1 indicated that the number of otological complaints, the number of otolaryngological diseases (section 4.3.2.2) and the number of abnormalities found during the otoscopic examination (section 4.3.2.1) increased in stage IV of HIV/AIDS. Section 4.3.3.5 also revealed that 18% of the participants experienced a significant conductive hearing loss. This correlates relatively well with the 25% who had abnormal tympanograms, especially considering that not all abnormalities identified by a tympanogram cause a significant loss of hearing sensitivity. Interestingly, stages I and IV had the highest incidence of conductive pathology, which may be explained by the fact that 70% of HIV-infected individuals experience ordinary flu-like symptoms in the early stages of HIV/AIDS (Bankaitis, 1998:122). This may suggest symptoms such as middle ear infections and thus explain the presence of conductive pathology. The high percentage of myringitis that was observed during the otoscopic examination of participants in stage I, as indicated in section 4.3.2.2, confirms this suggestion and the results indicated in this particular section. HIV disables the immune system resulting in a poor protective and defensive mechanism (Schountz and Bankaitis, 1998:131). Therefore with the progression of HIV to AIDS, the immune response becomes even more compromised and the number of opportunistic infections (including otological infections) that can be observed, increases. This explains why stage IV (AIDS) also presents with the highest incidence of conductive pathology. Gold and Tami (1998:165) confirm these results with the statement that conductive hearing loss are often found within this population. Therefore the

high incidence of conductive pathology or conductive components is confirmed by the statement made by Gold and Tami (1998:165).

4.3.5.1.2 Acoustic reflex results for each ear in the different stages of HIV/AIDS

Table 4.32 specifies the ipsilateral and contralateral acoustic reflex results that were obtained from the total research population across all the stages of HIV/AIDS. The mean of this section takes into account the number of ears per participant for each stage of HIV/AIDS and not the number of frequencies. The total research participants is n=84, however, these participants are distributed into four groups, namely stage I of HIV/AIDS (n=10), stage II of HIV/AIDS (n=14), stage III of HIV/AIDS (16) and finally stage IV of HIV/AIDS (n=44).

Table 4.32: Pattern identification in elicitation of acoustic reflexes with progression of HIV

ACOUSTIC REFLEXES						
REFLEXES		Incidence in stages of HIV				IDENTIFICATION OF PATTERN
		I n=10	II n=14	III n=16	IV n=44	
ISPI	Normal	50%	7%	37%	25%	Reflexes at normal intensities decrease as HIV/AIDS progresses. Stage I has the highest incidence of normal reflexes.
	Abnormal	50%	93%	63%	66%	Abnormal reflexes increase with the progression of HIV to AIDS. The final three stages of HIV has the highest incidence of abnormal reflexes.
	Absent	-	-	-	9%	Commences in stage IV.
CONTRA	Normal	60%	43%	37%	29%	Reflexes at normal intensities decrease as HIV/AIDS progresses. Stage I has the highest incidence of normal reflexes while stage IV reveals the lowest incidence of normal reflexes.
	Abnormal	40%	57%	63%	64%	Abnormal reflexes increase with the progression of HIV to AIDS. Stage IV has the highest incidence of abnormal reflexes
	Absent	-	-	-	7%	Commences in stage IV.

Table 4.32 reveals that ears in stage I of HIV (n=10) presented with five (50%) normal ipsilateral and six (60%) normal contralateral reflexes, five (50%) abnormal ipsilateral and four (40%) abnormal contralateral reflexes, while no ipsilateral or contralateral reflexes were absent.

Of the five (50%) ears with abnormal ipsilateral reflexes in stage I of HIV (n=10), ipsilateral reflexes at increased intensity levels, associated with conductive pathology or an abnormal tympanogram, were found in one (10%) ear and was therefore included in the two (20%) ears with an abnormal tympanogram. Those ipsilateral reflexes at increased sensation levels not associated with conductive pathology, but with retro-cochlear pathology, were found in three (30%) ears. As stated in section 4.2.5.1.2, it is clear that all reflexes elicited at increased intensity levels for this particular research population were due to N.VIII pathology. No facial nerve pathology was present in this research population. Only one (10%) ear displayed decreased reflexes suggesting the presence of cochlear pathology. In terms of the four (40%) ears with abnormal contralateral reflexes, no cochlear pathology was observed (decreased sensation levels), four (40%) ears presented with N.VIII pathology of which one (10%) ear was associated with an abnormal tympanogram. Thus, only three (30%) ears presented with N.VIII pathology. These contralateral results suggest that six (60%) ears had no indication of pathology.

Table 4.32 indicates that of the ears in stage II of HIV (n=14), one (7%) ear had ipsilateral and six (43%) ears had contralateral reflexes that were elicited at normal intensity levels. Thirteen (93%) ears had ipsilateral and eight (57%) ears had contralateral reflexes that were elicited at decreased or increased intensity levels. No ipsilateral or contralateral reflexes were absent.

Of the 13 (93%) ears of participants in stage II of HIV (n=14), ipsilateral reflexes at increased intensity levels, not associated with conductive pathology or abnormal tympanogram but due to N.VIII pathology, were found in one (7%) ear. Ipsilateral reflexes at decreased intensities suggestive of cochlear pathology were observed in nine (64%) ears. Of these ears with abnormal reflexes, two (15%) ears had a double pathology, both cochlear and retro-cochlear damage were identified in different ears. As indicated in section 4.3.5.1.1, one (7%) ear of

participants in stage II of HIV had conductive pathology. This means that one (7%) ear presented with no pathology, in other words all ears in stage II of HIV had some kind of pathology. In terms of the eight (57%) ears with abnormal contralateral reflexes, five (36%) ears had cochlear pathology (decreased sensation levels), three (21%) ears had N.VIII pathology.

Table 4.32 specifies that of the sixteen ears of participants in stage III of HIV (n=16), six (37%) ears had ipsilateral reflexes and six (37%) ears had contralateral reflexes elicited within normal intensity levels, while ten (63%) ears had ipsilateral reflexes and ten (63%) ears had contralateral reflexes elicited at decreased or increased intensity levels. No reflexes were absent in stage III of HIV.

Of the ten (63%) abnormal acoustic reflexes in the ears of participants in stage III of HIV (n=16), ipsilateral reflexes at increased intensity levels not associated with conductive pathology or abnormal tympanogram but due to vestibulo-cochlear nerve dysfunction, were identified in one (6%) ear (n=16). Ipsilateral reflexes at decreased intensities suggestive of cochlear pathology were observed in nine (56%) ears. As indicated in section 4.3.5.1.1, three (19%) ears of participants in stage III of HIV had conductive pathology. This means that three (19%) ears presented with no pathology. In terms of the ten (63%) ears with abnormal contralateral reflexes, one (6%) ear presented with N.VIII pathology, nine (56%) ears presented with cochlear pathology, three (19%) ears had conductive pathology and this suggests that three (19%) ears did not present with any pathology.

Table 4.32 also shows that four (9%) ears presented with ipsilateral and three (7%) ears presented with contralateral reflexes that were absent in the ears of participants with AIDS (n=44), while 29 (66%) ears had ipsilateral and 28 (64%) ears had contralateral reflexes that were abnormal, meaning that these reflexes were elicited at either decreased or increased

intensity levels. In participants with AIDS, 11 (25%) ears had normal ipsilateral reflexes and 13 (29%) ears had normal contralateral reflexes. Abnormal reflexes, indicative of cochlear pathology when elicited at decreased intensities (below 60dBSL) and retro-cochlear pathology when elicited at increased intensities (above 90dBSL) had the second highest incidence across all stages of HIV/AIDS.

Of the 29 (66%) ears of participants with AIDS (n=44), ipsilateral reflexes at increased intensity levels, not associated with conductive pathology or abnormal tympanogram but due to vestibulo-cochlear nerve dysfunction, were found in four (9%) ears. One (2%) ear presented with an absent ipsilateral reflex at 1000Hz due to vestibulo-cochlear dysfunction. Therefore a total of five (11%) ears presented with vestibulo-cochlear dysfunction. Ipsilateral reflexes at decreased intensities suggestive of cochlear pathology were observed in 25 (57%) ears. As indicated in section 4.3.5.1.1, 11 (25%) ears of participants with AIDS had conductive pathology. Absent reflexes due to the presence of conductive pathology were identified in three ears. Therefore these results are already included in the 11 (25%) ears that had conductive pathology. This means that three (7%) ears presented with no pathology, in other words all ears in participants with AIDS had some kind of pathology. In terms of the abnormal contralateral reflexes in 28 (64%) ears, four (9%) ears presented with N.VIII pathology, 22 (50%) ears presented with cochlear pathology, 11 (25%) ears had conductive pathology. The conductive pathology was also reflected in the absent contralateral reflexes obtained in the three ears. No pathology was identified in 7% of the ears.

Contralateral and ipsilateral reflexes were only absent in all test frequencies in 7% and 9% ears of participants with AIDS. Absent reflexes suggest no response with the presentation of the stimulus at any intensity level. Absent contralateral reflexes can be suggestive of auditory brainstem dysfunction, neural hearing loss, facial nerve dysfunction or conductive pathology

while absent ipsilateral reflexes can indicate the presence of conductive pathology, neural pathology or facial nerve dysfunction (Hall and Mueller, 1998:223-228).

Martin (1997:166) states that severe cochlear hearing loss, the presence of a severe conductive hearing loss or facial nerve or vestibulo-cochlear nerve dysfunction or brainstem dysfunction may lead to absent ipsilateral and contralateral reflexes. Gold and Tami (1998:168) mention that facial nerve palsy is more prevalent in individuals infected with HIV than in those not infected with this disease. Lalwani and Sooy, 1992 in Gold and Tami (1998:168) noted that 7,2% individuals infected with HIV/AIDS presented with a unilateral or bilateral facial nerve palsy. In this population, ipsilateral reflexes were absent in 7% of the ears.

Normal ipsilateral reflexes suggest reflexes elicited at 70dBSL to 90dBSL. The incidence of ipsilateral reflexes elicited within normal intensity levels at all frequencies decreased with the progression of HIV to AIDS, but with no particular pattern. The incidence of normal contralateral reflexes also decreased with the progression of HIV to AIDS. However, participants with AIDS had the lowest incidence of normal reflexes suggesting the presence of some kind of pathology, whether it is conductive, sensory or neural in nature.

Abnormal contralateral reflexes increased with the progression of HIV tot AIDS. Abnormal ipsilateral reflexes had a varying pattern of incidence across the four stages of HIV/AIDS. As explained in section 4.2.5.2, absent or elevated acoustic reflexes occur with damage to the vestibulo-cochlear nerve (Martin, 1997:165) which is most likely due to the alteration in the communication of the stimulus from the cochlea to the brainstem.

HIV/AIDS has proven to cause demyelisation of neurons in the brainstem and glial cells (Gold and Tami, 1998:167), but a cochlear hearing loss might also suggest that the intensity of the signal that reaches the brainstem is not sufficient enough to produce a reflex (Martin,

1997:165). This confirms that a conductive, cochlear or retro-cochlear hearing loss might be the possible reason for the elevated and absent ipsilateral acoustic reflexes.

4.3.6 Characteristics of the DPOAE results in the different stages of HIV/AIDS

Questions 7.1 to 7.4 of the Hearing Interpretation Recording Form (Appendix K) reveal the information regarding the presence or absence of the DPOAEs at the different frequencies. The DPOAE assessment is considered to fail when the DPOAEs were absent at two or more of the five frequencies.

4.3.6.1 DPOAE results in the different stages of HIV/AIDS

Questions 7.1 to 7.3 of the hearing interpretation recording form (Appendix K) reveals the information regarding the analysis of the DPOAE results. Table 4.33 specifies the analysis of the DPOAE results and provides a clear description of the results. The mean for each stage of HIV/AIDS is indicated in the graph below.

Table 4.33: DPOAE results in the different stages of HIV/AIDS

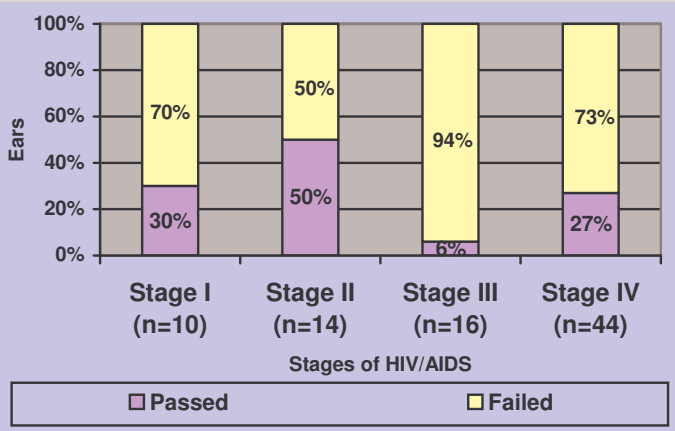
RESEARCH POPULATION	DIAGRAM SPECIFYING THE ABSENCE OF DPOAE's
In stage I of HIV, three (30%) ears passed the DPOAE assessment and seven (70%) failed. In stage II of HIV, seven (50%) ears passed the DPOAE assessment and seven (50%) failed. In stage III of HIV, one (6%) ear passed the DPOAE assessment and 15 (94%) failed. In participants with AIDS, 12 (27%) ears passed the DPOAE assessment and 32 (73%) failed.	

Figure 4.34: DPOAE results in the different stages of HIV/AIDS

Figure 4.34 reveals that most participants failed the complete DPOAE assessment by presenting with absent DPOAEs at two or more frequencies. The highest incidence of failed DPOAE assessment was found in stage III of HIV with 94% and then in those with AIDS with 73%. These results correlated well with the immittance results since the highest incidence of cochlear pathology according to the immittance results in section 4.3.5.1.2, was also found in stage III.

ART has well known toxic effects on especially the cochlea, and therefore it is understandable that ART may be the reason for the high incidence of absent DPOAEs in the last two stages of HIV/AIDS. ART is initiated from stage III of HIV and still administered in stage IV of HIV. These pharmaceutical regimens or in other words ART often include ototoxic agents with potential ototoxic complications (Bankaitis and Schountz, 1998:155). This may explain why the incidence of absent DPOAEs is so high. However, since OAEs are absent in the presence of conductive pathology as well as auditory nerve dysfunction, it is important to incorporate these findings into those of section 4.3.5.1 and section 4.3.5.2. These results are discussed in section 4.3.6.4.

4.3.6.2 Absence of DPOAE at all frequencies in the different stages of HIV/AIDS

The DPOAE was tested at 6000Hz, 5000Hz, 4000Hz, 3000Hz and 2000Hz. Pass or fail results were obtained for each frequency in each ear. When the DPOAE at all these frequencies were absent, it was indicated on the hearing interpretation recording form. Table 4.34 reveals the number of ears that had absent DPOAEs at all frequencies that were tested. The mean for the number of ears in each stage of HIV/AIDS is indicated in the table below.

Table 4.34: Absence of DPOAE at all frequencies in the different stages of HIV/AIDS

DPOAE frequencies	Incidence of absent DPOAEs				IDENTIFICATION OF PATTERN
	I n=10	II n=14	III n=16	IV n=44	
2000Hz to 6000Hz	0%	14%	6%	7%	Incidence of absent DPOAEs only commenced in stage II and varies across stages of HIV, but in general a very low incidence of absent DPOAEs at all frequencies was obtained.

Table 4.34 suggests that stage II had the highest incidence of absent DPOAEs at all frequencies. However, in general not all frequencies of the DPOAE that were assessed were absent, indicating that not all outer cochlear hair cells were damaged. These results clearly show that absent DPOAEs at all frequencies was not observed in stage I of HIV. However, stages II, III and IV displayed an incidence of absence of DPOAEs across the complete frequency spectrum. This could possibly suggest that the direct effect of HIV lead to cochlear dysfunction at all outer hair cells (processing all frequencies), but with the administration of ART, the direct effect of HIV was reduced even though ART is suspected to be cochleotoxic. It is important to take note that this research was cross-sectional in nature and not longitudinal. Therefore this assumption is merely an observation of the incidence of absent DPOAEs at all stages of HIV/AIDS. These observations may be due to the influence of other variables, such as the fact that the number of participants differed in each stage of HIV and the opportunistic infections to which each particular participant had been exposed, may have differed. This suggests that the percentages may be misleading.

4.3.6.3 Absent DPOAEs at different frequencies in the different stages of HIV/AIDS

Each frequency of the five frequencies was tested separately in order to determine where the specific problem was. The research participants in general presented mainly with absent DPOAEs at 4000Hz, 6000Hz and then 5000Hz. In this section, the absence of the DPOAE at

each frequency was distributed across the stages of HIV/AIDS and is discussed in table 4.35. The mean for the number of ears in each stage of HIV/AIDS is indicated in the following table.

Table 4.35: Pattern identification in terms of absent DPOAEs at specific frequencies in the different stages of HIV/AIDS

DPOAE frequencies	Incidence of absent DPOAE's				IDENTIFICATION OF PATTERN
	I n=10	II n=14	III n=16	IV n=44	
6000Hz	70%	57%	81%	66%	Absent DPOAEs vary across stages of HIV
5000Hz	50%	50%	63%	73%	Absent DPOAEs increase with progression of HIV
4000Hz	80%	64%	88%	73%	Absent DPOAEs vary across stages of HIV
3000Hz	40%	14%	31%	25%	Absent DPOAEs vary across stages of HIV
2000Hz	-	14%	25%	7%	Absent DPOAEs vary across stages of HIV, no absent DPOAEs in stage I of HIV

Table 4.35 reveals that all stages of HIV/AIDS tend to have the highest incidence of absent DPOAEs at 4000Hz. In stage I, 80%, in stage II, 64%, in stage III, 88% DPOAEs were absent at 4000Hz. Absent DPOAEs at 6000Hz displayed the second highest incidence in stage I (70%), II (57%) and III (81%) of HIV. The third highest incidence of absent DPOAEs was observed in stage I (50%), II (50%) and III (63%) at 5000Hz. In participants with AIDS, 73% had absent DPOAEs at 4000Hz and 5000Hz while 66% had absent DPOAEs at 6000Hz.

Table 4.35 suggests that the incidence of absent DPOAEs at each specific frequency varies across the stages of HIV. Only the 5000Hz test frequency displayed a tendency of absent DPOAEs, increased with the progression of the virus. Absent DPOAEs at 2000Hz only commenced in stage II and had a relatively low incidence compared to the incidence of failure at the other frequencies. Cochlear damage was therefore mainly observed in the outer cochlear hair cells responsible for the processing of 3000Hz to 6000Hz presentations. However, the highest incidence of cochlear damage was observed in the outer hair cells responsible for the processing of 4000Hz to 6000Hz stimuli.

Pure tone audiometry in both HIV-infected individuals and individuals with a noise-induced hearing loss present with a decrease at 3000Hz to 8000Hz. It was therefore difficult to distinguish between these two types of hearing losses and therefore also the cause of the hearing loss. However, the DPOAE assessment provides the audiologist with information to differentiate between the hearing profile of an individual with excessive noise exposure and an individual with HIV/AIDS. Clark (2004:112) clearly states that 4000Hz and 5000Hz are mainly absent when an individual has been exposed to excessive noise. When comparing these results to individuals with HIV/AIDS, it is clear that 4000Hz and 6000Hz DPOAEs were mainly absent. Since problems exist regarding the increase in compensation claims for NIHL, and the prevalence of HIV/AIDS increased over these past years, it is inevitable that concerns were raised with regard to the relationship of these aspects of hearing loss.

According to these results, the audiologist might be able to distinguish between these possible causes of hearing loss, since the frequencies mainly absent when conducting the DPOAE, differ. However, this cannot be the only measurement for distinguishing between NIHL and HIV/AIDS-related hearing loss. A complete battery of tests with objective and subjective measurements should be done. These results should then be incorporated and interpreted to establish a complete representation of the hearing profile.

4.3.6.4 Interpretation of Immittance and DPOAE results in the different stages of HIV/AIDS

Question 7.4 of the hearing interpretation recording form provides information on the interpretation of the DPOAE results by considering the immittance results as well. The mean for the number of ears in each stage of HIV/AIDS is indicated in the table below.

Table 4.36: Pathology indicated by DPOAE and immittance results for each ear in the different stages of HIV/AIDS

Pathology	Incidence of pathology in stages of HIV				IDENTIFICATION OF PATTERN
	I n=10	II n=14	III n=16	IV n=44	
No pathology[21]	0%	28%	0%	16%	Incidence of no pathology varies across stages of HIV with the highest incidence in stage II
Cochlear pathology	50%	43%	75%	48%	Incidence of cochlear pathology varies across stages of HIV with the highest incidence in stage III
Retro-cochlear pathology	30%	22%[22]	6%	11%	Highest incidence observed in stage II
Conductive pathology	20%	7%	19%	25%	Stages I and IV with highest incidence

Table 4.36 contains the incidence of conductive pathology, cochlear pathology and normal functioning of the ear. Since immittance measurements are most sensitive for the identification of middle ear pathology, the results described in section 4.3.5.1 were used to obtain information on the incidence of conductive pathology across the stages of HIV/AIDS. This showed that an abnormal tympanogram, indicative of conductive pathology was obtained in 20% of the ears in stage I, 7% of the ears in stage II, 19% of the ears in stage III and 25% of the ears in stage IV.

---

[21] In section 4.3.5.1.2, the researcher determined the presence of cochlear, retro-cochlear and conductive pathology and according to these values the number of ears with no pathology was identified. However, DPOAEs were used as the golden standard when the incidence of cochlear pathology was determined. This implied that the immittance results indicating cochlear pathology, as well as the presence of no pathology, changed since the DPOAE results were used as the final indication of cochlear pathology. This explains why the prevalence of no pathology in table 4.36 differed from the prevalence of no pathology in section 4.3.5.1.2.

[22] Since two (15%) ears in stage II of HIV presented with double pathology (cochlear and retro-cochlear pathology) according to the immittance results, but the DPOAEs were used to determine cochlear pathology, 15% ears were added to 7% ears with retro-cochlear pathology(section 4.3.5.1.2) that were already determined by the immittance results. In this way, cochlear and retro-cochlear pathology were taken into account when determining the relationship between the immittance results and DPOAE results. The sum of these two percentages was therefore calculated as 22% ears. This is also the reason why the percentage of ears with no pathology were determined to be 28% and not 7% as indicated in section 4.3.5.1.2.

A close correlation existed between the acoustic reflex results (immittance results) and the DPOAE results. However, since DPOAE's are the most sensitive measurement for cochlear dysfunction (Hall and Mueller, 1998:265), the results from section 4.3.6.1 were used to obtain information on the cochlear pathology. These DPOAE results were therefore used as golden standard to detect cochlear pathology.

In view of the fact that DPOAEs are absent in the presence of conductive pathology, the conductive pathology was subtracted from the cochlear pathology to obtain the real incidence of cochlear pathology. In this way, the real incidence of no pathology could be calculated. According to these calculations, 50% of the ears of participants in stage I, 43% of the ears of participants in stage II, 75% of the ears of participants in stage III and 48% of the ears of participants with AIDS had cochlear pathology.

Table 4.36 reveals that cochlear pathology had the highest incidence across all stages of HIV/AIDS. However, the incidence varied across the stages with no observable pattern of hierarchy. In order to simplify the results, the ipsilateral acoustic reflex thresholds were used to obtain the incidences of retro-cochlear pathology. The contralateral reflexes were used to differentiate between the places of lesion such as N.VIII pathology or facial nerve pathology. However, facial nerve pathology was not diagnosed in this research population and retro-cochlear pathology was mainly due to verstibulo-cochlear dysfunction.

In stage I of HIV, 30% of the ears had N.VIII pathology, in stage II of HIV, 22% of the ears, in stage III, 6% of the ears and in those ears of participants with AIDS, 11% of the ears presented with retro-cochlear pathology. Ears of participants in stage I and stage III of HIV had some type of pathology, whereas ears of participants in stage II and stage IV did present with ears not displaying any pathology. The general observations were that individuals with HIV/AIDS present with pathology. The types and incidences varied across the different stages of

HIV/AIDS. Therefore in terms of the hearing mechanism, definite pathology will be diagnosed in most of the individuals most of the time, whether it is conductive, cochlear or retro-cochlear in nature.

4.3.7 Characteristics of the auditory brainstem response in the different stages of HIV/AIDS

Auditory brainstem response was conducted to determine the integrity of the neurological components of the auditory mechanism. The results discussed in this section are distributed across the four stages of HIV/AIDS to determine the pathologies present in stages I to IV of HIV/AIDS.

4.3.7.1 ABR absolute latencies and interpeak latencies results in the different stages of HIV/AIDS

Table 4.37 contains a discussion and a graph representing and elucidating these results. These results are also tabulated according to the absolute wave latency values and interpeak latency values (Appendix P). The mean for the number of ears in each stage of HIV/AIDS is indicated in the graphs below.

Table 4.37: ABR interpeak and absolute wave latencies in the different stages of HIV/AIDS

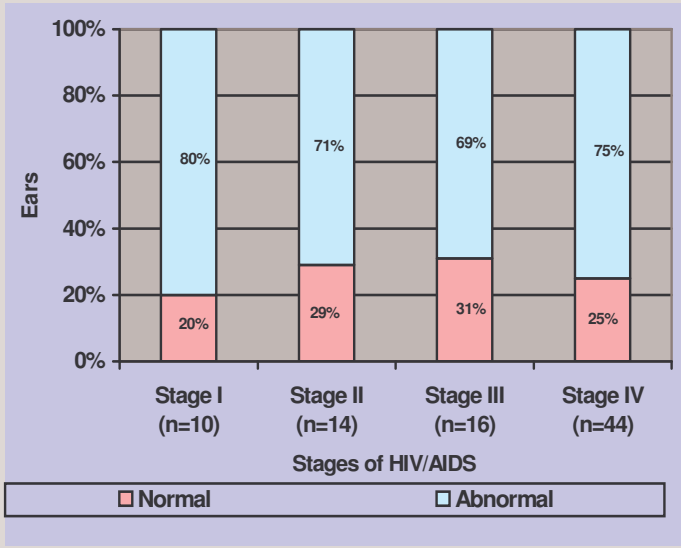
RESEARCH POPULATION	DIAGRAM SPECIFYING ABR RESULTS
In stage I of HIV/AIDS, eight (80%) ears presented with abnormal ABR results, while two (20%) ears presented with normal ABR results. In stage II of HIV/AIDS, four (29%) ears presented with normal ABR results, while 10 (71%) ears presented with abnormal ABR results. In stage III of HIV/AIDS, five (31%) ears presented with normal ABR results, while 11 (69%) ears presented with abnormal ABR results. In stage III of HIV/AIDS, eleven (25%) ears presented with normal ABR results, while 33 (75%) ears presented with abnormal ABR results.	

Figure 4.35: Auditory brainstem response findings in the different stages of HIV/AIDS

Table 4.37: ABR inter peak and absolute wave latencies in the different stages of HIV/AIDS (continued)

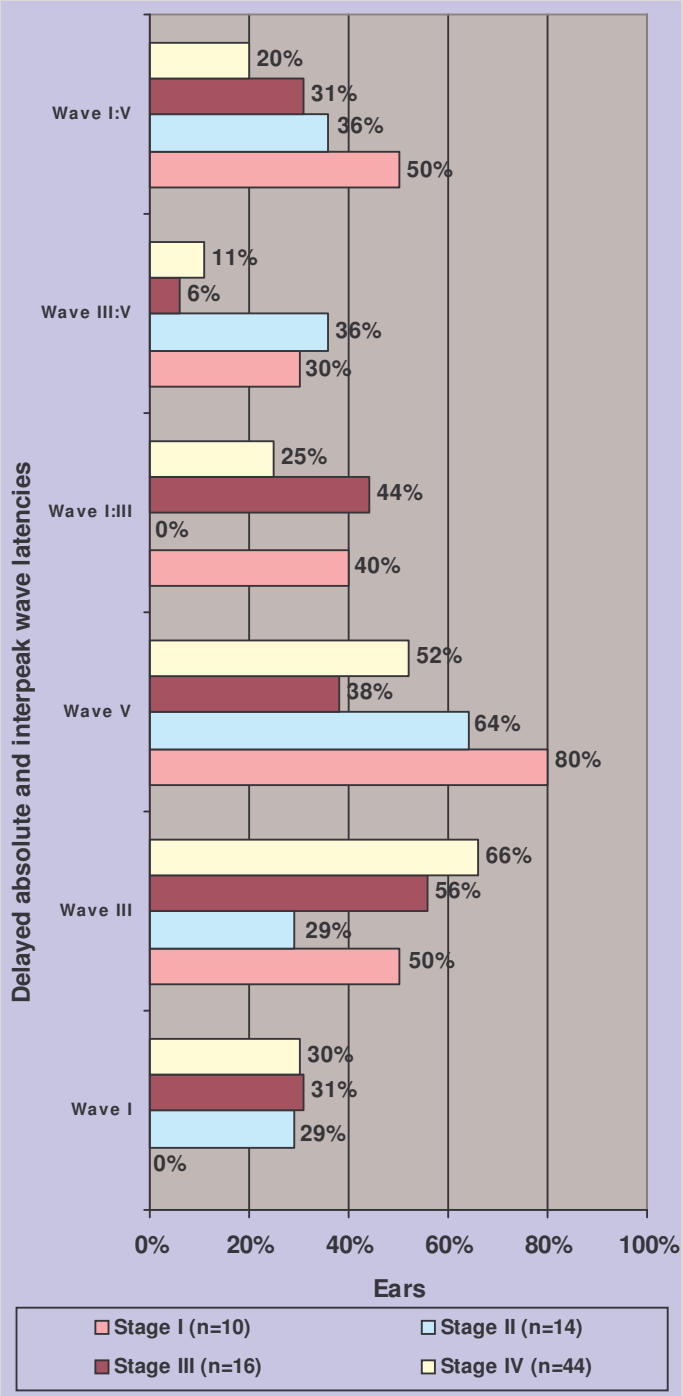
RESEARCH POPULATION	DIAGRAM SPECIFYING ABR RESULTS
Stage I of HIV/AIDS (n=10): Wave I was delayed in no (0%) ears, wave III was delayed in five (50%) ears and wave V was delayed in eight (80%) ears. Wave I:III interpeak latencies were prolonged in four (40%) ears, wave III:V was prolonged in three (30%) ears, while wave I:V was prolonged in five (50%) ears. *Stage II of HIV/AIDS (n=14):* Wave I was delayed in four (29%) ears, wave III was delayed in four (29%) ears and wave V was delayed in nine (64%) ears. Wave I:III interpeak latencies were not prolonged in any (0%) ears, wave III:V was prolonged in five (36%) ears, while wave I:V was prolonged in five (36%) ears. *Stage III of HIV/AIDS (n=16):* Wave I was delayed in five (31%) ears, wave III was delayed in nine (56%) ears and wave V was delayed in six (38%) ears. Wave I:III interpeak latencies were prolonged in seven (44%) ears, wave III:V was prolonged in one (6%) ears, while wave I:V was prolonged in five (31%) ears. *Stage IV of HIV/AIDS (n=44):* Wave I was delayed in thirteen (30%) ears, wave III was delayed in 29 (66%) ears and wave V was delayed in 23 (52%) ears. Wave I:III interpeak latencies were prolonged in eleven (25%) ears, wave III:V was prolonged in five (11%) ears, while wave I:V was prolonged in nine (20%) ears.	

Figure 4.36: ABR absolute wave latencies and interpeak wave latencies in the different stages of HIV/AIDS

Figure 4.35 indicates that abnormal ABR findings had the highest incidence across all the stages of HIV/AIDS. Interestingly, the highest incidence of abnormal ABR findings was found in stage I of HIV. This correlated well with the combined immittance and DPOAE results in section 4.3.6.4 which suggested that stage I of HIV had the highest incidence of retro-cochlear pathology. According to the pure tone audiometry results in sections 4.3.3.4 and 4.3.3.5, it is clear that only 10% of the ears presented with a conductive hearing loss and 20% of the ears had a configuration that slightly sloped in the high frequencies. However, according to the ABR results in figure 4.35, 80% of the ears presented with an abnormal ABR. This suggests that abnormal ABR findings were not solely due to the loss of hearing sensitivity, but rather as a direct result of the virus on the neurological functioning of the hearing mechanism. Since the protocol for the commencement of ART is in the two final stages (stages III and IV) of HIV/AIDS, the neurological pathology identified in stages I and II, but especially in stage I, must be due to the direct effect of the virus on the neurological pathways of the auditory system (Chisholm and Kredo, 2005:246). ART attempts to maintain the health and the CD4+ cell count of an individual infected with HIV/AIDS. In some cases ART even improves the CD4+ cell count and general health of these individuals, suggesting that according to these results, a person may be classified into stage II again after being classified in either stage III or stage IV. This could explain why these participants in stage I already had abnormal ABR findings. These results are gripping in the sense that this virus already causes neurological pathology in stage I of HIV. The expectations were that auditory conditions and manifestations usually commence later in the progression of the virus and that all symptoms worsen with the progression of the virus. This research indicates that these expectations are incorrect, since symptoms and conditions of the auditory system are present as early as in stage I. This reflects the power and domination of the virus when contracted by the human body.

A research project conducted by Malessa, Heuser-Link, Brockmeyer, Goos and Schwendemann in 1989 found that individuals with a CD4+ cell count of less than 400, meaning that the individual is in stage II, III or IV of HIV/AIDS, had a prolonged ABR wave III:V interpeak latency (Bankaitis et al., 1998:178). Rosenhall and associates found in 1989 that otoneurological abnormalities were identified through the prolonged wave I:V interpeak latency (Bankaitis et al., 1998:179). These findings by Rosenhall (1989) and Malessa et al. (1989) were also confirmed by this research project (Bankaitis et al., 1998:179).

The absolute wave latencies of waves III and V and the interpeak wave latencies of wave III:V and I:V had the highest incidence of abnormality. Although less than wave III and V, it was clear that wave I also had a relatively high incidence of prolonged wave latencies. According to these authors, this prolonged interpeak latency was indicative of central conduction defects in this population.

Interestingly, these ABR results did not concur to the exact percentages of normal and abnormal findings in the different stages of HIV/AIDS, even when the presence of a significant hearing loss was considered. This suggests that neurological pathology cannot always be diagnosed by pure tone audiometry and immittance results alone. Smith, Jakobsen, Gaub, Helweg-Larsen and Trojaborg (1988) also observed these results in their research project and they concluded that *"…these abnormalities reflected an otherwise clinically undetectable defect of brainstem conduction…"* (Bankaitis et al., 1998:179).

Therefore it can be concluded that even though individuals with HIV/AIDS do not all present with observable auditory manifestations or loss of hearing sensitivity, HIV/AIDS is likely to influence the integrity of the neurological pathways of the auditory system as early as in stage I of HIV/AIDS. The implication is that an ABR should always form part of the audiological test battery to enable the audiologist to diagnose these neurological abnormalities not otherwise

clinically detectable. The ABR permits the audiologists to determine specific neurological manifestations such as pathology at the caudal portion of the brainstem near the trapezoid body and the superior olivary complex (abnormal wave III), while an abnormal wave V suggests pathology at the lateral lemniscus as it enters the inferior colliculus (Hall and Mueller, 1998:328). Since these structures are responsible for localising sound sources, the assumption is that these individuals with HIV/AIDS may experience difficulty with the analysis of small differences in time or intensity of sounds arriving at both ears in order to localize the sound source (Martin, 1997: 328).

These ABR results can be helpful in cases where functional hearing loss is suspected due to poor emotional and psychological well-being. However, in terms of NIHL one can obtain valuable information to determine if retro-cochlear pathology is present, since noise causes cochlear and not retro-cochlear pathology. This will therefore enable the audiologist to distinguish between NIHL and HIV-related hearing loss.

4.4 RESULTS OF SUB AIM THREE

To compare the hearing profile of persons within each of the different clinical stages who did and who did not receive medication with ototoxic components (antiretroviral therapy and anti-tuberculosis drugs containing streptomycin and amikacin) for treatment of HIV/AIDS and HIV/AIDS-related illnesses. The comparison was also done with regard to the case history, otoscopic examination findings, the pure tone air-and-bone audiogram, speech discrimination audiometry, the immittance measurements, the distortion product oto-acoustic emissions [DPOAEs]; and auditory brainstem response of each participant with HIV/AIDS.

The third sub aim of this research project was to determine if the administration of ototoxic medication had any influence on the hearing profile of the participants diagnosed to be in a specific clinical stage of the HIV/AIDS. Ototoxicity has been linked with several of the drugs,

such as antifungal components, antineoplastic agents, aminoglycosides, as well as immunemodulators, used to treat HIV-infection and the associated problems (Matkin et al., 1998:149). The medical treatment used to combat HIV is known as antiretrovirals and these drugs have potential ototoxic effects (Bankaitis and Schountz, 1998:155). These findings are then compared to the hearing profile findings of those participants who did not receive drugs with ototoxic components for the treatment of HIV/AIDS and Tuberculosis. Sub-aim three will be discussed in accordance with these areas of the hearing profile. Questions 2 to 8 of the hearing interpretation recording form (Appendix K) revealed the various characteristics of the hearing profile for each participant. These results will be discussed and elucidated with the necessary figures.

4.4.1 Case history information in participants who did and did not receive ART

This category includes the otological complaints the participant may have experienced prior to being diagnosed with HIV/AIDS and during the data gathering for this research project.

4.4.1.1 Otological complaints across participants who did and did not receive ototoxic medication

Table 4.38 reveals the description of the otological complaints of these research participants at the stage of data gathering, as well as problems experienced prior to being diagnosed with HIV/AIDS. The mean in this section was determined as n=42. For the purpose of discussing the prevalence of otological complaints in those who received and did not receive ART, the researcher used n=42 as mean (and not the number of complaints as mean) to determine the percentages, because some of participants noted that they experience more than one otological complaint. The mean was divided into two groups: those with ART exposure (n=-33) and those without ART exposure (n=9). Some of these participants had more than one

complaint, thus suggesting that the percentage of complaints in these groups did not add up to only 100%.

Table 4.38: Current otological complaints in participants who did (n=33) or did not (n=9) receive ototoxic medication

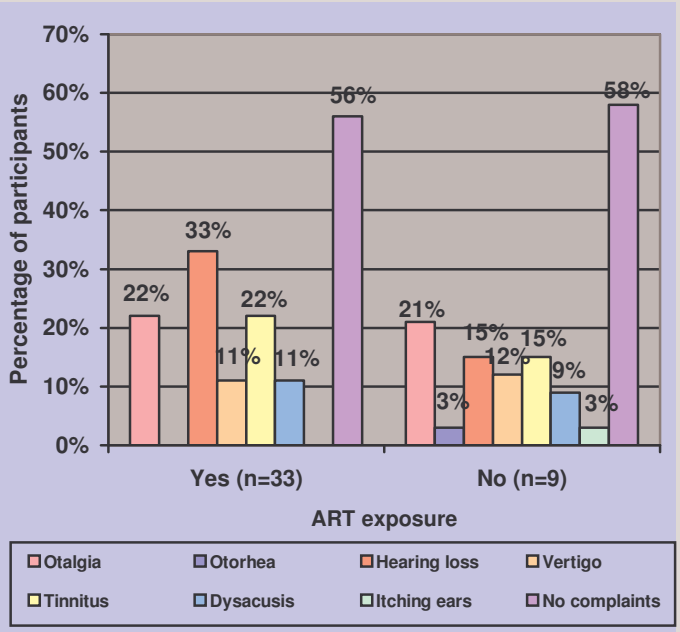
RESEARCH POPULATION	DIAGRAM SPECIFYING THE OTOLOGICAL COMPLAINTS
Two (22%) participants with no exposure to ART had otalgia, none (0%) complained of otorrhea, three (33%) complained of a hearing loss, one (11%) complained of vertigo and two (22%) complained of tinnitus, one (11%) experienced dysacusis and none (0%) experienced itching ears, while five (56%) had no otological complaints. Seven (21%) participants with exposure to ART complained of otalgia, one (3%) complained of otorrhea, five (15%) complained of a hearing loss, four (12%) complained of vertigo and five (15%) of tinnitus, three (9%) experienced dysacusis and one (3%) experienced itching ears, while nineteen (58%) had no otological complaints.	

Figure 4.37: Otological complaints of those who did (n=33) and did not receive ART (n=9)

Figure 4.37 reveals that more participants who received ART did not experience any otological complaints. Hearing loss, tinnitus, dysacusis and otalgia also had a higher incidence in those who did not receive ART. Those who received ART had a higher incidence of vertigo than those who did not. Other conditions that participants on ART seemed to have complained about were otorrhea, vertigo, and itching ears. On the whole, those who received ART had fewer otological complaints.

Bankaitis and Schountz (1998:159) mention that some of the agents in ART are associated with hearing loss, tinnitus and vertigo, dizziness, auditory disturbances, deafness and otalgia.

Interestingly, in this research project only vertigo had a slightly higher incidence in those who received ART compared to those with no history of ART administration. Only in this research project, the results indicated that both groups, those who had HIV/AIDS and received ART and those who had HIV/AIDS and did not receive ART, presented with these symptoms. Complaints of otorhea, itching ears and vertigo had a higher incidence in those participants with no ART exposure. These complaints are mere perceptions of each participant regarding the hearing status and functioning of the hearing mechanism. The incidence of definite cochlear, retro-cochlear and conductive pathology will be determined and discussed according to these results in the following sections. However, it seems as if ART may have a negative influence on the hearing mechanism (leading to vertigo), except when conditions related to conductive pathology is a concern, since ART seems to improve the general perception of conditions such as otalgia, otorhea and itching ears. This improvement in the health of the ears may partly serve as motivation to commence ART.

Audiologists should realise that those patients not on ART are expected to present with otological complaints such as hearing loss, tinnitus, dysacusis and otalgia more often. Therefore, when a patient presents with a large number of otological complaints and does not necessarily want to commence using ART, the audiologist might consider explaining the convalescing effects it has on the number of otological complaints. Therefore the audiologist might motivate them to consider taking ART and to visit a health care worker who might assist them in this respect.

4.4.1.2 Disease spectrum in participants who did and did not receive ototoxic medication

Table 4.39 provides a description of the disease spectrums found among these participants. Question 2.4 of the hearing interpretation recording form reveals the information discussed in this section.

Table 4.39: Disease spectrum distributed across those participants who did (n=33) or did not (n=9) receive ART [23]

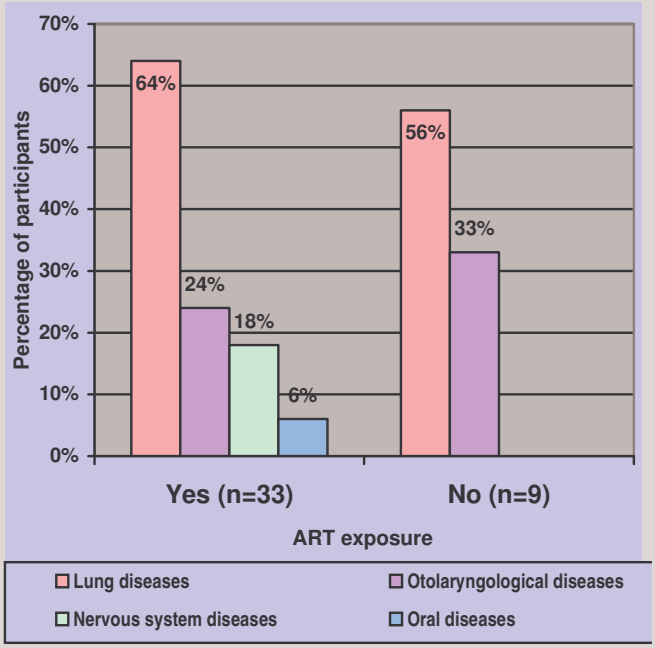
RESEARCH POPULATION	DIAGRAM SPECIFYING THE DISEASE SPECTRUMS
Five (56%) participants who were not on ART (n=9) presented with lung diseases, while three (33%) participants presented with otolaryngological diseases. Twenty-one (64%) participants on ART (n=33) presented with lung diseases, two (6%) presented with oral diseases, six (18%) presented with nervous system diseases, whereas eight (24%) presented with otolaryngological diseases.	

Figure 4.38: Disease spectrum in participants who did and did not receive ART (n=42)

[23] For the purpose of discussing the prevalence of different diseases in those who received and did not receive ART, the researcher used n=42 as mean (and not the number of complaints as mean) to determine the percentages, because some of participants were diagnosed with more than one type of disease. The mean was divided into two groups: those participants with ART exposure (n=-33) and those participants without ART exposure (n=9).

Interestingly, figure 4.38 reveals a possible trend that those participants who did receive ART more often complained of different diseases than those who did not receive ART. Figure 4.48 reveals that those participants who did receive ART were more often diagnosed with different lung diseases, nervous system diseases, otolaryngological diseases and oral diseases. Bankaitis and Schountz (1998:162) indicate that ART can cause neurological conditions such as facial nerve palsy, Bell's palsy, vertigo, dizziness, and facial numbness. Bankaitis and Schountz (1998:162-163) also noted that auditory ototoxicity leading to dizziness, roaring tinnitus, hearing loss, especially in terms of high frequency perception and cochlear damage, can be caused by ART. The opposite was found in terms of the presence of otolaryngological complaints. The incidence of otolaryngological conditions had a higher incidence in participants with no exposure to ART than in those who were on ART, suggesting that ART did reduce the otological symptoms.

Again, the decrease in otological conditions can partly serve as motivation to commence ART. Individuals are sometimes hesitant to take this medication and apart from the fact that it enhances good health, the audiologists should motivate individuals to take ART and to administer it correctly (as prescribed), since it reduces the number of otolaryngological conditions.

4.4.2 Otoscopic findings in participants who did and did not receive ART[24]

The otoscopic examination results are obtained from questions 3.1 and 3.2 of the Hearing interpretation recording form (Appendix K). These results are revealed in table 4.40 and table 4.41.

4.4.2.1 Otoscopic examination of the external ear canal in participants who did and did not receive ART

Table 4.40 reveals the information obtained from Question 3.1 of the Hearing interpretation recording form (Appendix K). It includes a discussion of all the landmarks and conditions that were observed by the researcher during the inspection of the ear canal and tympanic membrane. These observations include normal landmarks of the external ear canal, as well as possible conditions that may influence the participant's hearing.

[24] For the purpose of discussing the prevalence of different otoscopic findings in those who received and did not receive ART, the researcher discussed the results in terms of number of ears. Therefore n=84 were used as mean (and not the number of participants as mean) to determine the incidence of each observable condition of the external ear canal and the tympanic membrane. The total mean was divided into two groups: those with ART exposure (n=-66) and those without ART exposure (n=18), in order to determine the prevalence of each otological finding in each ear. Therefore the mean was calculated according to ears per group. Some ears presented with more than one abnormal landmark, thus explaining why the percentages do not add up to 100%. This is applicable to section 4.4.2.1 and section 4.4.2.2.

Table 4.40: Otoscopic findings of the external ear canal in participants who did and did not receive ART (n=84)

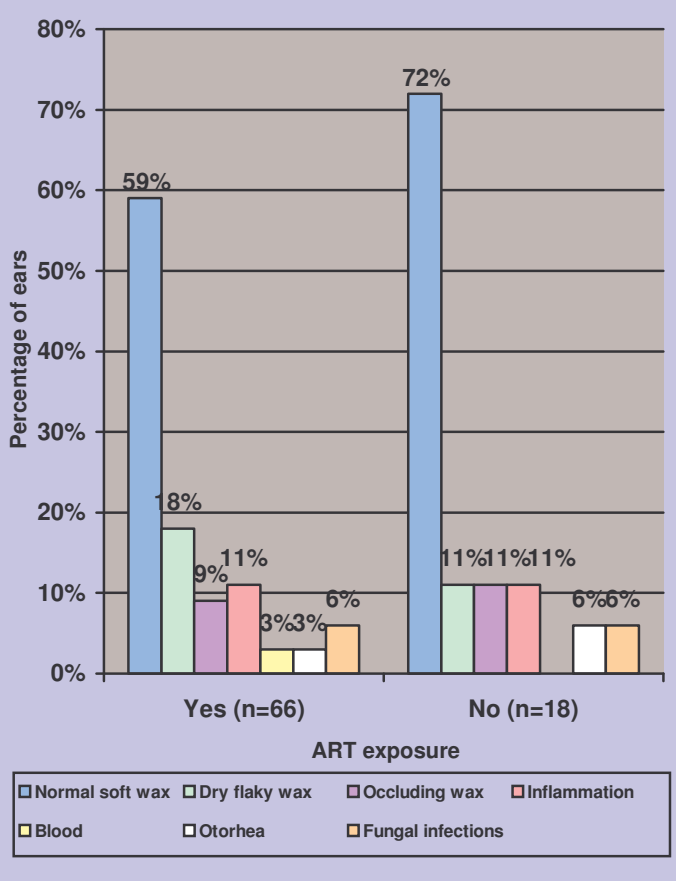
RESEARCH POPULATION	DIAGRAM SPECIFYING THE OTOSCOPIC FINDINGS
Participants who were not exposed to ART (n=18) presented as follows: Thirteen (72%) ears presented with normal soft wax. Two (11%) ears presented with dry flaky wax. Two (11%) ears presented with occluding wax and two (11%) ears presented with inflammation. One (6%) ear presented with otorrhea and one (6%) ear presented with a fungal infection. *Participants who were exposed to ART (n=66) presented as follows:* Thirty-nine (59%) ears presented with normal soft wax. Twelve (18%) ears presented with dry flaky wax. Six (9%) ears presented with occluding wax and seven (11%) ears presented with inflammation. Two (3%) ear presented with blood, two (3%) with otorrhea and four (6%) ears presented with a fungal infection.	

Figure 4.39: External ear canal observations in participants who did (n=66) and did not (n=18) receive ART

The trend according to figure 4.39 showed that those participants who did not receive ototoxic medication seemed to have a lower incidence of normal soft wax. Those who received medication tend to have a higher incidence of dry flaky wax.

The significant decrease in normal soft wax and significant increase in dry flaky wax with the administration of ART seems to suggest that ART may be causing dryness which may also be observed in the otoscopic examinations of individuals with HIV/AIDS. This may also explain why less (9%) occluding wax was observed in participants with ART exposure and more (11%)

occluding wax was observed in participants with no ART exposure. Inflammation and fungal infections were found equally in those who received ART and those who did not. Bankaitis and Schountz (1998:162) indicate that otitis may be caused be certain agents ART contains.

On the other hand, those who did not receive ART had a 3% higher incidence of otorhea, which may suggest that these participants with HIV/AIDS in the absence of ART may be more susceptible to otological infections and when ART is administered, it may decrease the susceptibility to a certain extent. Therefore in terms of the prevalence of conditions of the external ear canal and tympanic membrane, the trend seems to be that individuals need not feel threatened by taking ART to enhance their health, since it is clear that it enhances the health of the external ear. These results correlate with the results in section 4.4.3.1, which suggests that complaints of otorhea and itching ears had a higher incidence in those participants with no ART exposure. The otoscopic examination revealed that this was in fact true. Therefore it seems that the administration of ART has a positive impact on the hearing mechanism when observing conditions related to conductive pathology.

4.4.2.2 Otoscopic examination observations of the tympanic membrane in participants who did and did not receive ART

Table 4.41 specifies the otoscopic observations of the tympanic membrane. These results are obtained from Question 3.2 of the Hearing interpretation recording form (Appendix K). The total ears (n=84) were divided into those that received (n=66) and did not receive ART (n=18).

Table 4.41: Otoscopic findings of the tympanic membrane in who did (n=66) and did not (n=18) receive ART

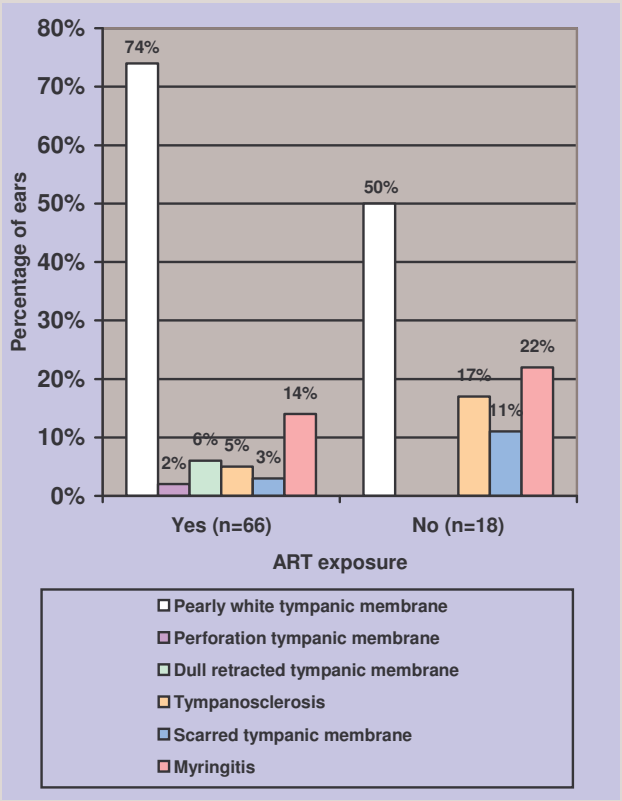
RESEARCH POPULATION	DIAGRAM SPECIFYING THE OTOSCOPIC FINDINGS
Participants who were not exposed to ART (n=18) presented as follows: Nine (50%) ears presented with a pearly white tympanic membrane. Three (17%) ears presented with tympanosclerosis. Two (11%) ears presented with a scarred tympanic membrane and four (22%) ears presented with myringitis. *Participants who were exposed to ART (n=66) presented as follows:* Forty-nine (74%) ears presented with a pearly white tympanic membrane. One (2%) tympanic membrane presented with a perforation and four (6%) were dull and retracted. Three (5%) tympanic membranes presented with tympanosclerosis, while two (3%) ears presented with a scarred tympanic membrane and nine (14%) ears presented with myringitis.	

Figure 4.40: Tympanic membrane observations in who did (n=66) and did not (n=18) receive ART

Comparing figure 4.40, reveals that the highest incidence of a normal pearly white tympanic membrane was found in the participants who were taking ART, suggesting that ART possibly clears some of the otological symptoms, therefore addressing the conductive component.

It seems as if the appearance of the tympanic membrane significantly improved with administration of ART which again suggests that ART possibly clears the otological pathology. ART seems to have improved the general health of the tympanic membrane, suggesting the prevalence of fewer conditions that may cause conductive hearing losses or even conductive

components (air-bone gaps) within normal hearing (between -10dB and 25dB). This suggests that ART has a possible positive effect on the health of the tympanic membrane and therefore correlates with the results of section 4.4.2.1 which suggests that ART improves the health of the external ear canal.

Audiologists should be aware of psychological aspects and phsycial well-being that may also affect the ears and how the patient perceives the health of his ears. Even though the number of complaints decreased with the commencement of ART, the conditions were actually still present. However, the fact that these individuals were on ART, made them feel better and improved their quality of life, as they did not perceive these otological conditions as demoralizing.

4.4.3 Characteristics of the pure tone audiogram of participants who did and did not receive ART

The characteristics of the audiogram, in terms of the type, nature and degree of the hearing loss, are portrayed in this section. This section provides information on the number of ears affected, the type and degree of hearing loss and lastly, the configuration of the audiograms.

All the results are distributed across those participants who did and did not receive ototoxic medication. Questions 4.1 to 4.11 of the hearing interpretation recording form (Appendix K) reveal information regarding the type, nature, degree and configuration of hearing loss at all audiogram frequencies.

4.4.3.1 Unilateral or bilateral hearing loss in those participants who did and did not receive ART

The presence of a hearing loss in one ear does not always imply a hearing loss present in the opposite ear of a particular participant. Figure 4.41 depicts the number of the participants who

presented with a bilateral or unilateral hearing loss, as well as those participants who did not experience a hearing loss. A bilateral hearing loss cannot be analysed per ear, but rather per participant. Therefore the mean was determined by the number of participants (n=42) and then divided into those who received ART (n=33) and those who did not receive ART (n=9).

Table 4.42: Number of ears affected with a hearing loss in participants who did (n=33) and did not (n=9) receive ART

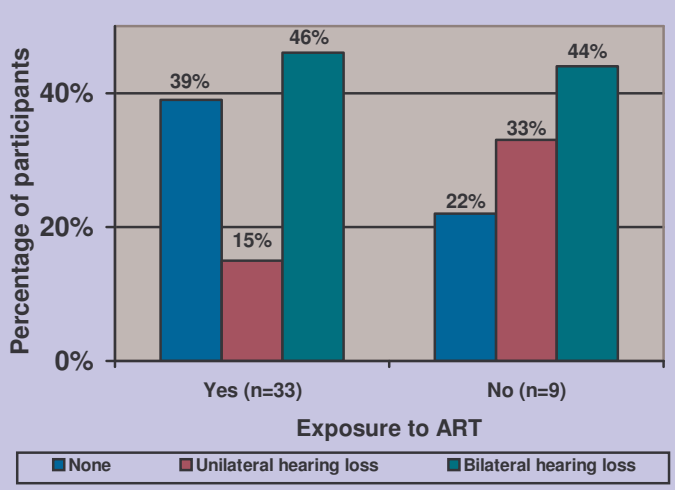
RESEARCH POPULATION	DIAGRAM SPECIFYING AMOUNT OF EARS AFFECTED
In participants with exposure to ototoxic drugs, 13 (39%) participants had no hearing loss and five (15%) had a unilateral hearing loss, while 15 (46%) had a bilateral hearing loss. In participants who were not exposed to ototoxic drugs, two (22%) had no hearing loss, three (33%) had a unilateral hearing loss and four (45%) had a bilateral hearing loss.	

Figure 4.41: Unilateral and bilateral hearing loss in participants who did (n=33) and did not (n=9) receive ART

Figure 4.41 indicates that bilateral hearing loss had a slightly higher prevalence in participants exposed to ART than in those not exposed to ART. A unilateral hearing loss had a higher incidence in those with no history of the administration of ART. Participants who received ART had a significantly higher incidence of normal hearing (39%) than those who did not receive ART (22%). However, from these results it seems as if ART leads to loss of hearing, but the direct effects of HIV/AIDS also lead to loss of hearing. Therefore it still serves as a motivation to commence ART. A hearing loss may start either way, with or without ART, but ART may improve immunity and general health.

4.4.3.2 The degree of hearing loss in participants who did and did not receive ART

Table 4.43 depicts the average degree of hearing loss in the low, mid and high frequencies and was categorized from normal to profound hearing loss. Questions 4.6 to 4.8 of the hearing interpretation recording form (Appendix K) supply the information provided in the table and graph. The mean of this section was determined by calculating the number of ears for the participants that did not receive ART (n=18) and those that did receive ART (n=66).

Table 4.43: Degree of hearing loss distributed across those participants who did (n=66) and did not receive ART (n=18)

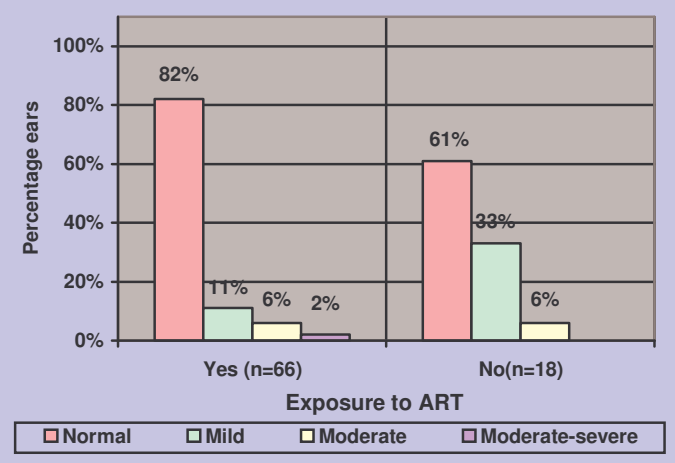
RESEARCH POPULATION	DIAGRAM SPECIFYING DEGREE OF HEARING LOSS
In participants who did have exposure to ART, 54 (82%) ears had normal hearing, seven (11%) ears had a mild degree of hearing loss, four (6%) ears had a moderate hearing loss and one (2%) ear had a moderate to severe hearing loss. In participants who did not have exposure to ART, eleven (61%) ears had normal hearing, six (33%) ears had a mild degree of hearing loss and one (6%) ear had a moderate hearing loss.	

Figure 4.42: Degree of hearing loss in participants who did (n=66) and did not receive ART (n=18)

Table 4.43 indicates the degree of hearing loss distributed across those who did and did not receive ART. A significant difference (p=0.02) were present in terms of the degree of hearing loss between those that received and those that did not received ART. Figure 4.42 shows that those participants on ART had a higher incidence of normal hearing thresholds (61%) compared to those who were not on ART. This was not expected, since the literature study clearly reveals that the use of ART, ...*experimental medications with relatively unknown toxicity*

as well as the use of ototoxic drugs in combination adds to the overall effect on hearing" (Gold and Tami, 1998:167). According to these results, it seems as if ART had an overall positive effect on the hearing sensitivity of participants by either improving or preventing the already damaging effects of HIV/AIDS. However, those who received ART and did present with a hearing loss, presented with moderate-to-severe degrees of hearing loss while those who were not on ART did not experience a hearing loss of worse than moderate degrees. The susceptibility to the ototoxic agents in ART and the duration of ART administration may explain why degrees of hearing loss experienced in the participants with ART exposure were more severe than those without ART exposure. The clinical importance of these results is that audiologists should understand that individuals with HIV/AIDS may develop a more severe degree of hearing loss when ART is administered. When considering amplification for these participants, the audiologist should always select a hearing aid with a wide fitting range to ensure the ability to adjust the hearing aid when the degree of hearing loss increases. This also implies that the audiologist should counsel the participant regarding the need for regular follow-up sessions and compliance to these appointments to determine if hearing aids should be adjusted, thereby improving the quality of life.

4.4.3.3 Configuration of hearing loss in participants who did and did not receive ART

Table 4.44 portrays the configuration of the hearing in left and right ears of the total research population distributed across those participants who did and did not receive ART. Question 4.9 of the hearing interpretation recording form provides the information supplied in table 4.44.

Table 4.44: Configuration of hearing loss in participants who did (n=66) and did not receive ART (n=18)

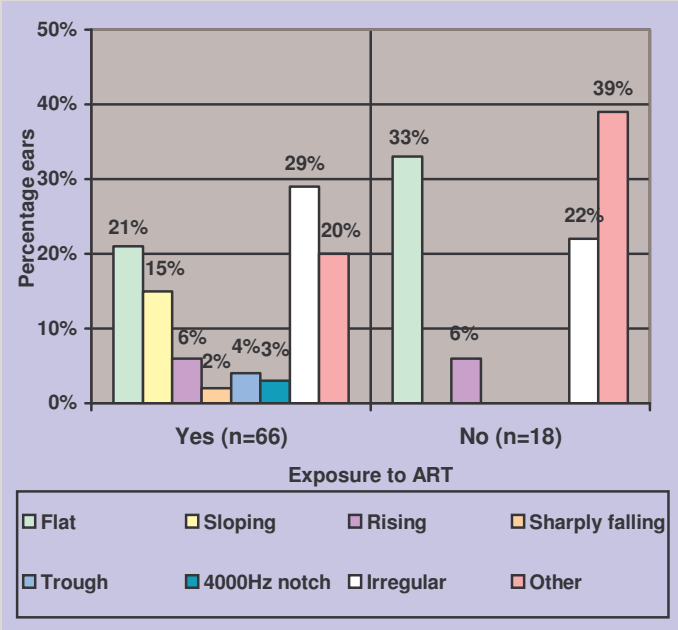
RESEARCH POPULATION	DIAGRAM SPECIFYING CONFIGURATION OF HEARING
In participants who were exposed to ART, 14 (21%) ears had a flat configuration, 10 (15%) ears presented with a sloping configuration, four (6%) ears had a rising configuration, one (2%) ear had a sharply falling configuration, three (4%) ears had a trough configuration, one (3%) ear had a notch at 4000Hz, while nineteen (29%) ears had an irregular configuration. Thirteen (20%) ears had an unspecified configuration. In participants who were not exposed to ART, six (33%) ears had a flat configuration, one (6%) ear presented with a rising configuration, two (22%) ears had an irregular configuration and seven (39%) ears had an unspecified configuration.	

Figure 4.43: Configuration of hearing loss in participants who did (n=66) and did not receive ART (n=18)

Figure 4.43 indicates that the ears of participants with no exposure to ART had a higher incidence of configurations that slowly rose from the low frequencies to mid-frequencies (within normal limits), then dropped slowly in the high frequencies with the progression to 4000Hz and finally with a sudden drop from 4000Hz to 8000Hz. This type of configuration is referred to as "other" in figure 4.43. Flat audiogram configurations had the second highest incidence in these participants who did not receive ART. The flat configurations and "other" configurations had a significantly higher incidence in those who did not receive ART compared to those who received ART. Those participants who did receive ART had a significantly higher incidence of irregular configurations and also presented with 4000Hz notches, trough configurations, sharply falling and high frequency sloping configurations.

The clinical importance of these results is again that relatively inexpensive technology such as two-channel amplification can be used to assist participants who did and did not receive ART. Flat configurations can even be fitted with less expensive technology than two-channel hearing aids, since the needed amplification is almost equally distributed across the different audiogram frequencies. However, amplification is not necessary in cases where individuals present with conductive hearing loss.

4.4.3.4 The type of hearing loss in participants who did and did not receive ART

The average of the pure tone thresholds is provided in table 4.45. Question 4.2 of the hearing interpretation recording form reveals the answers to these questions.

Table 4.45: Type of hearing loss in participants who did (n=66) and did not (n=18) receive ART

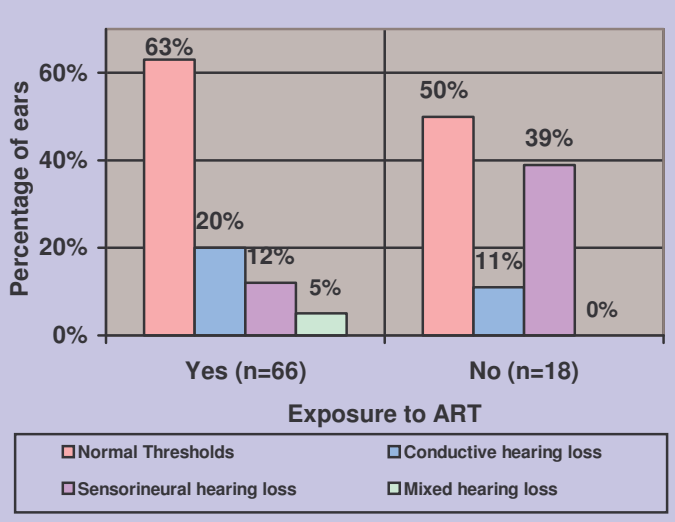
RESEARCH POPULATION	DIAGRAM SPECIFYING TYPE OF HEARING LOSS
In participants who did not receive ART, nine (50%) ears presented with normal thresholds, two (11%) presented with a conductive hearing loss and seven (39%) presented with a sensorineural hearing loss. In participants who did receive ART, 42 (63%) ears presented with normal thresholds, 13 (20%) presented with a conductive hearing loss, eight (12%) presented with a sensorineural hearing loss, while three (5%) ears were diagnosed with a mixed hearing loss in the high frequencies.	

Figure 4.44: Type of hearing loss for participants who did (n=66) and did not (n=18) receive ART

Comparing figure 4.44, it is clear that more participants who received ART had normal hearing. Again it is important to note that the degree of hearing loss is determined by the PTA (average

of thresholds at 500Hz, 1000Hz and 2000Hz). This means that the high frequencies and low frequencies are not taken into account when determining the degree of hearing loss.

However, it seems as if the direct effect of HIV had a greater influence on the cochlea and auditory nerve than the medication, but the fact remains that ototoxicity largely depends on the duration of administration and the susceptibility of an individual to the ototoxic agent (Debonis and Donohue, 2004:237).

A definite relationship between the ART and hearing loss was identified. Those who received ART had a significantly higher ($p=0.03$) incidence of normal hearing than those not on ART. Thus, those not on ART had a significantly higher incidence of hearing loss which includes conductive, sensorineural and mixed. This again stresses that the long term plan for an individual with HIV/AIDS suggests regular follow-up and re-assessment services in order to monitor when a hearing loss commences, diminishes, persists or changes in accordance with the progression of the virus. The type of hearing loss will also influence the management plan.

An addition to this fact, audiologists and health care workers should note that ART seems to prevent or delay the direct effect of HIV on the hearing sensitivity. However, it does influence the high frequency sensitivity. Therefore in terms of amplification, patients on ART will often be the ones to be fitted with two-channel hearing aids to amplify the high frequencies, while those patients not on ART will need two-channel hearing aids for both high and low frequencies.

4.4.4 Characteristics of speech audiometry results in participants who did and did no receive ART

The speech audiometry results include information on the correlation between the speech reception threshold and the pure tone average, as well as the rollover index according to the appropriate formula, as well as the configuration of performance-intensity function during

speech discrimination testing. This information was obtained from Questions 5.1 to 5.4 of the hearing interpretation recording form (Appendix K).

4.4.4.1 Speech threshold tests in participants who did and did not receive ART

Table 4.46 provides information regarding the correlation of the SRT with the PTA. The mean was determined by dividing the ears of participants into two groups, namely those who received ART (n=66) and those who did not receive ART (n=18).

Table 4.46: PTA and SRT correlation in participants who did (n=66) and did not (n=18) receive ART

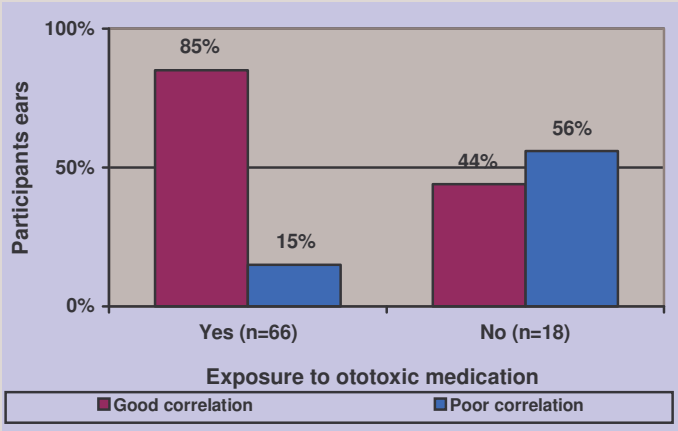
RESEARCH POPULATION	DIAGRAM SPECIFYING CORRELATION OF PTA WITH SRT
In participants who have been exposed to ART, the PTA of 56 (85%) ears correlated with the SRT, while the PTA of ten (15%) ears did not correlate with the SRT. In participants who have not been exposed to ART, the PTA of eight (44%) ears correlated with the SRT and the PTA of the ten (56%) ears did not correlate with the SRT.	

Figure 4.45: PTA-SRT correlation distributed across those who received ART (n=66) and those who did not receive ART (n=18)

Figure 4.45 illustrates the correlation between the PTA and the SRT of all participant ears distributed across those who received ART and those who did not receive ART. A significant difference (p=0.00) existed for the PTA-SRT correlation between those that did and did not receive ART. Those participants who did receive ART had the highest incidence of a good PTA-SRT correlation. This good correlation was significantly higher in these participants with

ART exposure than in those with no ART exposure. Those who did not receive ART had a higher incidence of poor PTA-SRT correlation.

Those participants who did receive ART had the highest incidence of a good PTA-SRT correlation. This good correlation was significantly higher in the participants with ART exposure than those with no ART exposure. The presence of a ski-slope audiogram configuration in participants who were exposed to ART was the main reason for the presence of a poor PTA-SRT correlation.

These findings may be due to the emotional well-being and their acceptance of the fact that they have HIV/AIDS. It is a well-known fact in the public and private sector that ART can only commence when individuals have accepted that they contracted HIV/AIDS. Part of HIV post-test counselling is to determine if participants are ready to commence with ART. A very important factor that is indicative of readiness to commence ART is the participants' acceptance of the disease. This suggests that the participants who receive ART have already accepted the fact that they have this fatal disease. Acceptance of the disease means that emotional instability is less. This could serve as possible explanation why these participants who accepted the disease presented with better PTA-SRT correlations, thus more reliable responses during pure tone audiometry testing.

4.4.4.2 Above threshold test results in participants who did and did not receive ART

The results are summarized in table 4.47 and figure 4.46. The mean for this section was determined by dividing the ears of participants into two groups, those who received ART and those who did not receive ART. The mean for those ears of participants who received ART was n=66 and the mean for the ear of participants with no ART exposure was n=18.

Table 4.47: Configuration of audiogram in participants who did (n=66) and did not receive ART (n=18)

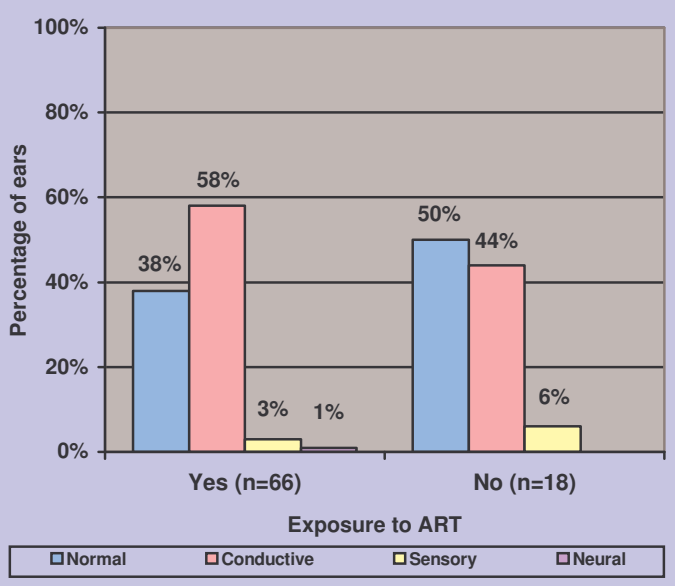
RESEARCH POPULATION	DIAGRAM SPECIFYING SPEECH DISCRIMINATION RESULTS
Twenty-five (38%) ears of those participants who received ART had normal hearing, 38 (58%) ears revealed a pattern suggestive of a conductive hearing loss, two (3%) revealed results indicative of a sensory hearing loss and one (1%) revealed results indicative of a neural hearing loss. Nine (50%) ears of those participants who did not receive ART had normal hearing, eight (44%) ears had speech discrimination results suggestive of a conductive hearing loss and one (6%) of a sensory hearing loss.	 **Figure 4.46: Speech discrimination results distributed across those participants who did (n=66) and did not receive ART (n=18)**

Figure 4.46 reveals that 50% of the ears of those participants who did not receive ART and 38% of the ears of those participants who received ART obtained between 92% and 100% speech discrimination scores at intensity levels of 40dB or better. Speech discrimination results of 92% to 100% at intensity levels higher than 40dB were obtained in 44% of the ears of those participants who did not receive ART and in 58% of the ears of those participants who received ART. A maximum word discrimination of 92% at increased intensity levels was obtained in 6% of the ears that did not receive ART and 3% of the ears that received ART. Only 1% of the ears of those who did receive medication presented a decrease in speech discrimination (according to the rollover index) with an increase in intensity.

Only one ear of a participant had a rollover configuration, indicating that neural pathology was present. This rollover was found in one participant with a history of ART. Conductive configurations had the highest incidence in those who received ART and normal configurations had the highest incidence in those who did not receive ART. Again it is relevant to discuss the significance of immittance results, the reliability and accuracy as stated in sections 4.2.4.2, 4.2.5 and 4.3.5. Gold and Tami (1998:167) suggest that even in the presence of a sloping or high frequency hearing loss, the speech discrimination remains near normal when a person is infected with HIV/AIDS. In this research project, only 50% of the participants still presented with normal speech discrimination configurations.

4.4.5 Results of immittance measurements in participants who received and did not receive ART

The immittance results include the tympanograms, as well as the ipsilateral and contralateral acoustic reflexes. This information is provided by Questions 6.1 to 6.5 of the Hearing interpretation recording form (Appendix K).

4.4.5.1 Tympanometry results in participants who did and did not receive ototoxic medication

Table 4.48 indicates the types of tympanograms that were obtained from the total research population. The mean was determined by dividing the ears of participants into two groups, namely those who received ART (n=66) and those who did not receive ART (n=18).

Table 4.48: Tympanograms in participants who did (n=66) and did not (n=18) receive ART

TYMPANOGRAM	Incidence in stages of HIV		OBSERVATION
	ART (n=66)	No ART (n=18)	
Type A-tympanogram	**86%**	**56%**	Type A-tympanogram with highest incidence obtained in those participants who received ART.
Type As-tympanogram	**5%**	**11%**	Type As-tympanogram found in those not on ART.
Type Ad-tympanogram	**3%**	**33%**	Type Ad-tympanogram with highest incidence in those who received ART.
Type B-tympanogram	**6%**	**-**	Only found in those with history of ART.

Table 4.50 indicates that of the participants who were taking ART, 57 (86%) ears had a Type A-tympanogram, while three (5%) ears had a type As-tympanogram and two (3%) ears presented with Type Ad-tympanograms. Four (6%) ears had a type B-tympanogram. In participants who were not taking any ototoxic medication, ten (56%) ears had a Type A-tympanogram, while two (11%) ears had a Type As-tympanogram and six (33%) ears presented with a Type Ad-tympanogram.

In terms of the tympanograms that were obtained, it was clear that the difference between those with and without exposure to ART was significant (p=0.007).These results indicate that type-A tympanograms had the highest incidence in those who received ART, possibly indicating ART addressed the middle ear problems that might have caused a conductive hearing loss. Type As- and Ad-tympanograms had a higher incidence in those participants without exposure to ART. However, type B-tympanograms were only present in those who received ototoxic medication. Apart from the fact that these participants were on ART, the fact of the matter is still that when ART commenced, these participants were already in the final

stages of HIV/AIDS, indicating a poor immunity which made them susceptible to severe otitis media. It could be possible that in these participants the administration of ART started recently, just prior to the research procedures being conducted. More abnormal findings were made concerning those who did not receive ART, thus confirming that ART improves the health of ears (in terms of conductive pathology), as indicated in section 4.4.2.1, 4.4.2.2 and 4.4.1.2.

4.4.5.2 Acoustic reflex results for all ears of participants who did and did not receive ART

Table 4.49 specifies the ipsilateral and contralateral acoustic reflex results that were obtained from the ears of the total research population distributed across those who did and did not receive ART.

Table 4.49: Ipsilateral and contralateral acoustic reflexes in participants ears who did (n=66) and did not (n=18) receive ART (n=84)

IPSILATERAL AND CONTRALATERAL REFLEXES						
	Levels of elicitation	Ipsilateral ART		Contralateral ART		IDENTIFICATION OF PATTERN
		Yes n=66	No N=18	Yes n=66	No n=18	
Reflexes	Normal	31%	0%	36%	34%	Those who did receive ART had a higher incidence of normal ipsilateral and contralateral reflexes.
	Abnormal	64%	94%	59%	66%	Those who did not receive ART had a higher incidence of abnormal ipsilateral reflexes.
	Absent	5%	6%	5%	0%	Absent reflexes had the highest incidence in those who received ART.

Abnormal reflexes suggest that reflexes, either contralateral or ipsilateral, were elicited at either increased or decreased sensation levels. Table 4.49 reveals the 31% ipsilateral reflexes and

36% contralateral reflexes in those ears with exposure to ART, as well as 34% contralateral reflexes distributed across the ears of those participants who did not receive ART. They had the highest incidence of normal reflexes, suggesting that the reflexes were elicited within 70dBSL to 90dBSL of the corresponding pure tone average. Those who did not receive ART had the highest incidence of abnormal ipsilateral (94%) and contralateral (66%) reflexes, suggesting the ipsilateral and contralateral reflexes were elicited at either sensation levels above 90dB or below 60dB. Ipsilateral reflexes were absent in 5% of the ears of participants with exposure to ART and 6% of the ears of participants without exposure to ART. Contralateral reflexes were absent in 5% of the ears of those participants with exposure to ART. Table 4.49 contains all ears that presented with a particular type of reflex and aspects such as conductive pathology leading to elevated reflexes were not included in this table. The following discussion will provide more precise information regarding the type of pathology in each ear according to the acoustic reflexes. In this discussion, the precise percentage of elevated and decreased acoustic reflexes and the reason for each acoustic reflex is discussed.

The ears of participant who had been exposed to ART exposure seemed to have had fewer normal ipsilateral and contralateral reflexes. This may suggest that ART definitely influenced the integrity of the hearing mechanism, especially in terms of the functioning of the cochlea and the vestibulo-cochlear nerve.

Ipsilateral reflexes and contralateral reflexes at decreased sensation levels in those participants with exposure to ART were elicited in 48% of the ears and 41% of the ears consecutively. Ipsilateral reflexes and contralateral reflexes at decreased sensation levels in those participants with no exposure to ART were elicited in 78% of the ears and 56% of the ears consecutively. In the ears of those participants with no exposure to ART, 17% of ipsilateral reflexes and 11% of contralateral reflexes were elicited at increased intensity levels. In terms of the reflexes at

increased sensation levels in the ears of those participants with exposure to ART, 15% of ipsilateral reflexes and 18% of contralateral reflexes were elicited. However, of the reflexes elicited at increased sensation levels in those individuals with ART exposure, 1% of ipsilateral reflexes and 5% of contralateral reflexes were associated with conductive pathology (abnormal tympanogram). This suggests that only 14% of ipsilateral and contralateral reflexes were due to N.VIII pathology.

Absent contralateral reflexes can be indicative of auditory brainstem dysfunction, neural hearing loss, facial nerve dysfunction, conductive pathology of hearing loss, while absent ipsilateral reflexes can indicate the presence of conductive pathology, neural pathology or facial nerve dysfunction (Hall and Mueller, 1998:223-228). However, in this case the absent ipsilateral and contralateral reflexes were mainly due to the presence of a conductive component since, it was associated with an abnormal tympanogram. Martin (1997:166) states that the presence of a severe conductive hearing loss or facial nerve or vestibulo-cochlear nerve dysfunction or brainstem dysfunction may also lead to absent ipsilateral and contralateral reflexes. Only one (5%) ear of a participant who did not receive ART presented with an ipsilateral reflex not related to a conductive component. As indicated in section 4.2.5.1.2, the absent reflexes in this research project were either due to conductive pathology or vestibulo-cochlear nerve damage. Since this one ear was not associated with conductive pathology, it suggests that the reflex was absent due to vestibulo-cochlear nerve damage. These results did not correlate well with the speech discrimination results. Therefore more objective tests such as ABR (for detecting retro-cochlear pathology) and OAE (for detecting cochlear pathology) should be included when assessing individuals with HIV/AIDS, but also those with HIHL.

4.4.6 Characteristics of the oto-acoustic emission in participants who did and did not receive ART

Questions 7.1 to 7.4 of the Hearing interpretation recording form (Appendix K) reveal the information regarding the presence or absence of the DPOAEs at the different frequencies. The DPOAE is considered to fail when the DPOAE failed at two or more of the five frequencies. According to Dunckley and Dreisbach (2004:563), the high-frequency hearing should be monitored when the administration of ototoxic medication is present, since it has been proved that it is an objective measure for drug-induced hearing loss.

4.4.6.1 DPOAE results in participants who did and did not receive ART

Questions 7.1 to 7.3 of the hearing interpretation recording form (Appendix K) reveal the information regarding the analysis of the DPOAE results. Table 4.50 includes figure 4.47 and it specifies the analysis of the DPOAE results and provides a clear description of the results.

Table 4.50: Absence of DPOAEs for the left and right ear in those participants who did (n=66) and did not (n=18)receive ART

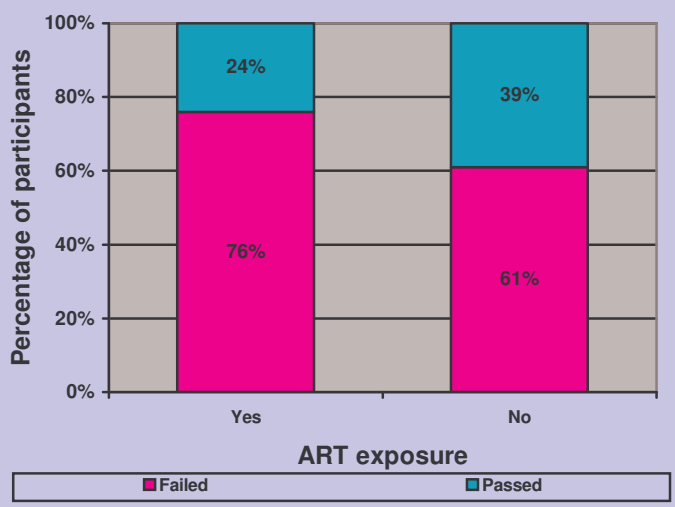
RESEARCH POPULATION	DIAGRAM SPECIFYING THE ABSENCE OF DPOAEs
In participants who were exposed to ototoxic medication, 50 (76%) ears failed the DPOAE assessment, while only 16 (24%) ears passed the DPOAE assessment. In participants who were not exposed to ototoxic medication, 11 (61%) ears failed the DPOAE assessment, while seven (39%) ears passed the DPOAE assessment.	

Figure 4.47: DPOAE results distributed across those participants who did (n=66) and did not (n=18) receive ototoxic medication

It is important to note that OAE assessment will be influenced by middle ear dysfunction (Hall and Mueller, 1998:278). However, the mean of the two groups differ which may influence the perception of the results. Figure 4.47 indicates that the participants on ART had a lower incidence of passing the DPOAE than those who did not receive ART, even though these ears of participants presented with a lower incidence of abnormal tympanograms. This implies that the participants who received ART failed the DPOAEs more often, due to the presence of early indications of cochlear pathology. It is clear that in these participants with ART exposure, ototoxicity had a significant influence on the cochlear functioning. However, section 4.4.3.4 revealed that only 12% had a sensorineural hearing loss and 5% had a mixed hearing loss (hearing loss with conductive and sensory components). Therefore it suggested that cochlear pathology was present in some ears before it was visible on the audiogram. This therefore

indicated the presence of early cochlear pathology in those who did not present with a hearing loss on the audiogram. Since conductive pathology influences the success of the DPOAE assessment, the conductive pathology indicated by the abnormal tympanograms was deducted from the percentage of ears that failed the DPOAE. Therefore in the group with exposure to ART, only 62% presented with cochlear pathology since 14% presented with conductive pathology according to the tympanometry, while only 17% of the participants with no exposure to ART presented with cochlear pathology, since 44% presented with conductive pathology.

4.4.6.2 Absence of DPOAEs at all frequencies in participants who did and did not receive ART

The DPOAEs was tested at 6000Hz, 5000Hz, 4000Hz, 3000Hz and 2000Hz. Pass or fail results were obtained for each frequency. Table 4.51 reveals the incidence of ears that failed the DPOAEs at all frequencies that were tested. Question 7.3 of the Hearing interpretation recording form (Appendix K) provides these results.

Table 4.51: Absence of DPOAEs at all frequencies in participants who did (n=66) and did not (n=18) receive ART

DPOAEs frequencies	Absent DPOAEs at all frequencies		IDENTIFICATION OF PATTERN
	Exposed to ART		
	Yes (n=66)	No (n=18)	
2000Hz to 6000Hz	9%	0%	Absence of DPOAEs at all test frequencies only present in those who received ART

Table 4.51 indicates that very few participants had absent DPOAEs at all test frequencies. The participants who did have absent DPOAEs at all frequencies had been exposed to ART. It is important to note that glue ears (type B-tympanograms) were only present in 6% of the ears of

participants who received ART (section 4.4.5.1). Since DPOAEs are absent in the presence of conductive pathology, the assumption is that only 3% of the ears failed the DPOAEs due to severe cochlear pathology.

4.4.6.3 Absence of DPOAEs at different frequencies in participants who did and did not receive ART

Each frequency of the five frequencies was tested separately in order to determine where the specific problem was. Question 7.2 of the Hearing interpretation recording form (Appendix K) contains the answer to these questions. The results are discussed in table 4.52.

Table 4.52: Absence of DPOAEs at the different frequencies in participants who did (n=66) and did not (n=18) receive ART

DPOAE frequencies	Incidence of DPOAE failure		IDENTIFICATION OF PATTERN
	Exposed to ART		
	Yes (n=66)	No (n=18)	
6000Hz	71%	55%	Incidence of failure higher in participants exposed to ART
5000Hz	65%	61%	Incidence of failure higher in participants exposed to ART
4000Hz	74%	78%	Incidence of failure higher in participants not exposed to ART
3000Hz	29%	17%	Incidence of failure higher in participants exposed to ART
2000Hz	14%	0%	2000Hz DPOAE only failed in those exposed to ART

Table 4.52 suggests that the incidence of DPOAE failure at the higher frequencies had a higher incidence in those exposed to ART, except at 4000Hz. DPOAEs at 2000Hz only failed in those participants exposed to ART. The cochlear outer hair cells responsible for processing 2000Hz frequencies are clearly more susceptible to the toxic agents in ART. Those participants on

ART had absent DPOAEs at 6000Hz, 5000Hz, 3000Hz and 2000Hz more often than those participants on ART. However, the mean of the two groups differ which influenced the percentages. The direct influence of HIV/AIDS, however, seemed to have affected 4000Hz frequencies more often.

4.4.6.4 Interpretation of immittance and DPOAE results distributed across those participants who did and did not receive ART

Question 7.4 of the Hearing interpretation recording form provides information on the interpretation of the DPOAE results. Table 4.53 contains a discussion and a graph representing and elucidating these results.

Table 4.53: Pathology indicated by DPOAE results for each ear in those participants who did (n=66) and did not (n=18) receive ART

Pathology	Incidence of pathology		IDENTIFICATION OF PATTERN
	Exposure to ART		
	Yes n=66	No n=18	
No pathology	7%	34%	No pathology had the highest incidence in those not exposed to medication
Cochlear pathology	62%	17%	Higher incidence of cochlear pathology in those exposed to ART
Retro-cochlear pathology	17%	5%	Retro-cochlear pathology had the highest incidence in the ears of participants with ART exposure.
Conductive pathology	14%	44%	Conductive pathology had the highest incidence in those not exposed to ART

Since oto-acoustic emissions are the most reliable test for the detection of cochlear pathology, especially to obtain site specific information (Hall and Mueller, 1998:265) and immittance measurements are most sensitive for the identification of middle ear pathology (Hall and

Mueller, 1998:177), the results described in section 4.4.5.1 and 4.4.5.2 were used to obtain information on the incidence of cochlear pathology, retro-cochlear pathology and conductive pathology across the stages of HIV/AIDS. In view of the fact that DPOAEs are absent in the presence of conductive pathology, the conductive pathology was subtracted from the cochlear pathology to obtain the real incidence of cochlear pathology. In this way, the real incidence of no pathology could be calculated.

Table 4.53 indicates that cochlear pathology (62%) and retro-cochlear pathology (17%) had the highest incidence in the participants who had been exposed to ART. Conductive pathology (44%) had the highest incidence in those who have not been exposed to ART. The cochlear integrity of the ears of those participants who have not been exposed to ART was more often normal, compared to those participants on ART.

4.4.7 Characteristics of auditory brainstem response in those who did and did not receive ART

Auditory brainstem response was conducted to determine the integrity of the neurological components of the auditory mechanism and to serve as a cross-check for other tests. The results in this section are discussed in terms of those who received ART and those who did not receive ART, to determine the pathologies present due to ART administration or the direct effects of HIV/AIDS.

4.4.7.1 ABR absolute latencies and interpeak latency results

Table 4.55 contains a discussion of the ABR results. The mean was determined by dividing the ears of participants into two groups, namely those who received ART (n=66) and those who did not receive ART (n=18).

Table 4.55: ABR results distributed across those who did (n=66) and did not (n=18) receive ART

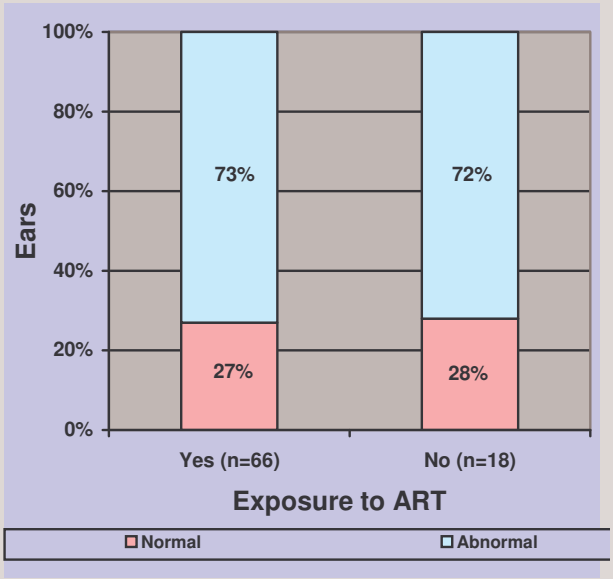
RESEARCH POPULATION	DIAGRAM SPECIFYING ABR RESULTS
In the ears of those participant who did not receive ART, five (28%) ears presented with normal ABR results, while 13 (72%) ears presented with abnormal ABR results. In the ears of participants who received ART, 18 (27%) ears presented with normal ABR results while 48 (73%) ears presented with abnormal ABR results.	

Figure 4.48: Auditory brainstem response findings for participants who did (n=66) and did not (n=18) receive ART

Figure 4.48 confirms that once sensorineural hearing loss results is present, it cannot be improved. Figure 4.48 indicates that abnormal ABR findings had the highest incidence in both groups, those who received ART and those who did not receive ART. Interestingly, the incidences of the abnormal ABR in both groups only differed with 1%, suggesting that there was not a significant difference between the group who received ART and those who did not receive ART. The assumption from these results is that ART, as well as HIV itself, has a significant influence on the neural integrity of the audiological pathways. When compared to the results in figure 4.20, it is clear that these results correspond with the results obtained for the complete research population. This means that even though ART was administrated in some of these participants, the incidence of ABR abnormalities stayed the same, because neural pathology are irreversible. This is interesting, since the literature study clearly indicates that certain ART agents may lead to peripheral neuropathy, damage to the auditory nerve

(N.VIII) or vestibular pathology (Bankaitis and Schountz, 1998: 162) and the expectation was that when exposed to HIV and to ART, the neural integrity of the auditory pathways would have been totally, if not severely, compromised. According to Venter et al. (2005:238), peripheral neuropathy "…may be the most common and serious side-effect of stavudine and didanosine which are ART composites and these side-effects are seen in Southern Africa especially. However, according to these results, two possibilities may explain the findings. One may be that ART did not influence the neural integrity and that the direct effect of HIV was the only significant factor that has lead to neural pathology and this was irreversible. The second possibility may be that ART and HIV in combination may have played a significant and equal part in causing neural damage.

Table 4.56: ABR interpeak and absolute wave latencies distributed across those who did (n=66) and did not (n=18) receive ART

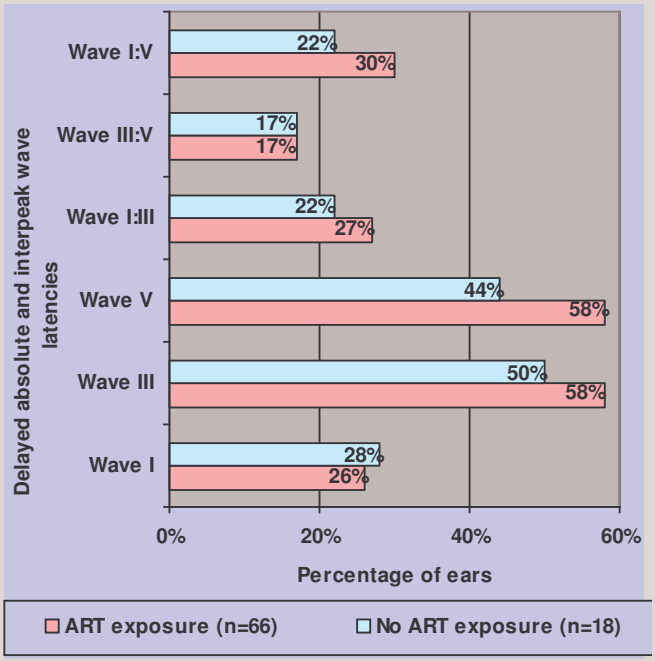
RESEARCH POPULATION	DIAGRAM SPECIFYING ABR RESULTS
In the ears of those participants who received ART (n=66): Wave I was delayed in 17 (26%) ears, wave III was delayed in 38 (58%) ears and wave V was also delayed in 38 (58%) ears. Wave I:III interpeak latencies were prolonged in 18 (27%) ears, wave III:V was prolonged in 11 (17%) ears, while wave I:V was prolonged in 20 (30%) ears. *In those participants' who did not receive ART (n=18):* Wave I was delayed in five (28%) ears, wave III was delayed in nine (50%) ears and wave V was delayed in eight (44%) ears. Wave I:III interpeak latencies were prolonged in four (22%) ears, wave III:V was prolonged in three (17%) ears, while wave I:V was prolonged in four (22%) ears.	

Figure 4.49: ABR absolute wave latencies and interpeak wave latencies for participants who did (n=66) and did not (n=18) receive ART

When analysing the absolute wave latencies and interpeak latencies, it was clear that wave I in the group with no ART exposure, had a 2% higher incidence of abnormality, as indicated in figure 4.49. This entails that the vestibulo-cochlear nerve was likely to be influenced by the direct effects of HIV, but also by ART. The ears of participants with ART exposure had a higher incidence of abnormal wave III and V latencies, as well as prolonged wave I:III and wave I:V interpeak latencies, when compared to those participants who had no ART exposure. Abnormal interpeak latencies of wave III:V had an equal incidence in those ears of participants who did and did not receive ART. According to these results, the assumption is that ART tends to influence the caudal portion of the brainstem near the trapezoid body and the superior olivary complex (wave III) and the lateral lemniscus as it enters the inferior colliculus (wave V). Hall and Mueller (1998:328) state that these structures represent the different waveforms.

Again these ABR results did not concur with the exact percentages of normal and abnormal findings of the immittance measurements and DPOAE results discussed in section 4.4.6.4. It suggests that neurological pathology was not always diagnosed by basic audiometrical procedures that were done during the research. Smith, Jakobsen, Gaub, Helweg-Larsen and Trojaborg (1988) also concluded from their research that neurological abnormalities were not always detectable by audiometry procedures other than the ABR (Bankaitis et al., 1998:179). Once more, the conclusion was reached that even though individuals with HIV/AIDS do not all present with observable auditory manifestations or loss of hearing sensitivity, auditory neural pathology may be observed in these individuals. The implication is that an ABR should always form part of the audiological test battery to enable the audiologist to diagnose these neurological abnormalities not otherwise clinically detectable.

4.5 SUMMARY

The results presented, discussed and interpreted in chapter four (Appendix Q) aimed to describe the nature of the audiometrical findings of the HIV-infected individual. Within the context of applied research, a quantitative approach was used to obtain numerical data and transfer the data into descriptive information to obtain a clear profile of hearing loss in each stage of HIV/AIDS. For the purpose of determining the nature of the hearing profile in each stage of HIV/AIDS a cross-sectional design was utilized.

The findings were discussed in accordance with the aims set in chapter three. The findings suggested a definite presence of hearing loss with the progression of HIV to AIDS. Even though normal findings were observed in all the audiological procedures conducted by the researcher to determine the hearing profile of participants with HIV/AIDS, it was undeniable that various types and degrees of hearing loss were diagnosed among these individuals. The site of the lesion tests also suggested that definite middle ear, cochlear and retro-cochlear pathology existed. However, the incidences of the different pathologies differed. It is important for all audiologists to know and understand the influence of HIV/AIDS on hearing in order to be able to answer questions that might be raised by the public or health care professionals seeking assistance, but more importantly to address the needs caused by the hearing disability.

The provision of quality hearing health care to individuals with HIV/AIDS has become an important responsibility of the audiologist of today. This is a reality, since research on hearing loss in individuals with HIV/AIDS has increased, not to mention the increase in the incidence of HIV-infected individuals (Bankaitis, 1998:117). This twofold motive suggests increasing awareness of the public, the hearing and health care professionals, as well as audiologists, regarding the effects HIV/AIDS may have on hearing. In turn, this could lead to an increase in

the number of people seeking the assistance of audiologists, but also an increase in referral rates from health care professionals to the audiologist. This research also generated a number of questions to which the answers have not yet been found and chapter five contains these questions in terms of possible recommendations for further research.

"The improvement of the understanding is for two ends: first, for our own increase of knowledge, secondly, to enable us to deliver and make out that knowledge to others".

John Locke (1632-1704)

CHAPTER FIVE

CONCLUSIONS AND IMPLICATIONS

"He that studies only men, will get the body of knowledge without the soul; and he that studies only books, the soul without the body. He that to what he sees, adds observation and to what he reads, reflection, is on the right road to knowledge provided that in scrutinizing the hearts of others he neglects not his own".

(Colton, 1780-1832)

5.1 INTRODUCTION

The increasing numbers of individuals becoming infected with HIV suggest that it becomes more likely that audiologists will come across these individuals at some point in their professional career in either the private or the public sector (Friedman and Noffsinger, 1998:205). Currently, the prevalence of hearing disorders and the life advantage of HIV/AIDS drugs are being researched worldwide and the predicted increase in the individuals with HIV/AIDS will lead to more and more HIV-infected individuals seeking audiological assessment and assistance (Bankaitis, 1998:118). The visit to the audiologist will mainly be due to the individual seeking assistance to improve his/her quality of life.

The literature study has indicated that a strong relationship exists between the presence of a hearing loss and a decline in emotional and social, as well as communicative performance and in addition to these associated problems, physical health status has shown to be compromised by hearing loss even if the hearing loss is to a minimal degree (Lewis, Crandell, Valente, Enrietto, Kreisman, Kreisman and Bancroft, 2003: 30). Research by Bess et al. (1989) in Lewis et al. (2003:30) has also signified that the greater the loss of hearing sensitivity, the greater the

prevalence of physical conditions or illnesses. The physical health status of individuals infected with HIV/AIDS is already compromised and an added hearing loss to the reduced wellbeing might influence the psychosocial health of these individuals negatively, leading to a reduced quality of life. This is in line with the research done by Sherer and Frisina in Lewis et al. (2003:30) that reveals that *"hearing impairment equals greater communicative, social and emotional handicap as well as lower self-esteem and social satisfaction"* compared to individuals with normal hearing.

Understanding the destructive consequences of HIV/AIDS and how it influences the health, including the hearing health of the individuals infected with this deadly virus, has therefore become imperative to all health care workers, including audiologists, for ensuring the quality of life of all individuals who have contracted this virus. The access to health services, but more importantly, the quality of service delivery and care, alarmed the National Department of Health and caused major concerns (Giddy and Reid, 2003:8). Providing an effective service delivery for this population requires knowledge about the disease and its potential and impending impact, directly and indirectly, on the hearing sensitivity and hearing health of the participant infected with HIV (Friedman and Noffsinger, 1998:205).

Information on the hearing profile of individuals infected with HIV is vague, especially in terms of the relation to HIV/AIDS manifestations (Bankaitis, 1998:123). Since there is still much unknown, implying much to learn, about the effects of HIV/AIDS on the audiological findings (Bankaitis, 1998:118), the compilation of data and verification of suspected consequences of this disease on hearing, are necessary for the development and rendering of high-quality service in South Africa and across the world. Good practice, suggesting high-quality service, depends on exploiting research activities that meet the inimitable strain and difficulties of the HIV-infected population and the application of these results within practice. The best practice

may depend on the utilization of the best available evidence obtained from research and integrating it with the personal clinical expertise obtained in practice (Mayosi and Setsubi, 2003:507). Focusing on the achievement of better audiological management of participants with HIV/AIDS, this research project aimed to describe the hearing profile of individuals with HIV/AIDS within the different stages of the infection. Evidence of manifestations and otological complications and their relation to hearing sensitivity, as well as the possible ototoxic effects of medical treatments these individuals are exposed to, were investigated. Consequently, recommendations regarding the best clinical practice and clinical management of the hearing health of individuals with HIV/AIDS, based on these research findings, will be discussed. These guidelines for better clinical practice can be utilized to ensure optimal identification, assessment and management of these individuals. It is imperative to focus on service delivery, but it is also important to consider the prevention of hearing loss. These results stressed the need for preventative care. Awareness campaigns not only directed towards the public, but also towards the health care workers involved with the management of individuals with HIV/AIDS. Possible guidelines regarding the information that should be supplied to these health care workers and the public within these awareness campaigns also arose from these research findings.

These guidelines, management options and clinical aspects that were established from these results are discussed in this chapter. More specifically, the aim of this chapter is therefore to draw conclusions and implications from the results discussed in chapter four, to review the research critically, indicating the shortcomings within this research project and to make recommendations for future research in this field.

5.2 CONCLUSIONS

The aim of this research project was to determine the hearing profile of persons infected with HIV/AIDS at different stages of this disease and the influence of ART on the hearing profile of these participants. The summarized conclusions of the results that were obtained from the three sub-aims developed for this research project are provided below:

- The main findings that emerged from the case history information were that upon contraction and progression of the virus, the number of otological complaints increased, indicating the direct influence of HIV/AIDS. It is clear from the results that prior to being infected or diagnosed with HIV/AIDS, participants mainly stated that they had no *otological complaints*, but these complaints increased with the progression of HIV to AIDS. Otalgia, hearing loss and tinnitus were the major complaints raised by these participants who contracted HIV/AIDS. Complaints of otalgia, hearing loss, vertigo, tinnitus and itching ears increased with a progression of HIV to AIDS. Participants who received ART, raised fewer otological complaints. Complaints of otalgia, hearing loss, tinnitus and dysacusis had a higher incidence in participants who did not receive ART even though ART is known to cause these symptoms. Those who received ART had a higher incidence of vertigo than those who did not. The conditions that seemed to exist more often in those who were on ART were otorrhea, vertigo, and itching ears.

- The *otoscopic examination* mainly revealed normal landmarks, suggesting normal external ear canals and normal pearly white tympanic membranes. The incidence of pearly white tympanic membranes decreased with the progression of HIV to AIDS, suggesting an increase in the presence of abnormal conditions of the external ear canal and tympanic membrane. The presence of fungal infections, otorhea, blood, occluding wax and normal soft wax had no particular pattern of incidence across the stages of HIV/AIDS. The

incidence of dry flaky wax increased with the administration of ART. Participants who received ART more often presented with normal pearly white tympanic membranes. Tympanosclerosis, scarred tympanic membranes and myringitis and otorhea were more often found in participants who did not receive ART. This possibly suggests that the administration of ART clear the otological symptoms, consequently addressing the conductive component.

- *Diseases* such as lung diseases and otolaryngological diseases had the highest incidence in these participants with HIV/AIDS. Nervous system diseases and oral diseases were also diagnosed, but less often. No apparent pattern in the incidence of these diseases was observed across the stages of HIV/AIDS. Those participants who received ART were more likely to experience lung diseases, oral diseases and nervous system diseases than those who did not receive ART. Those participants who did not receive ART were more likely to experience otolaryngological conditions, again confirming that ART addressed the otological diseases.

- In terms of the *pure tone audiometry*, most of the ears of participants with HIV/AIDS presented with normal hearing thresholds when using the PTA to determine the degree of hearing loss. However, when the high and low frequency thresholds were also taken into consideration, the incidence of normal hearing decreased significantly. The left and right ears were affected equally with hearing loss. Mild, moderate and moderate-to-severe degrees of hearing loss were identified in these participants' ears. Conductive and sensorineural hearing losses were equally found. Mixed hearing losses had a significantly lower incidence. Flat and irregular configurations as well as configurations that rise from the low frequencies to the mid-frequencies and drop in the high frequencies were the most prevalent types of configurations. A definite decrease in the incidence of normal hearing

with the progression of HIV to AIDS was found. The incidence of a bilateral hearing loss increased with the progression of HIV to AIDS. Unilateral hearing loss tends to occur more often in the first stage of HIV/AIDS. The degree of hearing loss increased to more severe degrees with the progression of HIV to AIDS. The final stage of HIV/AIDS had the highest incidence of mild, moderate and moderate-to-severe hearing loss. Earlier stages mainly presented with conductive hearing loss with flat and irregular audiogram configurations while the final stages more often presented with sensorineural hearing loss characterized by rising and/or falling audiogram configurations. Interestingly, the incidence of normal hearing was significantly higher in participants who received ART. Unilateral hearing loss was found more often in those who did not receive ART. Participants with hearing loss who received ART, presented with more severe degrees of hearing loss (such as moderate-to-severe hearing loss), whereas in those without ART exposure, moderate degrees were the most severe degree of hearing loss. A sensorineural hearing loss had a higher incidence in participants who did not receive ART. An interesting finding was that conductive hearing loss had a higher incidence in participants who received ART, even though it was clear that otological complaints and otological conditions that may cause conductive hearing loss decreased with the administration of ART. Irregular configurations had the highest incidence in participants with ART exposure while these participants also presented with configurations such as sloping, sharply falling, trough and 4000Hz notching configurations. Configurations that rise slowly to normal intensity levels in the mid-frequencies, then drop to abnormal intensity levels in the high frequencies, had the highest incidence in participants with no ART exposure.

- The *PTA-SRT correlation* in these individuals with HIV/AIDS was generally good. This indicated that the pure tone test results were by the large, reliable. In those ears of

participants where a poor PTA-SRT correlation existed, it was mainly due to the presence of a sloping hearing loss. Only a few ears of participants presented with questionable pure tone audiometry results most likely due to unreliable behavioural responses. In terms of *above-threshold tests*, most participants obtained 92% to 100% words correct at intensity levels above 40dB, indicative of conductive pathology. The highest incidence of good PTA-SRT correlations was found in participants in the first three stages of HIV/AIDS. No particular pattern of above-threshold results were identified across the stages of HIV/AIDS. Participants with ART exposure had the highest incidence of good PTA-SRT correlations. Participants with normal above-threshold test results, suggesting 92% to 100% correct speech discrimination at intensity levels below or better than 40dB, were found in participants who received ART, whereas above-threshold results indicative of conductive pathology had the highest incidence in those without ART exposure.

- The *tympanometry* results revealed that type-A tympanograms had the highest incidence among the individuals infected with HIV/AIDS. Interestingly, no type C-tympanograms were identified. Conductive pathology was mainly revealed by type Ad-tympanograms, type As-tympanograms and type B-tympanograms.

- The *acoustic reflex results* indicated that no N.VII pathology was present in these participants. Cochlear pathology had the highest incidence. Retro-cochlear pathology, mainly due to N.VIII pathology, were also identified relatively often. Only 10% participants' ears presented with normal acoustic reflexes. Cochlear pathology and retro-cochlear pathology (due to N.VIII dysfunction) were found in all four stages of HIV/AIDS. The earliest stage of HIV/AIDS presented with a high incidence of N.VIII pathology. Cochlear pathology had the highest incidences in the final three stages of HIV/AIDS. With the progression of HIV to AIDS, many ears presented with more than one type of pathology

such as cochlear and retro-cochlear damage which was identified through the acoustic reflex results. Participants who did not receive ART had the highest incidence of abnormal ipsilateral and contralateral reflexes. The ears of participants who had been exposed to ART seemed to have fewer normal ipsilateral and contralateral reflexes. This may suggest that ART definitely influenced the integrity of the hearing mechanism, especially in terms of the functioning of the cochlea and the vestibulo-cochlear nerve. A close correlation existed between the immittance results and the DPOAE results.

- Most participants failed the *DPOAE assessment*. A low incidence of participants had absent DPOAE at all test frequencies. The DPOAE were absent for most ears at 4000Hz indicating that 4000Hz was the most sensitive to cochlear damage. Cochlear damage was therefore mainly observed in the outer cochlear hair cells responsible for the processing of 4000Hz to 6000Hz presentations. The least cochlear damage was found at 2000Hz and 3000Hz. Compared to retro-cochlear and conductive pathology, these results revealed that cochlear pathology had the highest incidence across all stages of HIV/AIDS, however, the incidence varied across the stages with no observable pattern of incidence. The highest incidence of failed DPOAEs assessment was found the final stages of HIV/AIDS. The DPOAE assessment failed more often in those individuals who received ART than in those who did not receive ART, indicating that ART caused definite cochlear damage. Interestingly, 6000Hz and 5000Hz, 3000Hz and 2000Hz had a higher incidence of absent DPOAEs in those who did receive ART, while 4000Hz had a higher incidence of absent DPOAEs in those who did not receive ART. This suggested that ototoxicity was more often observed at 4000Hz. Failure of all frequencies during DPOAE testing was only found in individuals who received ART. Cochlear pathology had the highest incidence in those who did receive ART, but they had a lower incidence of hearing loss (according to

the pure tone audiogram) suggesting the presence of early cochlear damage not yet noticeable on the audiogram.

- Cochlear pathology had relatively high incidences among all stages of HIV/AIDS with no particular pattern of incidence. Retro-cochlear pathology were observed from the initial stage of HIV/AIDS to the final stages of HIV/AIDS. It was apparent that cochlear pathology and retro-cochlear pathology had the highest incidence in the participants who had been exposed to ART. Conductive pathology had the highest incidence in participants who had not been exposed to ART. The integrity of the hearing mechanism of participants who had not been exposed to ART was more often normal, compared to those participants on ART.

- Abnormal ABR findings had the highest incidence. The ABR results indicate that the absolute latencies of wave III and wave V had the highest incidence of abnormalities. The abnormal waves III and V may have been caused by this high frequency sloping hearing loss. The absolute wave latencies of waves III and V and the interpeak wave latencies of waves III to V and I to V had the highest incidence of abnormality, especially in the final stages of HIV/AIDS. Although presenting fewer abnormalities than waves III and V, it was clear that wave I also had a relatively high incidence of prolonged wave latencies, especially in the initial stage of HIV/AIDS. Interestingly, these ABR results did not concur with the exact percentages of normal and abnormal findings in the different stages of HIV/AIDS, even when the presence of a significant hearing loss was considered. This suggested that neurological pathology cannot always be diagnosed by pure tone audiometry and immittance results, and that ABR results are the most reliable measurements for the identification of neurological pathology. HIV/AIDS is likely to influence the integrity of the neurological pathways of the auditory system as early as in stage I of HIV/AIDS. It also suggests that neurological abnormalities are not always

detectable by audiometry procedures other than the ABR (Bankaitis et al., 1998:179). Abnormal absolute wave latencies and interpeak latencies were almost equally found in participants who received ART and who did not receive ART. This entails that the N.VIII was likely to be influenced by the direct effects of HIV, but also by ART. Participants with ART exposure had a higher incidence of abnormal wave III and wave V latencies, as well as prolonged wave I:III and wave I:V interpeak latencies. Abnormal interpeak latencies of wave III:V had an equal incidence in ears of the participants who did, and did not receive ART.

5.3 CLINICAL IMPLICATIONS AND RESEARCHED-BASED RECOMMENDATIONS

HIV/AIDS has become an integral part of the health care system in South Africa. Yet the descriptions of HIV and AIDS are frequently sinister and detached, and it is questionable how many audiologists or health care workers really know and understand the potential demoralizing impact and distress it may have on the individuals who contracted the virus. Audiologists in the future will continue to be confronted with the management of a person who contracted HIV to take care of their audiological needs. Comprehending the otological conditions and the related hearing sensitivity of an individual with HIV/AIDS can increase appropriate diagnosis and optimal management for each specific individual.

The strong relationship that exist in the literature between hearing loss and poor emotional and social well-being reinforces the fact that individuals with HIV/AIDS and hearing loss should be assisted as soon as possible. The results of this research project have significant implications for the rendering of effective audiological services to individuals with HIV/AIDS in South Africa. An unavoidable outcome of this study is that HIV/AIDS has a definite influence on the hearing system and the functioning of the hearing system in varying degrees and at some point during the progression of the disease. This influence may be due to the direct effect of the virus, but

is often associated with the administering of ART that is administered. Apart from the psychosocial effects that originate within the individual due to their being HIV-positive, this illness can either directly or indirectly lead to a hearing loss which could compromise the physical and emotional health of the individual even further. Creating awareness and improving the knowledge of audiologists, health care workers and the public is essential.

Changes in hearing profiles were observed during this research project across many areas of audiological assessments. This information should be disseminated among audiologists. These areas include changes in the type and nature, degree and configuration of the audiograms, types of pathology identified through immittance measurements, speech discrimination measurements and DPOAE assessments. The fact that the audiological findings change with the progression of the viral infection should raise awareness of expected changes in audiological findings and audiological complaints when audiologists are confronted by an individual with HIV/AIDS. The absence of a hearing loss at a certain point in the progression of the virus does not propose the absence of a hearing loss at a later stage of the infection, but the opposed is also true. The presence of a hearing loss, especially conductive, does not imply the presence of a hearing loss at a later stage in the infection. HIV/AIDS progresses over time and so it seems to be the case with the hearing sensitivity as well. Most importantly, the audiologist should realise that one specific pattern of hearing profile findings associated with HIV/AIDS do not exist, thus suggesting that the hearing profile of each individual may be affected differently.

The change in hearing sensitivity with the progress of HIV/AIDS necessitates regular monitoring of the hearing sensitivity by doing a complete audiological battery of tests to identify the place of lesion and to monitor damage at the recognized place of lesion. The type, degree and configuration of hearing loss tends to differ in the different stages of the infection. This

may suggest that the hearing loss may change with the progression of the virus. However, such longitudinal research should still be conducted. For now, audiologists should take note of these possible changes and ensure that the hearing of the patient be regularly monitored, especially with progression to a different stage of HIV/AIDS. The management of amplification and hearing health should then be monitored accordingly. However, the changes in the hearing profile do not solely depend on the progression of the virus, but on the administration of ART as well. A definite relationship between ART and hearing sensitivity was identified. Outer cochlear hair cell damage was more often obtained when ART was administered, suggesting that cochlear pathology was more often present with the administration of ART. This again stresses that the long term plan for an individual with HIV/AIDS should include regular follow-up and re-assessment services in order to monitor when a hearing loss commences, diminishes, persists or changes in accordance with the progression of the virus. The type of hearing loss will also influence the management plan. Neurological pathology cannot always be diagnosed by basic audiometrical procedures. In this research, neurological abnormalities were not always detectable by audiometry procedures other than the ABR. This means that even though individuals with HIV/AIDS do not all present with observable auditory manifestations or loss of hearing sensitivity, auditory neural pathology should not be overlooked in these individuals. The implication is that an ABR should always form part of the audiological test battery to enable the audiologist to diagnose these neurological abnormalities otherwise clinically undetectable. The ABR enables the audiologists to determine specific neurological manifestations such as pathology at the caudal portion of the brainstem near the trapezoid body and the superior olivary complex (abnormal wave III), while an abnormal wave V suggests pathology at the lateral lemniscus as it enters the inferior colliculus (Hall and Mueller, 1998:328). Since these structures are largely responsible for localizing sound sources, the assumption is that the individuals with HIV/AIDS may experience difficulty with the analysis of small differences in

time or intensity of sounds arriving at both ears, in order to localize the sound source (Martin, 1997: 328). In summary, the management of these individuals' hearing needs should therefore be based on or adjusted according to the findings of comprehensive diagnostic audiological assessment.

Adjustments to the management plan are specifically applicable when amplification and additional assistive devices are considered. The positive effect of amplification on the psychosocial and functional health status of any individual is foreseeable. Feelings such as reduced depression, fuller and richer relationships and an enhancement in the quality of life have been reported when a person with a hearing loss receives appropriate amplification. However, the progressiveness of hearing loss due to the HIV infection, as well as the ototoxic implications of the drugs used to treat the OIs, possibly suggest challenges when it comes to fitting these individuals with hearing aids. From the research it was clear that hearing loss became more severe and more prevalent with the progress of the HIV-infection. Since HIV has a progressive nature, the course of the hearing loss will most probably be regressive in most individuals as well, implying that the hearing ability will worsen over a period of time. Cases where an individual presents with a sensory hearing loss and the degree of hearing loss changes with the direct effect of the progression of the virus or the administration of medication, adjustment of the amplification is inevitable to ensure these positive effects. Yet, fitting a hearing aid with a certain fitting range applicable to that individual's hearing sensitivity at the time of the initial assessment and early stages of the illness, may influence the future success of the amplification. Over amplification or under amplification may occur. However, knowing that a hearing loss may be regressive in nature, will enable the audiologist to be proactive by keeping in mind that the hearing may regress over a short period of time and therefore to select a hearing aid with a greater fitting range. In this way, a suitable and still appropriate hearing aid is selected with enough options and room for adjustments when

necessary. Audiologists and health care workers should also note that ART seems to prevent or delay the direct effect of HIV on the hearing sensitivity. However, it does influence the high frequency sensitivity. Therefore, in terms of amplification, patients on ART will often be the ones to be fitted with two-channel hearing aids to amplify the high frequencies, while those patients not on ART will need two-channel hearing aids for both high and low frequencies.

Rehabilitation for those individuals with HIV/AIDS who do not comply with general selection criteria for specifically hearing aids may benefit more from FM-systems or auditory training therapy, depending on the diagnosis. The advantages of using an FM-system, especially in individuals with a sensorineural hearing loss, has been proved in the past (Lewis et al., 2003:33). This is therefore an assistive device that could be considered as part of the management plan in order to address the quality of life of the person with HIV/AIDS and assist the individual with activities of daily living. Rehabilitation services should therefore be structured more in terms of intensive follow-up sessions that include thorough assessments and adjustments to the current management plan.

Audiologists should be made aware of the positive effects of ART on the hearing mechanism of an individual with HIV/AIDS. According to this research, those patients not on ART are expected to present with otological complaints more often. Therefore, when a patient presents with a large number of otological complaints and does not necessarily want to commence ART, the audiologist might consider explaining the convalescing effects it may have on the number of otological complaints. Individuals are sometimes hesitant to take this medication and apart from the fact that it enhances good health, the audiologists should motivate individuals to take ART and administer it correctly (as prescribed), since it reduces the number of otological complaints.

Mining industries and industrial audiologists should be informed of the possible direct and indirect effects HIV/AIDS may have on the hearing ability of a person. Many industries are characterized by excessive noise. One of the most common occupational diseases that could be encountered in the industrial setting is noise-induced hearing loss. Increased expenditure in mining industries in terms of granting compensation claims are a growing concern. Current noise-induced hearing loss statistics serve as a clear indicator of the increase and significance of this occupational disability in the mining sector (Franz & Phillips, 2001 in De Koker, Clark, Franz & Mackay, 2003:i-iii). In 2004, 2724 claims for NIHL were reported to and approved by the compensation commissioner and these NIHL compensation claims account for the highest of all occupational disease claims (Department of Labour, 2005:21). Differentiating between extreme noise exposure as a high-risk cause of hearing loss or HIV/AIDS is a relevant and emerging topic in especially the mining and industrial sector.

HIV/AIDS and noise-induced hearing loss are both characterized by a decrease in hearing sensitivity. Noise-induced hearing loss is characterized by 4000Hz notching on the audiogram with an improvement at 8000Hz. However, sometimes 8000Hz may also be affected. Research has shown that 2000Hz to 6000Hz frequencies are also severely affected in cases of a NIHL (Edwards, 1980:42). In the case of HIV/AIDS, the loss of hearing sensitivity was found across the complete frequency spectrum. Sloping hearing losses did exist, but slowly-rising-sharply-falling, flat and irregular configurations were mainly identified in the HIV/AIDS population, thus clearly not suggestive of a NIHL. Unfortunately, it would still be difficult to differentiate between a NIHL and a HIV/AIDS-related hearing loss on the grounds of pure tone audiogram results and DPOAE results. Consequently, it is important to note that since a NIHL is characterized by a neurologically normal ABR, but HIV/AIDS-related hearing loss may be characterized by a neurologically abnormal ABR from as early as stage I, may assist with the differentiation between the cause of hearing loss. Hearing loss that might be caused by

something other than noise, such as the direct effect of HIV/AIDS or ototoxic complications of ART are therefore useful information for industries confronted with compensation claims submitted by individuals who may be HIV-positive.

Knowing the ABR-characteristics of both HIV-related hearing loss and noise-induced hearing loss may take today's audiologist one step closer to differentiate between these hearing losses and thus adjust the granted amounts of the compensation claims accordingly. Any unfairness and discrimination against both parties, the employer and employee, may hereby be addressed. By understanding the root of the hearing loss, the responsible entity can be held liable for the loss of hearing sensitivity because it is undeniable and inevitable that compensation claims should be granted. On the contrary, even though excessive noise exposure will affect hearing to some extent, the industrial sector cannot be held liable for a decrease in hearing sensitivity when a person is HIV-positive and presents with the above-mentioned audiological characteristics. In this section the significant implications and research-based suggestions resulting from the research findings were discussed. *"Knowledge always desires increase, it is like fire, which must first be kindled by some external agent, but which will afterwards propagate itself"* (Johnson, 1709-1784).

5.4 CRITICAL EVALUATION OF THIS RESEARCH

"Knowledge is the treasure, but judgement is the treasurer of a wise man" (William Penn, 1614 -1718) (retrieved February 9, 2007, from http://www.quotations.com). Justification of this research project by means of a critical evaluation is required to gain perspective regarding the implication of the data that was obtained. This critical review should echo both positive and negative aspects of the research.

What can be viewed very positively, is that the research is the first of its kind in South Africa, focussing on the audiological assessment of the complete hearing system within one study for

individuals with HIV/AIDS. Various suggestions and suspicions have been aired regarding the audiological findings that a person with HIV/AIDS might present with. Studies have been done where only certain parts of the hearing system were tested per study. Another study only focussed on the audiogram findings of females with HIV/AIDS (Fuzani, 1999). This research therefore confirms some of these findings. These results may be considered as yet another step in the direction of less discrimination against individuals with HIV/AIDS, an improved awareness and better understanding for the audiological needs of these individuals, as well as appropriate assessment and prompt management with regular follow-ups. This is echoed in the statement made by the HPCSA (2002:89) which reads as follows: *"Health care professionals are being reminded that an HIV diagnosis, without further examination, provides no information about a person's prognosis or actual state of health"*. This comprehensible statement was developed and established for medical and dental professionals. It can be brought in-line with audiologists as well. Awareness and knowledge might lead to good, appropriate, high-quality service that can be rendered to individuals who contracted HIV/AIDS and now present with hearing needs.

Furthermore, the research is done in a developing context (South Africa), indicating a higher incidence of HIV which gave the researcher easy access to a relatively large population with HIV/AIDS within a relatively short period of time.

The first negative aspect that needs to be reflected upon is the small sample size. Generalization of the results to the larger HIV/AIDS population is difficult. The fact that the population was so small also dictated the statistical methods that had to be used. Some conclusions and implications could not be made and in these occurrences only the presence of observed tendencies could be discussed. This was the case with the types of medication used for treatment of HIV/AIDS and the opportunistic infections. The researcher was unable to

distinguish between the influence of ART and Regime II TB drugs on hearing sensitivity and to make separate conclusions. The fact that all subjects came from one district in the Northwest Province also complicated the generalization of the finding. However, since the research took place at a public health institution, the general guidelines for the diagnosis and commencement of treatment are implemented at all public health institutions in South Africa. These protocols and guidelines are in-line with the guidelines set by the Health Professions Council of South Africa (2002:88) that read as follows: *"The guidelines are now much in keeping with international best practice and they reflect to a large extent, if not fully, the views of organisations such as the United Nations Joint Programme on HIV/AIDS and that of the World Health Organisation (WHO)".* Using a standarized protocol improves the generalizability to all public health institutions in South Africa, especially concerning the effects of the treatment on HIV-infected individuals.

Consistency during speech discrimination tests is another negative aspect that may have resulted in bias of the data that was obtained. The researcher aimed to obtain consistency in terms of the dialect of the person completing the speech reception and discrimination tests. The audiologist conducted all speech discrimination and speech reception tests to prevent the possibility of bias caused by dialect differences. The regular interpreters were not always available and other interpreters had to be used at times. Unfortunately, this resulted in a person who was not entirely familiar with the language conducting the speech audiometry. This may have lead to problems with the reliability of some of the speech audiometry results.

5.5 RECOMMENDATIONS FOR FUTURE RESEARCH

From the study, new research questions emerged. Recommendations for future research include the following:

- Research endevours specifically focussing on the separate influence of ART and Regime II on the hearing sensitivity of individuals with HIV/AIDS that might provide more in-depth information on the ototoxic effects of these drugs.

- Longitudinal research on the progression of hearing from stage I to stage IV of HIV/AIDS that may provide the audiologist with more definite information regarding the regression of hearing sensitivity associated with the progression of HIV/AIDS.

- Investigations on the hearing assessment findings in individuals with HIV/AIDS compared to their perception of the problem in order to provide information on the topics of information these individuals might need, but also to provide the audiologist with an approach to the assessment, management and education of individuals with HIV/AIDS.

- Research on the success and satisfaction rate of fitting hearing aids and assistive devices (FM-systems) on individuals with HIV/AIDS, specifically focussing on the emotional, social and communicative aspects before, during and after the fitting.

- Research to compare and determine a relationship or significant difference between the typical noise-induced hearing loss characterized at the present time with the types of hearing loss associated with HIV/AIDS.

- Research to determine the awareness, knowledge and skills of clinical audiologists and health care workers in private practice and the public health sector concerning audiological findings and management of individuals with HIV/AIDS.

- Assessment of auditory processing disorders among individuals with HIV/AIDS by conducting a full diagnostic APD test battery concerning the possible effects of fitting a FM-system to improve quality of life.

5.6 CLOSING STATEMENT

As audiologists, we are obligated to deliver quality service to any client that may cross our path. When graduating, we take an oath to fulfil our responsibility towards mankind to the best of our abilities. We declare that we will strive to maintain high standards and constantly improve our knowledge and skills and not let any political considerations cloud our performance (Faculty of Humanities, 2003). Therefore we have a responsibility… We have a responsibility towards ourselves and towards mankind, including individuals with HIV/AIDS. A responsibility to touch lives in the way we learnt to and the way we were meant to…

"Whoever acquires knowledge but does not practice it

is as one who ploughs but does not sow"

(Saadi, 1184-1291)

REFERENCES

Avert.org (2006). *World HIV & AIDS statistics*. Retrieved from http://www.avert.org/worldstats.htm (Date of access: 22 February 2006).

Arlinger, S. (1991). *Practical aspects of Audiology: Manual of Practical Audiology*. Volume 2. Whurr Publishers Ltd: London.

Bankaitis, A.E. (1998). An introduction to HIV/AIDS. *Seminars in Hearing*, 19(2): 117-129.

Bankaitis, A.E. & Keith, R.W. (1995). Audiologic changes associated with HIV infection. *ENT Journal*, 74: 353-359.

Bankaitis, A. E. & Schountz, T. (1998). HIV-related ototoxicity. *Seminars in Hearing*, 19(2): 155-163.

Bankaitis, A.E., Christensen, L.A., Murphy, O. And Morehouse, C.R. (1998). HIV/AIDS and auditory evoked potentials. *Seminars in Hearing*, 19(2):177-194.

Bless, C. & Higson-Smith, C. (1995). *Fundamentals of social research methods: An African Perspective*, 2nd ed. Kenwyn: Juta & Co, Ltd.

Chisholm, B. & Kredo, T. (2005). Antiretroviral therapy: The basics. *CME,* 23(5): 246-249.

Clark, A.L. (2004). *Otoacoustic emission testing in the early identification of noise-induced hearing loss in South African mineworkers.* Unpublished master's thesis. Pretoria: University of Pretoria.

Cohen, K. (2005). South African public sector adult antiretroviral treatment guidelines. *CME* 23(5): 250-254.

Conway, S. & Bartlett, J.G. (2003). *The 2003/2004 Southern African Abbreviated Guide to Medical Management of HIV Infection,* 1st ed. Johns Hopkins University, Division of Infectious Diseases JHU ID @ Lighthouse Point: Baltimore, USA.

Copeland, M. (2005). Turn down the volume. *TLC Magazine, South African Medical Association,* Autumn, 2005: 64-67.

Dane, F.C. (1990). *Research methods*. Brooks/Cole Publishing Company: Pacific Grove, California, USA.

De Andrade, V. and Ross, E. (2005). Beliefs and practices of Black South African traditional healers regarding hearing impairment. *International Journal of Audiology,* 44(9):489-499.

Debonis, D.A & Donohue, C.L. (2004). *Survey of Audiology: Fundamentals for audiologists and health professionals.* Pearson Education Inc: Boston, USA.

De Koker, E., Clark, A., Franz, R.M. & Mackay, J.G. (2003). *SIMRAC final report on project health 802. Feasibility of using oto-acoustic emission methods for screening early hearing impairment in South African mineworkers*. Safety in mines research advisory committee: South Africa. pp i-iii.

Department of Health. (2001). *World Summit in 2001: The record of proceedings, Communicable diseases HIV/AIDS and TB*. Retrieved from http://www.doh.gov.za (Date of access: 9 February 2007).

Department of Health. (2003). *Free health care services for disabled people now available*. Retrieved from http://www.doh.gov.za . (Date of access: 9 February 2007).

Department of Health. (2003). *Government communication and information system.* Retrieved from http://www.doh.gov.za. (Date of access: 9 February 9, 2007).

Department of Health. (2006). *Press release: More than 235 000 benifiting from ARV programme*. Retrieved from http://www.doh.gov.za (Date of access: 9 February,2007).

Department of Labour. (2000). *Employment Equity Act, Act no. 55 of 1998*. Code of Good Practice on Key Aspects of HIV/AIDS and Employment. South Africa: Pretoria.

Department of Labour (2005). *Labour Market Review 2005.* Retrieved from http://www.labour.gov.za (Date of access: 8 February 2007).

Doyle, J. (2002). *Practical Audiology for speech-language therapists.* Whurr Publishers Ltd: London, England.

Dunckley, K.T. and Dreisbach, L.E. (2004). Gender effects on high frequency distortion product Otoacoustic emissions in humans. *Ear and Hearing*, 25(6):554-564.

Easton, V.J. & McColl, H.M. Sta*tistics Glossary: Sampling.* Retrieved from http://www.stats.gla.ac.uk. (Date of access: 4 November 2006).

Edwards, A. (1980). Characteristics of noise-induced hearing loss in gold miners. Unpublished master's thesis. Pretoria: University of Pretoria.

Evian, C. (2000). *Primary AIDS care*, 3rd Ed. Jacana Education: Houghton.

Farham, B. (2005). Editor's comment: Where are we going? *CME*, 23(5):217.

Friedman, J.L., & Noffsinger, D. (1998). Hearing loss associated with HIV/AIDS: Social, Cultural, and Political Issues. *Seminars in Hearing*, 19(2): 205-213.

Fuzani, P.D. (1999). *The type, degree and prevalence of hearing lossin HIV positive black female patients, at various clinical stages of infection in South Africa.* University of Pretoria.

Gelfand, S.A. (2001). *Essentials of Audiology, 2nd edition*. Thieme: New York, Stuttgart.

Giddy, J. and Reid, S. (2003). Rural health matters: A broad overview of international, historical and current rural health issues in South Africa. *CME*, 21 (1):8-10.

Gold, S. & Tami, T.A. (1998). Otolaryngological manifestations of HIV/AIDS. *Seminars in Hearing*, 19(2): 165-175.

Haslett, C., Chilvers, E.R., Hunter, J.A.A & Boon, N.A. (1999). Principles and Practice of Medicine**,** *18th ed. Edinburgh, London, New York, Philadelphia, St. Louis, Sydney, Toronto, Churchill Livingstone.*

Hall, J.W. & Mueller, G.H. (1998). *Audiologists' Desk Reference*. 2nd ed. Volume I. Singular Publishing Group, Inc. San Diego.

Health Professions Council of South Africa. (2002) *Medical and Dental Board of the Health Proffessions Council of South Africa: Handbook Guidelines for good and ethical practice in medicine, dentistry and the medical sciences.*Pretoria.

Heywood, M. (2000). *A human rights approach to AIDS prevention at work: The Southern African Development Community's Code on HIV/AIDS and Employment.* Geneva, Switzerland: 1-60.

Johnsen, J.D. (1998). Legal support for patients and audiolgosits with HIV/AIDS. *Seminars in Hearing,* 19(2):215-226.

Kelly, B.R., Davis, D. & Hegde, M.N. (2001). Clinical Methods and Practicum in Audiology. Singular Publishing Group, Inc: San Diego, California.

Kemp, R.J. & Roeser, R.J. (1998). Infection control for audiologists. *Seminars in Hearing,* 19(2): 195-204.

Laubscher, A.M.U & Tesner, H.E.C. (1966). Enkellettergrepige woordelyste in Afrikaans. Ongepubliseerd. Departement Spraakheelkunde en Oudiologie. Pretoria.

Leedy, P.D. & Ormrod, J.E. (2001). *Practical research: Planning and dsign.* New Jersey: Prentice-Hall, Inc.

Lewis, M.S., Crandell, C.C., Valente, M., Enrietto, J., Kreisman, N.V., Kreisman, B.M and Bancroft, L. (2003). Study measures impact of hearing aids plus FM on the quality of life in older adults. *The hearing Journal*, 56(2): 30-34).

Lubbe, D.E. (2004). HIV and ENT. *CME,* 22(5): 250-253.

Maartens, G. (2005). The immune-compromised traveller. *CME*, 23(3): 126-129.

Martin, F.N. (1997). *Introduction to Audiology*, 6th ed. Boston, USA: Allyn & Bacon, 304.

Martin, F.N. & Clark, J.G. (2006). *Introduction to Audiology*, 9th ed. Boston, USA: Allyn & Bacon/ Pearson Education Inc.

Matkin, N.D., Diefendorf, A.O. & Erenberg, A. (1998). Children: HIV/AIDS and hearing loss. *Seminars in hearing*, 19(2): 143-153.

Mayosi, B.M. & Setsubi, O. (2003). Using best evidence in practice. *CME*, 21(9): 507.

Meintjies, G. and Rebe, K. (2004). Unexplained fever – an approach to defining the aetiology. *CME*, 22(4):180.

Mngadi, K. (2003). Palliative care in advanced HIV. *CME*: 21(5): 259-266.

MSD (1992). *The Merck Mannual*, 16th ed. Rathway, N.J: Merck Research Laboratories.

Musiek, F.E., Baran, J. A. & Pinheiro, M.L. (1994). Neuroaudiology: Case studies. Singular Publishing group, Inc: San Diego, California.

Neuman, W.L. (1997). *Social research methods: qualitative and quantitative approaches*, 3rd ed. Boston: Allyn & Bacon.

National Institute on Deafness and Other Communication Disorders (2006). *Presbycusis.* Retrieved from http://www.nidcd.nih.gov. (Date of access: 4 November 2006).

Occupational Health Services in South Africa, Chapter 19**.** Retrieved from http://www.hst.org.za. (Date of access: 8 February 2007).

Orrel, C. & Blockman, M. (2005). Antiretrovirals: Guest editorial. *CME,* 23(5): 220.

Orrel, C. & Wilson, D. (2003). The art of HAART: a practical approach to anti-retroviral therapy. *CME*, 21(6): 308-312.

Robinette, M.S & Glattke, T.J. (2002). Otoacoustic Emissions: Clinical Applications. 2nd Edition. Thieme: New York, Stuttgart.

Roeser, R.J., Valente, M. & Hosford-Dunn, H. (2002). *Diagnostic procedures in the professions of audiology, in Audiology Diagnosis,* eds R.J. Roeser, M. Valente & H.Hosford-Dunn. Thieme Medical Publishers, New York.

South African National Standards. (2000). *Guide to National and International Acoustics, Electro-Acoustics, Vibration and Ultrasonics Publication.* Pretoria.

Schountz, T. & Bankaitis, A.E. (1998). Basic anatomy and physiology of the immune system. *Seminars in Hearing*, 19(2): 131-141.

Scully, C. (2004). *Handbook of Oral Disease: Diagnosis and Management*, Revised edition. Martin Dunitz: London.

Singh, B. and Cohen, K. (2004). Common infections of the ear. *CME*, 22(4): 193-198.

Sininger, Y & Starr, A. (2001). *Auditory Neuropathy: A new perspective on hearing disorders,* Singular Thomson Learning: Canada.

South African.info reporter (2005). *Aids in SA 'starting to level off'*. Retrieved from http://www.southafrica.info (Date of access: 22 February 2006).

Spencer, D.C. (2005). *The Clinical Practice of HIV Medicine: A practical guide to the care of the HIV infected.* Goldstream books: Johannesburg: South Africa.

Stein, J. & Steinberg, M. (1995). *Response of the mining sector to the HIV/AIDS epidemic in the Southern Africa.* Report to the Human Resources Development Division, Economic Development Institute, World Health Organisation, 24-42.

Stevenson, B.L. (1993). *Hearing loss in human immunodeficiency virus infected subjects*. Unpublished thesis, Johannesburg.

Tanchel, I. (2003). Psychosocial issues in palliative care. *CME*: 21(5): 249-252.

Valente, M., Hosford-Dunn, H. & Roeser, R.J. (2000). *Audiology Treatment.* Thieme: New York, Stuttgart.

Valente, M., Hosford-Dunn, H. & Roeser, R.J. (2000). *Audiology Practice Management.* Thieme: New York, Stuttgart.

Venter, W.D., Ive, P. & Mmbara, N.W. (2005). *Long-term consequences of antiretroviral therapy. CME*, 23(5): 238-24.

Willemse, I. (1994). *Statistical Methods and Financial Calculations.* 2nd ed. Juta & Co Ltd: Kenwyn.

Williamson, I. (2004). Hearing loss. *UPDATE*: *The journal of continuing education for general practitionars*, XXI(8): 24-26.

Wood, R. (2005). New Antiretrovirals: What is on the way? *CME*, 23(5): 255-259. retrieved February 8, 2007, from http://www.alp.org.za and from http://www.doh.gov.za).

APPENDIX A

RESEARCH PROPOSAL/COVERLETTER TO THE ETHICAL BOARD OF KLERKSDORP/TSHEPONG HOSPITAL COMPLEX

University of Pretoria

Department of Communication Pathology
Speech, Voice and Hearing Clinic

Tel : +27 12 420 2357
Fax : +27 12 420 3517

To: Chairman of the Ethical Board of Klerksdorp/Tshepong Hospital Complex

CC: Dr Mfikwe (Medical Manager – East wing)

Dr Luke (Medical Manager – West Wing)

Ethical board of Klerksdorp Hospital

RE: RESEARCH PROJECT: A HEARING PROFILE OF PERSONS INFECTED WITH AIDS

My name is Maria de Lange. I am a qualified Speech Therapist and Audiologist and also an employee at Klerksdorp/Tshepong Hospital Complex. I am currently doing my Masters study in Communication Pathology at the University of Pretoria. To complete this Masters Degree successfully, I must conduct a research project.

This modern society contains an enormous amount of high-risk situations that can raise many atypical and unique problems for people. Recent statistics show that the prevalence of HIV/AIDS increased over the past few years. The researcher considered that this infection might lead to a faster decrease in hearing thresholds and possible retro-cochlear (neural) damage. This will have enormous implications for various issues related to hearing aid fittings:

1. **Aural Rehabilitation:** The current aural rehabilitation protocol should be adjusted to ensure optimal amplification even with the regression of hearing in a certain time frame.

2. **Financial Implications:** This also means that a more economical approach to hearing aid fittings could be followed in the Public Health Sector, meaning that hearing aids should be selected with the prediction that the hearing thresholds of the patient might deteriorate after the initial fitting has taken place.

3. **Hearing Aid Technology:** It could lead to the manufacturing of hearing aids with a larger fitting range that could be adjusted when hearing thresholds of a person infected with HIV worsen, in order to provide enough amplification and not having to fit brand new hearing aids each time the person's HIV/AIDS condition progresses to the following clinical stage.

4. **Medical Treatment:** Awareness of middle ear conditions leading to conductive hearing losses will increase. This will lead to better identification and treatment of these conditions and less interference of these conditions in aural rehabilitation.

The goal of the research is to determine the average range of hearing loss at a particular clinical stage of HIV/AIDS. The research will be conducted as follows:

1. Three different medical doctors working at the Wellness Clinic (Tshepong), Antenatal Clinic (Klerksdorp) and Park Street Clinic will be identified to be involved in the research project.

2. Each Medical Doctor will receive training in what is expected from them for the purpose of the research project.

3. Informed voluntary written consent will be obtained from each subject. Patients will not be included in the study if they do not want to participate. Consent may be withdrawn freely should the hospital, the patient or the medical doctors and staff nurse decide to do so.

4. The medical doctor will complete a referral card for those patients who gave their voluntary informed consent to participate in the research project. This will take the doctor less than 5 minutes per patient. The information necessary to complete the referral card will be obtained from the medical file and previous blood results. It will not be necessary to obtain more blood samples.

5. These patients will be referred to the Audiology Department.

6. The data collection will take place by collecting a complete patient history, an otoscopic examination and full diagnostic audiological test procedures that include, pure tone

audiometry, speech audiometry, immitance and Oto-acoustical emissions and Auditory Brainstem response. The blood results (CD4+ cell count and presence of HIV-defined illnesses) collected for the purpose of adjusting the ART will be obtained by the medical doctors and written on the referral card.

7. Data will by analysed. This research project will be cross-sectional in nature which, means that it involves one measurement of different groups that represent different time periods. The different groups will each undergo basic and specialized audiological testing. The results will be grouped into the 4 clinical stages of HIV infection, depending on the stage of the person who was tested. Each stage will then be divided into persons who have not yet received any medicinal treatment and those who have received treatment for this infectious disease. The results will be compared and correlations will be identified.

8. Results will be interpreted. Correlations will be drawn between the audio results, the different stages of HIV infection and between those who have received ART therapy and anti-TB drugs (Regime I and Regime II consecutively), and those who have not yet received these drugs.

9. Patient confidentiality is ensured at all times. The results will be discussed in a research thesis as an aggregate and not on an individual basis. All the results will be handled strictly confidentially even during the publication of the research results.

10. The results of the research project will be available upon request.

11. I guarentee that the research process will be transparent throughout the progress of the research project and that the research will be liable to informed consent from the hospital, patient, doctor, nurse and the Research Committee and Ethics Committee of the University of Pretoria.

12. A medical doctor will be consulted regarding the condition of a patient in stage IV (patient with AIDS) in order to provide a medical opinion regarding the appropriateness of intervention in terms of hearing aid fittings. Furthermore, the patients who will benefit from hearing aids will be fitted as soon as possible and if not immediately, they will be placed on the waiting list to receive hearing aids.

The information obtained through this research project will be used to write a thesis and a research article. A copy of the research article will be made available to this Complex after the

project is finished. Klerksdorp/Tshepong Hospital Complex as well as the medical doctors involved in the research project will be acknowledged for their participation in the project. **Keep in mind that nowhere in the world has this research been done before. The results obtained from this project will therefore be of great value in countries where people are battling with HIV.**

The patients will also be assisted in the sense that their hearing disability will be identified and intervention will take place in terms of hearing aid fittings, auditory training therapy and regular follow-up care. Not only will this improve our status as second best Wellness Clinic in our country, but it will also ensure improved care for the HIV patients.

This Hospital Complex is under no obligation to participate in the study. Should you decide to participate in the study, please complete the consent letter below.

If you need further information or have any inquiries regarding the research project, please contact the researcher at 082 427 8236. The researcher will answer any additional questions you may have.

Thank you in advance for the time you took to read this letter.

Kind regards

_____

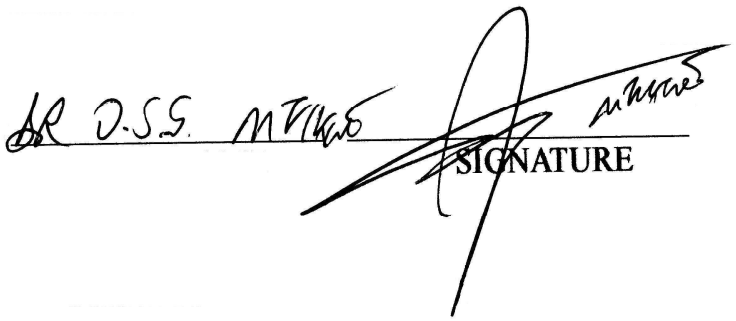
Maria de Lange
(Audiologist and Researcher)

I hereby give my permission that Mrs M. de Lange may:

1. proceed with the research project in Klerksdorp/Tshepong Hospital Complex;
2. may have access to the personal information in the medical files of the patients;
3. may use the Audiology Department's available equipment to conduct the necessary tests;
4. conduct the necessary audiological tests which include basic audiometry, Immitance measurements, Auditory Brainstem Response, Oto Acoustical Emissions, Otoscopic examinations;
5. make use of the services of three of the medical doctors (working in the Wellness Clinic, MOPD and antenatal clinic) employed by this Hospital Complex to obtain information such as CD4+ count and the presence of HIV/AIDS-defined illnesses;
6. involve only the patients whom voluntarily made an informed choice to participate in the research project;

On the following condition:

7. A medical doctor will be consulted regarding the condition of a patient in stage IV (patient with AIDS) in order to provide a medical opinion regarding the appropriateness of intervention in terms of hearing aid fittings. Furthermore, the patients who will benefit from hearing aids will be fitted as soon as possible and if not immediately, they will be placed on the waiting list to receive hearing aids.



CHAIRMAN OF ETHICAL BOARD

APPENDIX B

ETHICAL CLEARANCE FROM THE RESEARCH PROPOSAL AND ETHICS COMMITTEE OF THE FACULTY OF HUMANITIES, UNIVERSITY OF PRETORIA

University of Pretoria
Research Proposal and Ethics Committee
Faculty of Humanities

18 August 2005

Dear Dr Soer

Project:	***A hearing profile of persons infected with Acquired Immune Deficiency Syndrome (AIDS)***
Researcher:	**M de Lange**
Supervisor:	**Dr ME Soer**
Department:	**Communication Pathology**
Reference Number:	**9900963**

Thank you for the application you submitted to the Research Proposal and Ethics Committee, Faculty of Humanities.

I have pleasure in informing you that the Research Proposal and Ethics Committee formally approved the above study on 28 July 2005. The approval is subject to the candidate abiding by the principles and parameters set out in her application and research proposal in the actual execution of the research.

The committee requests you to convey this approval to the candidate.

We wish you success with the project.

Sincerely

Professor Brenda Louw
Chair: Research Proposal and Ethics Committee
Faculty of Humanities
UNIVERSITY OF PRETORIA

APPENDIX C

COVER LETTER: INFORMED CONSENT FROM THE HOSPITAL MANAGEMENT AND THE POTENTIAL RESEARCH ASSISTANTS

University of Pretoria

Department of Communication Pathology
Speech, Voice and Hearing Clinic

Tel : +27 12 420 2357
Fax : +27 12 420 3517

2006-02-28

To: **The Medical Doctor and Staff Nurse working in the Wellness Clinic, Antenatal Clinic and Park Street Clinic**

CC: Dr Luke (Medical Manager – West Wing)

Dr Mfikwe (Medical Manager – East Wing)

RE: RESEARCH PROJECT: A HEARING PROFILE OF PERSONS INFECTED WITH AIDS

My name is Maria de Lange. I am a qualified Speech Therapist and Audiologist and also an employee at Klerksdorp/Tshepong Hospital Complex. I am currently doing my Masters study in Communication Pathology at the University of Pretoria. To complete this Masters Degree successfully, I must conduct a research project.

This modern society contains an enormous amount of high-risk situations that can raise many atypical and unique problems for people. Recent statistics show that the prevalence of HIV/AIDS increased over the past few years. The researcher considered that this infection might lead to a faster decrease in hearing thresholds and possible retro-cochlear (neural) damage. This will have enormous implications for various issues related to hearing aid fittings:

1. **Aural Rehabilitation:** The current aural rehabilitation protocol should be adjusted to ensure optimal amplification even with the regression of hearing in a certain time frame.

2. **Financial Implications:** This also means that a more economical approach to hearing aid fittings could be followed in the Public Health Sector, meaning that hearing aids should be selected with the prediction that the hearing thresholds of the patient might deteriorate after the initial fitting has taken place.

3. **Hearing Aid Technology:** It could lead to the manufacturing of hearing aids with a bigger larger range that could be adjusted when hearing thresholds of a person infected with HIV worsen, in order to provide enough amplification and not having to fit brand new hearing aids each time the person's HIV/AIDS condition progresses to the following clinical stage.

4. **Medical Treatment:** Awareness of middle ear conditions leading to conductive hearing losses will increase. This will lead to better identification and treatment of these conditions and less interference of these conditions in aural rehabilitation.

The goal of the research is to determine the average range of hearing loss in a particular clinical stage of HIV/AIDS. The research will be conducted as follows:

1. Should you decide to be part of the research project, you will have to give written consent and there after you will receive training in what is expected from you for the purpose of the research project.

2. The staff nurse will need to re-determine whether or not a patient wants to participate prior to the doctor completing the referral card. The staff nurse must also assist the medical doctor by interpreting the message when information must be obtained.

3. The medical doctor will complete a referral card for those patients who gave their voluntary informed consent to participate in the research project. The completion of the referral card will take you approximately 5 minutes or less. The information will be obtained from the medical file and from the blood results taken for the purpose of monitoring the progress of the HIV virus and adjustments of medication. Thus, no more blood tests will be needed. Only the results of the blood tests that have already been done will be used.

4. After the referral card is completed, either the staff nurse or the medical doctor will refer these patients to the Audiology Department by handing the referral card to the patient and sending the patient to the Audiology Department. From this point on the research will be done by Audiologist.

The rest of the data collection will be as follows:

5. The data collection will take place by collecting a complete patient history, an otoscopic examination and full diagnostic audiological test procedures that include, pure tone audiometry, speech audiometry, immitance and Oto acoustical emissions and Auditory Brainstem response. The blood results (CD4+ cell count and presence of HIV-defined illnesses) collected for the purpose of adjusting the ART will be obtained by the medical doctors and written on the referral card.

6. Data will by analysed. This research project will be cross-sectional in nature which means that it involves one measurement of different groups that represent different time periods. The different groups will each undergo basic and specialised audiological testing. The results will be grouped into the 4 clinical stages of HIV infection, depending on the stage of the person who was tested. Each stage will then be divided into persons who have not yet received any medicinal treatment and those who have received treatment for this infectious disease. The results will be compared and correlations will be identified.

7. Results will be interpreted. Correlations will be drawn between the audio results, the different stages of HIV infection and between those who have received ART and anti-TB drugs (Regime I and Regime II consecutively), and those who have not yet received these drugs.

8. Patient confidentiality is ensured at all times. The results will be discussed in a research thesis as an aggregate and not on an individual basis. All the results will be handled strictly confidentially even during the publication of the research results.

9. The results of the research project will be available upon request.

10. I guarantee that the research process will be transparent throughout the progress of the research project and that the research will be liable to informed consent from the hospital, patient, doctor, nurse and the Research Committee and Ethics Committee of the University of Pretoria.

The information obtained through this study will be used to write a thesis and a research article. A copy of the research article will be available on request after the project is finished. Klerksdorp/Tshepong Hospital Complex as well as the medical doctors involved in the research project will be acknowledged for their participation in the project. **Keep in mind that nowhere**

in the world has this research been done before. The results obtained from this project will therefore be of great value in countries where people are battling with HIV.

The patients will also be assisted in the sense that their hearing disability will be identified and intervention will take place in terms of hearing aid fittings, auditory training therapy and regular follow-up care. Not only will this improve our status as second best Wellness Clinic in our country, but it will also ensure improved care for the HIV patients.

You are under no obligation to participate in the study. Should you decide not to participate any more, you can feel free to withdraw your consent. Should you decide to participate in the study, please complete the consent letter below. If you need further information or have any inquiries regarding the research project, please contact the researcher at 082 427 8236. The researcher will answer any additional questions you may have.

Thank you in advance for the time you took to read this letter.

_____

Maria de Lange
(Audiologist and Researcher)

CONSENT LETTER FOR THE MEDICAL DOCTORS (SAMPLE)

I, Dr. _____ from MOPD clinic/ Antenatal clinic/ Wellness clinic, hereby give my full voluntary consent to:

1. participate in the research project of Mrs M. de Lange to determine a hearing profile for persons infected with HIV/AIDS;
2. thoroughly complete the necessary referral cards indicated by the researcher;
3. re-determine if a subject still wants to participate in the research project prior to completing the referral card and referring the subject to the researcher.
4. involve only the patients whom voluntarily made an informed choice to participate in the research project;
5. keep strict doctor-patient confidentiality at all times and be obliged by normal ethical conduct;
6. make use of a staff sister/nurse who is also part of the research project to serve as an interpreter when a subject does not cope with the language being used.

Yes € No €

_____ _____

PRINT NAME **SIGNATURE**

_____

CONSENT LETTER FOR THE STAFF SISTER

I, Sr/ Nurse _____ from MOPD clinic/ Antenatal clinic/ Wellness clinic, hereby give my full voluntary consent to:

Participate in the research project of Mrs. M. de Lange to determine a hearing profile for persons infected with HIV/AIDS;

Involve only the patients whom voluntarily made an informed choice to participate in the research project;

Keep strict patient confidentiality at all times and be obliged by normal ethical conduct;

Serve as an interpreter when a subject does not cope with the language being used.

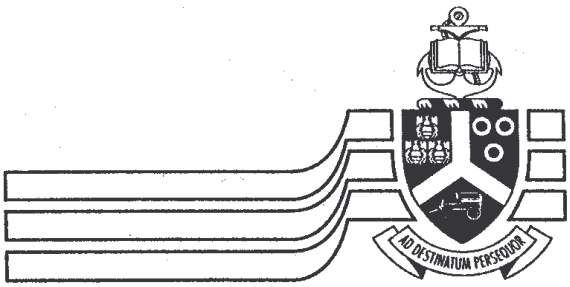
Yes € No €

_____ _____

PRINT NAME **SIGNATURE**

APPENDIX D

COVER LETTER: INFORMED CONSENT FROM THE POTENTIAL PARTICIPANTS



University of Pretoria

Department of Communication Pathology
Speech, Voice and Hearing Clinic
Tel : +27 12 420 2357
Fax : +27 12 420 3517

2006-02-28

Dear Patient

My name is Maria de Lange. I am a qualified Speech Therapist and Audiologist. I am currently doing my Masters study in Communication Pathology at the University of Pretoria. To complete this Masters Degree successfully, I must conduct a research project.

Currently our daily living encompasses an enormous number of problem situations that can cause us inconvenience. Illnesses such as HIV/AIDS infections, TB and Syphilis have increased over the past few years. It is possible that these infections might lead to hearing loss (deafness) that will worsen over a short period of time.

The goal of this research is to determine the effect HIV infection and AIDS have on your ability to hear. The researcher will determine this by testing your ability to hear different sounds at Klerksdorp Hospital through various tests and by using the results of blood and other medical tests that are available in your hospital file. No additional blood and medical tests will be required for the purpose of this study.

Should you decide to participate in this research project, you will undergo various non-invasive hearing tests once. These hearing tests include a test requiring a response from you when you hear a certain noise, as well as 3 tests where you do not have to respond. These hearing tests will be conducted for free, and should you have a hearing loss, the researcher will fit you with appropriate hearing aids and also enter you for auditory training therapy, provided you are interested. It also involves the researcher studying your medical files for information regarding your health and the blood tests that were taken for your follow-up sessions at the various

clinics, as well as your undergoing a medical examination performed by a qualified medical doctor.

It is important that you should know that no other patient or staff member that does not work with your file in the Wellness Clinic will ever know your medical results and your name. All the results will be handled strictly confidentially. Therefore no-one else will know whether you have a hearing loss or not, or whether you are HIV positive or not. Your participation in this study will not in any way influence you, your relationship with your friends, family or your colleagues at work because they will not know the results of the various tests.

The information obtained through this study will be used to write a thesis and a research article. **YOUR NAME WILL NOT BE INDICATED IN THE THESIS OR RESEARCH ARTICLE.** A copy of the research article will be available on request after the project is completed

You are under no obligation to participate in the study. Should you decide not to participate anymore, you can feel free to withdraw your consent. Should you decide to participate in the study, please complete the consent letter below. If you need further information or have any inquiries regarding the research project, please contact the researcher at 082 427 8236. The researcher will answer any additional questions you may have.

Thank you in advance for the time you took to read this letter.

_____

Maria de Lange
(Audiologist and Researcher)

Consent Letter (Sample)

I, _____ consent to participate in the research project: "*A hearing profile of persons infected with Acquired Immune deficiency syndrome(AIDS).*"

- I am aware that under no circumstances will my participation in this study influence my relationship with my doctor, friends and family.
- I am aware that I will need to consult with my audiologist and doctor.
- I give permission that my audiologist my consult with my doctor to obtain the necessary medical information regarding my health condition and other information written in my medical file.
- I am also aware that hearing tests will be performed by the researcher.
- I am aware that the results will be handled strictly confidentially;
- I am aware that I am under no pressure to give my consent to participate in this study and that I could withdraw my consent at any given point in time during the research project.

_____ _____

(Signature of participant) **(Date)**

APPENDIX E

REFERRAL CARD

KLERKSDORP/TSHEPONG HOSPITAL COMPLEX

RESEARCH PROJECT

REFERRAL CARD

Referred from: _____Medical doctor: _____

Please indicate the CD4 cell count of the patient gained from the blood tests:

CD4 cell count	X
More than 500-600cells / mm³	
350-500 cells / mm³	
200-350 cells / mm³	
Less than 200 cells / mm³	

Please indicate which of the following conditions and symptoms define the patient's current clinical condition:

Clinical conditions/symptoms	X
Fever	
Malaise	
Headache	
Fatigue	
Weight loss	
Diarrhoea	
Lymphadenopathy	
Wasting	
Oral Candida/Mouth ulcers	
Splenomegaly	
Bacterial septicaemia	
M.tuberculosis infection	

Toxoplasmosis	
Cryptococcosis	
Kaposi's sarcoma	
Pneumonitis	
Encephalitis	
Non-Hodgkin's lymphoma	
Herpes Zoster	
Neurosyphilis	
Brain abscess	
Meningitis	
Myelopathy	
Other STDs	
Otological infections or hearing complaints	
None	

Please indicate the spectrums of diseases noted in the patient:

Spectrum of disease	X
Skin diseases	
Oral diseases	
Small bowel diseases	
Lung diseases	
Nervous system diseases	
Otolaryngological manifestations	
None	

History of TB-Treatment

(Please note in the provided space how many times the patient was placed on the various TB treatments)

Treatment	X
Regime I	
Regime II (Streptomycin)	
MDR (Amikacin and Streptomycin)	
No history	

History of medical therapy (ART

Treatment	X
ARVD	
No treatment	

ART treatment commenced on:

_____

ART administration:

Treatment	X
Less than 6 months	
Longer than 6 months	
Longer than 12 months	
No treatment	

APPENDIX F

STRUCTURED INTERVIEW

KLERKSDORP/TSHEPONG HOSPITAL COMPLEX

RESEARCH PROJECT

CASE HISTORY INFORMATION

SECTION A: DEMOGRAFIC INFORMATION

1. **Gender of the subject**

Gender	X
Male	
Female	

2. **Age of patient**

Age group	X
18-20 years	
21-30 years	
31-40 years	
41-50 years	

3. **The racial group of the patient:**

Race	X
Black	
Coloured	
Caucasian	
Asian/Indian	

4. **Referred from:**

Referral Clinic	X
Wellness	
ANC	
Park Street	
MOPD	
MDR-TB	
Other	

SECTION B: CLINICAL INFORMATION

5. **Retro-viral status of the patient:**

RVD	X
Reactive	
Non-reactive	

6. **The RVD clinical stage of the patient:**

Clinical stage of RVD	X
Stage 1	
Stage 2	
Stage 3	
Stage 4	

7. **Does the patient have a possible history of Otitis media/Otitis extern? Please indicate which symptoms the patient exhibited in the past?**

History of Otitis media/externa	X
No symptoms	
Otalgia	
Otorhea	
Itching ears	

8. **Was grommets ever inserted into the patient's ear prior to being diagnosed with HIV/AIDS?**

History of Grommets	X
Received grommets	
No grommets	

9. **Has the patient ever undergone any surgery in his/her ear, nose or throat prior to being diagnosed with HIV/AIDS?**

History of ENT surgery	X
ENT surgery	
No ENT surgery	

10. **If yes, what kind of surgery did the patient have and why?**

_____

_____

11. **Does the patient have a history of trauma or assault to his/her head/ear?**

History of Trauma	X
Head injury	
Assault	
None	

12. **Does the patient currently have any Otological complaints?**

Otological Complaints	X
Otalgia	
Otorhea	
Loss of hearing	
Vertigo	
Tinnitis	
Dysacusis	
Itching ears	
No complaints	
Other	

13. **In case of other complaints, please list:**

_____

_____

14. **Does the patient have a history of any Otological complaints prior to being diagnosed with HIV/AIDS?**

Otological Complaints	X
Otalgia	
Otorhea	
Loss of hearing	
Vertigo	
Tinnitis	
Dysacusis	
Itching ears	
No complaints	
Other	

15. **In case of other complaints, please list:**

_____

_____

16. **Does the patient display certain characteristics that may have caused cochlear damage?**

Causes of cochlear hearing loss	X
History of ototoxicity (non HIV/AIDS related)	
Head trauma	
Baro-trauma	
Exposure to high noise levels	
None	

SECTION C: OCCUPATIONAL HISTORY

17. What type of profession does the patient practise?

Profession	X
Mineworker	
Mechanic	
Taxi Driver	
Contractor	
Gardener	
Domestic worker	
School Teacher/Lecturer	
Community worker	
Cleaner	
Company Representative	
Unemployed	
Other	

18. If the option "other" is selected, please specify:

_____

_____

19. Did the patient ever work in a noisy environment and did he/she wear hearing protectors?

Occupational history/Noise exposure	X
Working in noise	
No history of working in noise	

20. Does the patient exercise a hobby involving extreme noise exposure?

Hobby: Noise exposure	X
Yes	
No	

SECTION D: OTHER RELEVANT INFORMATION

21. **Does the patient have a relevant family history of hearing loss?**

Family history of hearing loss	X
Yes	
No	

22. **Does the patient have a congenital hearing loss?**

Congenital hearing loss	X
Yes	
No	

23. **Does the patient have any genetic condition that may cause a hearing loss?**

Genetic condition	X
Yes	
No	

24. **Did the patient give his/her full voluntary informed consent to participate in this study?**

Voluntary consent	X
Yes	
No	

APPENDIX G

AUDIOGRAM

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

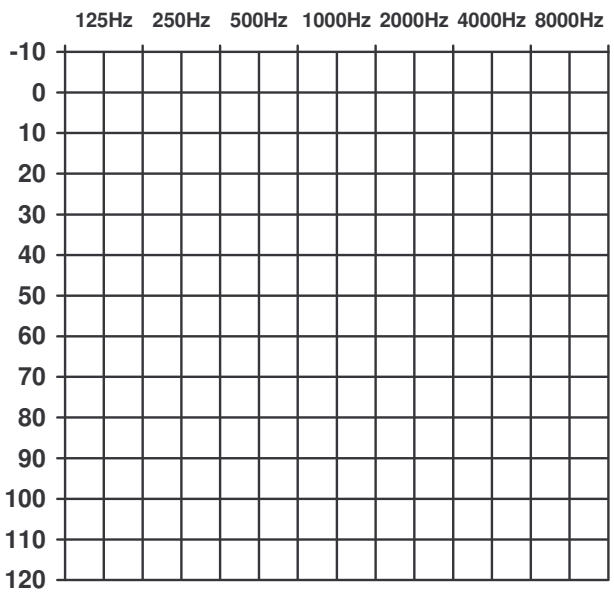
KLERKSDORP/TSHEPONG HOSPITAL COMPLEX

RESEARCH PROJECT

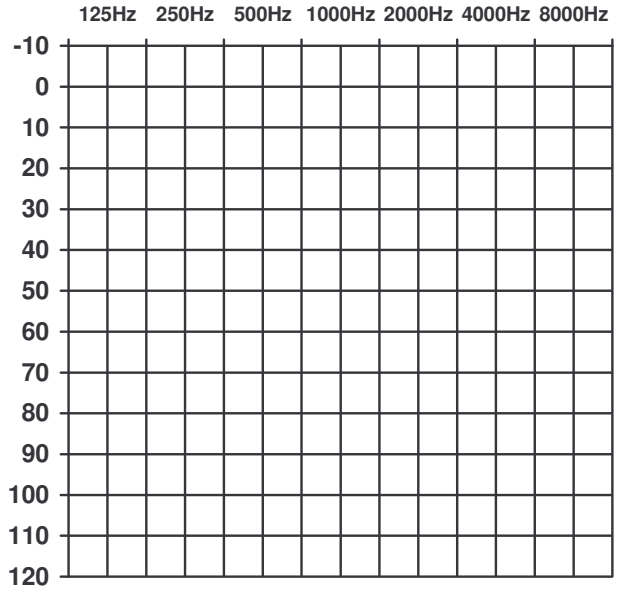
AUDIOGRAM

SYMBOL ALLOCATED

Left ear



Right ear

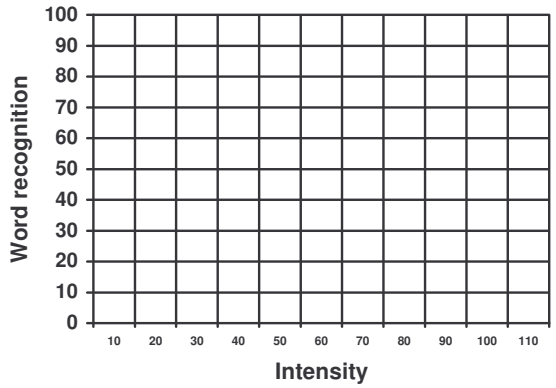


	125	250	500	1000	2000	4000	8000
AC							
BC							

MASKING

	125	250	500	1000	2000	4000	8000
AC							
BC							

Speech Audiogram



Thresholds	Left	Right
PTA		
SRT		
SD		
DPOAE		
6000Hz		
5000Hz		
4000Hz		
3000Hz		
2000Hz		
1000Hz		

APPENDIX H

OTOSCOPIC EXAMINATION CHECKLIST

KLERKSDORP/TSHEPONG HOSPITAL COMPLEX

RESEARCH PROJECT

OTOSCOPIC EXAMINATION

SECTION A: EXTERN AUDITORY MEATUS

1.1. Cerumen

Wax	X
None	
Soft, wet, yellow-brown	
Flakes, dry	
Wax Block	

1.2. Otitis Extern

Otitis Extern	X
None	
Otalgia	
Inflammation	
Debris	
Blood	
Discharge/ Otorhea	
Fungus/ Otomycosis	

1.3. Unfamiliar objects

Objects	X
None	
Foreign bodies	

1.4. Tumors

Type	X
None	
Osteomas	
Kaposi sarcoma	

1.5. Other conditions of the EAM:

Conditions	X
None	
Atresia	
Coleste atoma	
Stenosis	
Hematoma	

SECTION B: TYMPANIC MEMBRANE

2.1. Landmarks/ phenomena on Tympanic membrane

Tympanic membrane	X
Perforation	
Light reflex	
Malleus	
Short process of Malleus	
Tympanoscleroses	
Thickened / scarred	

2.2. Colour of Tympanic membrane

Characteristic	X
Pearl white/grey	
Yellow/Amber	
Red (Myringitis/inflamed)	

2.3. Transparency of Tympanic membrane

Characteristic	X
Transparent	
Dull/Dark	

2.4. Position of the Tympanic membrane

Characteristic	X
Retracted	
Normal	
Bulged	

APPENDIX I

SPONDAÏC WORDLISTS IN ENGLISH AND AFRIKAANS

KLERKSDORP/TSHEPONG HOSPITAL COMPLEX

AUDIOLOGY DEPARTMENT

SPONDAIC WORDLIST / ENGLISH

CID Auditory Test W-I as established by Technisonic Studios and the Central Institute for the Deaf

obtained from Martin (1997:475)

greyhound	padlock	playground
schoolboy	mushroom	airplane
inkwell	hardware	woodwork
whitewash	workshop	oatmeal
pancake	horseshoe	toothbrush
mousetrap	armchair	farewell
eardrum	baseball	grandson
headlight	padlock	drawbridge
birthday	mushroom	doormat
duckpond	hardware	hothouse
sidewalk	workshop	daybreak
hotdog	horseshoe	Sunset

	Left	Right
PTA		
SRT		

KLERKSDORP/TSHEPONG HOSPITAL COMPLEX

AUDIOLOGY DEPARTMENT

SPONDAIC WORDLIST / AFRIKAANS

handsak	speelgoed	roomys
yskas	sonskyn	roosboom
slaaibak	roomys	seilskip
huisvrou	seilskip	laaikas
spierwit	yskoud	reënboog
laaikas	rusbank	sitplek
reënboog	boomstam	grasgroen
sitplek	beesvleis	beesvleis
grasgroen	voetbal	vliegtuig
voordeur	bloedrooi	koekblik
kleingeld	handskoen	voordeur
leesboek	goudgeel	kleingeld

	Links	Regs
PTA		
SRT		

APPENDIX J

PHONETICALLY BALANCED WORDLISTS

IN ENGLISH AND AFRIKAANS

KLERKSDORP/TSHEPONG HOSPITAL COMPLEX

AUDIOLOGY DEPARTMENT

PHONETICALLY BALANCED WORDLIST/ ENGLISH

(CID Auditory Test W-22 as established by Technisonic Studios and the Central Institute for the Deaf obtained from Martin (1997:476)

	an	ewe	your	cars	book	tie	fish	catch
	yard	as	been	tree	when	do	pen	ink
	carve	wet	way	thumb	arm	end	key	pin
	us	chew	chest	cat	are	shove	roof	plate
	day	see	case	live	camp	have	hat	dial
	toe	deaf	smart	show	use	owes	roll	mix
	felt	then	gave	hurt	done	yes	phone	let
	stove	five	few	own	this	made	good	dog
	hunt	true	odd	key	farm	knit	cat	nail
	ran	Isle	move	oak	smooth	on	house	hit
	knees	oar	knew	off	he	if	sit	north
	not	law	jaw	ill	pie	raw	can	watch
	men	me	one	rooms	cream	clove	yet	high
	low	nun	hit	ham	oil	then	why	line
	owl	jam	sing	star	three	doll	bread	at
	it	poor	sent	eat	lie	though	tin	ride
	she	him	else	west	out	chair	cook	swim
	high	skin	tear	thing	is	we	knows	leg
	there	east	does	flat	say	ate	tea	sail
	corn	thing	to	wall	nest	year	save	head
	twins	dad	cap	buy	tan	all	hang	fork
	could	up	with	water	ears	wood	leave	tooth
	what	bells	air	bill	start	at	nut	knife
	bath	wire	and	add	light	where	so	love
	ice	ache	young	self	cute	chin	they	faith
% words correct								
L/R,Freefield								
Audiometer intensity								
HA model								
HA volume								
+/-lip reading								

KLERKSDORP/TSHEPONG HOSPITAL COMPLEX

AUDIOLOGY DEPARTMENT

WORDLIST FOR ABOVE THRESHOLD TEST / AFRIKAANS

	vlieg	brief	brood	vryf	een	vlag	brug	vroeg
	brand	eers	oop	praat	vriend	lets	eet	brul
	om	fraai	vroeg	vars	volg	vrag	vel	aand
	diens	vroeg	volk	beurt	blou	bruin	vlam	vleis
	klomp	drink	blind	dier	broer	droog	breuk	draai
	vra	rand	droom	klaar	deur	dank	diep	klaar
	koel	kraal	klein	druk	Klam	klink	krap	dink
	lof	kleur	kry	leer	lyf	les	loop	kort
	langs	lig	lag	krag	kloof	klim	klop	leuen
	hy	spring	plank	snaaks	vaal	lank	stoom	lomp
	staan	jaar	tree	los	skerp	skrif	swart	stert
	spuit	stroom	stil	hang	groen	skoon	spreek	hoof
	rak	haar	heel	hand	seep	hok	huis	self
	hulp	reën	huil	noem	paal	rok	hof	hark
	weet	hart	roep	streep	hier	half	roem	res
	reël	ruk	reg	traan	rug	maan	ring	woon
	moet	woes	nes	rond	raak	wat	riel	rand
	werd	weg	mond	mark	wol	merk	meer	werk
	neef	maat	mou	grap	maand	tong	wa	mos
	hart	jonk	teen	trok	was	perd	nog	my
	gras	neus	pos	ja	moes	prys	jaar	niks
	trap	groot	pluk	reus	tree	teer	plaas	peer
	tog	trek	groei	wen	plaat	jy	trou	plank
	plek	plan	weef	wind	nes	nee	groet	kort
	berg	staar	waar	erg	prop	golf	treur	trein
% woorde korrek								
L/R,vryeveld								
Oudiometer intensiteit								
GA model								
GA volume								
+/-lip lees								

APPENDIX K

HEARING INTERPRETATION RECORDING FORM

KLERKSDORP/TSHEPONG HOSPITAL COMPLEX

RESEARCH PROJECT

HEARING PROFILE FINDINGS

SYMBOL ALLOCATED TO PATIENT:

SECTION A: HEARING TEST BATTERY

FOR OFFICE USE ONLY

BACKROUND INFORMATION

1.1. Gender of participant

Gender	Yes	No
Male		
Female		

1	
2	

1.2 Age of participant

Age	Yes	No
18 to 30 years		
31 to 40 years		
41 to 50 years		

3	
4	
5	

1.3 Current CD4+ cell count of subject

CD4 cell count	Yes	No
More than 500-600cells / mm^3		
350-500 cells / mm^3		
200-350 cells / mm^3		
Less than 200 cells / mm^3		

6	
7	
8	
9	

1.4 Current clinical stage of HIV infection

Clinical stage	Yes	No
Stage 1		
Stage 2		
Stage 3		
Stage 4		

10	
11	
12	
13	

1.5 Exposure to ototoxic medication

Drugs	Yes	No		
MDR / Regime II (streptomycin/Amikacin)			14	
ART			15	
ART and MDR/Regime II			16	
No exposure			17	

1.6 In case of ART administration, please indicate time period

ART	Yes	No		
No exposure			18	
Less than 3 months			19	
3 to 6 months			20	
Longer than 6 months			21	
Longer than 12 months			22	

MEDICAL BACKGROUND INFORMATION / CASE HISTORY

2.1 Current otological complaints of participants

Complaints	Yes	No		
Otalgia			23	
Otorhea			24	
Loss of hearing			25	
Vertigo			26	
Tinnitis			27	
Dysacusis			28	
Itching ears			29	
No complaints			30	
None			31	

2.2 Previous otological complaints of participants since diagnosed with HIV/AIDS

Complaints	Yes	No		
Otalgia			32	
Otorhea			33	
Loss of hearing			34	
Vertigo			35	
Tinnitis			36	

Dysacusis			37
Itching ears			38
No complaints			39
None			40

2.3 If yes, please describe:_____

2.4 Disease spectrum participant presents with:

Spectrum	Yes	No	
Skin diseases			41
Oral diseases			42
Small bowel diseases			43
Lung diseases			44
Nervous system diseases			45
Otolaryngological diseases			46

2.5 If yes, please specify:_____

OTOSCOPIC EXAMINATION

3.1 Indicate the condition of the ear canal:

Characteristics	L	R		L	R
Normal, soft wax			47		
Flakes, dry			48		
Wax block (complete)			49		
Inflammation, oedema, red			50		
Blood			51		
Otorhea			52		
Fungus/Otomycosis			53		
Foreign body			54		
Osteomas			55		
Hematoma			56		

3.2 Indicate the condition of the tympanic membrane:

Characteristics	L	R		L	R
Normal, pearl white					

Perforation		
Dull, retracted/ bulged		
Transparent		
Tympanoscleroses		
Scarred/ Thickened		
Inflamed, yellow		
Red (Myringitis)		

57		
58		
59		
60		
61		
62		
63		
64		

PURE TONE AIR-AND-BONE AUDIOMETRY

4.1 Type and nature of hearing according to pure tone test results at 250Hz to 1000 Hz (Low frequencies):

Pure tone results	L	R
Normal thresholds		
Low frequency Conductive loss		
Low frequency Sensorineural		
Low frequency Mixed hearing loss		

	L	R
65		
66		
67		
68		

4.2 Type and nature of hearing according to pure tone test results 2000 Hz to 4000 Hz (High frequencies):

Pure tone results	L	R
Normal thresholds		
High frequency Conductive loss		
High frequency Sensorineural		
High frequency Mixed hearing loss		

	L	R
69		
70		
71		
72		

4.3 Unilateral/ Bilateral/ No Hearing loss

Ears affected	X
None	
One	
Both	

73	
74	
75	

4.4 If one ear is affected, please specify which ear

Ears affected	X
Left	
Right	

77	
78	

4.5 Average of pure tone thresholds at specified frequency ranges?

Frequencies	L	R
500Hz-1000Hz		
125Hz-250Hz		
4000Hz-8000Hz		

	L	R
79		
80		
81		

4.6 Degree of hearing according to average pure tone thresholds (500Hz, 1000Hz, 2000 Hz):

Degree	L	R
Normal (<26dB)		
Mild (26-40dB)		
Moderate (41-55dB)		
Moderate-Severe (56-70dB)		
Severe (71-90dB)		
Profound (>90dB)		

	L	R
82		
83		
84		
85		
86		
87		

4.7 Degree of hearing according to average pure tone thresholds (125Hz and 250Hz):

Degree	L	R
Normal (<26dB)		
Mild (26-40dB)		
Moderate (41-55dB)		
Moderate-Severe (56-70dB)		
Severe (71-90dB)		
Profound (>90dB)		

	L	R
88		
89		
90		
91		
92		
93		

4.8 Degree of hearing according to average pure tone thresholds (4000Hz and 8000Hz):

Degree	L	R
Normal (<26dB)		
Mild (26-40dB)		
Moderate (41-55dB)		
Moderate-Severe (56-70dB)		
Severe (71-90dB)		
Profound (>90dB)		

	L	R
94		
95		
96		
97		
98		
99		

4.9 Configuration of hearing loss:

Configuration	L	R
Normal hearing		
Flat		
Sloping (abruptly)		
Rising		
Sharply falling		
Trough		
4000 Hz notch		
Carhart's notch		
Irregular		
Other		

	L	R
100		
101		
102		
103		
104		
105		
106		
107		
108		
109		

4.11 In case of other, please describe:

_____

_____

SPEECH AUDIOMETRY

5.1 Does the SRT correlate with the PTA; in other words the SRT ranges between -7dB to 5dB of the PTA?

Correlation	L	R
Correlates		
Does not correlate		

	L	R
110		
111		

5.2 If no, please indicate the possible reason for poor correlation of SRT with PTA

Possible reason	L	R
Ski slope in high/ low frequencies		
Central Auditory Processing disorder		
No definite reason		

	L	R
112		
113		
114		

5.3 If applicable, please determine the Rollover index (RI) according to the following formula:

$$RI = \frac{(PBmax - PBmin)}{PB\ max}$$

RI ≥ 0.41	L	R
Yes		
No		

	L	R
115		
116		

5.4 Configuration of Performance-intensity function during speech discrimination testing:

	L	R
NORMAL: 90 to 100% words correct at normal intensity levels (20dB)		
NORMAL: 90 to 100% words correct at normal intensity levels (30dB)		
NORMAL: 90 to 100% words correct at normal intensity levels (40dB)		
CONDUCTIVE: 90 to 100% words correct at increased intensities (more than 40 dB)		
SENSORY: Increase in word discrimination with increase in intensity up to maximum of 90%		
NEURAL: Roll over; increase in intensity lead to decrease in percentage correct word discrimination		

	L	R
117		
118		
119		
120		
121		
122		

IMMITTANCE RESULTS

6.1 What types of Tympanograms were obtained?

Tympanogram	L	R
Type A		
Type As		
Type Ad		
Type B		
Type C		
Type M		
Type W		
Other		

	L	R
123		
124		
125		
126		
127		
128		
129		
130		

6.2 In case of other, please describe type of Tympanogram:

_____

6.3 Ipsi-lateral reflexes were elicited at _____ intensities:

Frequency in Hertz	PTA	Ipsilateral reflexes	L	R
250		Normal		
		Increased		
		Decreased		
		Absent		
500		Normal		
		Increased		
		Decreased		
		Absent		
1000		Normal		
		Increased		
		Decreased		
		Absent		
2000		Normal		
		Increased		
		Decreased		
		Absent		
4000		Normal		
		Increased		
		Decreased		
		Absent		

	L	R
131		
132		
133		
134		
135		

6.4 Contra lateral reflexes were elicited at ____ intensities:

Frequency in Hertz	PTA	Elicited at... intensities	L	R
500		Normal		
		Increased		
		Decreased		
		Absent		
1000		Normal		
		Increased		
		Decreased		
		Absent		
2000		Normal		
		Increased		
		Decreased		

	L	R
136		
137		
138		

		Absent		
4000		Normal		
		Increased		
		Decreased		
		Absent		

139		

6.5 Interpreting immitance results:

TYPE OF PATHOLOGY	L	R
No Pathology		
Cochlear pathology		
Retro-cochlear pathology		
Conductive Pathology		

	L	R
140		
141		
142		
143		

OTO-ACOUSTIC EMISSION RESULTS

7.1 Did the participant fail the DPOAE:

Frequencies	L	R
Yes		
No		

	L	R
144		
145		

7.2 Indicate which frequencies failed:

Frequencies	L	R
6000Hz		
5000 Hz		
4000 Hz		
3000 Hz		
2000 Hz		

	L	R
146		
147		
148		
149		
150		

7.3 Did all frequencies fail?

Frequencies	L	R
Yes		
No		

	L	R
151		
152		

7.4 Interpreting DPOAE:

Pathology	L	R
No Pathology		
Cochlear Pathology		
Conductive Pathology		

	L	R
153		
154		
155		

AUDITORY EVOKED POTENTIALS

8.1 ABR absolute latency values:

WAVE	Absolute Latencies	L	6 R
I	Normal		
	Delayed		
	Absent		
III	Normal		
	Delayed		
	Absent		
IV	Normal		
	Delayed		
	Absent		

	L	R
156		
157		
158		

8.2 Please indicate the wave morphology:

WAVE	Wave Morphology	L	7 R
I	Good		
	Poor		
	Small		
III	Good		
	Poor		
	Small		
I	Good		
	Poor		
	Small		

	L	R
159		
160		
161		

8.3 ABR repetition:

Repetition	L	R
Good		
Poor		

	L	R
162		
163		

8.4 ABR interpeak latency values:

WAVE	Interpeak latencies	L	R
I to III	Normal		
	Delayed		
III to V	Normal		
	Delayed		
I to V	Normal		
	Delayed		

	L	R
164		
165		
166		

8.5 Interaural wave V latency difference exceeding 0.4 msec

Interaural latency difference exceeds 0.4msec	L	R
Exceeds		
Does not exceed		

	L	R
167		
168		

8.6 If abnormal, indicate suggested site of lesion:

Lesion	L	R
Conductive (all waves delayed with normal interpeak latencies)		
Distal end of N.VIII (Wave I delayed)		
Proximal end of N.VIII (Wave II delayed)		
Caudal Brainstem/Pons (Wave III delayed)		
Midbrain/Lateral lemniskus (Wave IV delayed)		
More than one area		

	L	R
169		
170		
171		
172		
173		
174		

APPENDIX L

CALLIBRATION CERTIFICATE OF GSI 61 AUDIOMETER AND TYMPSTAR 28 VERSION 2 IMMITTANCE METER

hass

The Ear Institute, 1240 Webb Str. Queenswood Pretoria. Tel: (012) 333-3133 Fax: (012) 333-1124

H.A.S.S. Industrial (Pty) Ltd

Certificate of Calibration
No. J 20030161/05

Calibrated for:	**Klerksdorp Hospital** Audiology Department Klerksdorp
Calibration of:	Audiometer
Manufacturer:	GSI
Serial Number:	20030161
Calibration procedure:	Complete diagnostic calibration: Audiometer (GSI 61), Earphones (TDH 50: Right s/n C 59713; Left s/n C 59712), Bone Vibrator (B71) Free Field (Standard 90 dB sound field), Insert Phones (C 13688; Left s/n C 13687) & High Frequency Phones
Traceability:	The calibration was performed using instruments traceable to national standards.
Date of Calibration:	**2005-07-21** **Cal. Due Date:** **2006-07-21**
Results:	The instrument complies with the requirements for use of a Type 1 Audiometer. (Air, Bone, Free Field, Insert & High Frequency Phones).
Remarks:	None
Calibrated by:	Waldo Hanekom

Signature

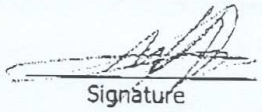
NOTE: The values in this certificate are correct at the time of calibration. Subsequently the accuracy will depend on such factors as the care exercised in the handling and use of the instrument and the frequency of use. Re-calibration should be performed annually to ensure that the instrument's accuracy remains within the desired limits.

hass

The Ear Institute, 1240 Webb Str. Queenswood Pretoria. Tel: (012) 333-3133 Fax: (012) 333-1124

H.A.S.S. Industrial (Pty) Ltd

Certificate of Calibration
No. J 20020101/05

Calibrated for:	**Klerksdorp Hospital** Audiology Department Klerksdorp
Calibration of:	GSI Tympstar V2
Manufacturer:	GSI
Serial Number:	20020101
Calibration procedure:	Complete probe, reflex and pressure calibration as described in the manufacturers specification.
Traceability:	The calibration was performed using instruments traceable to national standards.
Date of Calibration:	**2005-10-24** **Cal. Due Date:** **2006-10-24**
Results:	The instrument complies with the requirements for use as specified by the manufacturer.
Remarks:	None
Calibrated by:	Waldo Hanekom  Signature

NOTE: The values in this certificate are correct at the time of calibration. Subsequently the accuracy will depend on such factors as the care exercised in the handling and use of the instrument and the frequency of use. Re-calibration should be performed annually to ensure that the instrument's accuracy remains within the desired limits.

APPENDIX M

ADDITIONAL INFORMATION ON ART

NAME	BRAND	POSSIBLE SIDE-EFFECTS ON COCHLEAR AND VESTIBULAR MECHANISM
REVERSE TRANSCRIPTASE INHIBITORS		
AZT, Zidovine,	Retrovir	Dizziness, vertigo, hearing loss
ddC	Hivid	Otalgia, ear blockage, hearing loss, fluid in ears, tinnitus, vertigo, dizziness, disequilibrium, facial nerve paralysis
3TC	Epivir	Dizziness
PROTEASE INHIBITORS		
Indinavir	Crixivan	Vertigo, dizziness
Ritonavir	Norvir	Otalgia, hearing loss, increased tinnitus, dizziness
Saquinavir	Invirase	Otalgia, pressure in ear, hearing loss, otitis, tinnitus, dizziness
PHARMACOLOGICAL TREATMENTS FOR OI's/ PROPHYLAXIS		
Amikacin	Amikin	Otalgia, Pressure in ear, hearing loss, otitis, tinnitus, dizziness
Ciprofloxacin	Cipro	Hearing loss, tinnitus
Clofazimine	Lamprene	Tinnitus
Gentamicin	Garamycin	Vestibular and auditory ototoxicity, dizziness, vertigo, tinnitus, roaring in ears, hearing loss
Streptomycin	Streptomycin	Vestibular ototoxicity, vertigo, cochlear ototoxicity, hearing loss
Daunorubicin	Cerubidine	Hearing loss, tinnitus, otalgia
Vinblastine	Velban	Vestibular and auditory damage to VIII nerve, partial and total deafness (temporary or permanent), dizziness, vertigo
Vincristine	Oncovin	Vestibular and auditory damage to VIII nerve, partial and total deafness (temporary or permanent), dizziness, vertigo
Amphotericin B	Amphotericin B	Tinnitus, hearing loss, transient vertigo

NAME	BRAND	POSSIBLE SIDE-EFFECTS ON COCHLEAR AND VESTIBULAR MECHANISM
Flucytosine	Flucytosine	Hearing loss, vertigo
Intraconazole	Intraconazole	Vertigo, tinnitus
Metronidazole	Metronidazole	Vertigo, dizziness
Atovaquone	Mepron	Dizziness
Dapsone	Dapsone USP	Vertigo, tinnitus
Sulfamethoxazole	Bactrim, septra	Vertigo, tinnitus
Clyclosporine	Clyclosporine	Tinnitus
Erythropoisetin	Erythropoisetin	Hearing loss, tinnitus
Dronabinol	Dronabinol	Dizziness, tinnitus

Ototoxic effects on the cochlear and vestibular mechanism as provided by Bankaitis and Schountz (1998:162 to 163)

APPENDIX N

TABULATED PURE TONE AIR- AND BONE AUDIOGRAM THRESHOLDS AT ALL FREQUENCIES

LEFT EAR

FINAL PURE TONE AIR CONDUCTION RESULTS

SUBJECT	FREQUENCIES TESTED						
	125Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
A	25	30	20	5	10	25	35
B	15	10	15	20	20	25	70
C	30	30	35	35	15	20	25
D	25	25	5	5	5	30	30
E	15	0	-10	-10	0	-10	15
F	15	10	5	0	0	0	0
G	20	15	5	10	25	20	15
H	25	30	20	0	0	0	10
I	10	15	15	15	20	20	20
J	10	10	10	5	10	20	50
K	15	15	15	5	10	15	30
L	25	20	10	10	15	15	20
M	5	5	0	15	15	10	5
N	20	25	20	15	25	20	25
O	10	15	5	10	10	5	20
P	30	20	10	5	5	10	15
Q	15	10	10	10	10	30	0
R	20	20	15	5	10	15	15
S	45	30	30	30	40	45	50
T	10	20	10	5	15	25	10
U	15	15	15	20	25	15	20
V	25	35	25	10	30	25	30
W	10	15	5	0	10	15	15
X	15	15	15	20	15	25	30
Y	45	60	60	55	35	45	65
Z	40	35	35	35	40	55	70
AA	40	40	30	20	50	55	65
BB	20	20	10	5	10	5	10
CC	65	90	65	65	60	65	80
DD	35	30	5	20	15	10	5
EE	20	5	25	10	5	20	15
FF	5	15	10	10	5	10	15
GG	20	15	10	10	10	25	20
HH	30	35	30	35	30	30	35
II	40	35	25	20	30	40	60
JJ	30	50	35	20	35	45	75
KK	25	15	30	25	20	10	10
LL	55	55	55	50	55	60	70
MM	40	20	20	10	20	20	10
NN	40	35	35	20	20	25	35
OO	5	5	10	5	5	10	20
QQ	35	25	30	25	40	35	35
Average	**24.761905**	**24.285714**	**19.642857**	**16.309524**	**19.642857**	**23.452381**	**29.761905**
STD Dev	**13.878936**	**16.877299**	**15.632707**	**15.22432**	**14.914098**	**16.692634**	**22.549468**

RIGHT EAR

FINAL PURE TONE AIR CONDUCTION RESULTS

	FREQUENCIES TESTED						
SUBJECT	125Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
A	5	0	10	5	5	15	65
B	20	15	15	10	10	5	60
C	25	25	25	15	25	30	30
D	15	15	5	15	15	35	50
E	15	10	15	10	10	0	5
F	5	10	5	0	0	5	0
G	10	5	5	0	15	20	10
H	15	25	20	15	0	10	20
I	25	20	15	15	20	15	20
J	20	25	20	20	15	50	70
K	50	40	30	40	50	60	80
L	35	30	20	20	5	15	25
M	5	15	5	5	20	10	15
N	20	30	15	20	15	20	35
O	10	15	10	10	10	10	15
P	20	10	0	5	10	10	10
Q	10	15	10	10	10	10	10
R	10	10	5	5	10	15	15
S	50	40	35	30	20	35	70
T	5	20	5	0	5	20	15
U	25	10	15	25	20	10	5
V	25	35	30	25	25	20	20
W	25	20	15	10	20	15	20
X	15	25	25	15	5	10	50
Y	30	35	35	25	30	40	80
Z	35	40	35	25	30	40	75
AA	60	45	30	20	45	50	65
BB	25	25	30	10	10	5	5
CC	25	25	5	30	25	55	80
DD	25	20	15	10	10	5	10
EE	40	35	10	20	25	10	40
FF	15	20	10	5	15	10	15
GG	30	25	25	10	15	30	60
HH	10	15	35	40	30	25	35
II	35	30	25	20	20	20	35
JJ	80	70	60	35	40	55	110
KK	20	20	15	15	10	5	10
LL	40	45	40	40	55	65	85
MM	40	30	20	10	10	20	20
NN	30	20	20	20	15	15	20
OO	10	10	5	5	10	10	15
QQ	30	25	20	15	30	25	25
Average	**24.761905**	**23.809524**	**18.809524**	**16.190476**	**18.214286**	**22.142857**	**35.714286**
STD Dev	**15.732225**	**13.057543**	**12.337209**	**10.752738**	**12.58248**	**17.00584**	**28.275031**

LEFT EAR					
FINAL PURE TONE BONE CONDUCTION RESULTS					
SUBJECT	FREQUENCIES				
	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
A	10	15	5	10	15
B	10	10	20	15	10
C	20	10	30	15	20
D	25	0	0	0	15
E	0	0	0	0	0
F	10	5	0	0	0
G	10	5	10	20	15
H	0	15	0	0	0
I	5	15	15	20	15
J	5	5	5	10	20
K	10	10	5	10	10
L	20	10	10	15	15
M	5	0	10	15	10
N	20	15	10	20	20
O	0	0	0	5	5
P	15	10	5	5	10
Q	10	10	10	10	30
R	10	15	5	10	15
S	30	30	30	40	45
T	20	10	5	15	25
U	15	10	15	25	15
V	10	15	5	15	15
W	15	5	0	10	15
X	15	15	20	15	15
Y	60	60	55	35	45
Z	35	30	25	25	20
AA	30	30	20	50	55
BB	20	10	5	10	0
CC	10	20	25	35	55
DD	20	5	20	15	10
EE	5	20	10	5	15
FF	10	10	5	5	10
GG	15	10	10	10	20
HH	25	25	35	30	20
II	25	20	15	20	35
JJ	45	35	20	35	45
KK	10	20	20	20	10
LL	40	35	20	35	45
MM	15	15	10	15	10
NN	20	20	20	20	25
OO	5	5	5	5	10
QQ	25	30	25	40	35
Average	**16.785714**	**15.119048**	**13.333333**	**16.904762**	**19.52381**
Std Dev	**12.387121**	**11.816075**	**11.458657**	**12.19518**	**14.432751**

RIGHT EAR

FINAL PURE TONE BONE CONDUCTION RESULTS

SUBJECT	FREQUENCIES				
	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
A	0	10	5	5	10
B	15	15	10	10	5
C	25	20	15	20	5
D	10	5	10	15	20
E	5	10	10	10	0
F	10	5	0	0	5
G	0	0	0	10	20
H	10	15	15	0	5
I	15	5	15	20	15
J	25	20	10	15	40
K	15	5	5	20	20
L	25	20	20	5	15
M	15	-5	0	20	10
N	25	15	20	15	20
O	15	10	10	10	10
P	10	0	5	10	10
Q	5	5	15	0	25
R	5	0	0	10	15
S	35	35	25	20	30
T	20	5	0	5	20
U	10	5	25	20	10
V	20	10	15	15	20
W	20	15	10	20	15
X	25	20	15	5	10
Y	35	35	25	30	40
Z	30	15	20	25	35
AA	45	20	20	40	50
BB	10	15	5	10	0
CC	20	5	30	25	55
DD	15	15	10	10	5
EE	35	10	20	25	10
FF	15	10	5	10	10
GG	25	25	10	15	25
HH	10	35	35	30	25
II	25	25	20	20	20
JJ	45	60	35	40	55
KK	20	15	15	10	5
LL	35	35	35	45	55
MM	20	20	10	10	10
NN	20	20	20	15	15
OO	5	5	5	10	5
QQ	25	20	15	30	25
Average	**18.928571**	**15**	**14.047619**	**16.190476**	**19.047619**
Std Dev	**11.017487**	**12.247449**	**9.6422657**	**10.638719**	**14.948615**

APPENDIX O

TABULATED IMMITTANCE RESULTS IN TERMS OF TYMPANOMETRICAL VALUES AND ACOUSTIC REFLEX THRESHOLDS

LEFT EAR

SUBJECT	TYMPANOMETRY			TYPE OF TYMPANOGRAM						ACOUSTIC REFLEXES Ipsi (in dB)					ACOUSTIC REFLEXES Contra (in dB)			
	VOLUME	PRESSURE	COMPLAINCE	A	As	Ad	B	C	OTHER	250Hz	500Hz	1000Hz	2000Hz	4000Hz	500Hz	1000Hz	2000Hz	4000Hz
A	1	10	2.3	0	0	1	0	0	0	100	85	90	95	105	90	85	95	95
B	1.4	0	1	1	0	0	0	0	0	85	90	90	95	105	100	100	100	105
C	1.3	5	0.5	1	0	0	0	0	0	80	70	80	80	80	90	80	85	95
D	1.5	5	0.5	1	0	0	0	0	0	105	105	105	105	100	105	105	105	105
E	1.1	5	0.5	1	0	0	0	0	0	90	90	90	90	90	90	90	90	95
F	1.2	5	0.9	1	0	0	0	0	0	90	85	85	85	85	100	90	90	90
G	1.3	5	0.5	1	0	0	0	0	0	85	85	85	85	85	90	90	85	85
H	1	-25	1.6	1	0	0	0	0	0	95	85	85	90	90	85	85	90	90
I	1	5	0.5	1	0	0	0	0	0	85	90	85	85	90	90	85	90	90
J	0.8	10	1.2	1	0	0	0	0	0	95	95	90	95	95	100	90	95	95
K	0.6	10	0.5	1	0	0	0	0	0	90	85	85	85	85	105	95	105	105
L	1	5	0.8	1	0	0	0	0	0	90	90	85	95	90	95	90	95	100
M	1.5	5	0.5	1	0	0	0	0	0	95	95	90	100	100	100	95	95	100
N	1.3	10	0.3	1	0	0	0	0	0	95	95	85	85	85	105	100	90	95
O	1.1	5	0.9	1	0	0	0	0	0	95	95	90	85	85	90	95	95	90
P	0.9	5	0.6	1	0	0	0	0	0	90	95	90	100	90	105	90	90	90
Q	1.3	-5	0.7	1	0	0	0	0	0	90	85	90	90	95	85	85	85	95
R	1.2	10	1.3	1	0	0	0	0	0	95	100	100	100	100	100	90	95	105
S	1	-10	0.02	0	1	0	0	0	0	95	105	105	105	100	105	105	105	105
T	1.5	5	0.5	1	0	0	0	0	0	85	85	85	85	90	85	85	90	85
U	1.1	-5	0.7	1	0	0	0	0	0	85	90	85	85	90	90	90	95	85
V	1.1	-60	1.8	0	0	1	0	0	0	95	95	90	95	85	100	90	95	85
W	1.6	5	0.5	1	0	0	0	0	0	95	95	95	90	85	95	85	95	90
X	1.7	0	0.8	1	0	0	0	0	0	85	85	85	90	85	90	85	85	90
Y	1	-35	0.9	1	0	0	0	0	0	85	85	85	85	85	75	75	75	70
Z	0.9	0	0.6	1	0	0	0	0	0	85	85	85	85	90	105	105	90	100
AA	1	5	2.8	0	0	1	0	0	0	100	100	85	85	85	100	105	105	85
BB	0.6	0	0.7	1	0	0	0	0	0	90	85	85	90	100	90	85	90	105
CC	1.1	0	2.1	0	0	1	0	0	0	NR	NR	NR	NR	NR	NR	NR	NR	NR
DD	1.2	5	0.6	1	0	0	0	0	0	95	95	95	95	95	95	95	95	95
EE	0.6	-60	0.5	1	0	0	0	0	0	90	85	85	100	85	90	105	105	105
FF	1.1	5	0.7	1	0	0	0	0	0	95	90	85	85	85	105	105	105	105
GG	1.2	10	0.5	1	0	0	0	0	0	85	85	85	85	85	90	85	85	90
HH	1.1	-30	1.1	1	0	0	0	0	0	95	90	85	85	85	100	100	100	100

LEFT EAR

SUBJECT	TYMPANOMETRY			TYPE OF TYMPANOGRAM						ACOUSTIC REFLEXES Ipsi (in dB)					ACOUSTIC REFLEXES Contra (in dB)			
	VOLUME	PRESSURE	COMPLAINCE	A	As	Ad	B	C	OTHER	250Hz	500Hz	1000Hz	2000Hz	4000Hz	500Hz	1000Hz	2000Hz	4000Hz
II	1	5	1.1	1	0	0	0	0	0	95	90	95	100	85	105	105	105	105
JJ	1.2	5	1.9	0	0	1	0	0	0	95	105	105	105	100	105	105	105	105
KK	1.1	5	1.4	1	0	0	0	0	0	95	95	85	95	100	90	85	100	85
LL	0.6	NR	NR	0	0	0	1	0	0	95	105	105	105	100	105	105	105	105
MM	1.2	5	0.5	1	0	0	0	0	0	95	100	100	90	100	100	100	100	105
NN	1.7	0	1	1	0	0	0	0	0	95	95	95	100	100	95	95	100	105
OO	1.6	5	1.2	1	0	0	0	0	0	90	85	85	90	85	85	85	90	90
PP	0.8	-25	0.6	1	0	0	0	0	0	95	85	85	85	85	105	105	105	90
QQ	1.1	5	0.5	1	0	0	0	0	0	90	85	85	90	95	90	90	85	95
AVERAGE	**1.130233**	**-2.142857143**	**0.907619048**	**36**	**1**	**5**	**1**	**0**	**0**	**91.7857**	**90.9524**	**89.5238**	**91.6667**	**91.3095**	**95.7143**	**93.2143**	**94.881**	**95.3571**
STDEV	**0.28076**	**16.86180766**	**0.579149122**							**5.15863**	**7.34499**	**6.69997**	**7.04226**	**6.9895**	**7.69633**	**8.46956**	**7.61001**	**8.36608**

RIGHT EAR

SUBJECT	TYMPANOMETRY			TYPE OF TYMPANOGRAM						ACOUSTIC REFLEXES Ipsi (in dB)					ACOUSTIC REFLEXES Contra (in dB)			
	VOLUME	PRESSURE	COMPLAINCE	A	As	Ad	B	C	OTHER	250Hz	500Hz	1000Hz	2000Hz	4000Hz	500Hz	1000Hz	2000Hz	4000Hz
A	1.1	5	1.2	1	0	0	0	0	0	90	90	95	95	105	100	85	95	90
B	1.2	-10	1	1	0	0	0	0	0	100	95	95	90	90	95	100	105	105
C	1.1	5	0.5	1	0	0	0	0	0	85	85	80	85	85	90	90	85	85
D	1.4	5	0.7	1	0	0	0	0	0	105	105	85	105	100	105	105	105	105
E	1	5	0.5	1	0	0	0	0	0	85	85	NR	85	90	90	85	90	95
F	1.1	5	0.9	1	0	0	0	0	0	90	90	85	85	90	100	90	95	100
G	1.2	5	0.5	1	0	0	0	0	0	90	85	85	90	85	105	105	90	95
H	1	10	1.7	1	0	0	0	0	0	95	90	95	90	95	100	95	95	100
I	1	0	0.5	1	0	0	0	0	0	85	85	85	85	85	90	85	90	90
J	0.7	-10	0.2	0	1	0	0	0	0	105	105	105	105	100	105	105	105	105
K	0.4	-55	0.1	0	0	0	1	0	0	105	105	105	105	100	105	105	105	105
L	1.1	5	1	1	0	0	0	0	0	90	85	85	85	95	90	90	95	95
M	1.5	-10	0.2	0	1	0	0	0	0	100	100	95	100	95	100	95	100	95
N	1.2	5	0.5	1	0	0	0	0	0	95	90	85	85	85	100	90	85	95
O	1.2	5	1.1	1	0	0	0	0	0	95	95	85	85	85	100	95	90	95
P	1	5	0.5	1	0	0	0	0	0	85	85	85	90	85	105	90	85	85
Q	1.6	-5	0.7	1	0	0	0	0	0	85	85	85	85	85	85	85	85	85
R	1.3	-5	3.6	0	0	1	0	0	0	100	90	95	85	85	100	95	95	100
S	0.8	-45	0.2	0	1	0	0	0	0	95	100	95	100	100	105	105	105	105
T	1.5	0	0.6	1	0	0	0	0	0	90	85	85	95	85	85	85	85	85
U	1.2	5	1.5	1	0	0	0	0	0	95	95	95	100	95	90	90	85	90
V	1.1	-90	1.4	1	0	0	0	0	0	85	90	90	80	85	105	105	100	85
W	1.3	0	0.4	1	0	0	0	0	0	95	90	90	90	90	95	90	90	85
X	1.7	15	1.2	1	0	0	0	0	0	85	85	85	85	85	85	85	85	85
Y	1.1	-5	0.8	1	0	0	0	0	0	85	85	85	85	85	85	85	85	85
Z	1.3	-80	0.1	0	0	0	1	0	0	105	105	105	105	100	105	105	105	105
AA	1.1	10	2.6	0	0	1	0	0	0	100	95	105	85	85	105	85	105	85
BB	0.7	0	0.4	1	0	0	0	0	0	105	105	105	105	100	105	105	105	105
CC	1.2	0	1.2	1	0	0	0	0	0	100	85	105	100	105	105	105	105	105
DD	1.2	10	0.7	1	0	0	0	0	0	95	95	95	100	100	100	95	95	90

RIGHT EAR

SUBJECT	TYMPANOMETRY			TYPE OF TYMPANOGRAM						ACOUSTIC REFLEXES Ipsi (in dB)					ACOUSTIC REFLEXES Contra (in dB)			
	VOLUME	PRESSURE	COMPLAINCE	A	As	Ad	B	C	OTHER	250Hz	500Hz	1000Hz	2000Hz	4000Hz	500Hz	1000Hz	2000Hz	4000Hz
EE	0.6	-60	0.5	1	0	0	0	0	0	90	85	85	90	85	95	90	100	95
FF	1	5	0.6	1	0	0	0	0	0	85	90	85	85	90	85	105	105	85
GG	1.3	20	0.2	0	1	0	0	0	0	105	105	105	105	100	105	105	105	105
HH	1	-45	1.7	1	0	0	0	0	0	90	90	85	85	90	105	95	105	95
II	0.8	0	1.1	1	0	0	0	0	0	90	95	90	90	100	105	105	105	105
JJ	1.3	15	3.4	0	0	1	0	0	0	90	85	90	95	85	90	105	105	85
KK	0.9	10	1.6	1	0	0	0	0	0	95	95	85	85	85	90	85	90	100
LL	0.7	NR	NR	0	0	0	1	0	0	95	105	105	105	100	105	105	105	105
MM	1.7	0	0.6	1	0	0	0	0	0	95	100	100	95	100	105	105	100	105
NN	1.7	0	0.8	1	0	0	0	0	0	95	100	95	100	100	105	90	105	105
OO	104	5	1.3	1	0	0	0	0	0	90	85	90	85	85	85	85	95	90
PP	0.7	-75	0.5	1	0	0	0	0	0	85	85	85	90	85	95	95	95	90
QQ	1	5	0.5	1	0	0	0	0	0	90	85	85	85	95	85	85	90	100
AVERAGE	3.51163	-7.9761905	0.935714286	33	4	3	3	0	0	93.3721	92.3256	91.7857	92.093	91.9767	97.4419	95	96.5116	95.3488
	15.692	27.0964745	0.778936557							6.70118	7.42813	7.87257	7.88553	6.99826	7.74382	8.23754	7.83269	7.97282

APPENDIX P

TABULATED ABR RESULTS IN TERMS OF ABSOLUTE WAVE LATENCIES AND INTERPEAK LATENCY VALUES

SUBJECTS	AUDITORY EVOKED RESPONSES LEFT EAR						AUDITORY EVOKED RESPONSES RIGHT EAR						I/A LATENCY DIFFERENCE
	ABSOLUTE LATENCIES			INTERPEAK LATENCIES			ABSOLUTE LATENCIES			INTERPEAK LATENCIES			
	I	III	V	I-III	III-V	I-V	I	III	V	I-III	III-V	I-V	
A	1.71	3.8	6.16	2.09	2.36	4.45	1.71	3.8	6.16	2.09	2.36	4.45	0
B	1.8	4.43	6.34	2.63	1.91	4.54	1.71	4.25	5.99	2.54	1.74	4.28	-0.35
C	1.62	3.71	5.7	2.09	1.99	4.08	1.62	3.71	5.7	2.09	1.99	4.08	0
D	1.35	3.53	5.7	2.18	2.17	4.35	1.98	3.98	6.16	2	2.18	4.18	0.46
E	1.62	3.62	5.52	2	1.9	3.9	1.62	3.62	5.52	2	1.9	3.9	0
F	1.53	3.8	5.7	2.27	1.9	4.17	1.53	3.89	5.7	2.36	1.81	4.17	0
G	1.62	3.71	5.61	2.09	1.9	3.99	1.62	3.71	5.7	2.09	1.99	4.08	0.09
H	1.62	3.89	5.64	2.27	1.75	4.02	1.62	3.8	5.54	2.18	1.74	3.92	-0.1
I	1.44	3.68	5.43	2.24	1.75	3.99	1.71	3.71	5.61	2	1.9	3.9	0.18
J	1.44	3.62	5.52	2.18	1.9	4.08	1.71	3.89	5.88	2.18	1.99	4.17	0.36
K	1.44	3.8	5.61	2.36	1.81	4.17	1.71	3.64	6.34	1.93	2.7	4.63	0.73
L	1.44	3.59	5.34	2.15	1.75	3.9	1.53	3.71	5.5	2.18	1.79	3.97	0.16
M	1.62	3.89	6.07	2.27	2.18	4.45	1.62	3.71	5.7	2.09	1.99	4.08	-0.37
N	1.44	3.62	5.61	2.18	1.99	4.17	1.53	3.8	5.7	2.27	1.9	4.17	0.09
O	1.44	3.89	5.79	2.45	1.9	4.35	1.44	3.98	5.79	2.54	1.81	4.35	0
P	1.44	3.98	5.7	2.54	1.72	4.26	1.44	3.89	5.79	2.45	1.9	4.35	0.09
Q	1.53	3.89	6.07	2.36	2.18	4.54	1.62	3.8	5.7	2.18	1.9	4.08	-0.37
R	1.62	3.62	5.79	2	2.17	4.17	1.62	3.62	5.79	2	2.17	4.17	0
S	1.53	3.62	5.34	2.09	1.72	3.81	1.71	3.89	5.7	2.18	1.81	3.99	0.36
T	1.53	3.89	5.88	2.36	1.99	4.35	1.44	3.89	6.07	2.45	2.18	4.63	0.19
U	1.44	3.71	5.43	2.27	1.72	3.99	1.71	3.89	5.63	2.18	1.74	3.92	0.2
V	1.53	4.16	5.98	2.63	1.82	4.45	1.62	4.07	6.34	2.45	2.27	4.72	0.36
W	1.53	3.53	5.52	2	1.99	3.99	1.44	3.62	5.61	2.18	1.99	4.17	0.09
X	1.35	3.62	5.52	2.27	1.9	4.17	1.44	3.71	5.61	2.27	1.9	4.17	0.09
Y	1.62	3.89	5.61	2.27	1.72	3.99	1.98	3.89	5.81	1.91	1.92	3.83	0.2
Z	1.89	3.74	5.67	1.85	1.93	3.78	1.71	3.8	5.54	2.09	1.74	3.83	-0.13
AA	1.89	3.89	5.61	2	1.72	3.72	1.71	3.91	5.67	2.2	1.76	3.96	0.06
BB	1.62	3.95	5.67	2.33	1.72	4.05	1.53	3.91	5.67	2.38	1.76	4.14	0
CC	1.44	3.89	6.07	2.45	2.18	4.63	1.44	3.89	5.98	2.45	2.09	4.54	-0.09
DD	1.53	3.8	5.79	2.27	1.99	4.26	1.62	3.8	5.98	2.18	2.18	4.36	0.19

	AUDITORY EVOKED RESPONSES LEFT EAR						AUDITORY EVOKED RESPONSES RIGHT EAR						
	ABSOLUTE LATENCIES			INTERPEAK LATENCIES			ABSOLUTE LATENCIES			INTERPEAK LATENCIES			
EE	1.62	3.62	5.61	2	1.99	3.99	1.62	3.71	5.7	2.09	1.99	4.08	0.09
FF	1.53	3.53	5.43	2	1.9	3.9	1.53	3.62	5.36	2.09	1.74	3.83	-0.07
GG	1.53	3.62	5.34	2.09	1.72	3.81	1.71	3.89	5.79	2.18	1.9	4.08	0.45
HH	1.53	3.8	5.7	2.27	1.9	4.17	1.53	3.8	5.79	2.27	1.99	4.26	0.09
II	1.44	3.71	5.44	2.27	1.73	4	1.44	3.8	5.55	2.36	1.75	4.11	0.11
JJ	1.35	3.89	5.79	2.54	1.9	4.44	1.89	4.52	6.52	2.63	2	4.63	0.73
KK	1.44	3.53	5.43	2.09	1.9	3.99	1.44	3.62	5.43	2.18	1.81	3.99	0
LL	1.44	3.62	5.34	2.18	1.72	3.9	1.71	3.89	5.79	2.18	1.9	4.08	0.45
MM	1.8	3.8	5.7	2	1.9	3.9	1.8	3.98	5.98	2.18	2	4.18	0.28
NN	1.8	3.8	5.7	2	1.9	3.9	1.8	3.98	5.98	2.18	2	4.18	0.28
OO	1.62	3.95	5.67	2.33	1.72	4.05	1.53	3.92	5.67	2.39	1.75	4.14	0
QQ	1.53	3.44	5.79	1.91	2.35	4.26	1.44	3.71	5.48	2.27	1.77	4.04	-0.31
Mean	1.553571	3.763571	5.674524	2.21	1.910952	4.120952	1.622143	3.838571	5.78381	2.216429	1.945238	4.161667	
STDEV	0.136361	0.18665	0.232591	0.190083	0.174059	0.23103	0.142633	0.17341	0.254826	0.171149	0.198005	0.227209	

APPENDIX Q

SUMMARY OF RESULTS FOR EACH CLINICAL STAGE OF HIV/AIDS AND FOR EXPOSURE TO ART

ASSESSMENTS	MOST PROBABLE FINDINGS					
	CLINICAL STAGE OF HIV/AIDS				ART EXPOSURE	
	Stage I	Stage II	Stage III	Stage IV	ART	No ART
Otological complaints	Hearing loss Tinnitus	Hearing loss Tinnitus Otalgia.	Hearing loss-increased Tinnitus Otalgia Otorhea Dysacusis.	Otalgia-increased Tinnitus Itching ears Dysacusis Hearing loss Vertigo	Otalgia Otorhea Hearing loss-less often Vertigo Tinnitus Dysacusis Itching ears	Otalgia Hearing loss-more often Vertigo Tinnitus
Diseases	Oral Lung **Otolaryngological**	Lung Nervous system **Otolaryngological**	Oral Lung **Otolaryngological**	Lung Nervous system **Otolaryngological**	Lung Nervous system Oral **Otolaryngological**-less often	Lung-less often **Otolaryngological**-more often
Otoscopy	Normal soft wax Pearl white TM Inflammation Fungal infections Myringitis	Normal soft wax Pearl white TM Occluding wax Dry flaky wax. *Not often:* inflammation, fungal infections, blood Myringitis, Tympanosclerosis	Normal soft wax Pearl white TM Dry flaky wax *Less often:* Inflammation, occluding wax, Myringitis Tympanosclerosis	Normal soft wax Pearl white TM Dry flaky wax, Fungal infections. *Less often:* Inflammation, occluding wax, otorhea Perforations, myringitis, Tympanosclerosis, dull retracted tympanic membrane, scarred tympanic membrane	Normal soft wax-less often Pearl white TM-more often Dry flaky wax-more often Inflammation Blood Otorhea Fungal infections Perforation Dull retracted TM Tympanosclerosis Scarred Myringitis	Normal soft wax-more often Pearl white TM-less often Dry flaky wax-less often Occluding wax Inflammation Otorhea Fungal infections Tympanosclerosis Scarred TM Myringitis

ASSESSMENTS	MOST PROBABLE FINDINGS					
	CLINICAL STAGE OF HIV/AIDS				ART EXPOSURE	
	Stage I	Stage II	Stage III	Stage IV	ART	No ART
Pure tone audiometry	***Hearing*** Normal hearing Unilateral hearing loss-high or low frequencies Usually in left ears ***Degree*** Normal PTA ***Configuration***: Flat, Trough, Irregular or slowly rising, slowly falling ***Type***: Conductive	***Hearing*** Bilateral hearing loss Less often-Normal hearing and unilateral hearing loss-high or low frequencies ***Degree*** Normal PTA (Less often than stage I) Mild degree ***Configuration***: Flat, sloping, rising, trough, Irregular or slowly rising-slowly falling ***Type***: Conductive, Sensorineural	***Hearing*** Bilateral hearing loss Less often-Normal hearing ***Degree*** Normal PTA (less often than stage II) Mild degree(more often than stage II) Less often: Moderate degree ***Configuration***: Flat, sloping, Irregular or slowly rising, slowly falling ***Type***: Conductive, Sensorineural, mixed	***Hearing*** Bilateral hearing loss Less often-Normal hearing and unilateral hearing loss-high or low frequencies ***Degree*** Normal PTA (less often than stage III) Mild degree (more often than stage III) Moderate degree (more often than stage III) Moderate-to-severe degree ***Configuration***: Flat, sloping, rising, sharply falling, trough, irregular, notching or slowly rising-slowly falling ***Type***: Conductive, sensorineural, mixed .	***Hearing*** Bilateral hearing loss Less often-Normal hearing and unilateral hearing loss ***Degree*** Normal PTA-more often Mild degree-less often Moderate degree Moderate-to-severe degree ***Configuration***: Flat, sloping, rising, sharply falling, trough, irregular, notch or slowly rising, slowly falling ***Type***: Conductive, Sensorineural (less often than those on no ART) or mixed	***Hearing*** Bilateral hearing loss Less often-Normal hearing and unilateral hearing loss (more often) ***Degree*** Normal PTA-less often Mild degree-more often Moderate degree ***Configuration***: Flat, rising, Irregular or slowly rising, slowly falling ***Type***: Conductive, sensorineural.

ASSESSMENTS	MOST PROBABLE FINDINGS					
	CLINICAL STAGE OF HIV/AIDS				ART EXPOSURE	
	Stage I	Stage II	Stage III	Stage IV	ART	No ART
Speech audiometry	***Speech thresholds:*** PTA-SRT correlation worse than stages II and III possibly due to Unreliable PTA-emotional component (acceptance of disease) ***Above thresholds:*** -90% to 100% word discrimination: Levels better than 40dB. -90% to 100% word discrimination: Levels above than 40dB.	***Speech thresholds:*** Good PTA-SRT correlation ***Above thresholds:*** -90% to 100% word discrimination: Levels better than 40dB. -90% to 100% word discrimination: Levels above than 40dB.	***Speech thresholds:*** Good PTA-SRT correlation ***Above thresholds:*** -90% to 100% word discrimination: Levels better than 40dB. -90% to 100% word discrimination: Levels above than 40dB.	***Speech thresholds:*** PTA-SRT correlation worse than all three first stages. Unreliable PTA-Possibly due to emotional component (acceptance of fatal outcome of disease) ***Above thresholds:*** -90% to 100% word discrimination: Levels better than 40dB. -90% to 100% word discrimi-nation: Levels above than 40dB. *Less often:* -Less than 90% word discrimination at high intensity levels -Increase in intensity equals and decrease in word discrimination (unable to obtain 100%)	***Speech thresholds:*** Good PTA-SRT correlation ***Above thresholds:*** -90% to 100% word discrimination: Levels better than 40dB. -90% to 100% word discrimination: Levels above than 40dB. *Less often:* -Less than 90% word discrimination at high intensity levels -Increase in intensity equals and decrease in word discrimination (unable to obtain 100%)	***Speech thresholds:*** PTA-SRT correlation worse than those on ART possibly due to unreliable PTA-emotional component (acceptance of disease must have taken place prior to commencement of ART) ***Above thresholds:*** -90% to 100% word discrimination: Levels better than 40dB. -90% to 100% word discrimination: Levels above than 40dB. *Less often:* -Less than 90% word discrimination at high intensity levels

ASSESSMENTS	MOST PROBABLE FINDINGS					
	CLINICAL STAGE OF HIV/AIDS				ART EXPOSURE	
	Stage I	Stage II	Stage III	Stage IV	ART	No ART
Immittance and DPOAE results	***Tympanograms:*** Type A, As and Ad ***Pathologies in order of incidence:*** Cochlear Retro-cochlear Conductive	***Tympanograms:*** Type A and Ad ***Pathologies in order of incidence:*** Cochlear No pathology Retro-cochlear Conductive	***Tympanograms:*** Type A, As and Ad ***Pathologies in order of incidence:*** Cochlear Conductive Retro-cochlear	***Tympanograms:*** Type A, As, Ad and B ***Pathologies in order of incidence:*** Cochlear Conductive No pathology Retro-cochlear	***Tympanograms:*** Type A (more often), As, Ad and B ***Pathologies in order of incidence:*** Cochlear Retro-cochlear Conductive No pathology	***Tympanograms:*** Type A, As (more often) and Ad (more often) ***Pathologies in order of incidence:*** Conductive No pathology Cochlear Retro-cochlear
ABR results	Abnormally higher than normal ABR No delayed wave I Wave III and V delayed relatively frequently Interpeak latencies: Wave I:III delayed Wave III:V delayed Wave I:V delayed	Abnormally higher than normal ABR Wave I and III delayed Wave V delayed more often Interpeak latencies: Wave III:V delayed Wave I:V delayed	Abnormally higher than normal ABR Wave I and V delayed, but wave III delayed more often Interpeak latencies: Wave III:V delayed (less often than other stages) Wave I:V delayed	Abnormally higher than normal ABR Wave I delayed Wave III and V delayed more often (wave III more often than V) Interpeak latencies: Wave I:III delayed (less often than other stages Wave III:V delayed Wave I:V delayed (less often than other stages)	Abnormal ABR (same incidence) Wave I delayed Wave III and V delayed (more often than those not on ART) Interpeak latencies: Wave I:III abnormal less often Wave III:V abnormal Wave I:V abnormal less often	Abnormal ABR (same incidence) Wave I delayed Wave III and V delayed (less often than those not on ART) Interpeak latencies: Wave I:III abnormal more often Wave III:V abnormal Wave I:V abnormal more often