The audiological profile of singers' and musicians' in South Africa

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Declaration

I hereby declare that this research report is based on my own effort. It has only been submitted to the Speech Pathology and Audiology Department at the University of the Witwatersrand. Any Contribution made to the research by others has been explicitly acknowledged.

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Aimee Flowers **Date**

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Abstract:

Introduction: Excessive exposure to loud music is shown to have a negative impact on hearing, necessitating studies that explore the impact of music on the audiological profile of musicians and singers. The tonotopic arrangement of the cochlea plays an important role in the perception of music. Audiological testing can provide insight into the functioning of the auditory system of musicians and singers and it can provide information about the possible noise/music induced impact of music on the auditory system. The rationale for this study was to fill in the gaps in knowledge pertaining to the effects of noise/music induced hearing loss on musicians and singers in South Africa

Methodology: The study aimed to document the audiological profile of musicians and singers in South Africa. The participants were recruited using purposive and snowball sampling. The study consisted of 57 participants. The age range was 13 years to 75 years of age. The design of the study was exploratory and data were collected via a case history questionnaire and a diagnostic audiological investigation. The data were analysed using qualitative and quantitative analyses.

Results: Music induced hearing loss (MIHL) is present among musicians and singers however, age and years of experience are influential factors in this result. The results of the current study indicated that 88% of the participants did not use HPDs for various reasons such as stigma or lack of awareness. Participants showed knowledge related to ear cleaning and high noise levels, however, there was a lack of insight into the importance and good ear hygiene practices. Fifty-one participants indicated that there is a need for the implementation of programs to inform the general public about good ear hygiene. The results of the diagnostic audiological testing indicated age was a significant factor in relation to pure tone thresholds and distortion product otoacoustic emissions(DPOAEs). Noise notches were evident at 3000Hz and 6000Hz and correlated with both the pure tone threshold and DPOAE results. The DPOAE results indicated that being a professional singer was also a significant factor.

Conclusion: The current study highlights the effects of music on the auditory system. The effects of music can be detrimental to a musician and singer's hearing, and the incorrect ear care can have devastating effects for performers. Therefore, the need for the implementation of programs to educate musicians and singers about ear hygiene, the correct ear hygiene practices and the effects of music on the audiological system as well as the correct way to mitigate these effects is imperative.

Keywords: music, hearing, musician, singer, music induced hearing loss, audiological profile

Terminology

The study uses the following terms in relation to the definitions below:

Musician: An individual who plays a musical instrument professionally and/or recreationally.

Singer: An individual who sings solo or in a group professionally and/or recreationally.

Professional musician/singer: An individual who is paid for a performance (playing an instrument or singing).

Recreational musician/singer: An individual who is not remunerated for a performance or perform for enjoyment (playing an instrument or singing).

Audiological profile: Comprises of the results from the diagnostic audiological test battery. Identifying the overall status of the functioning of the individual's auditory system (Sanchez, Bianchi, Fereczkowski, Santurette, & Dau, 2018).

Music Induced Hearing Loss (MIHL): Hearing loss caused by consistent exposure to music levels above the recommended safe listening levels. The recommended safe listening levels is less than 85dB, if one is exposed to 85 dB the recommended safe listening time is 8 hours and for every 3dB increase the listening time halves (WHO, 2018). However this normative data was created from and is applied to the industrial sector. To date there is no normative data available for the music industry.

Chapter1: Introduction

Hearing loss is one of the leading causes of disability worldwide with noise-induced hearing loss (NIHL) as one of the largest contributors (WHO, 2018). A NIHL occurs after exposure to an extremely loud sound, frequently a sound above 85 dB HL. Sound exposure that causes a NIHL may occur over a prolonged period or within an instant of exposure (Fligor, Chasi, & Neitzel, 2015). For example, an individual exposed to a gunshot can have an immediate NIHL conversely, factory workers, miners, or musicians are exposed to noise that leads to a NIHL over a prolonged period (Fligor et al., 2015).

Literature shows that music is enjoyed by the majority of individuals globally (IFPI, 2019; Mclntyre, 2017; Petrescu, 2008; Schäfer, Sedlmeier, Städtler, & Huron, 2013), resulting in a larger number of individuals exposed to loud music or recreational noise compared to those working in occupational environments with occupational noise exposure. Musicians are exposed to a different type of noise to occupational noise when involved with music. The noise created by music differs slightly in its effects on the cochlear and its overall features. Therefore, the NIHL experienced by performers exposed to music is referred to as MIHL.Music has evolved from the native African tribes, religions such as Judaism (Kligman, 2014), Christianity (Kallen, 2013), and Buddhism (Greene, Howard, Miller, Nguyen, & Tan, 2002), the ancient Greeks, and Romans to the technologically infused sounds heard today (Feld, 2020). Technological advancements have resulted in amplified music using high intensity speakers, resulting in a compounded effect on one's audiological system (Meyer-Bisch, 1996).

The anatomy and physiology of the ear, especially the tonotopic arrangement within the cochlea plays a large role in the identification of frequency-specific information. The frequency-specific information plays an important role in the perception of sound and music (Seikel, King, & Drumright, 2010). High frequency sounds are analysed at the basal end of the cochlea and low frequency sounds are analysed at the apical end of the cochlea (Seikel et al., 2010). The frequency specific information allows for musicians to play in tune with a song. Music has a damaging effect on the outer hair cells (OHC) resulting in hair cell death and consequently, MIHL. The audiological noise-induced notch observed on the audiogram illustrates the impact of noise on hearing and the frequencies that are effected (Seikel et al., 2010). The cochlea is tonotopically arranged as a result, high frequency sounds occur at the basal end and low frequency sounds at the apical end (Seikel et al., 2010). The audiological notch is typically observed at 4000Hz, indicating that damage occurs first at the basal end of the cochlea (Seikel et al., 2010).

The effects of the music on the audiological system can be identified through various audiological assessments such as puretone audiometry and OAEs (Mehrparvar et al., 2014). During the audiological assessment, the audiologist will identify the presence or absence of a hearing loss, the presence or absence of noise notches, as well as the state of functioning of the cochlea. Upon obtaining the results the audiologist will identify the severity and type of hearing loss and if exposure to noise was a possible cause.

The presence of notches at 3000Hz, 4000Hz, and/or 6000Hz are suggestive of the presence of noise damage. The impact of a MIHL can be assessed, however, prevention is preferred as there is no medical cure for a hearing loss (Einborn, 2019). The damaging effects of music to the auditory system can be prevented by using hearing protection devices (HealthandSafetyLaboratory, 2008). Hearing protection devices (HPDs) attenuate high intensity sound to decrease the damaging effects on the ear (Ntlhakana, Kanji, & Khoza-Shangase, 2015).

Although HPDs decrease the harmful audiological effects of high intensity sounds, they may negatively impact musicians due to the occlusion effect, decreased pitch sensitivity and a reduced ability to communicate with other musicians (HealthandSafetyLaboratory, 2008).

Rationale

The current research study aims to fill in the gaps in knowledge pertaining to **the audiological system of musicians and singers in South Africa.** The gaps are related to hearing loss in musicians and singers, prevention of MIHL, policy and program formation surrounding ear hearing protection, tailor managed programs and support structures.

To fully understand the effects of music on singers' and musicians' hearing we need to identify their hearing profile. This will provide the information required to tailor safety programs to the music industry (Horrell, 2013). Understanding musicians' and singers' awareness of the effects of noise will enable professionals to provide the correct information and implement the correct procedures for hearing conservation (Callshsn et al., 2011). While there is research pertaining to hearing loss in musicians internationally, there is no research available about South African musicians and singers.

The study proposed to assess not only the status of the auditory system, but also to determine how musicians and singers subjectively perceive the impact of music on the auditory system in the South African context. In South Africa, there is a large variety of local music that makes use of indigenous instruments. These genres and instruments are not found internationally, and the information obtained from the study may provide new global insights. Therefore, the relationship between the behavioral aspect and the objective hearing results can be analyzed.

Music-induced hearing loss can be prevented if the correct safety measures are put in place. Research indicates a decrease in effects of music when HPDs are used and acoustic parameters adapted (HealthandSafetyLaboratory, 2008). Hearing is a tool used for playing music and if it is damaged it can negatively affect the career of a musician and singer (Fligor, 2015). Therefore, the need for education and the implementation of the correct practices is imperative (O'Brien, Ackermann, & Driscoll, 2014). International research indicates that musicians do not make use of HPD’s and/or lack the knowledge surrounding hearing protection and the prevention of a hearing loss (Fligor, 2015). However, in South Africa there is no research available that discusses hearing protection and the prevention of hearing loss in singers and musicians.

Identification of the gaps in knowledge surrounding the effects of music, will allow for the creation of information booklets, posters, or campaigns to help promote and educate musicians and singers about the appropriate practices, allowing musicians and singers to be more proactive in protecting their ears from the damaging effects of music, resulting in less audiological complications (McGinnity, 2017). Currently, there do not appear to be policies in place that protect the hearing of musicians and singers in South Africa.

Musicians’ and singers’ audiological needs are unique due to the nature of their work. Musicians and singers are exposed to the damaging effects of the noise created and electrically amplified from the instruments and their voices if they sing as well (Lindenbaum, 2017). The performance spaces are architecturally designed to produce as much amplification for the audience (Lindenbaum, 2017). Therefore, the results of this study can assist in the creation of tailored management programs that consider all aspects for the protection of musicians' and singers' hearing.

Musicians' and singers are a vulnerable population in relation to MIHL because of the intensity of the music and the design of the performance space (Lindenbaum, 2017).Thus, the results of this study can assist in the implementation of the correct support structures to assist musicians with hearing protection and hearing difficulties.

The purpose of this research is therefore to determine the audiological status of musicians and singers in South Africa. The research question driving this study is as follows:

What is the hearing profile of singers and musicians in South African?

The researcher hypothesized that with a basic audiological test battery as well as the addition of DPOAEs a MIHL in musicians and singers will be identifiable earlier than with the standard audiological testing protocols. It is also hypothesised that the musical practices and behaviour of musicians and singers will impact the audiological results.

Chapter 2: Literature review

Definition of music

Music can be defined as,

'*sounds that are arranged in a way that is pleasant or meaningful to listen to*' Oxford English Dictionary (2020),

'Music is like a dream' Beethoven (Cmuse, 2016),

'Music is a language that doesn't speak in particular words. It speaks in emotions' Kieth Richards (Cmuse, 2011).

Music is not exclusive to one nation, race, or culture as, its boundaries are unseen, it transcends between people, time, and place. Technical descriptions of music emphasise variations of pitch and rhythm (Montagu, 2017). Pitch and frequency are scientific terms used to express the meaning of music. Music refers to both instrumental music and music with vocals. A precise definition of music is difficult to ascertain as, each individual has a different definition of what they constitute as music (Montagu, 2017). The emotion and social meaning attached to specific pieces of music cannot be generalised and is held in the 'ear' of the beholder (LifestyleLounge, 2020). The genre of music impacts the emotion elicited from the listener. The music one chooses to listen to may be influenced by the environment and mood required.

There are countless genres that make up the vast array of music such as rock, blues, jazz, classical music, pop, country, dance, rap, and rhythm & blues (R&B), each with their own history (Montagu, 2017). Music is further described as having four purposes: rituals, dance, social cohesion, and entertainment (Montagu, 2017). Rituals use music in a repetitive manner to preform religious traditions, while dance uses the body as an expressive medium to communicate the message of a musical ensemble. Music brings individuals from different backgrounds together and allows them to find a common ground in which to interact, build a relationship and escape from the hardships of daily life. This escapism is also a form of enjoyment and recreation for individuals who are involved in music (Montagu, 2017).

Archaeological evidence indicates that dance and song were used to communicate messages such as danger, joy and for ritualistic purposes (Montagu, 2017). The origin of music within South Africa can be traced back to the native African tribes who used music and dance for traditional ceremonies and entertainment (Nissen, 2018).

The Ngunis (Xhosa, Zulu and Swazi tribes) one of the largest cultural groups within South Africa representing 2/3 of South Africa's black population (Adekoya, 2015) used song and dance in everyday activities and ceremonial events (Nissen, 2018), the use of work songs symbolized the nature of the work through rhythmic representation. Musical bows and rattles were used for recreational purposes, the drums were used for spiritual and devotional expression (Nissen, 2018).

There are specific dances that are performed such as solo rite of passage dances at cultural events, collective dances, and devotional dances (Nissen, 2018). Mtshali (2020) explains that examples of solo rite of passage dances include dances celebrating a woman's first menstruation, and dances performed by sangomas at traditional healings etc. Collective dances include those performed at weddings and war re-enactment ceremonies. Devotional dances would be those performed at religious ceremonies (Mtshali, 2020).

The Sotho Tsonga and Tswana tribes emphasise praise in their musical expression (Nissen, 2018). The songs and dances embody a celebration of the tribe's ancestry, recounting historical and mythic stories as well as, educating and re-enforcing social norms (Nissen, 2018). The dances are responsive with improvised calls from the leader. They include wide-ranging textual and vocal spontaneity, hand clapping, and foot stomping as the basis of rhythmic accompaniment (Nissen, 2018).

The Tswana and Tsonga dance songs are more socially functional, including work songs, seasonal songs, wedding, and burial songs (Nissen, 2018). The rhythm of these songs is related to the body movement and uses melodic instruments such as reedpipes, musical bows and morapas (round clay drum) (Nissen, 2018). The Venda tribe consider all music to be songs of the Venda people. The songs and dances of the Venda tribe are responsive with the song leader initiating and the chorus responding (Nissen, 2018).

History of Western Music

The history of western music was influenced from ancient Greece and Rome. Most western music originated from religious worship, in the form of prayers and poems (Daniel, 2017). There are six historical eras leading up to modern day music. The medieval era (700 C.E -1400 C.E) (Feld, 2020) saw the catholic church as the main source of power and songs consisted of prayers and psalms sung by the clergy during services. The psalms and some songs date back to biblical times. King David composed the book of psalms and musical tunes were later composed for the psalms (Montagu, 2017). The religious sect saw music and songs as a powerful religious source of praise and prayer (Kallen, 2019) Secular music began with poems being set to music resulting in a large scale of love songs (Feld, 2020).

The renaissance era of music (1400 C.E-1600 C.E) is known for polyphonic music, which incorporated a range of vocal styles such as bass, tenors, altos, and sopranos (Feld, 2020). The vocal styles were written up in such a way that two or more different melodies were combined thus, creating a richness in the music (Kallen 2019).

The Baroque era (1600 C.E -1750 C.E) also known as western classical music, displayed two stylistic tendencies (Feld, 2020). The increased use of solo voice and the use of instrumental music. Music was typically written in a particular key, and this technique is still widely used in Western classical and popular music (Kallen 2019). The music genre of opera developed during the Baroque era and musicians valued the use of the violin as an instrument (Feld, 2020).

The Classical period (1750 C.E – 1820 C.E) consisted of reforming opera to a more modern day version, the use of piano allowed for variation in intensity depending on the force placed on the keys, and the introduction of symphonies (Kallen, 2019). There was an increase in the size of the orchestra as well as its range thus allowing for more standardisation (Kallen 2019). The Classical era saw the emergence of various composers whose works are still highly regarded today, namely Mozart and Beethoven (Feld, 2020).

The Romantic era (1820 C.E -1900 C.E) saw the rise of programmatic orchestral work thus music was used to form a narrative (Feld, 2020). The music in this era was artistic and characterised by its emphasis on emotion, larger dynamic ranges and pitches as well as a bigger orchestra (Kallen, 2019). The music placed a greater emphasis on the melody and used more harmonic progressions (Kallen, 2019).

Modern music (1900 C.E -present) has involved experimentation and change through the development of technology (Daniel, 2017). Singing has also evolved due to the development of technology as the various vocal pitch ranges namely, Bass (male's lowest singing range), Tenor (highest male singing range, may extend into female range and allow for falsetto), Alto (Lowest female singing range), and Soprano (highest female singing range) (Musicnotes, 2019), may occur solo or in an ensemble and may include various styles such as acapella, choir, and singing with instrumental accompaniment (Hu & Sataloff, 2015).

Additionally, Some genres that have developed from these advancements include, The Blues, Jazz, Rock and Pop (Kopp, 2015). The Blues originated from African individuals who were taken as slaves to work in America (Kopp, 2015). The men were not allowed to sing native songs resulting in the formation of songs that contained aspects of their heritage in a western format (Kopp, 2015), reiterating the native African cultural links to songs about the work during activities. The African

American individuals sang songs about overcoming hardships, ridding frustrations and having fun (Kopp, 2015).

Many years later in South Africa songs about hardship were adapted and used again during Apartheid (Schadeberg & Albert, 2007). The Blues heavily influenced the development of Jazz music. Jazz music was influenced by the European harmonic structure and African rhythms (Schuller, 2020). Jazz involves varying degrees of improvisation that uses syncopated rhythms and a polyphonic ensemble. Musical instruments include: the piano, saxophone, trumpet, and violin (Schuller, 2020).

Rock music emerged around the 1940s and makes use of electric guitars, bass, drums, and a vocalist (Grierson, 2018). Rock music allowed for the expression of a sexual freedom during a conservative time period and gave birth to many musicians whose work is still widely listened to today. Musicians such as Queen, The Beatles, The Rolling Stones, U2, and many others are rock icons (Grierson, 2018). Rock allowed for the development of many other types of music such as heavy metal, house (electronic dance music), and trans music that are identified today (Grierson, 2018).

Pop which is commonly associated with ballads and most modern-day music (Hagan, 2004), lead to the development of Rhythm & Blues, Rap, Dance, and Country music (Hagan, 2004). Pop Icons include Michael Jackson, Celine Dion, Brittany Spears, and Madonna to name a few. Singing has evolved to include a large variety styles within the above-mentioned genres of music.

History of South African Music

Current South African music genres have developed from native African tribes and western musical influences (Nissen, 2018). In South Africa, music became the platform for protests, demonstrations, and political agendas. The music contained fast, upbeat, and intrinsic rhythm together with marching actions (Nissen, 2018).Colonialism in Africa brought with it western music which impacted the existing native African music. This lead to the development of various new African genres namely:

- Nguni, it involves the transfer of the melodic voice to instruments (Nissen, 2018);

- Makwaya, which formed from colonisation bringing Christianity and hymns that were sung by church choirs (Nissen, 2018);
- Marabi, also known as African Jazz developed during the Apartheid regime and was used as a symbol of the struggle faced by many South Africans (Nissen, 2018). It was the most common genre that appeared in the shebeens (bar in the townships), and the music contained messages about the hardships faced, the work carried out, political messages as well as positive messages about the future (Nissen, 2018);
- Kwela, it has a Jazz undertone and is a pennywhistle-based street music;
- Kwaito, also known as township pop is like house music, but it has a slower tempo. It is a mixture of various African rhythms such as Marabi and Kwela. Miriam Makeba, Yvonne Chaka Chaka, and Brenda Fassie were singers with a major influence on the development of Kwaito music (Nissen, 2018);
- Afro-pop, its development was greatly influenced by probably the most internationally known apartheid musical activist, the late Johnny Clegg (Nissen, 2018). During his formative years Johnny Clegg learnt about African culture and music, which influenced his music later in life (Clegg.com, 2009). Johnny Clegg was one of the first musicians/singers to incorporate African and western music. The musical team comprised of Johnny Clegg, Sipho Mchunu, and subsequently Dudu Zulu who composed songs that contained elements of western pop and African Zulu rhythms (Clegg.com, 2009).

Music Induced Hearing Loss

South Africa has various cultural groups such as the Xhosa, Zulu, Sotho, Khoisan, and Afrikaans etc. (Nissen, 2018) that make-up the ‘rainbow nation’. The diversity of the nation has resulted in the diversity of music within the country (Nissen, 2018). Present-day music in South Africa is a culmination of the above history with the inclusion of technology. Technology has allowed for music to become readily available (Feld, 2020), resulting in an increase in the number of recreational musicians and singers with access to instruments and training within the recreational setting (Lindenbaum, 2017).

Music is most popular among adolescents across the world because they identify with the messages portrayed (Musicmania, 2016).Technological advancements allow for certain aspects of music to be highlighted, as well as the increase or decrease of the volume of the instruments through electronic amplification. The development of amplification systems for music occurred in 1875 (Mulder, 2013). The amplification of music at excessively loud intensities results in negative effects on the auditory system (Lindenbaum, 2017). The structures of auditory system are impacted by amplified sound.

The structures of the auditory system, including the organ of hearing, function collectively in a unique way to allow for the perception of sound. The pinna and the external auditory meatus direct sound waves to the eardrum creating the resonant frequency of the ear, allowing for an increase in strength of the stimulus through resonance (Seikel et al., 2010). This results in an enhanced signal intensity between 1500 Hz to 8000Hz (Seikel et al., 2010). The sound wave reaches the tympanic membrane resulting in a vibration of the tympanic membrane and the ossicles. When the ossicles vibrate, the footplate of the stapes moves backwards and forwards against the oval window ensuing stimulation of the fluid within the cochlea (Seikel et al., 2010).

The inner ear plays an important role in the analysis of spectral components (the process of extracting or defining various frequency components) and temporal acoustic parameters (Seikel et al., 2010). The tonotopic arrangement of the cochlear hair cells ensure the identification of low frequency sounds at the apical end and the high frequency sounds at the basal end of the cochlea (Seikel et al., 2010). The point of maximum amplitude excursion of the travelling wave on the basilar membrane is the central point of neural excitation of the hair cells within the organ of corti (Seikel et al., 2010). Exposure to amplified sounds that exceed 85 dBA over a period of time results in a NIHL (WHO, 2018), and ensuing a permanent hearing threshold change (Jansen, Helleman, Dreschler, & de Laat, 2009). If the sound is at a higher intensity the duration of exposure must decrease. According to the National Institute for occupational safety and health (NIOSH) guidelines for every 3 dB HL increase in sound pressure intensity, the safe listening time decreases by half (Fligor et al., 2015).

A MIHL is classified according to two types of threshold shifts: a temporary threshold shift (TTS) occurs when the individual’s hearing thresholds are altered for a short period of time, typically followed after a live music concert (Fligor et al., 2015); a permanent threshold shift (PTS) refers to the permanent shift of an individual's hearing thresholds resulting in a permanent hearing loss commonly referred to as a NIHL (Fligor et al., 2015).

A PTS has various causes: an acoustic trauma, caused by a sudden exposure to loud noise, such as an explosion or being right next to a gunshot, resulting in permanent damage to the cochlea and/or middle ear (Fligor et al., 2015); prolonged exposure to noise, this is widespread among people who work in noisy environments such as factories, airports, mines, and music industry (Fligor et al., 2015).

Noise and in turn music, have a damaging effect on the auditory system (Kujawa & Liberman, 2009). With a TTS it is suggested that there is no hair cell death, but rather that the cochlear nerve terminals at the hair cell synapse swells resulting in a temporary hearing loss (Kujawa & Liberman, 2009). This inflammatory process occurs due to a process known as glutamate excitotoxicity. The process occurs from overstimulation of the neurotransmitter glutamate from an increased intensity in sound (Henderson, Bielefeld, Harris, & Hu, 2006). Consequently, there is a decrease in cochlea blood supply, effecting the hearing thresholds of the individual (Henderson et al., 2006). Once the swelling of the nerve terminals subsides, hearing thresholds should return to where they were prior to the noise exposure (Kujawa & Liberman, 2009). Research conducted by Kujawa & Liberman (2009) on mice suggests that hair cell damage can be seen within minutes after over exposure to sound.

A PTS or MIHL results in a permanent loss of hearing due to damage to the hair cells (Kujawa & Liberman, 2009), resulting from stereocilia damage (Strauss, 2013). After the exposure to the sound, the stereocilia lose their stiffness and their ability to vibrate in response to sound (Strauss, 2013). After, continuous repeated exposure to sound the stereocilia do not repair, resulting in a PTS (Strauss, 2013). The damage to the OHC is larger than that of the inner hair cells (IHC) The OHC undergo a shearing force at the stereocilia, whereas the IHC are stimulated by viscous drag (Strauss, 2013).

Cell death occurs through two mechanisms: apoptosis, the elimination of unwanted, damaged, and dying cells with minimal damage to the neighbouring cells. During apoptosis the cell membrane remains intact while the cell condenses and pulls away from the neighbouring cells (Henderson et al., 2006); necrosis, occurs after physical or chemical insult to the cell, resulting in the swelling of the cell followed by the cell rupturing and spilling out the cell contents (Henderson et al., 2006). This results in damage to the surrounding tissue and the initiation of an inflammatory response (Henderson et al., 2006) that can last for up to a few days, illustrated by Kujawa & Liberman’s (2009) research. .

Metabolic stress contributes to cell death leading to a PTS through the formation of reactive oxygen species called free radicals (Oishi & Schacht, 2011). Free radicals cause a reduction in blood supply, and are formed from the presence of excess calcium in the cell due to excessive noise stimulation, triggering cell death (Oishi & Schacht, 2011). The free radicals emerge immediately after noise exposure and can last for 7 to 10 days spreading apically from the basal end of the organ of corti (Oishi & Schacht, 2011).

A symptom is a manifestation of a disease that is subjectively reported by the person experiencing the problem. A sign on the other hand is an objective manifestation of the disease that can be identified by the health care worker upon examination. The symptoms associated with MIHL include tinnitus, hyperacusis, and abnormal pitch perception.

To accurately identify the effects of music on the auditory system, a full audiological evaluation is needed. The evaluation consists of an otoscopic examination, immittance audiometry, a DPOAE, pure tone audiometry, extended high-frequency audiometry and speech audiometry. A DPOAE and extended high-frequency audiometry are not part of the basic test battery but are additional tests that can be used to accurately identify a NIHL (Jansen et al., 2009). A study conducted by Jansen et. al (2009) on the effects of music on the musician suggested that hyperacusis, tinnitus and abnormal pitch perception were the most reported symptoms in relation to noise exposure from music. Jansen et al. (2009) emphasised the importance of educating musicians about these phenomena as well as exploring their effects on musicians.

Hyperacusis is the unusual tolerance to ordinary environmental sounds, resulting in a consistently exaggerated or inappropriate response to sounds (Tyler, Noble, Coelho, Roncancio, & Jun, 2015a). Individuals perceive the sound to be louder than it is. The exact cause of hyperacusis is not known, however, it is suspected that the mechanism is similar to that of tinnitus (Baguley, 2003). There appears to be an increase in the extent of hyperacusis with factors such as stress, anxiety, and fatigue, suggesting that endogenous endorphins are released causing glutamate to be released and the sound being perceived as excessively loud (Baguley, 2003). Hyperacusis may be caused by auditory efferent dysfunction. Dysfunction of the medial auditory system results in a disturbance in the ability to modulate gain, ensuing in persistent sensitivity (Baguley, 2003).

Tinnitus is classified as the involuntary awareness of sound that originates in the head (Fagelson, 2018). Tinnitus is caused by factors that result in hearing loss such as medication, aging or head injury (Tyler et al., 2015a). Tinnitus is grouped into three categories; middle-ear tinnitus is associated with middle-ear vascular or muscular dysfunction and commonly presents as pulsatile tinnitus (Tyler et al., 2015a); sensory/neural tinnitus originates in the cochlear and/or neural pathway and commonly presents as non-pulsatile tinnitus (Tyler et al., 2015a)

The system responsible for coding tinnitus originates in the cochlea. It is suggested that tinnitus is linked with; hair cell damage, an imbalance between inner and OHC, and an overall degradation in the message sent to the cochlear nerve (Tyler et al., 2015a).

The brain stem or the central nervous system may also contribute to tinnitus following damage to the cochlear nerve in conjunction with asynchronous firing of the nerve (Tyler et al., 2015a). It is thought that auditory cortex, the part of the brain that perceives sound, is active with tinnitus. This activity is associated with an increase in spontaneous activity, synchronous spontaneous activity across nerve fibres, and more fibres tuned to the same frequency (Tyler et al., 2015a).

The effects of tinnitus are exaggerated by anxiety (HarvardWomen'sHealthWatch, 2011). When the individual is cognisant of the sound, it is in their conscious thought ensuing in the stimulation of emotional pathways (HarvardWomen'sHealthWatch, 2011). The stimulation of the emotional pathways prompts the autonomic fight or flight response, causing in an increased consciousness. This increased perception results in additional arousal of the emotional pathways causing the same reaction and a vicious cycle to ensue (HarvardWomen'sHealthWatch, 2011). This same mechanism is also believed to play a role in hyperacusis, resulting in the individual developing negative emotions toward sound perception (Baguley, 2003). Musicians and singers with tinnitus and hyperacusis may become depressed, withdraw from daily activities, and experience a decreased quality of life. This occurs when the tinnitus is extremely bothersome and interferes with the musician's and singer's ability to perform (Fagelson, 2018). A study conducted by Stormer, Laukli, Hoydal and Stenklev (2015) indicated that 20% of the musicians presented with chronic tinnitus, indicating that a large number of musicians suffer from tinnitus.

Studies conducted by Jansen et. al (2009), Callshsn et al. (2011) and Chesky et al. (2009) explored the perceptions and knowledge of musicians towards NIHL and the associated symptoms. Jansen et al. (2009), found that musicians felt embarrassed to admit they were experiencing hearing loss. Musicians reportedly felt embarrassed due to the attached stigma that one who has a hearing loss cannot be a good musician (Jansen et al., 2009) and believed that if they had a hearing problem their colleagues would doubt their abilities to play music, resulting in job loss (Jansen et al., 2009).

According to Jansen et al, (2009) musicians reported that they had an understanding of hearing health and the symptoms related to hearing loss. Musicians appeared to be aware of HPDs with 52% of participants wearing them (Jansen et al., 2009). Nineteen percent of participants reported that they were too embarrassed to wear them (Jansen et al., 2009), or felt as though HPDs impacted their ability to work as they cannot hear themselves or others resulting in the sound quality being affected (Callshsn et al., 2011).

Singers are exposed to the instrumental music and the sound of their own voice resulting in damage to the auditory system. A study by Hu (2018) found that 17.5% of singers presented with a MIHL and many do not wear HPDs. Chesky et al. (2009) reported that musicians find HPDs uncomfortable, painful, and difficult to work with. Additionally, it was reported that HPDs increased the occlusion effect experienced by musicians and singers (Chesky, Pair, Yoshimura, & Landford, 2009).

The WHO (2018) describes hearing loss as the 4th leading cause of disability worldwide. It is believed that 22% of workplace health-related problems are caused by noise exposure (WHO, 2018). Music-related hearing loss has been given little attention within the South African context. It is estimated that that the burden of world-wide occupational noise is 21% in developing countries and 7% in Western countries. Therefore, it is imperative to mitigate the effects of noise on the auditory system.

Hearing Protection

The effects of noise on the auditory system may be mitigated using HPDs. There are various types of HPDs available: earmuffs or earplugs (HealthandSafetyLaboratory, 2008); sound restoration level dependent protection devices, which contain similar processors to a hearing aid. Instead of amplifying sound these processors dampen the sound (HealthandSafetyLaboratory, 2008). The technology detects an increase in the noise level and in turn responds by gradually reducing the amount of noise transmitted. This device is typically used by musicians who play instruments with a large dynamic range (Callshsn et al., 2011); flat or tailored frequency hearing protectors target the low-frequency sounds and allows for a more natural sound to be produced through reduction across a large range of frequencies (HealthandSafetyLaboratory, 2008); custom moulded vent earplugs allow for the attenuations of high-frequency sounds, while low-frequency sounds can escape out the vent (HealthandSafetyLaboratory, 2008); a moulded flat response earplug is custom moulded and provide 9dB attention for low-frequency sounds and 15 dB HLattenuation for high-frequency sounds (HealthandSafetyLaboratory, 2008).

With the large variety of HPDs available, there are various factors to consider when choosing the right HPD for a musician or singer. The attenuation of noise may affect the musician’s and singer’s ability to perform. (HealthandSafetyLaboratory, 2008). Musicians and singers need to be able to hear themselves and others play. Therefore, if too much attenuation is provided they will not be able to do so (HealthandSafetyLaboratory, 2008).

The occlusion effect results in the build-up of noise within an enclosed space causing the sound pressure level at the eardrum of the occluded ear to increase (HealthandSafetyLaboratory, 2008). This effect changes the individual’s perception of voice quality and other body-generated sounds. It is possible to combat this effect with earmuffs or earplugs that are custom-made and have a canal length that passes the second bend (HealthandSafetyLaboratory, 2008). Musicians and singers who have a hearing loss and wear hearing aids also experience some of the above-mentioned difficulties such as the occlusion effect.

A musician/singer who wear hearing aids may experience a loss of frequency-specific information (Fligor, 2015) that can negatively impact the performance. Distortion from the hearing aid may impact the output (Fligor, 2015). Which may result in the musician and singer not wearing the hearing aid (Fligor, 2015).

To prevent damage to the auditory systems of musicians and singers, there should be designated policies and hearing protection programs (HCP). Hearing protection programs involve a risk assessment, education and training, the reduction of noise through noise control engineering, scheduling and administrative measures to decrease noise, the provision of HPDs, risk-based medical evaluations and medical surveillance and audiometry (Wells & Madison, 2017). A study conducted by Luders et al. (2016) highlighted the need for the inclusion of HCPs within the music industry.

Around the world, and in South Africa there are policies in place that indicate regulations surrounding the industrial effects and safety practices with regards to noise and the effects it has on the auditory system. In South Africa, we have the Occupational Health and Safety Act 85 of 1993. This act states that an employer needs to ensure that a working environment is required to be safe and without risk where reasonable to the employee. In order for the employer to achieve the requirement of the act the employer is required to eliminate or mitigate potential hazardous and safety concerns to the employee’s health before providing personal protective equipment (Governement, 1993). Additionally, the employer is required to establish precautionary measures. The act however does not mention anything about musicians, singers or any-one in the music industry, but rather to factories, mines and machinery. Within South Africa there appears to be a lack of guidelines available for the music industry regarding health and safety. Rennie- Salonen (2022) conducted research in the area of music and was unable to find any documents providing guidelines for the protection of musicians in South Africa just as the author of this paper has been unable to.

However, there does appear to be some guidelines present for the protection of musicians in the United Kingdom. The British Association for Performing Arts

Medicine has published guidelines in which they provide the best practice for the care of hearing health for musicians (Shephard, 2022)(Shephard, Ryan, Checkly, & Cordaux, 2020). According to the best practice guideline a HCP should be implemented to protect employees of the music industry. The HCP should be aimed at controlling the sound source, preventing and controlling too much sound exposure, the use and education of HPDs, and the education and training of musicians and singers and other employees about the effects of music on the auditory system and how to correctly care for the auditory system.

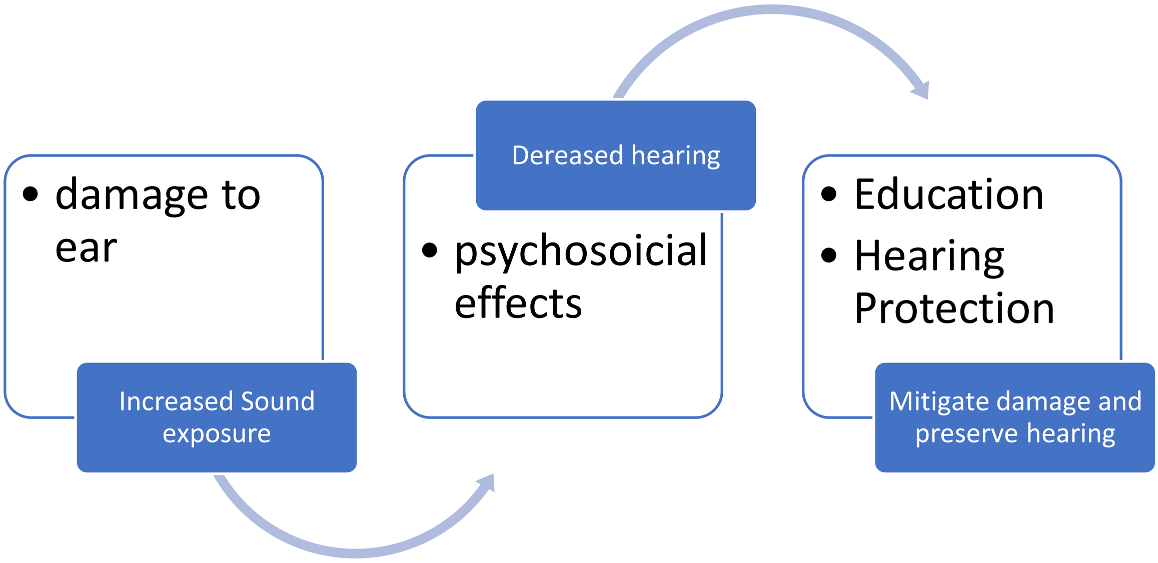
Additionally the Centre for Disease Control also published a guideline in 2015 to help mitigate MIHL. The guideline published came from recommendations made by NIOSH and recommended the decrease of the intensity of the music, the use of HPDs, where possible to distance the musician from the instrument as much as possible, regular sound level and hearing assessments, regular rest breaks which include quiet time and education and awareness campaigns (CDC,2015).

While there is a lack of research available on the programmes available and implemented within South Africa there has been research conducted into the various aspects of the music industry which would be able to assist in compiling these programs. One such study is that by Horell (2013) in which the effect of the acoustics of a performance venue on participants was conducted. The results indicated that after a short performance participants experienced TTS and that the ambient noise exceeded that of the recommended safe listening level.

Therefore, it is imperative that more research be conducted on the effects of music on musicians, singers and other players in the music industry in order to create effective plies to protect their health and safety both audiologically and overall.

Theoretical Frame work

Chart 1: Theoretical Framework 1



The theoretical framework of the study worked on the idea that with an increase in sound exposure damage to ear structures will occur. As a result there will be a decrease in hearing thresholds which will lead to psychosocial effects for the musician or singer. Therefore the study proposes that a solution to mitigate the damage caused by the increased exposure to sound is to educated singers and musicians and encourage the use of hearing protection. Additionally, empowering musicians and singers with tools to mitigate the damage may also preserve their and decrease negative psychosocial effects.

Chapter 3: Methodology

Aims of the study

Primary Aim:

To explore the audiological profile of musicians and singers in South Africa.

To achieve the above aim the following sub-aims will be employed

Sub Aims:

- To determine how musicians and singers perceive the impact of music on the auditory system.
- To document the ear history as well as if and how musicians and singers are using ear hygiene protocols and HPDs.

- To assess the outer ear, middle ear, and inner ear functioning of musicians and singers in South Africa.
- To assess the impact of tinnitus if it is perceived by the musician or singer.

Research Design

This study utilised an exploratory design that incorporated both qualitative and quantitative analyses. An exploratory design was selected as it is based on the idea that exploration is needed for several reasons (Creswell & Clark, 2007). The reasons include measures or instruments are not available, the variables are unknown or there is no guiding framework (Creswell & Clark, 2007). An exploratory design is also well suited for investigating a specific phenomenon as it begins qualitatively and progresses to a quantitative analysis. Lastly, an exploratory design is appropriate when generalisations are being made (Creswell & Clark, 2007).

The data were collected in phases one and two of the study provided qualitative information. Qualitative methods involve the use of open-ended questionnaires to answer questions pertaining to experience, meaning and perspective (Hammarberg, Kirkman, & de Lacey, 2016), therefore, a questionnaire was chosen as the data collection instrument for phase one of this study.

Phase two of the study utilised quantitative methods to obtain the data for this study, as diagnostic hearing assessments were conducted. Quantitative research makes use of the collection of quantifiable data that can be statistically analysed (Hammarberg et al., 2016). The qualitative results should assist in informing the quantitative results (Creswell & Clark, 2007).

Sampling

Purposive and snowball sampling was employed to obtain participants. The researcher aimed to purposively contact individuals within the music industry to request for participation. Participants were required to meet the inclusion criteria to ensure that they were suitable for the study population (Cottrell & McKenzie, 2011). The participants were recruited using social media adverts (Appendix L) that were posted on specific music platforms on Facebook and Instagram pages. Additionally, an e-mail was sent to the South African Music Association, The Arts and Culture faculty at various universities, the School of arts in South Africa, radio stations and musical talent agents requesting that they can please send the advert to their members, staff and students (Appendix M).

Each participant was asked to inform individuals about the study. The researcher provided her contact details to the participant for distribution to potential participants. Potential participants were then able to decide if they wanted to contact the researcher for further information. Snowball sampling is the process whereby participants inform potential participants of the study by providing them with information surrounding the study (Statisticshowto, 2017) . Snowball sampling was therefore be employed as it was beneficial given the large sample size required.

Sample

The target number of participants was between 50 and 100 individuals in total from both recreational and professional music spheres.

Inclusion Criteria:

Participants needed to meet the following inclusion criteria to be included in the study

1. Participants must partake in musical activities either recreationally or professionally.
   Rationale: Individuals need to be exposed to music for there to be an effect on the auditory system.

2. Participants should have at least six months experience as a musician or singer.
   Rationale: Noticeable damage to the auditory system can be identified after six months of exposure (Petrescu, 2008).

3. Participants must be 13 years or older.
   Rationale: participants must be able to understand and answer the questions in the questionnaire. Additionally, music is popular among the teenage population. Parental consent and participant assent will be obtained from participants between the ages of 13 and 17 years (Appendix C & D) Participants over the age of sixty years will also be included. Although they

may present with presbycusis, they will provide valuable information in other areas. The researcher is aware of the impact of presbycusis on the auditory system and results will include a discussion related to geriatric participants.

4. Participants can be from any gender description or race group.
   Rationale: Race and gender should not have an impact on the results as the study is focusing on all recreational and professional singers and musicians.

5. Participants may be from any part of the South Africa, provided they are able to get to the University of the Witwatersrand for the audiological evaluation.
   Rationale: The data will be more generalisable if participants are from different parts of South Africa.

Exclusion Criteria:

- Participants who are unable to get to the testing facilities at their own cost.
  Rationale: The testing will be performed at the convenience of both the researcher and participant free of charge at the practice of Dr Tami Mehl therefore, the assessment must be conducted at that location.
- Individuals who have been playing an instrument or singing for less than 6 months
  Rationale: individuals will not have sufficient exposure to music for a noticeable effect to be identifiable (Petrescu, 2008).

Data Collection Procedure and Instrumentation

Once ethical clearance was obtained from the Human Research and Ethics committee (medical) (M200729), an information letter (Appendix A) containing information about the study including the purpose of the study, benefits of the study, what will happen with the results from the study as well as the ethical considerations taken for the study was forwarded to participants who were interested in participating, the adverts were posted on social media to obtain participants (Appendix L) and Willing participants were required to complete a consent form (Appendix B or Appendix C & D in the case of a minor). Once the consent forms were signed the data were collected in two phases.

Phase1: Questionnaires (hearing related questionnaire and the Tinnitus Handicap Inventory if needed).

Instruments:

The first phase encompassed the administration of an online questionnaire (Appendix E) that was developed by the researcher. was administered. A questionnaire is a predefined set of questions that are used to gather information from participants(McLeod, 2018). If the participant indicated that they were experiencing tinnitus, the THI (Appendix F) The questionnaire is designed to acquire data pertaining to:

- history
- ear care
- perceptions of the musicians and singers in relation to ear health and hearing protection.

The questions contained open and closed-ended questions. Open-ended questions necessitate participants to provide the answers in their own words (McLeod, 2018). Closed-ended questions contain predetermined response for participants to select an answer from (McLeod, 2018).

Procedure:

The individual was required to fill in the questionnaire online using Google forms by answering questions surrounding their case history and knowledge and perceptions surrounding hearing health. The questionnaire was completed prior to the appointment for the testing.

Phase2: Full diagnostic hearing assessment, and diagnostic DPOAE

Instruments:

The second phase of this study encompassed a full diagnostic audiological assessment. This assessment included an otoscopic examination, immittance audiometry, pure tone audiometry, speech audiometry, and a diagnostic DPOAE. The DPOAEs are not part of the basic audiometry test battery and form part of the extended testing. An audiogram was used to record the results obtained in phase 2 (Appendix G).

The instruments required for the second phase of the study are:

- HD visual earwax clean tool (video otoscope) and computer
- Tympanometer (Interacoustics Impedance Audiometer AT235) and nubs
- Headphones (Circumaural TDH39)
- Bone conductor
- Audiometer (Natus Aurical Audiometer)
- Wordlist (South African Spondee word list & Arthur Boothroyd word list) (Appendix H & I)
- OAE machine (Path Sentiero OAE) and nubs
- Ultracide and alcohol swaps
- Audiogram (Appendix G)
- Referral letter (Appendix J)
- List of appropriate professionals (Appendix K)

Procedure:

Upon arriving at the testing site, the participant underwent the required Covid-19 Screening. Following which phase two was be completed with a full audiological test battery. This test battery included an otoscopic examination, tympanometry, pure tone and speech audiometry. Additionally, a diagnostic DPOAE was performed.

The results were recorded on an audiogram with the participant's number. This number correlated to the number on the questionnaire, to ensure anonymity while still allowing for corresponding results. The individual received the results of the assessment immediately. If the results indicated a problem, the individual was appropriately counselled and referred to the appropriate healthcare practitioner.

Pilot Study:

Instruments:

To assess the reliability and validity of the study, the entire procedure was conducted on an individual who met the inclusion criteria. The results were not included in the main study. The instrumentation and procedures included in the pilot study were, the questionnaire (Appendix E), the THI (Appendix F) an otoscope examination, speculi, a tympanometer, nubs, ultracide and alcohol swaps to clean the speculi and nubs, headphones, audiometer, South African spondee list (Appendix H), Arthur Boothroyd word list (Appendix I), Audiogram (Appendix G), DPOAE machine, referral letter (Appendix J) and referral list of appropriate professionals. (Appendix K)

Procedure:

The research site for data collection was originally planned for the Audiology Department at The University of the Witwatersrand. However, due to the Covid-19 Pandemic this site was no longer available for the duration of the study. As a result, the offices of Dr Tami Mehl Audiology in Illovo were rented and used. The researcher ensured that all the equipment was calibrated.

The first stage of data collection involved administering a questionnaire online via Google forms. The questionnaire contained questions pertaining to the individual's case history, knowledge and perceptions surrounding hearing health and the effects of music on the auditory system. If the individual indicated that they were experiencing tinnitus, the THI was administered.

The second phase of the data collection involved an otoscopic examination, tympanometry, acoustic reflex testing, pure tone, and speech audiometry, and a diagnostic OAE. The results were recorded on a record sheet with the participant's number. This number correlated to the number on the questionnaire, to ensure anonymity while still allowing for corresponding results. The pilot study indicated no overt problems with the procedure and instrumentation therefore, no amendments were made.

Data Analysis

Phase 1

Thematic analysis was employed on the qualitative data as, it allows the researcher to detect, examine, and report on themes within the data collected. The researcher searched through the data set for repeated patterns of meaning that encapsulate the information relevant to the research question as recommended by Braun & Clarke, (2006). Thematic analysis was used to scrutinize the answers to the open-ended questions of the questionnaire, and to find common trends regarding the case history, knowledge and perceptions of musicians surrounding hearing health.

Qualitative analyses through a systematic review were used to analyze the policies and procedures currently in place to protect the hearing health of musicians and singers.

Phase 1 and 2

Descriptive statistics were utilised to analyse the data obtained in phase 2 of the study. The closed-ended questions from the questionnaire, as well as the audiometric results, were analysed using this method. The descriptive analyses that were used are measures of central tendency and measures of variance, Logistic regression, the prediction of the probability of a dataset giving a specific categorical response to explain a relationship between variables, contingency tables, a table displaying the frequency distribution of variables, and the chi squared test of independence. This statistical analysis compares two variables in a contingency table to assess their relation to one another (Statisticshowto, 2020). This test was used to compare the audiometric information obtained from the pure tone, DPOAE and speech audiometry results of the professional and recreational musicians and singers. Additionally, the pure tone audiometry results of musicians and singers from various genres were compared. The chi squared test of independence was also utilised to analyse the results. A comparison between the musical background of the participants was explored and analysed using the chi squared test of independence. Microsoft Excel was used to organise the data set and Studio R was used to conduct the statistical tests.

Validity, Reliability and Vigour

Reliability identifies whether the results obtain are consistent (Statistics How To, 2016). Validity refers to whether the tests evaluate what they are intended to evaluate (Statistics How To, 2016). The reliability and validity of this study was ensured using a questionnaire with pre-determined questions. Furthermore, the equipment used for the audiological examinations were previously identified as being reliable through rigorous testing procedures.

The equipment was also all up to date with calibration. While the interpretation of the test results is subjective, the results were interpreted by the researcher. Therefore, the same criteria was assessed throughout the study. Furthermore, the researcher used quantitative (closed-ended questions, audiological test battery) and qualitative

(Open-ended questions) research approaches thus, providing a diverse perception of the areas investigated.

Vigour refers to the concept of the trustworthiness of the data (Naughton & Hughes, 2008). Vigour is synonymous with validity when addressing qualitative data (Naughton & Hughes, 2008). The trustworthiness of the data collected in qualitative research is dependent on the skill of the researcher, the appropriateness of the questions asked and the methods used to answer the question (Naughton & Hughes, 2008). Vigour was ensured through the participants writing down their responses on the questionnaire form, therefore, decreasing the probability of misinterpretation. Furthermore, the responses of the different participants were compared to one another in order to identify if the themes highlighted were consistent.

Ethical Considerations

The following ethical considerations were accounted for when conducting this research:

(1) Confidentiality, anonymity, and safekeeping of information.

Privacy denotes access to personal records and confidentiality is the use of the personal information once it has been accessed (DOH, 2015). All information will be kept strictly confidential between the research supervisor and the researcher. A research code number will be allocated to each participant to ensure that his/her personal identity will only be known to those involved directly with the research. The data will be stored in a locked cupboard or in a password-protected computer file and only the researchers will have access to it. Once the data is no longer required it will be destroyed

(2) Autonomy

Autonomy is the capacity to think, decide and act on the basis of this thought and decision freely and independently (SASLHA, 2011). The participants autonomy will be ensured by explaining the following to them.

Participation in the study is completely voluntary: participants have the right to refuse to participate and there will be no penalty. They also have the right to withdraw at any time with no penalty and without stating any reason. This means that participation, non-participation, or withdrawal will not influence any aspect of the research.

(3) Consent

The following information will be explained to the participant: the purpose of the research, as well as any potential risks, discomforts, or benefits to participation (Babbie, 2012). The researcher’s contact details, a copy of the participation information sheet (Appendix A) were also be provided to the nature, risks, benefits, and purpose of the study will be explained to the participant. The participant will be given the opportunity to ask any questions concerning the study. The participant will be asked to sign an informed consent form (Appendix B or Appendix C &D for a minor) acknowledging the above and that he/she has understood everything that had been explained to him/her.

(4) Beneficence and non-maleficence

Beneficence refers to the long-term benefits of partaking in the study while non-maleficence refers to the risks of partaking in the study (DOH, 2015). The diagnostic assessment risks revealing a hearing loss, resulting in possible psychological distress. The participant was, however, counselled during the feedback session with regards to the results obtained. A potential benefit of participation in this study, is education surrounding good listening practices and hearing health.

(5) Justice

Justice is the fair selection of research participants and the ideal distribution of risks and benefits when recruiting volunteer participants to participate in the study (SASLHA, 2011). This research does not aim to exploit, inconvenience, or manipulate the participants.

(6) Debriefing of participants

The participants will receive the results of their audiological straight away. However, participants will only receive the results of the study should they wish to have them. On the consent form there will be an option of whether they want to receive the results and if they do, they can provide an e-mail address where the results will be sent.

(7) Relevant referrals

Should any abnormalities be detected during the audiological examination, the participant will be provided with counselling and the appropriate referrals. Additionally, a list of doctors, either general practitioners, or ear nose and throat surgeons will be provided to the participant.

Chapter 4: Results & Discussion

The results of the study are presented in relation to the aims and sub-aims of the study. The results will first be presented, followed by a discussion of the results. This chapter commences with a description of the effects of covid-19 on the study, followed by the biographical information of the participants. Thereafter, the participants' perceptions of the impact of music are discussed, followed by the ear history, hygiene practices and use of HPDs by participants. Lastly the participants' audiological testing results are analysed and interpreted with the view of drawing a conclusion as to what the participants audiological profile is.

Background information of the study

The questionnaire had to be converted to an online format using google forms to allow participants to easily access it and minimize contact resulting from Covid-19. Additionally, at the time the questionnaire was created there was no studies available documenting the effects of Covid-19 on the auditory system. As a result, questions surrounding Covid-19 were not included. Data collection occurred during the peaks and lulls of the second and third waves. The waves impacted the data collection as the data collection process was slowed down due to participants cancelling appointments due to isolation, pulling out of the study as they felt unsafe, and the researcher having to reschedule as the researcher was required to isolate.

Lastly, the covid 19 pandemic impacted the researcher's state of mind, as it was more difficult than expected to find participants, overall health was of great concern, and stress levels were increased as there were delays at all levels including the university level due to the pandemic that resulted in the study's timeline being pushed out to later dates.

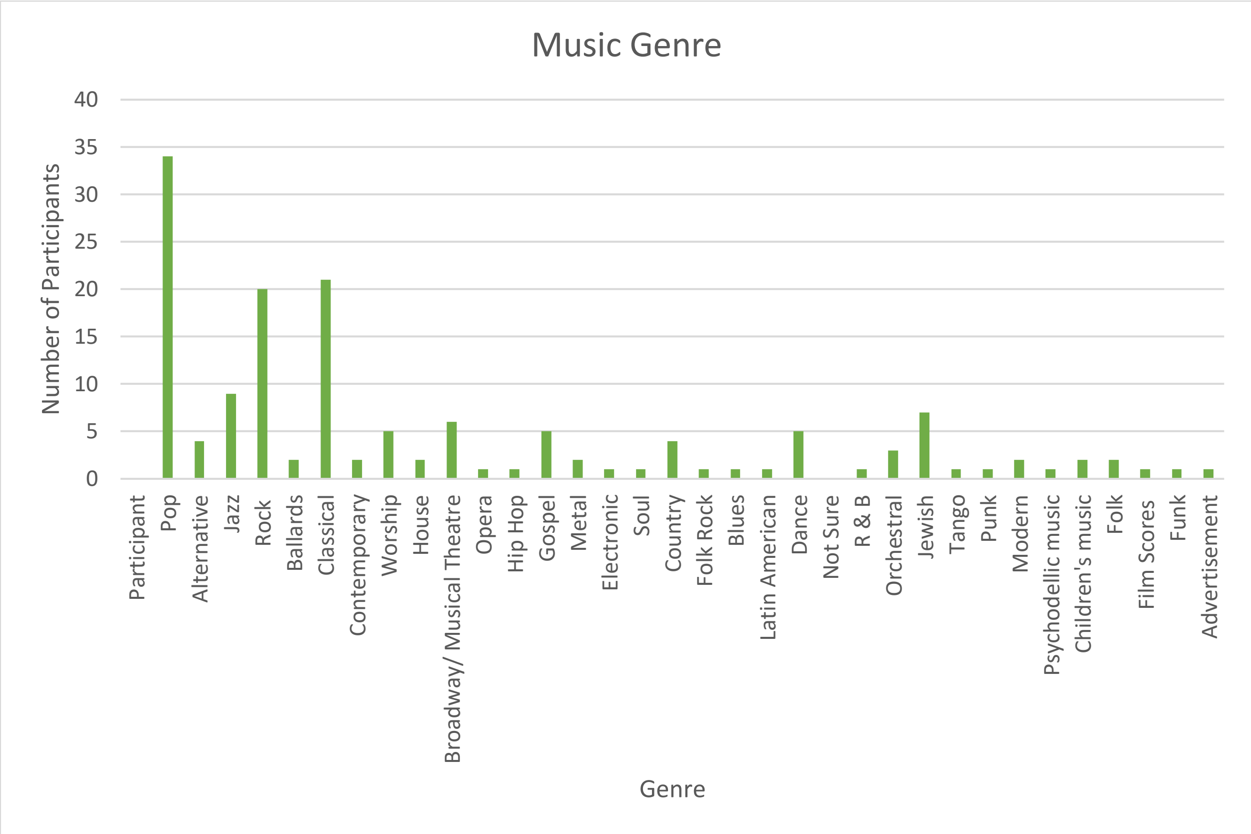
Participant biographical and musical/singing history

The final number of participants was 57, participants were asked to identify if they were musicians, singers or both and their preferred gender. Twenty-nine participants indicated they are male and twenty-eight participants indicated they are female. Thirty-two participants indicated they are singers, of these 14 participants indicated they are male and 18 participants indicated they are female. The participant's gender was included on the case history form for various reasons such as pronoun identification for specific genders or the use of gender-neutral pronouns (Wamsley, 2021) as well as, the impact on the analysis of the data in relation to patterns or trends with in specific categories. For example singing and the association of gender and vocal ranges.

Additionally, 13 of the participants indicated that they sing socially, and 15 participants indicated that they sing professionally. Forty participants indicated that they are musicians, of these 22 participants indicated that are male and 18 indicated that they are female. Fourteen of the 40 participants play music socially, and 16 participants play music professionally. Fourteen of the overall participants indicated that they are both musicians and singers, of these 7 participants indicated that are male and 7 indicated that they are female. Ten participants of the 40 participants indicated that they play music and sing socially, and 9 participants indicated that they sing and play music professionally.

The age of the participants ranged from 13 to 75 years . Participants indicated a variety of 34 genres that were played and/or sung: Pop, Alternative, jazz, Rock, Ballard's, Classical, Contemporary, Worship, House, Broadway, Musical Theatre, Opera, Hip/Hop, Gospel, Electric, Soul, Country, Folk Rock, Blues, Latin American, Dance, R&B, Orchestral, Jewish, Tango, Punk, Modern, Psychedelic, Film scores, Funk, Advertisements, Children's music and not sure. Sixteen percent of the participants indicated that they only played or sang one genre, therefore, majority of participants engaged in more than one genre.

Figure 1 Music Genre



Singers indicated that they had been singing from 1 year to over 41 years either for a duration of more or less than 8 hours. The singers indicated the vocal categories into which they fall of which there were 13: contralto, soprano, mezzo-soprano, tenor, baritone, base, alto bass-baritone, I don't know, acapella, with instrumental backing, solo, ensemble. Twenty-three singers indicated that they have had formal training. Due to the small sample size the singers that indicated that they sang bass, alto and 'don't' know' were combined to form a group other for the purpose of analysis.

The results from the questionnaire indicated that singing solo and singing ensemble are highly negatively correlated to each other, therefore, the one is opposite to the other. Additionally, singing acapella and singing with instrumental backing is also highly negatively correlated to each other. A possible explanation for this may be that these categories are opposites to one another therefore, if the participant does not fall in one they must fall in the other.

Vocal categories were statistically significant in relation to gender, according to the chi squared test of independence the vocal categories were statistically significant at the 10% confidence level. The results revealed that soprano and mezzo-soprano singers were female and baritone and acapella singers tended to be males. These results may be due to the different vocal pitches naturally associated with the different genders. Soprano, mezzo-soprano, and other are statistically significant at 10 % confidence level in relation to singing mor than 8 hours a day. This may be of significance later on when analysing the audiological results and the effect of music on the auditory system.

Musicians indicated that they played their instruments ranging from 1 year to over 41 years either for a duration of either more or less than 8 hours a day. The musicians indicated that 26 different types of instruments were played: piano, guitar, drums, bass, violin, recorder, keyboard, percussion, marimba, banjo, ukulele, cello, saxophone, clarinet, church organ, trombone, djembe, euphonium, tuba, French horn, double bass, keytar, clarinet, flute, bass guitar, electric guitar, keyboard, electric bass, electric drums, electric bass guitar, electric double bass.

Sixty five percent of participants indicated that they have had formal musical training. In order to simplify the analysis of the results the instruments were grouped into 6 categories: keyboard, string, electric, percussion, woodwind, woodwind, brass and acoustic (instruments that do not fall into any of the above categories). The distribution of the age of the musicians and singers was compared, and results revealed that musicians tended to be older in age than singers therefore, the age of the musicians was skewed to higher ages.

The chi squared test of independence revealed a 10% confidence level between gender and electric instruments, indicating that more males play electric instruments than females. This may be important when interpreting the audiological results later on. Analysis of the results also indicated that the musicians who play string instruments play music for more than 8 hours. Seventy eight percent of participants who have not received formal training play electric instruments.

Participants indicated a variety of genres in which they sang or played music. There were 34 genres indicated, however for ease of analysis these genres were grouped into 10 categories. The categories are; Pop, Modern (alternative, contemporary, modern, house, R&B, hip hop), Jazz (ballads, soul, blues), Rock (rock, metal, electronic, psychedelic, punk), Classical (classical, orchestral), Worship (worship, gospel, Jewish), Country (country, funk, folk, folk rock), Broadway (Broadway, musical theatre, opera), Dance (dance, tango, Latin) and Miscellaneous (children's music, film scores, advertisements).

Table 1 shows the percentage of participants in each genre group. It must also be noted that participants indicated that they were part of more than one genre group.

Table 1: Percentage of Participants per genre group

	Percentage
Pop	59.649
Modern	17.544
Jazz	22.807
Rock	35.088
Classical	38.596
Worship	29.825
Country	10.526
Broadway	10.526
Miscellaneous	7.018
Dance	12.281

There were no statistically significant correlations between the genre categories therefore, they were well grouped and mostly independent of each other. As a result, the results of each genre category did not affect a different genre category. Jazz, Rock, and Broadway were statistically significantly associated with gender at the 10% confidence level. There was a significant proportion of jazz performers who were female when compared to non-jazz performers. Additionally, a larger proportion of rock performers were male when compared to non-rock performers. Lastly, there were no men in the Broadway category, however, this may be due to the sample size and may not be a true reflection of the population. Gender imbalance has dominated the music industry for many years. Traditionally Jazz performers were associated with being male, one reason is that women were associated with playing instruments that did not obscure their physical features and did not require physical strength. The reasons that women could not play all the same instruments as men were linked to roles that defined gender and the belief that women should be at home looking after the family (Wehr, 2015).

The results of the current study indicate the opposite. The current study indicates that more female participants were involved in Jazz. These results may be as a result of the general global trend to open up previously male-dominated spheres to women (Wehr, 2016). Globally women are stepping out into the male-dominated spheres such as business, medicine and music etc., and showing that women are just as capable as men and do not belong in a family only role as previously imposed by society (Walker, 2017). The results indicating the involvement of more females in jazz may be also due to the small sample size. Therefore, further investigation is needed to determine if Jazz players are indeed associated more frequently with being female. The Classical music genre was significantly related to being a professional performer at the 10% confidence level and a social performer at the 5% confidence level statistically. These results may be supported by classical music being related to traditional instruments therefore, performers who play these types of instruments are usually trained and pursue a career in music (Oxford English Dictionary, 2022)

The Classical genre was also statistically significant at the 5% confidence level with being a musician. Most classical performers were professional however, of those only a small number were singers. This may be due to the fact that classical music is more instrument based therefore, musicians may be biased in participating in the classical genre over singers. (Kallen, 2013).

The Broadway genres was statistically significant at the 10% confidence level with being a singer. This result is not surprising given the definition of Broadway according to The Oxford English Dictionary (2022) is ‘the theatre district’ and the theatre productions often associated with this area are musicals.

Genre also showed a significant relationship to the various instruments. Rock was significant at the 5% confidence level with keyboards. However, closer inspection revealed that a smaller percentage of rock musicians were able to play the keyboard than non-rock musicians. This may be as a result of the types of instruments frequently used when playing rock music such as an electric guitar, bass guitar and drums (Clark, 2022). A keyboard may be used for rock music but it is not as common as the other instruments (Clark 2022). String instruments are commonly used for rock music, and this correlates with the results indicated in this study with rock being significantly related to the string instruments at the 1% confidence level.

Both rock and percussion were statistically significant with percussion instruments at the 10% confidence level, with half of all rock musicians playing a percussion instrument. Therefore, there is a strong statistical correlation between being a rock musician and being able to play a percussion instrument. Whereas in comparison there were few musicians in the classical category who played a percussion instrument.

Genre and the vocal category soprano were significant at the 1% confidence level. This association may be because as stated earlier all Broadway singers are female which may have skewed the results. Pop, Worship and Singing with instrumental backing were significant at the 5% confidence level with genre. The results indicated that pop singers sang with instrumental backing and worship singers sang acapella.

Additionally, worship singers appeared not to sing solo and this was confirmed by the chi-squared test with a confidence level of 10%. These results are reinforced by the nature of both pop and worship music. Pop music is often associated with having various instruments creating a melody in the background and lyrics that are sung by a lead singer (Montagu, 2017). On the other hand, worship music is associated with religious use and is often sung by choirs at places of worship (Sliwinska-Kowalska & Davis, 2012). A larger proportion of rock performers used headphones to listen to music compared to non-rock performers. This was confirmed by the chi-squared test of independence at the 10% confidence level. There was no clear reason for this and further research would be required to determine the relationship between the use of headphones and rock performers.

Sub-aim 1: To determine how musicians and singers perceive the impact of music on the auditory system.

The effects of music on the auditory system are vast, therefore it is vital that researchers understand these effects by delving into the various audiological symptoms.

Table 2:Chi squared results for occurrence of ear disorders

	Age	Gender	Profes.	Social	Singer	Musician	Prev. H.A.	Head/Neck
Dizziness	0.675	0.209	0.858	0.800	0.935	0.971	0.146	0.618
Vertigo	0.102	0.397	1.000	1.000	0.309	0.827	1.000	0.357
Nausea	0.693	1.000	0.760	1.000	1.000	0.522	0.133	0.789
Bleeding ears	0.175	1.000	0.966	0.396	0.584	1.000	0.652	0.992
Temporary Hearing Loss	0.206	0.816	0.408	0.054	0.824	1.000	0.016	0.765
Itchy Ears	0.289	0.885	0.108	0.208	1.000	0.665	0.007	0.059
Discharging Ears	0.484	1.000	1.000	1.000	0.202	0.716	0.578	0.862
Tinnitus	0.568	1.000	0.784	0.280	0.749	0.333	0.001	0.097
Hyperacousis	0.675	0.209	0.858	0.800	0.935	0.971	0.146	0.618

Table 3: Chi squared results for frequency of ear disorders

	Age	Gender	Profes.	Social	Singer	Musician	Prev. H.A.	Head/Neck
Dizziness	0.675	0.209	0.858	0.800	0.935	0.971	0.146	0.618
Vertigo	0.102	0.397	1.000	1.000	0.309	0.827	1.000	0.357
Nausea	0.693	1.000	0.760	1.000	1.000	0.522	0.133	0.789
Bleeding ears	0.175	1.000	0.966	0.396	0.584	1.000	0.652	0.992
Temporary Hearing Loss	0.206	0.816	0.408	0.054	0.824	1.000	0.016	0.765
Itchy Ears	0.289	0.885	0.108	0.208	1.000	0.665	0.007	0.059
Discharging Ears	0.484	1.000	1.000	1.000	0.202	0.716	0.578	0.862
Tinnitus	0.568	1.000	0.784	0.280	0.749	0.333	0.001	0.097
Hyperacousis	0.675	0.209	0.858	0.800	0.935	0.971	0.146	0.618

Tables 2 and 3 indicated that there are 9 audiological symptoms (dizziness, vertigo, nausea, bleeding of the ears, discharging ears, hearing loss, itchy ears, and hyperacusis) that were recorded, as well as the occurrence and frequency that the participants experienced the symptoms. The occurrence of the symptoms and the frequency of the occurrence was analysed separately. However, it is noteworthy that most participants indicated having experienced more than one of the audiological symptom. The results suggest a directly proportional relationship between the symptoms and age, as one gets older so too does the number of symptoms experienced.

Due to participants experiencing multiple disorders correlations were used to analyse the results. Hyperacusis and dizziness were highly positively correlated, and so too was nausea and dizziness and nausea and hyperacusis. Therefore, these results suggest that the presence of one symptom implies the presence of the other e.g. dizziness implies the presence of hyperacusis and vice versa. Research suggests that the reason these symptoms often co-occur is because they are associated with damage to the vestibular pathway and auditory pathway simultaneously either due to injury or illness (Shin et al., 2022). The, anatomy of the ear supports the research, the cochlea, the semi-circular canals the ampule, saccule and the vestibulocochlear nerve are all with in a small space and close proximity to each other (Seikel et al., 2010). Thus suggesting that an infection in one can easily effect a surrounding structure. There are many infections that can affect the ear these infections can be viral, bacterial or fungal. However, the most common type of infection is otitis media, often referred to as a bacterial middle ear infection (CDC), 2021).

Self-reported hearing loss is of special interest to this study and the results were as follows. Twelve percent of participants reported only occasionally experiencing hearing loss, 9% of participants reported continuously experiencing hearing loss and only 3.5% of participants reported experiencing hearing loss after exposure to music. The chi-squared test of independence indicates with 10% confidence that self-reported hearing loss is significant with social singers and musicians. However, these results may be skewed as there was a greater number of professional performers that reported ‘occasionally’ experiencing hearing loss compared to the vast number of social participants who reported ‘often’ experiencing hearing loss.

Self-reported hearing loss, itchy ears and tinnitus are all statistically significant at 5% confidence with having had previous assessments. Research indicates that there is a discrepancy between self-reported hearing loss and hearing loss identified through objective measures (Choi, Moon, Baek, Kim & Cho, 2019). This discrepancy appears to be influenced through a variety of contextual factors such as demographics and the severity of the hearing loss (Choi, Moon, Baek, Kim, & Cho, 2019). Forty-three percent of participants who reported experiencing hearing loss also reported having undergone previous hearing assessments compared to those who do not. Therefore, the self-report aspect does not play such an important role as these participants already have objective results to refer back to.

Dizziness, vertigo, bleeding, and hearing loss are significant at the 10% confidence level with age. The effects of age on the auditory system has been widely researched and indicates an increase in the presence of audiological symptoms particularly hearing loss and tinnitus (Cheslock & De Jesus, 2022). The current study did not have an upper age limit, therefore it is important to consider the effects of age when interpreting the results of participants within the older age groups (60 years and older). Research suggests that the presence of these symptoms are primary from age-related changes in the stria vascularis, hair cells and afferent spiral ganglion neurons (Cheslock M, 2022).The questionnaire also revealed that 65% participants felt that their auditory system had been impacted by music, with only 33% participants stating that they did not feel music had any impact on their auditory systems. The reasons participants felt that their auditory systems were impacted gave rise to one prominent theme surrounding music and the auditory system. This theme is *the attitude to the effects of music* Participants indicted that they felt music had effected the way that they perceive sound. Participants 6, 13, 20, 28 & 32 stated that it,

'*helped with noticing the detail and paying more attention to smaller less obvious sounds'*.

Additionally, participant 27 stated that they felt music

'helps with hearing softer sound'.

Lastly, participant 8 stated that they were

' *more sensitive and aware of pitch, vocal control, timbre, dynamic rhythm and that "they" are more focused the individual parts of complex sounds'*.

Research indicates that over the years music has been found to provide various functions such as reducing anxiety, social cohesion, providing a sense of calmness etc. (Schafer, Sedlmeier, Stadtler, Huron, 2013).Recent research shows that in addition to providing positive psychological reinforcement music also assists with positive cognitive reinforcement (Schafer et al, 2013). Music allows various neurological pathways in the brain to fire and become active, which in turn allows for more brain activity in these areas (Schafer et al, 2013). The participants of the current study indicated increased awareness to right sided brain function skills such as rhythm, non-verbal cues, and musical qualities etc.. This is in line with the above research as music activates the pathways on the right side of the brain.

Thirty nine percent of participants stated they felt music had an audiological impact. The participants indicated that they perceived experiencing hearing loss, tinnitus and hyperacusis. Participants experienced both tinnitus and hearing loss. However, 14% participants stated that they only experienced hearing loss and 5% participants stated that they only experienced tinnitus. One participant reported that they experience hyperacusis. It is widely known through various research studies that music has damaging effects on the auditory system such as MIHL and tinnitus. Research conducted by Zhao, Manchaiah, French & Price (2010), in which they reviewed various studies focusing on the effects of music on musicians highlights the above point. Zhao et.al. (2010) found that music effects all areas of the auditory system therefore, more efficient tools for monitoring should be used.

Summary of findings for sub-aim 1:

Therefore, participants felt that music had both a positive and negative impact on their auditory systems. The age and gender of participants appears to have an impact on the audiological symptoms experienced. Participants who reported they were experiencing hearing loss may have been influenced by previous hearing assessment results.

Sub-aim 2: To document the ear history as well as if and how musicians and singers are using ear hygiene protocols and HPDs.

Sub-aim 1 looked at the participants perceived audiological symptoms. These symptoms also tie into the participants ear history and cannot be ignored when exploring sub-aim 2.

While most the data is presented above in sub-aim 1, there are some areas of the participants’ history that are of interest and need to be included within this section. Forty percent of participants stated that they had undergone a previous audiological assessment. The results of the previous audiological assessment are important to the study as they impact the findings of the study. The reason for documenting previous audiological disorders is that previous disorders need to be accounted for and excluded from the results as pre-existing and not necessarily related to the effects of music. Most participants who indicated that they had gone for previous hearing assessments indicated that they did not go often for a hearing assessment. Sixteen percent of participants stated the results indicated a hearing loss and 4% of participants indicated the results showed eustachian tube dysfunction. Eustachian tube dysfunction can cause an air bone gap on the audiogram (Tyler, Noble, Coelho, Roncancio, & Jun, 2015b) and needs to be accounted for as a pre-existing condition.

Sixteen percent of participants indicted that they had undergone head and neck surgery, of these12% of participants indicated they had received grommets and 1 participant indicted they had also undergone a tympanoplasty. Previous ear surgery such as grommets and a tympanoplasty can cause scarring on the tympanic membrane (Schlauch & Nelson, 2015). Scarring may result in a reduction of movement leading to a possible air bone gap and conductive hearing loss (Schlauch & Nelson, 2015).

Additional contributing factors to ear disorders are the use of audio devices and the ear hygiene protocols. Therefore, the study explored these aspects and the results are as follows. Only participants who indicated the frequency (number of times a week) at which the audio devices were used as well as the level (volume) at which they listened to sound on these devices were included in this sample. Two participants indicated that they used more than one device.

Table 4: Use of audio devices

Audio device	Participants
Headphones	15
Airpods/Earphones	13
Inserts	9
No device/ Speakers	4

As indicated in table 4 the device categories include air pods, earphones, headphones, inserts or in ear monitors, and speakers or no devices. The variables that were analysed included how often the participants listen to music or use the device, the volume at which participants use the device, whether or not participants cleaned the device, and how often the devices were cleaned. Table 5 shows the Chi-squared results of the device factors as well as the variables that effected these factors.

Table 5: Chi squared results for audio devices and variables

	Age	Gender	Profes.	Social	Singer	Musician	No. of Disord.
Device Usage Hours	0.752	0.313	0.384	0.683	0.400	0.656	0.639
Volume	0.624	0.527	0.641	0.704	0.613	0.234	0.597
Airpods/Earphones	0.067	0.733	1.000	0.565	0.906	0.270	0.203
Headphones	0.144	0.347	0.727	0.116	0.444	0.934	0.756
Inserts	0.219	0.618	0.227	0.882	0.170	0.825	0.124
No Device/Speakers	0.874	0.080	0.351	1.000	0.944	1.000	0.001
Clean Earphones	0.364	1.000	0.904	0.565	0.125	1.000	0.392
Earphone Cleaning Frequency	0.586	0.109	0.203	0.422	0.106	0.916	0.387

The chi-squared table of independence was used to determine the association between the devices and various variables such as age, gender, singer, musician, social, professional, ear disorders etc. Air pods and earphones were statistically significant at the 10% confidence with age group, indicating that younger participants used Air pods or earphones. These results are in line with current research which indicates that the younger generation 'the millennials' are reliant on earbuds and wearing them more frequently than previous generations (Fasanya & Strong, 2019). Thus, the more frequent use of air pods by younger participants is supported by previous research conducted. Participants who used no devices or speakers had a higher number of disorders compared to their counterparts. However, due to the small sample size this result cannot be extrapolated, and the chi squared results may not be deemed as reliable.

Figure 2: Frequency of device usage

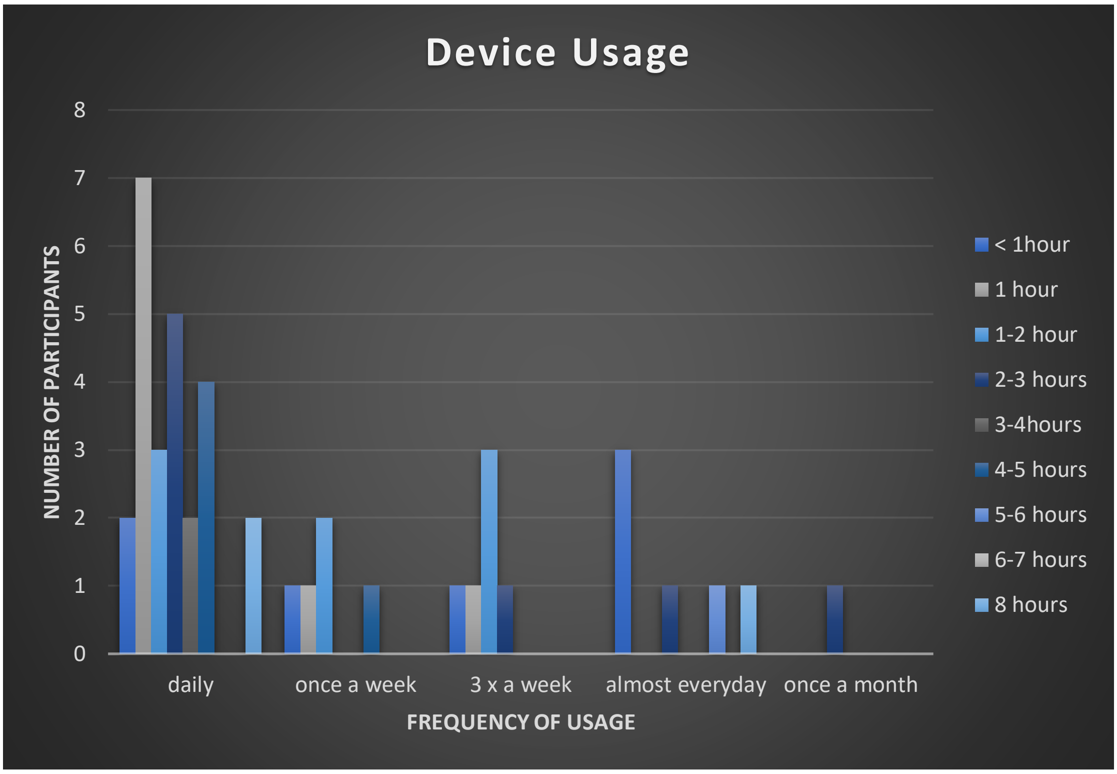
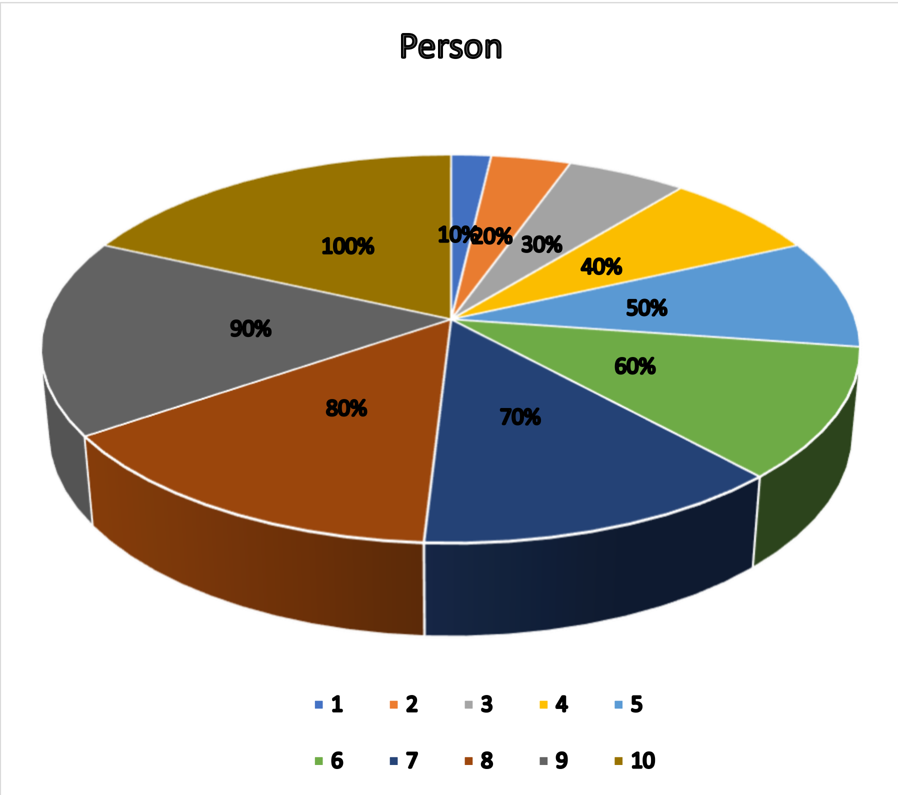


Figure 2 shows the frequency of usage of devices by the participants. Device usage of hours per day and inserts or earphones are statistically significant at 10% confidence with hearing loss. The number of hours per day and inserts or earphones was also significant at the 10% confidence level to the frequency of reported itchy ears.

The prolonged exposure to increased listening levels may impact the participants' hearing as well as influence some of the audiological symptoms experienced. Research suggests that exposure to sounds over 85 dB HL for longer than 8 hours a day is considered hazardous to the auditory system. Research further suggests, as the intensity of the sound increases, the time spent listening to the sound safely halves (Fligor et. al 2013). Therefore, participants who are exposed to increased levels of sound for extended periods of time require closer monitoring (Chadha, 2014). As a result, education of participants surrounding the harmful effects of music is warranted.

Participants were asked to subjectively indicate on a scale up to 100% how loudly they listened to music. Majority of participants indicated they listened to music in the louder regions (60% - 80%) with 23% participants listening at 60%, 37% participants at 70% and 18% participants at 80%. These results can be seen in the figure 3.

Figure 3: Device listening levels



Additionally, the use of HPD's was explored and the results indicated that 88% of the participants did not use them. There were a number of reasons given by participants as to why they did not use HPDs. The reasons given were;

- participants did not know what HPDs were or how to use them,
- participants felts that HPDs were unnecessary,
- participants felt that HPDs effected the sound quality,
- participants felt that HPDs were too costly.

A study conducted by Jansen et. al (2009) indicated that musicians who were aware of HPDs chose not to wear them due to the decrease in sound quality and the discomfort they caused. Additionally, it was found that there was a psychological aspect as well in which musicians felt that their peers would judge them or thing poorly of their skills for using HPDs (Jansen et al., 2009). However, the current study indicated that the most common reason for the lack of use of HPDs was lack of knowledge, with 37% of participants indicating this as the reason. Although, previous research does not indicate a lack of education as a prominent reason for the poor use of HPDs by musicians and singers Jansen et. Al., (2009) did comment on inadequate education as one of the contributing factors.

The current study found that seven participants indicated that they did use HPDs, however, 4 of them indicated that they only wore it in one ear due to decreased sound access when both ears were occluded Research conducted by Callshsn et.al. (2010) also indicated that musicians and singers felt that HPDs decreased the quality of sound, and provided and increased occlusion effect when worn. Participants indicated that they used 3 types of HPDs. Four participants indicated that they use over the counter (OTC) ear plugs, one participant indicated that they use noise-cancelling headphones and two participants indicated that they use custom made hearing protection. Themes within the data set surrounding the use of HPDs include Education and Apathy.

Two themes that emerge from the data surrounding the use of HPD's are of lack of education and apathy (lack of concern).

'not aware [about HPD's]' participants 14, 17 & 18.

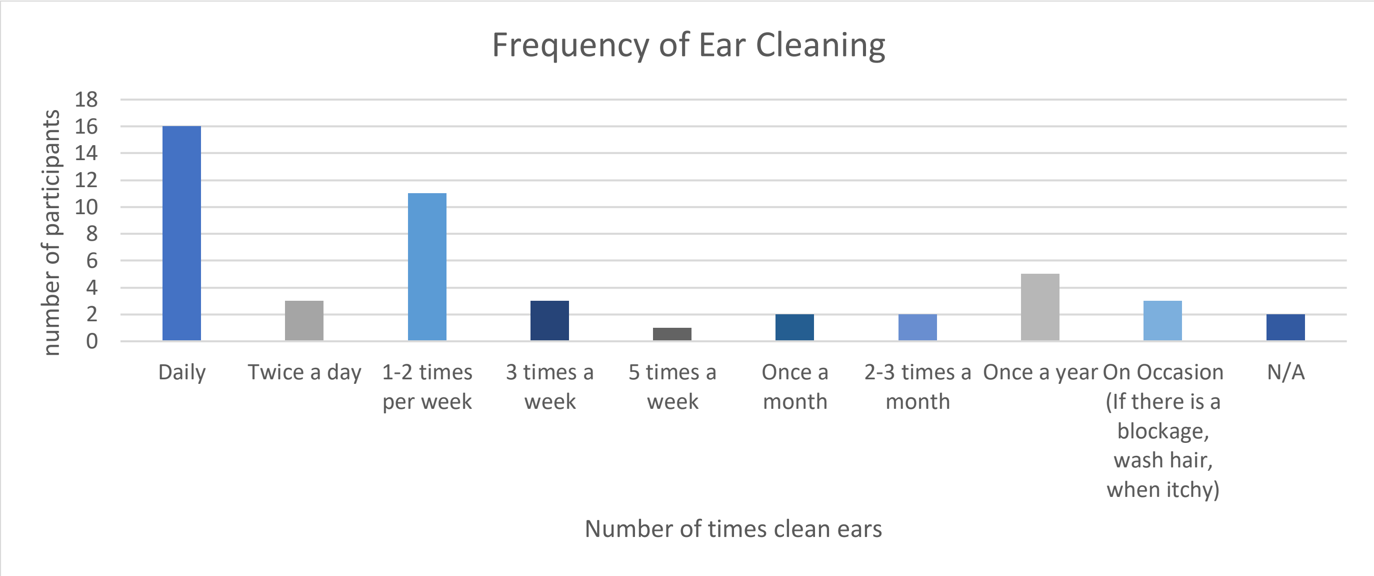
'*did not know about* HPD's]' participants 1,2,3,6,15,20, 21,22, 27, 47, 48, 53 and 54.

'did not know it was necessary' participants 9, 11, 12, 16, 19, 23, 28, 29, 31, 38 and 40.

The 3 quotes describing the participants views on HPDs highlight the need for education surrounding the role, use and function of HPDs. What was of greater concern is that 13 participants indicated that they felt the use of HPDs 'was not necessary'. The reason for this comment was not stated however, it should be further investigated as to why performers feel that hearing protection is not necessary.

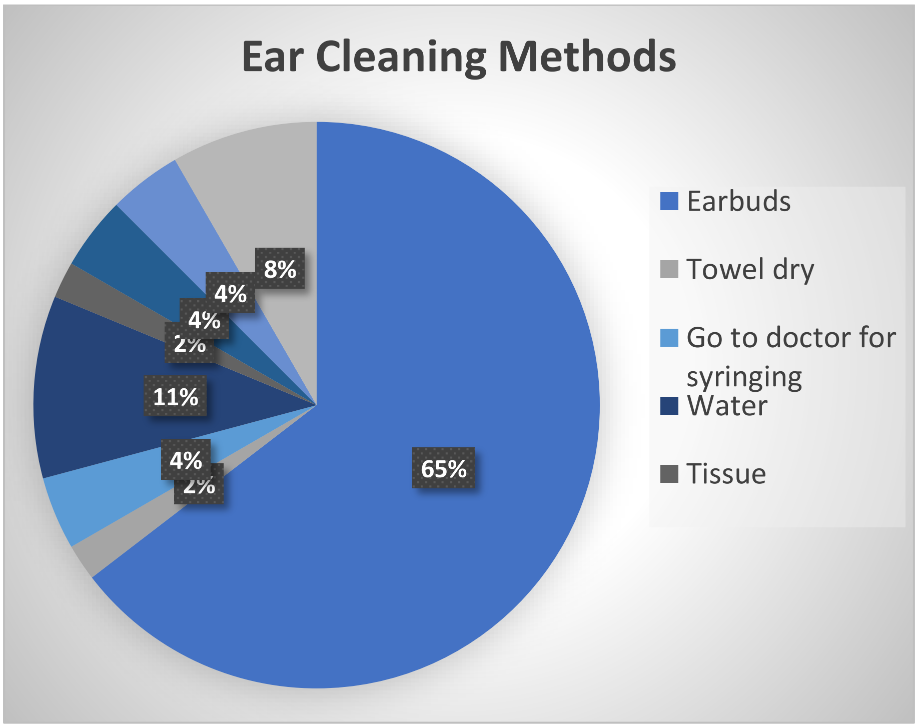
The results pertaining to ear hygiene practices are also documented. Eighty-one percent of participants indicate that they clean their ears. The frequency at which participants clean their ears can be seen in the figure 4.

Figure 4: Frequency of ear cleaning



These results indicate that 35% of participants clean their ears daily and 24% of participants clean their ears once a week. This is suggestive that participants who clean their ears do so regularly. Research conducted by Flowers & Pillay (2021) correlates with the results of the current study, that ear cleaning is done regularly. The various methods used by participants to clean their ears can be seen in figure 5.

Figure 5: Ear cleaning methods



These results indicate that participants cleaned their ears with more than one method. The most common method used was earbuds with 67% of participants utilising this method to clean their ears. The second most utilised method was the use of water in the shower, with 28% of participants making use of this method. The use of earbuds as the most common method for ear cleaning indicates the lack of knowledge of the participants surrounding the correct methods to keep the ear clean. These results correlate with those obtained in a study conducted in South Africa by Flowers & Pillay (2021), wo assessed the ear hygiene practices of sportsmen and women. The results of the current study as well as the study conducted by Flowers & Pillay (2021) indicated that participants did not have adequate knowledge about the correct methods to clean their ears and aural hygiene in general. This highlights the theme of education that has been evident throughout the data set with in this aim and it will be explored further later.

Participants were asked about what their understanding and perceptions of what ear health were. Fifty percent of participants indicated that they did not have a lot of knowledge and understanding in relation to good ear health practices.

'*not much' participants 2, 5, 8, 17, 21, 25, 27, 41, 44, 53, and 57.*

Participants' responses also indicated a very basic understanding of ear health practices if any. Eighteen percent of participants indicate that their understanding of ear health related to cleaning the ear

'*importance of clean ears'*, participants, 10, 13, 18, 20, 41 and 49.

Sixteen percent of participants indicated that their understanding related to noise and damage to the ear.

'*noise exposure and damage to the ear'*. Participants 1, 4, 19, 22, 29, 37, 40, 51,52 and 55.

The participants' understanding about ear health indicates that participants only spoke to one area of ear health. However, it must be noted that 9% of participants did indicate broader knowledge bases stating that both noise and clean ears were involved in good ear health. Analysis of these results once again highlights the emergence of the theme of education which is to be explored further down.

Two participants indicated that they knew of the importance of ear health however, they had no concerns due to their age.

'*not worried about it*', at '*a young age'*. Participants 15 and 33.

This statement is of great concern as it shows the possible mindset of younger musicians.

Additionally, Participants 16, 28, 30 and 42 stated:

'understand ear health but do not do it'.

This further reinforces the theme of apathy which has been identified earlier on in the data set when analysing the use of HPDs. The apathetic attitude of the participants highlights the need for further studies into why these attitudes exist.

The theme of education has been present throughout the data within sub-aim 2. The data indicated that participants lack the education about safe listening practices. The safe listening practice guidelines suggest that harm is done to the auditory system after repeated prolonged exposure to sounds 85dB HL for 8 hours or more (WHO, 2018). The statement by participant 27 stating she had

'*never heard of them'*

when referring to HPDs also highlights the need for education surrounding safe listening practices. Participants were asked if they felt programs should be implemented to educated musicians and singers about hearing health, and 90% of participants felt that this would be beneficial. Participant 23 commented

'*Definitely. There isn't enough education'.*

Research by Jansen et al. (2009), also found that there was a lack of education amongst musicians. Furthermore, current research in South Africa revealed that there is also a lack of education surrounding ear care practices (Flowers & Pillay, 2021). Additionally, the incorrect use of earbuds by participants to clean their ears further demonstrates the dire need for the implementation of the program. The research conducted Flowers & Pillay (2021) was on sports men and women. This suggests that the lack of education extends beyond the population of musicians and singers with in South Africa.

The second theme that was identified while analysing the data set' was that of a lack of concern. Some of the participants possessed the knowledge but felt that they would not be effected by the harmful effects to the auditory system of poor aural hygiene. Participant 16 stated:

'*they do not feel it is necessary (to wear HPDs) on their level of exposure'.*

This statement highlights what many participants who did not use the correct hearing protection felt. The participants did not identify themselves as being at risk or did not identify music as a significant enough exposure to cause damage. Research conducted by Chesky et.al (2009) indicated that musicians also found that HPDs were difficult to work with which further impacted their decision not to use them. Participant 8 stated:

‘*Earbuds. Put in, wiggle around, hope for the best? I really don't know how you're supposed to do it’.*

This statement suggests that Participant 8 knows that earbuds are not the best way to clean their ears but because she does not know another way or has not found out how to clean her ears correctly she continues cleaning them incorrectly and risking damage to the ear.

Therefore, the results of sub-aim 2 indicate that having gone for previous assessments influenced the participants indication of self-perceived hearing loss on the questionnaire. Younger participants wore earphones or earbuds compared to the older participants, and participants who indicated that they did not use listening devices or used speakers had a higher incidence of ear pathologies. The results also indicated that participants did not use HPDs for various reasons such as cost and lack of knowledge etc. Additionally participants did not know the correct ear hygiene practices and correct ways to protect their hearing.

Sub-aim 3: To document the audiological profile of musicians and singers in South Africa by determining the outer ear, middle ear, and inner ear functioning.

Diagnostic audiological assessments were performed on both ears per participant. Therefore, there were a total 114 ears within the sample of results. Due to the nature of music the ears were analysed individually, therefore, some of the results have no significant difference between the ears and thus this should not be heavily focused on. The audiological tests consisted of otoscopy, tympanometry, DPOAEs, Pure Tone air and bone assessments, Pure Tone Average (PTA) and Speech Reception Correlation (SRT) as well as high frequency PTA and SRT correlation and Speech detection thresholds (SDT). Where an ear was unable to be tested due to wax impaction or a pathology it was excluded from the data set for statistical reasons, there were 18 ears that fell within this criteria. Additionally, the Chi-squared test of independence was used to analyse the relationship between the variables, and only factors that were statistically significant at the 10% confidence level were analysed.

The otoscopic examination gave way to 9 variations of results. The results were grouped into two categories; relevant to music (full wax occlusion, partial wax occlusion, foreign body and perforation) and not relevant to music (no abnormalities detected, scarring, growth, dull tympanic membrane, and microtia).The groups were created according to results that could have been influenced by music versus results that were unlikely to have been affected. An example of the reasoning is that the increased use of ear phones can lead to an excess of wax, whereas scarring is typically due to previous ear infections or surgery (Jansen et al, 2009).

The otoscopic examination indicates a statistically significant chi-squared result of 5% confidence for the right ear with the self-reported effects of music. In response to a question in the questionnaire asking the participants self-reported impact of music on their hearing, many participants felt there was no impact. However, the results indicated that the opposite was obtained. Choi et al (2019) indicated that self-reported was not a reliable measure as individuals often have false perceptions to the objective test results due to external factors. Therefore, the current study reinforces the unreliability of self-report.

The use of headphones was statistically significant at the 10% confidence level for the left ear with the otoscopic results. The results indicated that a larger proportion of participants that use headphones presented with otoscopic results that were relevant to music. However, the sample size of headphone users was decreased which may have contributed to the results. Therefore, these results cannot be extrapolated across the entire population. The use of headphones introduces foreign bodies such as dust and bacteria into the external auditory canal which can lead to infections and other audiological complications (Flowers & Pillay, 2021).

The tympanometry results did not include the results of individuals who could not be tested due to abnormalities identified during the otoscopic examination which presented as a contraindication for this assessment. Therefore, a total of 93 ears were tested, 45 right and 48 left. The results for both ears were similar and therefore have the same underlying distribution as per tables 6 and 7, showing the tympanograms obtained for both the right and left ear.

Table 6: Right ear tympanometry results

Var1	Freq
Type A	37
Type Ad	3
Type As	5

Table 7: Left ear tympanometry results

Var1	Freq
Type A	40
Type Ad	3
Type As	4
Type C	1

The chi-squared test of independence showed statistical significance between the amount of time spent singing and the effect on the status of the middle ear. Singers who sang for more than 8 hours a day yielded tympanometry results of a type Ad tympanogram at the 10% confidence level. Similarly, the use of headphones indicated statistically significant results of type Ad tympanograms at the 5% confidence level. However, the sample size with a type Ad tympanogram was small and the results need to be interpreted with caution. A type Ad tympanogram is typically associated with a hypermobile middle ear system or TM. Often the causes are linked to ossicular chain discontinuity and a thinning TM (Hunter & Sanford, 2015). However, none of the participants reported any of these conditions, and as stated the sample size was small. Therefore, the researcher suggests further research into the correlation between music and Type Ad tympanograms before the conclusion of any relationships is determined.

There were 3 participants who presented with type As tympanograms. These participants indicated that they sang for less than 8 hours. A type As tympanogram is associated with reduced movement of the TM typically due to fluid in the middle ear or scarring on the TM. Individuals who experience flu-like symptoms and sinus difficulties often struggle with fluid in the middle ear space. Scarring on TM can be caused by a perforation, previous infection and surgery (Hunter & Sanford, 2015). Due to the influence of flu and covid on a type As tympanogram these results need to be interpreted with extreme caution. Furthermore, the same can be said for participants who did not wear headphones. There was a small group of participants who indicated that they did not wear headphones presented with Type As and Type C tympanograms. However, due to the small sample size and the influence of middle ear pathologies and eustachian tube dysfunction on a type As and a type C tympanogram these results need to be interpreted with extreme caution. There was no statistical significance between any of the variables considered and type A tympanograms. This is not unexpected as a type A tympanogram is considered a 'standard' response for normal middle ear functioning.

The acoustic reflex threshold results were also interpreted. There were a total of 94 ears tested, 46 right and 48 left. The acoustic reflex threshold results did not include the results of individuals who could not be tested due to abnormalities identified during the otoscopic examination which presented as a contraindication for this assessment. The frequencies assessed were 500Hz, 1000Hz, 2000Hz, and 4000Hz. There were two result possibilities, 'present' and 'absent'. The results indicated that gender was a statistically significant factor at 10% confidence level with the right ear at 1000Hz 4000Hz. The results indicated that a significant proportion of men presented with absent acoustic reflex results in the right ear compared to women. However, research indicates that gender does not have a statistical significant effect on the ART results (Feeney & Schairer, 2015), Therefore, these results may be skewed due to the small data set.

The results for ensemble and solo singers were significant at 500HZ and 4000Hz in the left ear at 10% confidence. Solo singers had a higher incidence of absent acoustic reflex thresholds at 500Hz and 4000Hz in the left ear, whereas ensemble singers presented with the opposite. Ensemble singers showed a higher incidence of present acoustic reflex threshold at 500Hz and 4000Hz in the left ear. One possible explanation for these results may be that results indicated solo singers sang more frequently with a backing sound therefore, their exposure to sound while singing may be more than that of ensemble singers. Research suggests that noise damage to the cochlea typically occurs first at 4000Hz (McBride & Williams, 2001), and with a SNHL one would expect to see absent results at the frequencies affected (Feeney & Schairer, 2015). The statistical significance of the left ear over the right ear requires further investigation as these results do not provide further insight.

The interpretation of the DPOAE results were as follows. There were a total of 92 ears tested, 44 right and 48 left. The acoustic reflex threshold results did not include the results of individuals who could not be tested due to abnormalities identified during the otoscopic examination which presented as a contraindication for this assessment. The frequencies assessed were 500Hz, 1000Hz, 1500Hz, 2000Hz, 3000Hz, 4000Hz 5000Hz, 6000Hz and 8000Hz. There were four result possibilities, ‘robust’, ‘present’, ‘reduced’ and ‘absent’.

Age group was identified as a statistically significant factor with a 5% confidence level at all frequencies bilaterally. The results indicated that with increasing age there was a an increased chance of the presence of reduced or absent DPOAE results. The fact that all frequencies are effected suggests that this is a strong result. An increase in age is strongly related to the decline of the audiological system, often causing a hearing loss. The hearing loss is as a result of damage to the stereocilia inside the cochlea (Seikel et al., 2010).

An otoacoustic emission is measuring the output of the efficacy of these outer hair cells. Therefore, if age causes these effects one would expect the presence of poor DPOAE results upon testing. The DPOAEs also indicated with 10% confidence at all frequencies except 3000Hz and 8000Hz on the right and 1500Hz, 2000Hz and 5000Hz on the left that being a professional performer is statistically significant. The results indicated robust DPOAEs for professional performers. A possible explanation for this is that professional performers have exposure to sound that is longer in duration in higher in intensity. The frequencies which are not presenting as robust according to the data are which are effected by loud sounds (Jansen et al., 2009) these results require further investigation. Although the type of head and neck surgery undergone by participants was not indicated it did appear to be of significance with the DPOAE results. DPOAEs were robust in participants who had not had previous head and neck surgery. The chi-squared test of independence confirms this statistical significance at the10% confidence level. The frequencies tested using DPOAEs that appear to highlight these results are 1500Hz, 3000Hz, 6000Hz bilaterally.

The pure tone threshold results were as follows. There were a total of 114 ears tested, 57 right ears and 57 left ears. There were three possible result options, normal hearing, a conductive hearing loss(CHL), a sensory neural hearing loss(SNHL). The table below shows the results of hearing and age group.

Table 8: Hearing results according to age group

	Not normal hearing	Normal Hearing
0-5years	0	1
11-20years	2	15
21-30years	0	6
31-40years	5	1
41+years	1	0
6-10years	0	9

The age group of the participants was statistically significant at the 10% confidence level bilaterally. The results indicated that with an increase in age there was an increase in the number of participants with hearing loss. Therefore, this relationship is directly proportional. Naturally, the next factor also presents with a directly proportional relationship indication the same trend as above, this factor is years of experience. The years of experience was statistically significant at the 5% confidence level bilaterally.

Table 9: Severity of hearing loss according to age group

	Not mild / profound H.L.	Mild / profound H.L.
0-5years	1	0
11-20years	15	2
21-30years	6	0
31-40years	1	5
41+years	0	1
6-10years	9	0

The above table shows the degree of hearing loss of participants who presented with a SNHL. Performers with a greater number of years of experience presented with a higher incidence of SNHL. Due to the sample size it was difficult to determine the relationship with the degree of hearing loss but majority of participants fell within the mild to severe range. As seen through out the data set age plays an important role to the functioning of the auditory system. The hair cells with in the cochlea become less firm and more flaccid, losing their ability to conduct sound at the various frequencies. Therefore, in order for an individual to be able to hear the sound the intensity needs to be increased as more robust and more frequent sound waves must pass through the system to stimulate the cochlea (Seikel et al., 2010).

The noise notches that were present on the audiogram from the pure tone testing results were analysed. There were 36 right ear noise notches and 39 left ear noise notches present. Age group was statistically significant at 5% confidence. The results indicated that only participants between the ages of 31 years to 35 years presented with a notch at 4000Hz. Research does not present an answer for this finding, therefore, more research would be needed to explain this phenomenon, or it may be due to the small sample size. The rest of the notches at 3000Hz and 6000Hz were not dependant to age. The noise notches at 3000Hz and 6000Hz would not be expected to be dependent on age as research indicates that these are the frequencies commonly effected by MIHL (Kahari, Axelsson, Hellstrom, & Zachau, 2001)

The SRT/PTA correlation results as well as the high frequency SRT/PTA correlation results did not provide much data to draw conclusions from. The only information provided by this test was the reliability of the Pure tone threshold results which adds to the validity of the study.

The speech detection results indicated results that were with in normal limits for all participants. These results do not add variability to the results but do indicate the consistency of the results throughout the testing process. This may indicate the necessity for further investigations into the validity of speech detection tests for musicians. Recorded speech stimuli was used instead of live voice stimuli. The use of the recorded stimuli adds more validity to the study as the recorded speech is regulated in terms of rate, calibration of the VU meter and the same voice with the same characteristics. All these features highlight the accuracy of the recorded speech tests. However, with live speech there is more variability such as accent, voice features and exceeding the VU meter reading, which all cause variations which can affect the validity of the results.

Due to the debate between the efficacy surrounding the validity of self-reported symptoms, additional calculations were done to determine the significance of self-reported hearing loss versus how many participants presented with a hearing loss upon testing. In total, 12% participants presented with a hearing loss in both ears and 21% had hearing loss in at least one ear. Fourteen participants answered that they perceived a loss in hearing.

The chi-squared test of independence was used and the results indicated a statistically significant result at the 1% confidence level therefore, the assumption of independence is rejected and it is concluded that there appears to be some degree of association between perception of hearing loss and actual hearing loss should both ears be affected. However, when looking at a unilateral hearing loss we cannot reject the assumption of independence . Therefore, it is concluded that it appears that the perception of hearing loss and actual hearing loss are independent of one another if either ear is affected by hearing loss. Therefore, the efficacy of self-reported hearing loss appears to be correlated to whether the loss is bilateral or unilateral. These results contradict research previously conducted which showed that self-report was not a valid tool when identifying hearing loss (Tsimida, Kontopantelis, Ashcroft & Pangioti, 2020). Due to the small sample size more research is needed to confirm these results of the current study or to confirm results obtained by previous research.

In conclusion The otoscopic examination yielded statistically significant results, indicating that self-report is not a reliable tool when assessing participants and the use of earphones may contribute to the susceptibility of the ear to infections. The tympanometry results indicated few pathological results and the acoustic reflex testing thresholds indicated that ensemble singers presented with absent reflexes at 4000Hz. The ART results indicate an early identification of MIHL. Lastly, the pure tone threshold results and the DPOAE results correlated with one another, indicating the presence of noise notches.

Sub-Aim 4: To assess the impact of tinnitus if it is perceived by the musician or singer.

The total number of participants who indicated on the questionnaire that they subjectively experienced tinnitus was 34. Thirty-two percent of Participants indicated that they occasionally experienced tinnitus, 21% of participants indicated that continuously experienced tinnitus and 7% of participants indicated that they only experience tinnitus after playing music. Research conducted by Fagelson, (2018) indicated that many musicians had high complaints of tinnitus. He reported that often these musicians also experienced hearing loss. From the questionnaire in the current study one would have expected that on the day of testing there would be a fair number of participants filling out the Tinnitus Handicap Questionnaire. However, on the day of testing, not a single participants indicated that they were suffering from tinnitus that was bothersome or that there was a need to fill in questionnaire.

Typically, an individual who suffers from tinnitus is not suffering from the perception of the sound but the reaction to the sound. The amygdala which is the part of the responsible for fear, is aware of the sound, unaware of the origin or cause, and thus in response triggers the fight or flight response which starts the vicious circle of event that makes tinnitus bothersome (Fligor, 2015). The individual becomes even more aware of the sound and the more aware of the sound they are the more anxious they become. Research indicates that one of the main causes for tinnitus together with hearing loss is anxiety (Fligor, 2015). Therefore, a treatment for tinnitus involves breaking the cycle by making the individual aware of the processes involved in tinnitus and this is where the THI becomes a useful tool (Fligor, 2015).

In the current study there was no need for the use of the THI as the participants did not feel their tinnitus was bothersome. The sample size may have played a role in this finding or the population may be more resilient than previous populations tested. Therefore, one would require further investigations in order to identify a clear result.

Chapter 5:Conclusion

This study aimed to identify the audiological profile of musicians and singers in South Africa. The participants' background information, musical training and experience, singing training and experience audiological symptoms experienced after playing music and singing, listening habits, knowledge and perception about ear hygiene, hygiene practices and audiological assessments were recorded. The past ear history of the participants may have an impact on the hearing results, where previous pathologies cause long lasting effects. Furthermore, statistical analyses revealed that various genres and instruments can affect the auditory system in different ways by effecting different frequencies or aspects of hearing.

The results of the current study indicated that participants did not use HPDs for various reasons such as cost, lack of knowledge and misguided perceptions. Moreover, the knowledge and perceptions about ear hygiene of the participants were identified. The results indicated that the participants had some knowledge however, lacked a general overview of the importance and good practices of ear hygiene. Furthermore, participants indicated that there is a need for the implementation of programs to provide information surrounding good ear hygiene. The use of educational programs can help mitigate the harmful effects of MIHL, as, musicians and singers would have the correct knowledge and skills to protect their hearing.

Additionally, the results of the audiological practices of the individual indicate that while the majority of the participants were aware about cleaning their ears, they were unaware of the correct practices. The study also explored the perception of the impact of music on the participants' auditory systems. The results indicated that some participants felt there was a cognitive impact while others felt there was an audiological impact. There were two themes identified with in the current research, namely; education and a lack of concern.

Lastly, The study explored the audiological profile of participants. The otoscopic examination yielded statistically significant results, indicating that self-report is not a reliable tool when assessing participants and the use of earphones may contribute to the susceptibility of the ear to infections. The tympanometry results indicated few pathological results and the acoustic reflex testing thresholds indicated that ensemble singers presented with absent reflexes at 4000Hz. The ART results indicate an early identification of MIHL. Lastly, the pure tone threshold results and the DPOAE results correlated with one another, indicating the presence of noise notches.

Therefore, the current study highlights the need for the implementation of programs to provide education about good ear hygiene, the correct ear hygiene practices and the effects of music on the audiological system as well as the correct way to mitigate these effects. Furthermore the current study confirmed the detrimental effect and presence of MIHL. Lastly, the current study identifies the need for policy formation surrounding the health and safety of musicians and singers.

Potential Limitations

Most research studies present with limitations. One limitation of this study and most likely the biggest limitation is the sample size. The reason being that the sample size was relatively small in comparison to the amount of South African citizens who are musicians and singers. Singers and musicians over the age of sixty were included in the study. As a result, the presence of presbycusis may have skewed the audiological results obtained for this age group.

A further limitation is the listening environment of the participant prior to the assessment cannot be controlled for. This may cause a skewing of the results as it may have resulted in a TTS. Additionally, a research bias may be present due to the singer's and musicians' perceptions around hearing. Furthermore, the noise level exposure duration and intensity provided is subjective and may not be accurate. Also, the current study did not look at extended high frequency pure tone audiometry, and it did not analyse the frequency range on the audiogram of the speech errors. Lastly, the population only includes musicians and singers and with the rise of personal listening devices the exposure to loud music is no longer limited to musicians and singers.

Implications and Significance of this Study

The implication of this study is that it will be useful for audiologists. The role of an audiologist is to promote hearing and ear health and prevent hearing disorders. This study will enable this as it will provide the audiologist with information pertaining to the knowledge and perceptions of musicians and singers surrounding hearing health.

Additionally, it will allow for the early detection of noise induced hearing loss in musicians and singers, thus resulting in early management of disorders should there be any present. Furthermore, this study will bring attention to the need for hearing protection programs within the music industry. Lastly this study will pave the way for the implementation of hearing care and protection programs within the music industry.

Future Directions of this study

The current study highlighted various areas that were not explored in depth and required further consideration. A future study should focus on replicating the current study on a much larger scale to determining if there are in fact correlations between the many patterns identified. However, due to the small sample size of the current study these patterns were unable to be confirmed. Furthermore, it would be useful to investigate the effects of music on the high frequencies of musicians and singers by performing extended high frequency pure ton audiometry. It would also be beneficial to investigate which speech sounds musicians and singers are getting incorrect during speech testing to identify the accuracy of the speech tests in diagnosing and identifying hearing loss within this population. Additionally, it is imperative to investigate the best way to create and implement policies for the health and safety of musicians and singers in South Africa. A large-scale study that also focuses on HCP programs would ensure that programs can be implemented.

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Appendices

Appendix A: Adult Participant information sheet

Appendix B: Adult Participant consent letter

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Appendix A: Adult Participant Information Sheet

Hi,

My name is Aimee Flowers. I am a Masters student at the Audiology Department within the University of the Witwatersrand. As part of the requirement for my degree, I am required to conduct a research study. I would appreciate it if you would consider participating in my research study titled: <u>"The audiological profile of singers' and musicians' in South Africa"</u> Your participation would provide essential information that would enhance my findings.

This information sheet has two sections. Section one explains why this study is being done, how it will be conducted and what your role will be should you wish to participate. Section two will be the consent form (should you agree to participate in this study).

If there is anything which you do not understand, please feel free to contact me or my supervisor for further details.

Why is this study being done?

This research study has an essential role in gaining a deeper understanding into the hearing status of musicians and singers. Additionally, the study will provide insight into the policies and programs in place for the protection of musicians' and singers' hearing.

What is your role?

This study requires your participation, you will be required to fill out a short Questionnaire consisting of three sections. The first section contains questions pertaining to your musical history, section two contains questions about your hearing history and the third sections contains questions about hearing protecting and ear care hygiene. The questionnaire will take approximately 20-30 minutes to complete. Upon completion of the questionnaire, the researcher will assess your hearing at the a location to be discussed. The hearing assessment consists of an examination of the outer ear and middle ear, a hearing test and an Otoacoustic emission test. The test will last a maximum of 1 hour, you will be given a set appointment time for the assessment. The assessment is done free of charge. You will be required to come to the appointment at your own cost. We will end the assessment with a thorough feedback session where I will present you with the results.

What happens should an abnormality be identified?

If the hearing assessment reveals an abnormality, you will be counselled on the results, referred appropriately and further assessments that may be required due to the abnormality will be at your own expense.

What happens to the information being gathered?

At the end of the study, I will write up the results in a research report. You will be given the results of the study if you would like to know them. The data gathered will be kept in a locked cupboard at the University of the Witwatersrand. The data will be kept for 2 years if the study is published and 6 years in the absence of publication.

What are the benefits of participating in this study?

One benefit of participating in the study is that you will receive information about good hearing practices and health. Additionally, your involvement within the study may provide information about the audiological functioning of musicians and singers, which can further add to the knowledge of our profession and may help with educating others.

What are the risks of participating in this study?

There are no risks involved in the participation of my study. A potential risk of participating in the study is if an abnormality is revealed you may feel some psychological distress. The feedback session in which you will receive the results of your assessment will provide you with the necessary counselling and information to ease the psychological distress.

What are your rights as a participant?

Your participation in this study is completely voluntary, therefore

1. You have the right to remove yourself from the study at any time, without penalty/consequences

2. You have the right to contact me at any time during the study with any questions.

3. You have a right to be informed of the results of the study.

Confidentiality

Your identity will only be known to the researchers of the study. Your name will not appear on any documentation and will be replaced with a code. If you have any questions with regard to the study please contact my supervisor or myself, our contact details are below.

If you have any questions that are related to the ethics of the study, you are welcome to contact the Medical Human Research Ethics Committee.

Aimee Flowers

Speech Therapist & Audiologist

072 611 0248

Aimee.flowers1@gmail.com

Dr Dhanashree Pillay

Research Supervisor

0117174564

Dhanashree.Pillay@wits.ac.za

D.Pillay

Zanele Ndlovu

Secretariat Human Research Ethics Committee (Human)

011 717 1252

hrec-medical.researchoffice@wits.ac.za

Professor Clement Penny

Chairperson of Human Research Ethics Committee

011 717 2700/1234

Clement.Penny@wits.ac.za

Appendix B: Adult Participant Consent Letter

I,____ have read and understood this document and information sheet and agree to participate in Aimee Flowers's research study. In giving consent, I understand the following:

- This research is for a degree requirement at the University of the Witwatersrand.
- I will need to give up approximately 20-30 minutes of my day to answer questions and approximately 60 minutes to have my ears examined.
- I voluntarily agree to participate in the study by answering a questionnaire, with questions pertaining to my musical history, hearing history and my knowledge about hearing protection and ear care hygiene, and having my hearing examined, consisting of an examination of the outer ear and middle ear, a hearing test and an Otoacoustic emission test. and am aware of my right to withdraw from the study at any time without any risk to myself.
- My identity will be kept confidential and will be replaced by a code on all documentation.
- I can contact Aimee (the researcher) if I have any questions regarding the study.
- I recognize that Aimee is the researcher of this project and I agree to participate in her study.

I would like to receive the overall results of the study: yes/no

e-mail address:___________________________

Participant Name: _____________________________

Participant Signature: __________________________

Date and Place: __________________________

Appendix C: Parental Consent Letter

I,____ have read and understood this document and information sheet and agree to allow my son/daughter to participate in Aimee Flowers's research study. In giving consent, I understand the following:

- This research is for a degree requirement at the University of the Witwatersrand.
- My son/daughter and I will need to give up approximately 20-30 minutes of our day in order to answer questions and approximately 60 minutes to have his/her hearing examined.
- I voluntarily agree to allow my son/daughter to participate in the study by answering a questionnaire and having his/her hearing examined and am aware of my his/her right to withdraw from the study at any time without any risk to his/her.
- My son/daughter's identity will be kept confidential and will be replaced by a code on all documentation.
- I can contact Aimee (the researcher) if I have any questions regarding the study.
- I recognize that Aimee is the researcher of this project and I agree to allow my son/her in her study.

I would like to receive the overall results of the study: yes/no

e-mail address:___________________________

Parent Name: _____________________________

Parent Signature:___________________________

Date and Place: ______________________________

Umthombo Building – 1st Floor, Room U132, Braamfontein East Campus , Private Bag 3, WITS 2050
T +27 11 717 4577 | **E** sppa.SHCD@wits.ac.za | www.wits.ac.za/shcd/speech-pathology-and-audiology/

Appendix D: Participant (minor) Assent Letter

I,____ have been told about the study and I understand all the information. I agree to be part of the study Aimee Flowers is doing

- I know that I have the right to leave the study at anytime
- I know that I need to complete a questionnaire with questions pertaining to my musical history, hearing history and hearing protection and ear care hygiene practices.
- I know that my hearing will be tested as part of the research. The testing will involve an outer and middle ear examination, hearing test and Otoacoustic emission test.
- I know that I can ask questions at any time of the study
- I know that my name will be kept in confidence and people will not know my results.
- I know that my results will be explained to me at the end of the testing and should an abnormality be identified I will be referred appropriately

Participant Name: _____________________________

Participant Signature:___________________________

Date and Place: ______________________________

Appendix E: Case History Form

Instructions:

Please answer the following questions clearly; you may tick the appropriate box where necessary. If you are unsure about a question you are welcome to ask for clarity.

Biographical Details

Date of the Assessment: _______________ Participant Number: _______________

Audiologist: ______________________Audiometer:____________________________

:_____________________________ Age: ________ Gender:________

Are you a:

	Social	**Professional**
Musician Only		
Singer Only		
Musician and Singer		

Which are the top 3 Genres of music that you are involved with?

1.________________________________

2 ________________________________

3.________________________________

Please list the acoustic and/or electronic instruments you play in the table below

Acoustic Instruments	Electronic Instruments

Section A: If you are a musician and/or singer:

- Do you play an instrument or sing ☐ professionally or ☐ socially?
- How long have you been involved with music (socially or professionally)?:

0-5 Years	5-10 Years	10- 20 Years	20-30 Years	30-40 Years	41> Years

- List the instruments that you are able to play as a Musician, starting with the one you play most often and ending with the one that you play least often:

____

____

____

____

____

____

- Select the option for your Singing Voice Range:

Contralto	
Soprano	
Mezzosoprano	
Tenor	
Baritone	
Bass	
Other (Please State):	
I don’t know	

How often do you:

- Play your instrument/instruments in a week (practice and formal playing):

> 8 hours in total	< 8 hours in total

- Sing in a week (practice and formal singing)

> 8 hours in total	< 8 hours in total

- Do you sing with instrumental backing or acapella?
- Do you sing solo or in an ensemble?
- Describe any formal training that you received when learning to play an instrument:

____
____
____

- As a Singer, describe any formal vocal training that you received when learning to sing:

____
____
____

- Do you use Headphones, In Ear Monitors, Speakers or Insert Earphones?

Yes	
No	

  - If Yes, please indicate all the devices that you use and the duration of its use

	Yes/No	Duration of Use in One day	How many days a week are you using the device?
Headphones			
Inserts			
In Ear Monitors			
Speakers			
Other: Please list			

- At what level do you listen to the music? (Mark your average listening level)

10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Section B: Hearing History

- Have you had a hearing assessment conducted before?

Yes	
No	

If Yes:

- Why did you get your hearing assessed?

  ____

  ____

  ____

- What were the results of your hearing assessment?

____

____

- How often do you assess you hearing?

____

____

- Please describe any head/neck and/or ear surgery that you underwent?

____

____

- Have you/ Do you currently experience any of these ear related signs and symptoms?

Signs and Symptoms	Occasionally/Less than 5 times a year	Every time I'm involved with Music	Continuously/More than 5 times a year…Add a description to your answer please	Never

Dizziness				
Vertigo				
Nausea				
Bleeding of the Ear/Ears				
Pain in the Ear/Ears				
Temporary loss or decrease in hearing				
Itchy Ear/Ears				
Ear Infections				
Discharging Ears				
Ringing in the ears				
Perception of sound being too loud				

- Do you suffer from recurrent ear infections? Yes□ No□
    - If yes what type (outer, middle or inner ear) and how often?

___

    - When was your last infection?

___

    - Did you seek medical treatment? Yes□ No□
    - What was the treatment recommended?

Section C: Hearing Protection and Ear Care hygiene practices (Everyone to complete)

- Do you use hearing protection?

Yes	
No	

If No, why don't you wear hearing protection?

____

____

If Yes

- Describe the hearing protection that you use:

____

____

__

- Do you wear both hearing protection devices at the same time?

Yes	
No	

If No

- Describe why you take one out :

____

____

__

- Do you clean your ears? Yes □ No□
  - How often do you clean your ears?

____

- Describe how do you clean your ears?

- Do you clean your earphones? Yes □ No□
    - How often do you clean your earphones?

    - Describe how do you clean your earphones?

- What is your understanding and perceptions about ear health?

- Do you think that programs should be implemented to educate musicians about ear health and help them maintain good aural hygiene?

- Do you feel that music has impacted your hearing in any way? If yes, please provide details as to how?

Appendix F: Tinnitus Handicap Inventory

TINNITUS HANDICAP INVENTORY

Patient Name: ______________________________ Date: ____________

INSTRUCTIONS: The purpose of this questionnaire is to identify difficulties that you may be experiencing because of your tinnitus. Please answer every question. Please do not skip any questions.

1. Because of your tinnitus, is it difficult for you to concentrate?	Yes	Sometimes	No
2. Does the loudness of your tinnitus make it difficult for you to hear people?	Yes	Sometimes	No
3. Does your tinnitus make you angry?	Yes	Sometimes	No
4. Does your tinnitus make you feel confused?	Yes	Sometimes	No
5. Because of your tinnitus, do you feel desperate?	Yes	Sometimes	No
6. Do you complain a great deal about your tinnitus?	Yes	Sometimes	No
7. Because of your tinnitus, do you have trouble falling to sleep at night?	Yes	Sometimes	No
8. Do you feel as though you cannot escape your tinnitus?	Yes	Sometimes	No
9. Does your tinnitus interfere with your ability to enjoy your social activities (such as going out to dinner, to the movies)?	Yes	Sometimes	No
10. Because of your tinnitus, do you feel frustrated?	Yes	Sometimes	No
11. Because of your tinnitus, do you feel that you have a terrible disease?	Yes	Sometimes	No
12. Does your tinnitus make it difficult for you to enjoy life?	Yes	Sometimes	No
13. Does your tinnitus interfere with your job or household responsibilities?	Yes	Sometimes	No
14. Because of your tinnitus, do you find that you are often irritable?	Yes	Sometimes	No
15. Because of your tinnitus, is it difficult for you to read?	Yes	Sometimes	No
16. Does your tinnitus make you upset?	Yes	Sometimes	No
17. Do you feel that your tinnitus problem has placed stress on your relationships with members of your family and friends?	Yes	Sometimes	No
18. Do you find it difficult to focus your attention away from your tinnitus and on other things?	Yes	Sometimes	No
19. Do you feel that you have no control over your tinnitus?	Yes	Sometimes	No
20. Because of your tinnitus, do you often feel tired?	Yes	Sometimes	No
21. Because of your tinnitus, do you feel depressed?	Yes	Sometimes	No
22. Does your tinnitus make you feel anxious?	Yes	Sometimes	No
23. Do you feel that you can no longer cope with your tinnitus?	Yes	Sometimes	No
24. Does your tinnitus get worse when you are under stress?	Yes	Sometimes	No
25. Does your tinnitus make you feel insecure?	Yes	Sometimes	No

FOR CLINICIAN USE ONLY

Total Per Column				
	x4	x2	x0	
Total Score	+	+	=	

Newman, C.W., Jacobson, G.P., Spitzer, J.B. (1996). Development of the Tinnitus Handicap Inventory. Arch Otolaryngol Head Neck Surg, 122, 143-8.

To interpret the score please refer to the Tinnitus Handicap Severity Scale shown on the reverse side.

TINNITUS HANDICAP INVENTORY SEVERITY SCALE

GRADE	SCORE	DESCRIPTION
1	0-16	Slight: Only heard in quiet environment, very easily masked. No interference with sleep or daily activities.
2	18-36	Mild: Easily masked by environmental sounds and easily forgotten with activities. May occasionally interfere with sleep but not daily activities.
3	38-56	Moderate: May be noticed, even in the presence of background or environmental noise, although daily activities may still be performed.
4	58-76	Severe: Almost always heard, rarely, if ever, masked. Leads to disturbed sleep pattern and can interfere with ability to carry out normal daily activities. Quiet activities affected adversely.
5	78-100	Catastrophic: Always heard, disturbed sleep patterns, difficulty with any activity.

McCombe, A., Baguley, D., Coles, R., McKenna, L., McKinney, C. & Windle-Taylor, P. (2001). Guidelines for the grading of tinnitus severity: the results a working group commissioned by the British Association of Otolaryngologists, Head and Neck Surgeons, 1999. Clin. Otolaryngol 26, 388-393.

Appendix G: Audiogram

University of the Witwatersrand Speech and Hearing Clinic

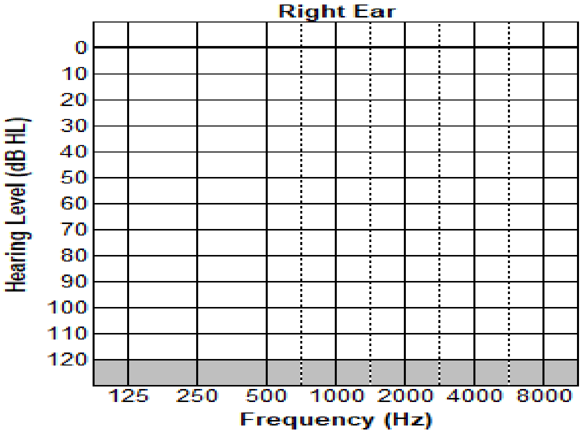
AUDIOLOGY ASSESSMENT

Name: ______________________ DoB: ______________ Age: ________

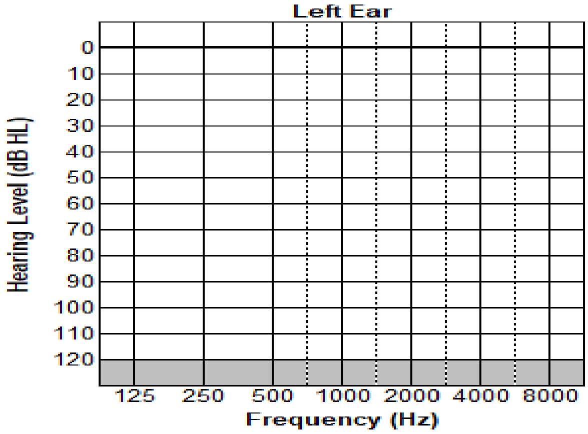
Audiometer: ____________ Audiologist: ____________________ Test date: ________

Pure Tone Audiometry

Right Ear



Left Ear



Masking levels

Right Ear							
AC							
BC							

Left Ear							
AC							
BC							

Add to symbol if no response	masked	un-masked	Symbols	un-masked	masked	Add to symbol if no response
↙	Δ	O	AC	X	□	↘
	[	<	BC	>	]	
		S	SF	S		

Speech Audiometry

EAR	SRT dB	MCL dB	TD dB	DR dB	MASKING TYPE	MASKING LEVEL	MASKING EAR
RIGHT							
LEFT							
FF							

EAR	Mat.	SL dB	HL dB	%	MASKING TYPE	MASKING LEVEL	MASKING EAR
RIGHT							
LEFT							
SOUND FIELD							

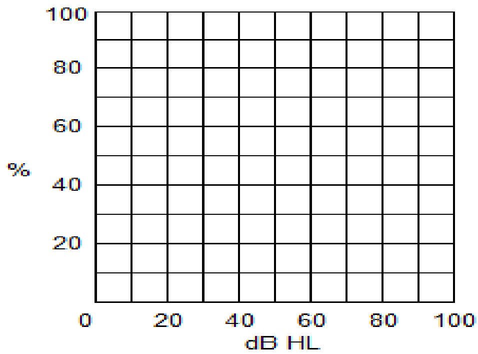
Reliability:

Good	
Fair	
Poor	

PTA (dB HL)

RIGHT	LEFT

Performance - Intensity function



Otoscopy

RIGHT LEFT

Tympanometry

Ear	Type	ECV	MEP peak	Static compliance	Description
Right					
Left					

Acoustic Reflexes

RIGHT				Probe ear	LEFT			
CONTRA		IPSI		Stimulus ea	IPSI		CONTRA	
ARD % in 5s	ART dBHL	Meta dBSL	ART dBHL	Frequency Hz	ART dBHL	Meta dBSL	ART dBHL	ARD % in 5s
				500				
				1000				
				2000				
				4000				
				BBN				

Test notes: ______________________

Additional Tests

OAEs: ______________________

ABR: ______________________

Other: ______________________

Summary of Results: ______________________

Recommendation ______________________

Audiologist: ______________________

Appendix H: South African Spondee Wordlist

South African Spondiac (SAS) Wordlist	'More familiar' CID W-1 Wordlist	Unfamiliar Spondaic Words
Recommended for South African patients who are English Second Language speakers	Recommended for South African patients who are English First Language speakers	Not recommended for use in South Africa
cellphone	schoolboy	greyhound
bathroom	sunset	inkwell
sandwich	grandson	whitewash
building	toothbrush	mousetrap
township	playground	duckpond
dancing	cowboy	sidewalk
welcome	northwest	horseshoe
housewife	hotdog	baseball
lightning	mushroom	stairway
toothbrush	hardware	iceberg
basket	workshop	railroad
public	eardrum	oatmeal
workshop	headlight	drawbridge
suitcase	birthday	hothouse
birthday	pancake	daybreak
sunlight	armchair	airplane
homework		padlock
sunshine		nutmeg

Hanekom, T., Soer, M. & Pottas, L. (2015). Comparison of the South African Spondaic and CID W-1 wordlists for measuring speech recognition threshold. *South African Journal of Communication Disorders, 62(1), Art. #97, 10 pages. http://dx.doi.org/10.4102/sajcd.v62i1.97*

A dissertation submitted in fulfilment of the requirements for the degree M Communication Pathology (Audiology) in the Department of Speech-Language Pathology and Audiology at the University of Pretoria, Faculty of Humanities.

Durrant, T. (2006). *The development of a familiar spondaic wordlist for the South African population who use English as one of their multiple languages. Unpublished 4th year research report submitted in partial fulfilment of the requirements for the degree: B.A (Sp.&H.Th) Department of Speech Pathology and Audiology, School of Human and Community Development, Faculty of Humanities, University of the Witwatersrand.*

(Permission was expressly granted by the University of the Witwatersrand to use this wordlist for the above study)

Hirsh, I.J., Davis, H.D., Silverman, S.R., Reynolds, E.G., Eldert, E., & Benson, R.W. (1952). *Development of materials for speech audiometry. Journal of Speech and Hearing Disorders, 17(3), 321-327. http://dx.doi.org/10.1044/jshd.1703.321*

- Familiarise patients with the words at suprathreshold levels prior to determining SRT.
- Words may be repeated.

Queries? Contact hanekomtanya@gmail.com

Appendix I: CID W22 Wordlist

C.I.D. AUDITORY TESTS W.22

P.B. WORD LISTS

NAME : ____________________ DATE : ____________________

LIST 1A	EAR S.L.
1. an	______
2. yard	______
3. carve	______
4. us	______
5. day	______
6. toe	______
7. felt	______
8. stove	______
9. hunt	______
10. ran	______
11. knees	______
12. not (knot)	______
13. mew	______
14. low	______
15. owl	______
16. it	______
17. she	______
18. high	______
19. there (their)	______
20. earn (urn)	______
21. twins	______
22. could	______
23. what	______
24. bathe	______
25. ace	______

LIST 1A	EAR S.L.
26. you (ewe)	______
27. as	______
28. wet	______
29. chew	______
30. see (sea)	______
31. deaf	______
32. them	______
33. give	______
34. true	______
35. isle (aisle)	______

LIST 1A	EAR S.L.
36. or (oar)	______
37. law	______
38. me	______
39. none (nun)	______
40. jam	______
41. poor	______
42. him	______
43. skin	______
44. east	______
45. thing	______
46. dad	______
47. up	______
48. bells	______
49. wire	______
50. ache	______

LIST 2A	EAR S.L.
1. yore (your)	______
2. bin (been)	______
3. way (weigh)	______
4. chest	______
5. then	______
6. ease	______
7. smart	______
8. gave	______
9. pew	______
10. ice	______
11. odd	______
12. knee	______
13. move	______
14. new	______
15. jaw	______
16. one (won)	______
17. hit	______
18. send	______
19. else	______

LIST 2A	EAR S.L.
20. tare (tear)	______
21. does	______
22. too (two, to)	______
23. cap	______
24. with	______
25. air (heir)	______

LIST 2A	EAR S.L.
26. and	______
27. young	______
28. cars	______
29. tree	______
30. dumb	______
31. that	______
32. die (dye)	______
33. show	______
34. hurt	______
35. own	______
36. key	______
37. oak	______
38. new (knew)	______
39. live (verb)	______
40. off	______
41. ill	______
42. rooms	______
43. ham	______
44. star	______
45. eat	______
46. thin	______
47. flat	______
48. well	______
49. by (buy)	______
50. ail (ale)	______

/2.......

Appendix J: Referral Letter

Participant name:_______________________________

To whom it may concern,

The above mentioned participant participated in my research study, where a full diagnostic audiological evaluation was performed. It would be kindly appreciated if you could further assess the participant. Upon examination the following was noted:

Otoscopic Examination:

Right ear:____

____

Left ear: ____

____

Tympanometry

	Ear Canal Volume	Compliance	Pressure	Type
Right ear				
Left ear				

Acousitic Reflexes

	Right		*Left*	
	Ipsilateral	*Contralateral*	*Ipsilateral*	*Contralateral*
500Hz				
1000Hz				
2000Hz				
4000Hz				

Pure tone audiometry ____

Speech Audiometry ____

Reason for referral:____

Umthombo Building – 1st Floor, Room U132, Braamfontein East Campus , Private Bag 3, WITS 2050
T +27 11 717 4577 | **E** sppa.SHCD@wits.ac.za | www.wits.ac.za/shcd/speech-pathology-and-audiology/

Should you have any further queries please feel free to contact me.

Kind Regards

Aimee Flowers

Speech Therapist

& Audiologist

072 611 0248

Aimee.flowers1@gmail.com

Dr Dhanashree Pillay

Audiologist/Lecturer

Research Supervisor

0117174564

Dhanashree.Pillay@wits.ac.za

D.Pillay

Appendix K: List for referrals if needed

General Practitioners:

1) Manor Medical Centre: 011 802 5338
2) Ubuntu Family Health Centre: 010 822 3151
3) Bluebird Medical Suites: 011 440 1412

Ear Nose and Throat Surgeons

1) Dr Burnell and Dr Quail: 011 883 3340
2) Dr Soma: 011 807 2684
3) Dr Gersun: 011 4850070

Audiologists

1) Equilibrium Audiology: 011 268 0491
2) Kelly Nathan: 011 656 4542
3) Hearing and Balance Clinic: 011 463 4639

Appendix L: Social Media Advert

If you are a **musician** or **singer**, you are invited to be part of a research study at the University of the Witwatersrand, titled:

The Audiological Profile of South African Singers and Musicians

This will require approximately 90minutes of your time. If you are willing to be a participant in this research study, you are welcome to contact Aimee Flowers or Dr Dhanashree Pillay to book your **FREE** hearing assessment.

Contact Details:

E-mail:

Aimee.flowers1@gmail.com

OR

Dhanashree.pillay@wits.ac.za

Telephone:

0726110248

OR

(011)7174567

Appendix M: Letter of Request for Advert

To whom it may concern,

My name is Aimee Flowers and I am a Masters student at the University of the Witwatersrand. In fulfilment of the requirements for the degree M.A. Audiology, I would like to invite you and your members to participate in my research study titled: The audiological profile of singers' and musician's in South Africa

My research study aims to explore the effects of music on, the auditory system, of musicians and singers in South Africa. The study involves a questionnaire that will take approximately 30 minutes to complete and a full audiological assessment that will take approximately 60 minutes of your time. The audiological assessment will be provided at no cost to participants at a location to be discussed. Participation is entirely voluntary, and the participant may withdraw at any given point without penalty. There are no risks or foreseeable benefits for participating in the study. All the information will be kept anonymous and strictly confidential.

I would greatly appreciate if you could please disseminate the attached advert for the study to your members.

Should you have any further queries or concerns please do not hesitate to contact me, Aimee Flowers at: aimee.flowers1@gmail.com or my research supervisor Dr Dhanashree Pillay at: dhanashree.pillay@wits.ac.za.

Thanking you for your assistance!

Aimee Flowers

Speech Therapist and Audiologist