Economic cost of Noise-Induced Hearing Loss in individuals exposed to Excessive Occupational noise within the South African Mining Sector: Practitioner perspective

No one needs to lose his or her hearing in order to earn a living. Noise-induced hearing loss is preventable (American Academy of Audiology, 2003)

Economic cost of Noise-Induced Hearing Loss in individuals exposed to Excessive Occupational noise within the South African Mining Sector: Practitioner perspective

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DECLARATION

I Thandeka G.P. Radebe hereby declare that "The **economic cost of noise induced hearing loss in individuals exposed to excessive occupational noise in the South African mining sector- practitioners' perspective" is** my own work. To the best of my knowledge and belief, this work has never been submitted for any examination or degree in any other university, and that all sources to which I have made reference or quoted have been indicated and acknowledged by complete references.

(Thandeka Radebe)

30 day of April 2021

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LIST OF ABBREVIATIONS

AIDS:	Acquired Immunodeficiency Syndrome
CDC:	Centers for Disease Control and Prevention
COIDA:	Compensation for Occupational Injuries and Diseases Act
CSV:	Comma-separated values
DALY:	Disability Adjusted Life Years
dBA	Decibels A weighted
DOD:	Department of Defence
ENT:	Ear, Nose and Throat
GDP:	Gross Domestic Product
GNP:	Gross National Product
HCP:	Hearing Conservation Program
NIHL:	Noise Induced Hearing Loss
NIOSH:	National Institute for Occupational Safety and Health
HIV:	Human Immunodeficiency Syndrome
ILO:	International Labour Organisation
ISO:	International Organisation for Standardisation
MHSC:	Mine Health and Safety Council
NHANES:	National Health and Nutrition Examination Survey
ODMWA:	Occupational Diseases in Mines and Works Act
OHS:	Occupational Health and Safety
OSHA:	Occupational Safety and Health Association
PTS:	Permanent Threshold Shift
SAS:	Statistical Analysis Software

SANS:	South African National Standard
TTS:	Temporal Threshold Shift
TB:	Tuberculosis
WHO:	World Health Organisation

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ABSTRACT

Purpose: The aim of the study to estimate the economic cost of noise-induced hearing loss (NIHL) to the South African mining sector. Specific objectives included firstly to estimate the direct costs incurred during investigation of NIHL. Secondly, was to estimate the direct costs incurred during treatment and management of NIHL. Lastly was to determine the compensation paid-out due to NIHL.

Participants: A purposive and snowball sampling strategies were used to identify and recruit participants who had experience and were knowledgeable in the management of NIHL in the mining sector. Data were obtained from two sources. The first set of data were derived from 30 Occupational Audiologists working in both state and private institutions. The second source of data were obtained from compensation reports compiled by the workmen's compensation scheme representative. Data was collected using a structured questionnaire which was compiled in using English language. Participants were emailed the questionnaire link and were given time to complete the questionnaire at their convenient time.

Design: The design used was quantitative, the study adopted the economic evaluations approach, cost analysis approach, and in particular micro costing analysis as the study was concern with assessing the net monetary impact of a disease (NIHL).

Data Analysis: A quantitative descriptive analysis approach was adopted for the current study. This allowed for a meaningful and objective means of answering the question "what is the economic cost of NIHL".

Results: Findings of the current study revealed that NIHL posed huge economic burden to the country, as evident by the high costs incurred during investigation, management and compensation of NIHL. Based on the direct costs incurred, the study revealed that R9 million costs were incurred during investigation of NIHL in the period of 2008-2018. Also, the individuals with reported NIHL are likely to incur these costs.

Likewise findings from the study indicated that, costs incurred during management of 7199 individuals with NIHL in the mining sector were estimated at R56 million for the stated period. These costs were 5 times more than the investigation costs, indicating how costly it is to manage NIHL.

With regards to compensation paid-out, the analysis indicated that R1.9 billion was spent by the mining sector to compensated 7199 individuals with acceptable claims. Majority (90%) of these costs were incurred by the gold mine commodities at R1.1 billion.

Conclusion: The findings of the study strongly indicated that the mining sector in general represents the heaviest burden on the economy, as evident by the high compensation costs, which demonstrates the costly impacts and magnitudes of inadequately managed NIHL in a place of work. Importantly, these effects of NIHL should not be taken lightly as they have a potential to extend beyond compensation in particular to developing countries such as South Africa where poverty levels are high. In addition the impact of NIHL on one's health and quality of life cannot be quantified in tangible measures or standards. Thus NIHL may be considered one of the greatest threats to the country's economy and public health systems.

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CHAPTER 1: BACKGROUND AND LITERATURE REVIEW

Chapter 1 provides an overview of noise induced hearing loss (NIHL), as well as the theoretical framework, rationale, and the objectives of this study.

1.1 Background

Since the dawn of mankind, the ear has played a vital role in the safety of human beings (Protect ear, 2012). Hence, ears have no ear lids. Hearing detects all sounds, wanted and unwanted, in all directions in three dimensional space, whether awake or asleep (Protect ear, 2012). Thus the involuntary sense of hearing should be protected from voluntary exposure to hazardous sounds**.** Employment embody both a positive and an adverse effect on the health of the employee. The positive effects of employment include providing income and material outputs for meeting the necessities of life. The adverse effects of employment may affect physical, emotional and mental health of an individual, which may lead to job dissatisfaction, workplace injury and stress to mention a few (Salvagioni, 2017). Similarly, the right to health and safety at work is part of basic human rights (Tshoose, 2014; WHO, 2017). However the South African mining sector has neglected the basic rights for most mine workers (Teke, 2017). One of the important basics rights neglected by the mining industry is that of adequate occupational health and safety for miners (National Institute for Occupational Safety and Health [NIOSH], 1996)

Occupational health is an important strategy not only to ensure the health of workers, but also to contribute positively to productivity, quality of products, work motivation, job satisfaction and thereby to the overall quality of life of individuals and society (WHO, 2000; Reddy, 2014). However, some conditions, such as excessive noise in the workplace for instance, which is ever-present in certain occupations, introduces a distinct and even severe hazard to health which negatively impacts the well-being, working capacity and the life span of working individuals (WHO, 2015). Excessive noise in the workplace is a global occupational health hazard with considerable social and physiological impacts (Nelson, 2005; WHO, 2015). However, the most devastating impact of excessive noise is the resultant noise induced hearing loss (NIHL). There is sufficient evidence connecting excessive occupational noise exposure and NIHL (Lie et al., 2015; Kanji, Khoza-Shangase & Ntlhakana, 2017; Le et al., 2017; Themann & Masterson, 2019; Grobler, Swanepoel, Strauss et al., 2020).

Occupational noise is defined as any type of noise produced in the workplace which is 85 dB(A) and greater in intensity over an 8-hour working shift for a 40-hour/week time weighted average (COIDA, 1993). The International Organization for Standardization (ISO) sets the maximum permissible occupational noise levels at 85dB for an 8-hour work shift in developing countries in order to regulate the impact of high level occupational noise level (ISO, 1999, 2003). Statutory occupational noise exposure limits vary from country to country. In South Africa, the Occupational Health and Safety (OHS) Act (85/93) NIHL Regulations regulate the noise exposure levels in South African industries with variation levels from 85dB (A) to 90dB (A). However, the regulated occupational noise exposure level s in South Africa as per OHS Act (85/93) is an 8-hour time weighted average of 85 dB (A). This is aligned with Noise Induce Hearing Loss Regulations (2003) (SIMRAC, 2001; OHS Act 85, 1993) which is in line with the ISO recommendations. Mining in South African is yet another sector associated with high noise levels produced by various sources of noise in the workplace.

High levels of occupational noise remain a problem in all regions of the world (Śliwińska-Kowalska & Zaborowski 2017). In addition to the huge economic burden associated with the resultant NIHL, the quality of life for affected individuals is diminished (Śliwińska-Kowalska & Davis, 2012). Globally, approximately 120 million occupational accidents with 200,000 fatalities are reported annually (ILO, 2015; Hämäläinen, Takala & Kiat, 2017). Additionally, some 68-157 million new cases of occupational disease are reportedly emanating from various exposures at work (ILO, 2015; Hämäläinen et al., 2017). Not only does this lead to unnecessary human suffering. The costs involved in these health hazards have been estimated to amount to high percentages (between 1 and 3 %) in some countries' Gross National Product (GNP) (WHO, 2005; Trung, Louise, Straatman, Lea & Westerberg, 2017). Moreover between 1.8 and 6.0% of Gross Domestic Product (GDP) in country estimates, the average being 4%, for example in Singapore's economic costs were estimated to be equivalent to 3.2% (Takala et al., 2014). Overall, occupational noise contributes between 7% and 21% (averaging 16%) of adult hearing loss globally Nelson, Nelson, Concha-Barrientos, & Fingerhut, (2005); Trung et al., (2017), including NIHL.

1.2 Noise induced hearing loss

Noise induced hearing loss is defined as a permanent, irreversible, sensori-neural hearing impairment, resulting from prolonged exposure to excessive noise levels (Ding, Yan, & Liu, 2019). Characteristically, it begins in the higher frequency range (3000–6000 Hz) and gradually progresses to lower frequencies with continued exposure to excessive noise levels (McReynolds, 2005; Rachiotis, Alexopoulos, & Drivas, 2006; Fuente &Hickson, 2011). Globally, the major cause of NIHL in adults is occupational noise (Nelson, 2005; Ding et al., 2019). Due to industrial revolution particularly throughout Western Europe and North America, the 19th century introduced the use of machinery in the workplace (Deanne, 2000). This migration to machinery however resulted in hazardous noise. The introduction of steam power as a result of industrial revolution brought attention to noise as an occupational hazard (NIOSH, 1998; Agarwal et al., 2015). A high number of hearing impairments referred to as the boil maker's disease was reported among craftsmen who designed steam boilers (Clark, 2000; NIOSH, 1998). The discovery of boilermaker's disease is one of the main historical events in linking NIHL to noise exposure (Johnson, 1999). Subsequently, in 1890, Haberman discussed the histological features of NIHL in the organ of Corti. Thereafter, Fowler described the 4 kHz notch which is characteristically a hallmark of NIHL. Finally, in 1939, Bunch explained the audiometric findings of NIHL (Alberti, 1991).

The World Health Organisation (WHO) states that NIHL is the most common industrial disease and the biggest compensable occupational hazard (WHO, 2015). Similarly in South Africa NIHL is the most reported occupational health condition and its prevalence remains high in the mining sector (Edwards, Dekker, Franz, van Dyk, & Banyini, 2011; Kanji et al.,2017; Ntlhakana, Kanji, & Khoza-Shangase, 2015; Strauss, Swanepoel, Becker , Eloff, & Hall, 2012; van Coller, 2015). Furthermore, NIHL has become a significant public health factor due to the spread of industrialisation, consequently adding to the global burden of disease (Nandi & Dhatrak, 2008; Yongbing & Martin, 2013).

Noise induced hearing loss results in health problems for many individuals and it presents a significant social, economic and human cost (Arthur, 2016). These costs include lost jobs, increased absenteeism, reduced performance, lost opportunities for promotion or other

employment and impaired family and social relationships (Gaganija et al, 2011; Cunningham et al., 2017). In addition, if an individual's hearing is damaged it could result in workplace accidents (Abdalla et al., 2017; Feder et al., 2017). Unfortunately, the effects of noise are often underestimated because the damage occurs gradually and there are no externally visible physical changes (Min-Yong, 2003; Munzel et al., 2018). According to Gaganija et al., (2011) individuals exposed to excessive noise have not paid much attention to this occupational disease for the following reasons: not being aware of the condition in its early stages, fear of dismissal, and fear of loss of wages due to transfer of jobs.

Furthermore, Tye-Murray,(2009); Healey,(2017) states that since NIHL is an invisible disability, people have traditionally not appreciated its serious impact on their daily living until they experience communication problems or ongoing ringing in their ears, known as tinnitus (Arthur, 2016; Hoffman & Reed, 2004; Moller, 2011; Atik, 2014). Tinnitus often occurs after noise exposure, and usually becomes permanent (Han, 2009; Rauschecker, Leaver & Muhlau, 2010; Gilles, 2013). Evidence indicates a relationship between NIHL and tinnitus (Dias, 2006). A study by Edwards, (2008) revealed that 57, 8% of the gold miners younger than 60 years presented with tinnitus. Interestingly, the age group 21-20 had the highest incidence (20.8%) of tinnitus. The incidence of tinnitus in this age group is concerning, considering its association with NIHL. This suggests that these participants are at greater risk of acquiring NIHL. Moreover approximately one in seven people suffer from tinnitus and it may have adverse impacts on the health of affected person (Guyton & Hall, 2010).

In addition, majority causes of hearing losses are linked with aging and excessive noise exposure without any other evident ear disease (Dobie, 2008; Kirchner et al., 2012; Hong et al., 2013; Oh et al., 2014). Since age related hearing loss (ARHL), also known as presbycusis is not preventable, preventing NIHL can potentially reduce the societal burden of hearing loss than medical and surgical treatment of all other ear diseases combined (Dobie, 2001; Dobie, 2015). Moreover, increased noise levels may further lead to a number of non-auditory adverse effects, including elevated blood pressure and sleep interference (Basner, 2014; Stansfeld, 2015; Munzel, 2018). It may interfere with communications and performance in the workplace, and ultimately the occurrence of accidents in the workplace (Girard et al., 2009; Picard, Girard, Simard, Larocque, Leroux & Turcotte, 2008; Abdalla et al., 2017; Feder et al., 2017). Exposure

to excessive sound levels, even for short duration, can result in loss of hearing sensitivity **(**Ryan et al., 2016). Temporal threshold shift (TTS) depends on the intensity and characteristics of the stimulus and the duration of exposure (Martini, 2006; Finneran, 2015). It may take minutes, hours or even days before the sensitivity of the ear returns to normal (Guyton & Hall, 2010; Ryan et al., 2016). This can be attributed to metabolic changes in the auditory receptor cells (as a result of over stimulation) (Hall, 2011; Wolak et al., 2016).

If exposure to noise, which causes TTS is sustained, the threshold of hearing will not recover completely with time and this will result in a permanent threshold shift (Ryan et al., 2016; Kurabi et al., 2017). It seems that prolonged exposure to noise brings about metabolic changes in the auditory receptors cells and nerves that eventually lead to degenerative damage to the cell structure (Ychida et al., 2005; Syka & Popela, 2000; Hall, 2011; Wolak et al., 2016). According to Concha-Barrientos et al., (2004) threshold shift is a sign for NIHL, the main outcome of occupational noise. Hearing impairment is usually gradual, therefore the affected individual will not notice changes in hearing ability until a great threshold shift has occurred. Thus, there is an irreversible elevation of the auditory threshold with associated permanent pathological cochlea changes.

Moreover it is documented that the risk of injury and hearing loss increases with noise intensity; duration of exposure; frequency of exposure and individual susceptibility (Trung et al., 2017). These aggravating elements are particularly true for steady-state noise Trung et al., (2017) which is typically the type of noise found in industrial settings such as mining (Lie et al., 2016). This is due to the fact that in industrial settings the source of noise is machinery that generates noise by repetitive mechanical displacement of its components, which in turn produces energy that is transferred to surrounding air. When this energy is transferred through the air at frequencies below 20Hz it is perceived as vibration, (SIMRAC, 2001). If the propagation frequency is 20Hz – 20 000Hz this energy is noticeable via the hearing sense as sound (Richardson et al., 2013; Charifi et al., 2017). Sound is regarded as noise if it has the potential to damage people's hearing (Hong et al., 2013). This is how the steady-state noise is generated, causing hazardous industrial noise.

1.3 Prevalence of NIHL

Globally it is estimated that 1.3 billion people suffer from hearing loss due to noise exposure (Vos, Flaxman, Naghavi et al., 2012) Approximately 16% of adult hearing loss cases are associated with exposure to noise more than 85 dB (A) in the workplace (Beyan, Demiral, Cimrin, et al, 2016). NIHL is one of the most common forms of sensori-neural hearing loss and is a major health problem (Trung et al., 2017). It is the second most common form of acquired hearing loss after presbycusis (Krishnamurti, 2009; Mostaghaci et al., 2013). The exposure to excessive noise contributes to 37% of all adult cases of hearing loss and remains a significant contributor to employment morbidity internationally (Mizan et al., 2014; Rachiotis et al., 2006). In 1995, it was estimated that approximately 2 percent (120 million people) of the global population presented with some type of disabling hearing loss (Nelson et al., 2005; Suzuki, Kobayashi, & Koga, 2012). In less than a decade the figure doubled to 240 million cases in 2003 (Suzuki et al., 2012). Furthermore in 2005 Nelson et al.,(2005) provided global estimates ranging between 7% and 21% and attributed this disabling hearing loss to exposure to noise at work. Recently, Feder et al., (2017) revised these estimates to be between 16% and 24% indicating an increase when compared to earlier years. Moreover the effects of NIHL are more prevalent in developing countries than developed countries (Chadambuka et al., 2013; Feder et al., 2017; Strauss, Swanepoel, Becker, Eloff, & Hall, 2014). According to the Third European survey on working conditions, about 20% of European workers are exposed to noise so loud that they would have to raise their voice to talk to other people (Feder et al., 2017). Exposure to noise is particularly common in construction, and the manufacturing sectors. The same source notes that about 7% of European workers consider that their work affects their health in the form of hearing disorders.

In the United States of America , it is estimated that 22,4 million workers are exposed to hazardous noise in their job (Cantley et al., 2015; Masterson, Tak, Themann, & al, 2013). In Germany, 4−5 million people (12−15% of the workforce) are exposed to noise levels defined as hazardous by WHO (Zare et al., 2018). In Sweden, about 9% of the entire workforce is constantly exposed to harmful levels of noise, and approximately 100 million dollars are paid yearly in compensation (Khoshakhlagh & Ghasemi, 2017). In Malaysia more than 3000 cases of NIHL were reported in 2015 and has shown an increasing trend annually (Noraita, Aljunid, Hashim, & Begum, 2014). As illustrated in figure 1, this figure demonstrate the global impact

of NIHL, though the impact is poorly studied in Africa (Nkosi, Claassen, & Voyi 2015; Ologe, Tanimola, Olajide, & Oajide 2005), as evident by the scarce prevalence data in this region. However available evidence suggests that average noise levels are well above the occupational level recommended in many developed nations (Concha-Barrientos et al., 2004; Anjorin, Jemiluyi, & Akintayo, 2015).

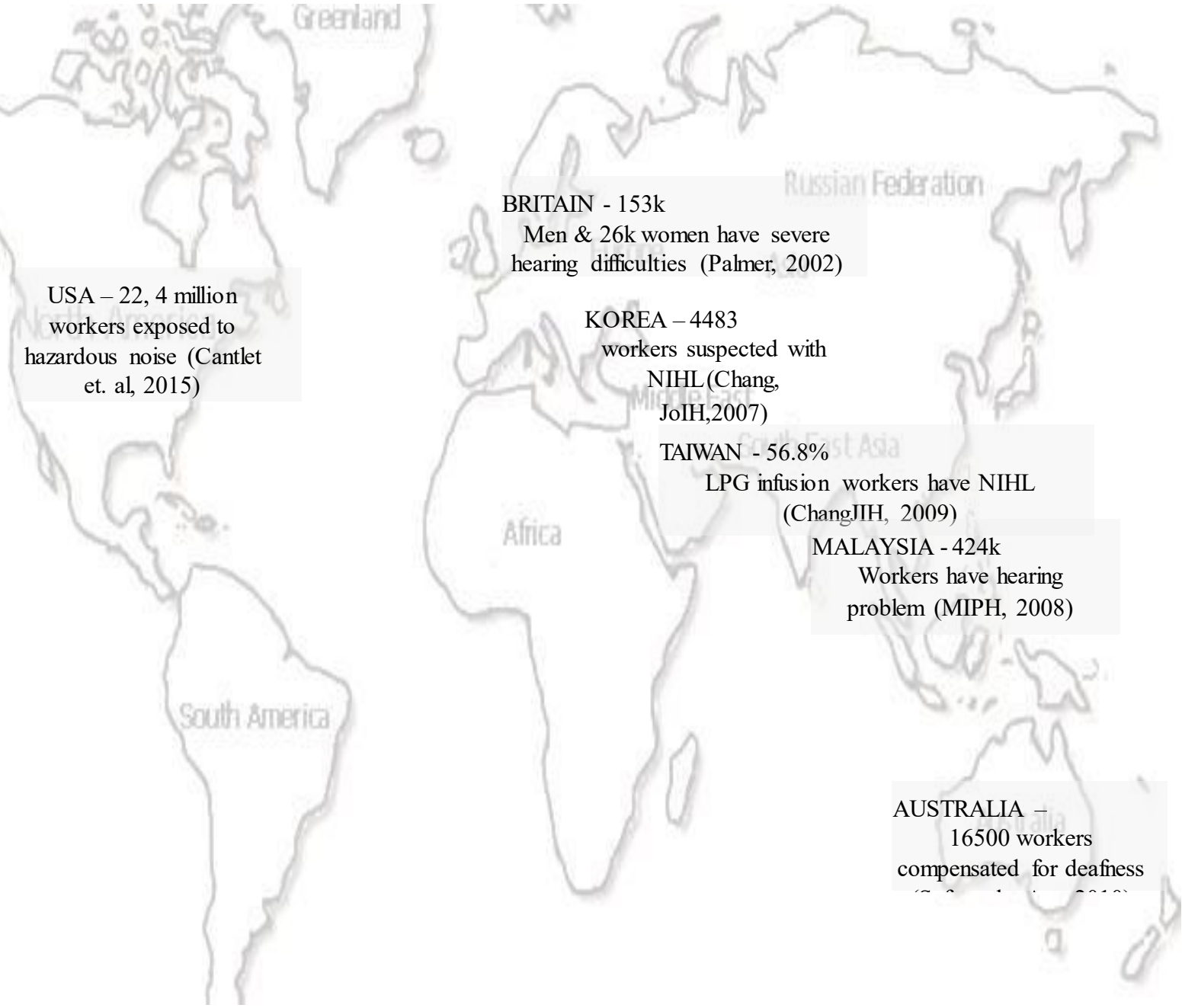

Figure 1: Global prevelance of NIHL Aljunid et al., (2014)

NIHL is considered the most commonly reported occupational health condition, especially in developing countries such as South Africa (AngloGold, 2008; Kanji, Khoza-Shangase, & Ntlhakana, 2018). It is estimated that (18% eastern sub region of the African continent including South Africa) versus (9% North America) of adult-onset hearing losses in the 20 southern most countries in Africa, are due to occupational noise exposure (Nelson, et al., 2005;

Straus, 2013). Recent data suggest that much of the South African workforce is still exposed to damaging noise levels in the workplace (Balfour-Kaipa, 2014; Moroe & Khoza-Shangase, 2018). Prevalence studies in occupational diseases, such as NIHL, might be disadvantaged by the fact that there is often a prolonged lead time for the disease to develop (Scott, Grayson, & Metz, 2004). If hearing assessments are not conducted regularly, NIHL might be underreported as demonstrated in figure 2. Due to this latency period of many occupational diseases, symptoms often present after an individual had left a workplace and thus go unidentified (Hermanus, 2006).

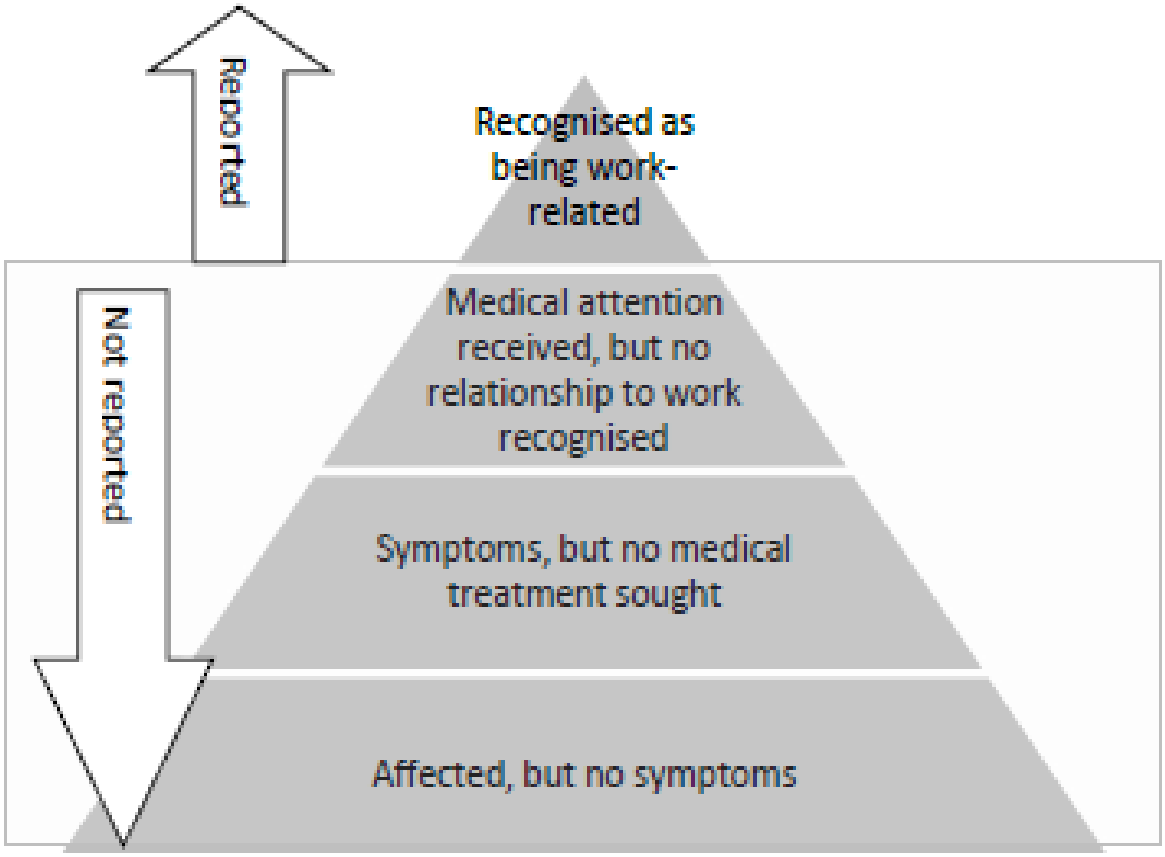

Figure 2: Underreporting of occupational diseases Source: Scott, Grayson & Metz, (2004)

1.4 Prevalence of Noise-Induced Hearing Loss in South African Mining sector

Globally, mining as an employment is identified as an economic sector with heavy burden of NIHL (Nelson, et al., 2005). South Africa in particular has a great share of "noisy jobs" since the country has a large mining sector. The South African mining sector gives employment to

more than 1 million employers and majority being black males (Minerals Council South Africa, 2019). A survey conducted by Franz & Phillips (2001), investigated noise exposure in South African mines. The findings, found that exposure levels for individuals who operates production machinery and those individuals in close proximity to the machines range between 95 and 110dB. It is further estimated that 68 to 80% of South African mineworkers are exposed to hazardous noise levels. This indicates a significant risk of hearing loss for the majority of workers in this sector (Franz & Phillips, 2001). The above reference is dated yet of relevance to the current study. In 2011, 10 years later, Edwards et al., (2011) reported similar findings to the above study, where the mean noise exposure levels in the South African mining sector ranged from 63.9 to 113.5 dB(A). Additionally, these authors reported that approximately 73.2% of miners in the sector are exposed to noise levels above the legislated occupational exposure limit of 85 dB (A). Subsequently, the high prevalence of NIHL in South African mines is realized through compensation pay out, for example in 2004 the compensation fund paid 75 million in compensation (Hermanus, 2004). In less than a decade this amount increased to R3431 578. 235 in 2011/2012 financial year (South Africa department of labour, 2012). It is evident from the above discussion that NIHL in South African mines is strongly prevalent and research into the incidence and prevalence and impact of NIHL is necessary.

The high prevalence of NIHL is concerning, considering that NIHL is a preventable disease. An audit of the Department of Mineral Resources in South Africa reported 1 820 cases of NIHL in 2007 (PMHSA (2008). Since then, the Chamber of Mines reported a positive downward trend in the number of NIHL cases since the baseline in 2002/2003 (a rate of 15 per 1000 workers was reported then), thereafter the rate of NIHL was 3.1 cases per 1 000 employees (Chamber of Mines Annual Report 2011). The report attributed this decrease to the possibility that the reported NIHL cases inflated soon after 2001 as baseline hearing testing was only mandated after 2001 when Circular Instruction 171 was issued under the Compensation for Occupational Injuries and Diseases Act (No. 130 of 1993) (COID,1993).

In 2003 due to high incidence of NIHL and costs to the South African mining industry, the industry stakeholders set up targets to eliminate NIHL (DME, 2008). In order to achieve the targets and to monitor the progress towards achieving them, the mining industry needed reliable, representative and noise exposure data. Therefore, the South African Mine Health and Safety Council (MHSC: 2006) conducted a study to quantify the noise exposure levels in the mining industry. The MHSC (2006) study included objectives relating to both noise and dust

exposure and prevention of NIHL and silicosis (Dekker et al., 2007). In 2005, the Mine Health and Safety Council (MHSC), comprising representatives of state, labour and employers, signed an agreement with the mining industry. Subsequently, the MHSC (2006) recommended the calculation of reliable prevalence data on NIHL as a focus area within occupational health research. However apart from annual reports available from specific mining groups, the MHSC (2006) and the Chamber of Mines, there is limited data on the prevalence and incidence of NIHL in the mining industry against which to measure the MHSC's (2006) target to reduce NIHL.

1.5 Productivity losses

Excessive noise results in a decrease in work performance and the quantity of work completed (Melamed et al., 2001). It decreases the coordination function of workers (Seixas et al., 2005; Lusk et al., 1998). It interrupts an individual's attention processes and reaction time and therefore the accuracy, quantity of the work is affected, and the number of errors increases (Landen et al., 2004). This is common in industries where continuous noise exists (Landen et al., 2004). Being unable to perform work well reduces the worker's self-esteem, affects personal well-being and creates an aversion to returning to work each day (Mizoue et al., 2003; Nakaniski et al., 2000). Reduced participation of hearing-impaired individuals in the workforce accounts for a much higher share of the total costs of hearing loss than health or education sector costs. Hearing loss has multiple impacts on participation in employment: rates of employment are lower than for people without disabilities (Woodcock & Pole,2008; Rydberg, Gellerstedt & Danermark, 2010; Jung & Bhattacharyya, 2012; Pierre et al., 2012; Stam et al., 2013; Garramiola-Bilbao & Rodriguez-Alvarez, 2016). Hearing loss is also a reason for early retirement (Helvik, Krokstad & Tambs, 2012). Additionally, there are restrictions to career opportunities and levels of income because of hearing loss (Hogan et al., 2009).

Various studies in the United Kingdom have estimated the costs of productivity losses. Using a prevalence-based approach to determine the level of hearing loss, the Commission on Hearing Loss (ILC-UK, 2014) estimated productivity losses to be $36.4 billion (£24.8 billion at 2013 prices). Another study estimated losses of $3135 (£2136 at 2013 prices) per person, totalling almost $6 billion in 2013, as a consequence of reduced earning for hearing impaired individuals in employment (Archbold et al., 2015). An earlier United Kingdom study estimated the costs

due to lost employment and reported a loss of $33 billion for all those experiencing hearing loss and of $25 billion if the estimate was restricted to individuals who did not use hearing aids (Shield, 2006). The above figures indicate that NIHL has negative impacts on work productivity globally. While many developed countries can account for the burden of occupational disease, including hearing loss, many developing countries still lack published and accurate population-based data on this topic (WHO, 1997; Smith, 1998; Dekker, Edwards, Franz, van Dyk, & Banyini, 2013). South Africa is one such developing country that presents limited documentation pertaining to the economic cost of occupational disease. It is of great concern that no studies are conducted on the costs incurred due to productivity losses, as it has dire impact on the company (profits affected), individual's (deteriorating health) and the government (through company's GDP contribution to the country's economy).

1.6 Intangible costs

NIHL can have a profound impact on the quality of life and may have domino effect of increased fatigue, frustration, stress, anger, embarrassment, isolation, negative self-image and reduced autonomy (Palmer et. al, 2001). There is limited literature addressing intangible costs associated with NIHL on a global scale. Although it is hard to place a value on stigma, grief and social exclusion, NIHL poses a significant challenge in the lives of those affected and their families. Moreover hearing loss is associated with decreased social, psychological, and cognitive functioning (Dawes et al., 2015). Hearing ability is inversely associated with distress, somatization, depression, and loneliness among all age groups (Theman, Suter, & Stephenson, 2013). In developing countries occupational noise accounted for about 3.8 million years of healthy life on an annual basis in 2000 compared to 0.3 million years in developed countries (Nelson, Nelson, Concha-Barrientos, & Fingerhut, 2005). According to the WHO loss of productivity, due to unemployment and premature retirement among people with hearing loss, is conservatively estimated to cost $105 billion annually (WHO, 2017). The result of social isolation, communication difficulties and stigma add a further $573 billion each year (WHO, 2017). These costs are calculated on the basis of the monetary value attached to avoidance of a year lived with disability and draw upon disability-adjusted life years (DALYs) attributed to hearing loss. NIHL represents a much heavier burden in developing countries such as South Africa than in developed regions of the world (WHO, 2017). Unless suitable care is made

available, the inevitable exclusion from communication, feelings of loneliness, isolation and frustration, in elderly individuals it may also lead to cognitive decline (WHO, 2017).

1.7 Economic Impact of NIHL

While the causes of NIHL are well known and preventive strategies have been identified, there has been relatively few attempts to assess its economic costs globally. This is evidenced by scarce studies examining the economic effect of this emerging public health problem. Shelese, Stucky, Kenneth and Wolf,(2010) conducted an analysis which aimed to address this gap by evaluating direct medical costs and costs attributable to lost productivity for hearing loss in the United States. Estimates were presented at the national, state, and local levels for 2002 and 2030, using California and Los Angeles country as illustrative cases. These authors' findings indicated that the economic cost to society due to hearing loss is estimated to be $297,000 over the lifetime of every affected person (Shelese, Stucky, Kenneth & Wolf, 2010. Nationally, the total cost of first-year hearing loss treatment is projected to increase fivefold between 2002 and 2030, from $8.2 billion to $51.4 billion (Shelese, Stucky, Kenneth & Wolf, 2010. Where feasible, estimates were adjusted for healthcare inflation.

The total costs of first-year treatment of hearing loss in 2002 was approximately $1,292 per person or $8.2 billion nationally, $855 million in California, or $229 million in Los Angeles. By 2030, these costs would increase to approximately $51.4 billion nationally, $6 billion in California, and $1.4 billion in Los Angeles Country (Shelese, Stucky, Kenneth & Wolf, 2010. The above study further suggest that the financial and societal burden of treating hearing loss will increase substantially in the upcoming decades (Shelese, Stucky, Kenneth & Wolf, 2010. Much of this burden will fall disproportionally, because poor and underserved individuals are likely to feel this burden the most, adding to health disparities (Shelese, Stucky, Kenneth & Wolf, 2010).

Three years later Santana et al., (2013) estimated the direct health care costs and socioeconomic consequences of work injuries. They reported that approximately half the cases suffered loss of earnings, and female workers were more frequently dismissed than male workers. Total costs for management work injuries were approximately US$40,000, half of that was out of-

pocket costs paid by relatives or workers themselves. Most out-of-pocket costs were related to transport and purchasing medicines.

More recently the National Foundation for the Deaf in 2016 compiled a report on the social and economic costs of hearing loss in New Zealand. Findings of this report estimated that the total size of the New Zealand hearing aid market was approximately 36,000 units in 2007. This is approximately 74% of binaural (two aids) and 26% of monaural (one aid). McLean, (2008) reported that, on average, audiologists charge $400 and $600 for fitting services for monaural and binaural hearing aids, respectively. Thus, the average cost of fitting was reported as being $548 in 2007. This value was inflated to $692 in 2016 using health inflation The total cost of maintenance services provided by audiologists or audiometrists was estimated to be $21.9 million in New Zealand in 2016. Expenditure for other health professionals associated with hearing loss was calculated as the sum of hearing assessments and fitting costs conducted by audiologists and audiometrists. Total expenditure for other health professionals was estimated to be $78.1 million in New Zealand in 2016. Kurmis and Apps, (2007) found, based on Access Economics (2006) that NIHL accounts for approximately 1.4% of GDP in Australia. For a condition that is potentially avoidable, this is a large burden for the health system to bear.

Therefore, when an employee acquires NIHL from work, everyone loses. The toll of NIHL is not only felt by the workers but is also a financial burden on the employer and government. The NIHL results in communication difficulties, the worker may be seen as incompetent or reluctant which will eventually impact on team work and group productivity (Nelson, Nelson, Concha-Barrientos, & Fingerhut, 2005). Furthermore communication difficulties may lead to increased risks of accidents (ACOEM, 2012). Thus causing the mine millions in the form of compensation. In South Africa majority of the mine workforce comprises of Black South African males (Worldwide Recruitment Solutions, 2014). The South Africa's political history has resulted in high levels of poverty and deprivation for its Black citizens. For example, under apartheid, Black mine workers were denied formal education (Naidoo 2007). Without basic numeracy skills, the large numbers of innumerate mine had limited options for better jobs. In addition, NIHL can present a limitation on the kind of employment suitable for a person with a hearing loss (Thorne, 2006). Therefore, Individuals might struggle with month-to-month expenses as it might be difficult to be employed again due to historically low level of education

among mine workers. This has lifelong consequences for miners and their families as they may not be employable, therefore deemed eligible for occupational compensation. However, compensation pay-out may not be sufficient due to the state maximum pay out of R140 506 (Jeffery, 2018). Subsequently, be indirectly forced to access state services such as state pension and health care facilities, which are already burden with diseases and high volumes of people. Therefore improving the overall wellbeing of employees exposed to excessive noise in their occupation, is likely to positively influence the economy of the country. Given the current economic challenges such as high rate of poverty, social inequality, unemployment and public service access disparities (Cook, 2020). It is imperative to contain costs.

1.8 Management of NIHL

Initially audiologists focused mainly on the treatment of NIHL. Since then the focus has shifted from intervention to prevention of NIHL. While the methods of testing hearing loss were possible prior to 1940, it was only in 1937 that actual reports of hearing tests were made of persons with NIHL (Glorig, 1980). In 1981 the Occupational Safety and Health Association (OSHA), developed hearing conservation standards for employees exposed to excessive noise (US Department of Labor, 1983). The standards specified the permitted sound levels and duration of noise exposure and also mandated hearing conservation programmes (HCP). Soon thereafter in 1988 the South African Chamber of Mines currently known as the Minerals Council of South Africa published guidelines for the implementation and control of HCP in the mining industry (COMRO, 1988). In 1996 the components of HCPs were included in the Mine Health and Safety Act (Department of Minerals and Energy, 1996).

HCP are multi-component interventions aimed at managing NIHL in a workplace(Seixas, Neitzel, Stover, & al., 2011; Moroe et al., 2018). Comprehensive and well incorporated HCP encompass seven pillars namely: periodic noise exposure monitoring, engineering controls, administrative controls, personal hearing protection, audiometric evaluations, employee/management education and training and record keeping (Amedofu, 2007; Hong, Kerr, Poling, & Dhar, 2013; Moroe et al., 2018). The purpose of industrial HCP is to protect workers from developing NIHL in the workplace (Allooef, 2017). Amedofu and Fuente

(2011); Moroe et al., (2018) emphasized that any successful program has to cover all components of the HCP without exception.

Since the declaration of the Mine Health and Safety Act of 1996 (President's office, 1996) researchers have assessed the effectiveness and efficacy of HCP in the management of NIHL within the South African mining industry (Edwards et al., 2011; Edwards, Milanzi, Khoza, Letsoalo, & Zungu, 2015; Edwards & Kritzinger, 2012; Kanji, Khoza-Shangase, & Ntlhakana, 2018; Ntlhakana et al., 2015; Strauss et al., 2012). These researchers' findings indicated little, if any, success with HCPs. Even with emphasis revised from treatment to prevention and the worldwide implementation of HCP, hearing loss caused by noise is still prevalent SANS10083:2004, (2004) with severe financial and quality of life consequences. The reality is, approximately 73.2% of South African miners are exposed to excessive noise exceeding the legislated occupational exposure limit of 85 dBs, regardless of HCPs being implemented in the mining sector (Edwards et al., 2011; Strauss et al., 2012). The above findings paint- a picture that the South African mining sector is not making the desired progress in the management of NIHL. Additionally majority of studies in HCP focuses on a specific pillar within the HCP. However, all pillars of the programme play a crucial part in the effectiveness of the programme and ignoring any of the pillars could lead to programme failure. Such evidence highlights the importance of focusing on and investing in HCPs in mines to reduce and eventually eliminate auditory health hazards due to occupational noise exposure. Thus, strict enforcement of the noise level regulation act and implementing comprehensive HCP is a key to preventing and reducing NIHL.

1.9 Compensation of NIHL

Theoretically, NIHL is entirely preventable, yet it still occurs. According to the WHO, NIHL is the most common industrial disease and the biggest compensable occupational hazard (WHO, 2015). The costs involved in compensation of health hazards have been estimated to amount to high percentages of some countries' Gross National Product (GNP) (WHO, 2005). Millions are spent on the workmen's compensation claims in an attempt to hold the employer accountable for poor health and safety working conditions (Eijkemans, 2004). Worldwide,

according to the International Labour Organization (ILO), annually, 160 million people are affected by occupational injuries and illnesses, and 2 million people die, with costs that equate to nearly 4% of world GDP. That's over $3 trillion U.S. dollars. The United States Government Accountability Office report on noise, (2011), indicated that hearing loss was the most prevalent occupational health disability in the Department of Defence (DoD)(Yankaskas, 2013). The DoD civilian worker compensation costs were approximately $56 million in fiscal year 2003, and Veterans Affairs compensation costs were approximately $1.102 billion in fiscal year 2005 with hearing loss as second most common type of disability(Humes & Durch, 2005). A Canadian study reported an average of 55 injuries as a result of exposure to noise and a cost of CA$6, 985, 579 per year during the period 2005-2007 (Lebeau, Duguay, & Boucher, 2013). In the United Kingdom (U.K.), 230,000 insurance claims related to NIHL were awarded during the period of 1991-1995 (Palmer et al., 2002). In Australia, 16,500 compensation claims were accepted between the period July 2002-2007 Commonwealth of Australia, (2010) and the estimated annual cost per individual employee was AUS$1,880.

In South Africa NIHL is a scheduled compensable disease in terms of Schedule 3 of the Compensation for Occupational Injuries and Diseases Act (Edwards, 2010; Strauss, Swanepoel, Becker, Eloff & Hall, 2018). Compensation takes the form of reimbursement of medical expenses plus a lump-sum payment to a maximum of R140 506 (an increment of 33% effective April 2018 from R105 000 maximum limit) (Jeffery, 2018). In 2016 it is said that R1.4 billion was paid out over the past 30 years to nearly 97 000 beneficiaries (Kane-Berman, 2018). NIHL is responsible for ± 15% of all compensation claims submitted and accounts for ±45% of costs paid out claimants.

NIHL is considered compensable when an individual exposed to hazardous noise experiences an average change in hearing of 10dB or more at frequencies of 2000Hz, 3000Hz and 4000Hz in one or both ears as compared to the individual's baseline audiogram (Bomela, 2006; Edwards, 2010; South African Department of Mineral Resources, 2016; Strauss et al., 2018). In 1991 in South Africa, 104 people were compensated for occupational disease of any kind. In 1997 this number increased to 3615 and of these a staggering 1903 were for NIHL. Moreover 4000 cases of NIHL were reported in 2004 in South Africa and R75 million rand was spent on compensation (Hermanus, 2009). In the 2011 and 2012 financial year, the Compensation Fund paid out claims to the amount of R 2 431 578 235(2.4 million) for work-related accidents (South Africa Department of Labour, 2012). The highest incidence of occupational injuries and fatalities were found in the mining, construction, and iron and steel sectors as well as the

agriculture sectors. The most commonly reported occupational diseases were NIHL, pneumoconiosis, asthma and skin diseases (South Africa Department of Labour, 2012).

In addition, mining sector is known to have a high number of migrant workers in South Africa (Coderre-Proulx, Campbell & Mande', 2015). Therefore detection of mine induced disease may occur very late in a day, if at all due to migratory labour system. For example it can take up to 15 years before symptoms of silicosis or of noise become apparent (Jeffery, 2018). Thus migrant workers who return to rural areas in South Africa or to neighbouring states, after completing their years of service on the mines and do not have easy access to testing facilities, let alone treatment are particularly disadvantaged in this regard (Jeffery, 2018). There are apparently another 90 000 claims that have been approved but not yet paid, and up to 700 000 still to be assessed (Kane-Berman, 2018). One of the problems for many people suffering from mine induced disease and entitled to compensation is the complexity of the application process (Kistnasamy, Yassi, Yu et al., 2018). Unfortunately many migrant workers or their bereaved dependants may be ignorant of their rights and be disadvantaged in this regard. Drawing from the above illustrations, it is evident that NIHL is a costly global burden and if not managed it could negatively affect the economy of the world.

Compensation in its present form remains a double edged sword: while it provides recognition of the sufferer's situation and can ameliorate some of the hardships, it also curtails employer liability because it limits the amount of compensations for which employers are responsible (Hong et. al, 2013). Compensation does not recognise the functional disability caused by NIHL and thus does not take into account the loss of quality of life for the affected worker (Hong et. al, 2013). In addition, compensation does not restore the individuals hearing. Moreover, while certain developing countries are reported to have compensation funds for injuries, the definition of occupational injuries such as hearing loss is inconsistent and can contribute to the criteria of not being compensated in the work place (Sanghavi, 2016). This, for a mineworker whose health is debilitating due to occupational exposure has profound impact on the quality of life. Therefore good health and safety should be seen as an investment, not a barrier to productivity (Sanghavi, 2016).

1.10 Theoretical framework

The aim of economic evaluation studies is to present evidence on the costs and consequences (in terms of patient outcomes) of quality improvement strategies and methods for increasing the uptake of evidence-based practices (Hoomans & Severens, 2014). In doing so, it informs whether specific initiatives are (or have been) a worthwhile (or 'cost-effective') use of the limited resources of health systems. Given tight budgets and ballooning healthcare costs worldwide, policymakers are increasingly interested in ways of ever-changing the balance of effort toward preventative activity that has the potential to both improve health and reduce healthcare cost. Depending on the service and population context, the methods used in economic evaluations can vary depending on the perspective taken. This can range from a narrow assessment of patient outcomes alongside immediate health care provider cost impacts through to the quantification of costs and consequences affecting other (non-health related) sectors, organisations and wider society (Roberts, Healey & Sevdalis, 2019). Since the current study was concerned with the costs effects of NIHL, the cost finding approach (specifically cost evaluation) was adopted to capture the costs incurred during the investigation and management of NIHL in individuals exposed to excessive occupational noise in the South African mining sector.

The literature review presented in this study has highlighted the cost component framework by Judith and Baker (2006) subsequently revised by Ajunid et al, (2010) (Figure 3) as the most appropriate and relevant theoretical framework for this current study. The Cost Component Frameworks takes into consideration two major components (direct and indirect costs) in cost evaluations of a disease. Cost component frameworks are mainly aimed at quantifying the economic burden of various illnesses and injuries and subsequently play a vital role in decision making regarding allocation of resources (Black& Pole, 1975). The cost components can be used as a baselines to evaluate alternative intervention strategies and to select the most suitable intervention with maximum social benefits. Furthermore, the cost components are more useful for estimating benefits which can be derived from preventing or reducing the incidence of specific disease such as NIHL (Scitovsky, 1982).

According to the WHO, (2010) the consumption of health goods and services in general does not yield utility or welfare directly. As such, people would prefer not to incur expenses in terms of money and time. The key direct determinants of economic welfare can be summarized as the consumption of non-health goods and services, leisure, and health itself. It is the impact of disease or injury on these domains of economic welfare that should form the basis of estimation (WHO, 2009). In order to have a clear economic meaning, it is important that economic impact studies be explicit and consistent about which of these domains of welfare are to be captured.

Cost components have been used for a long time to capture the economic cost of a disease (WHO, 2009). Recently it was used in a study by Ajunid et al., (2015) where the authors conducted a study in Malaysia on the economic burden of NIHL in the manufacturing sector. The authors aimed to estimate the risks and the economic burden of NIHL in workers exposed to excessive noise in manufacturing industry. This study utilized on the Cost Component Framework to accurately capture direct and indirect costs incurred by the employer, the government and employees themselves through the management of NIHL.

Moreover a study by Alamgir et al., (2016) used cost components to determine the economic impact of hearing impairment and NIHL injuries among active duty United State service members. These authors added that the cost components assist with listing of cost items to be developed, review list of cost items, categorize them into broad groups, and identify data sources with variables relevant to calculating these costs (Alamgir et al., 2016). Therefore drawing from the above discussions, the current study adopted the Cost Component Framework as this study sought to estimate the economic cost of NIHL in the mining sector in South Africa. In line with the cost components the direct and indirect costs incurred are seen as core components that needs to be investigated in the current study.

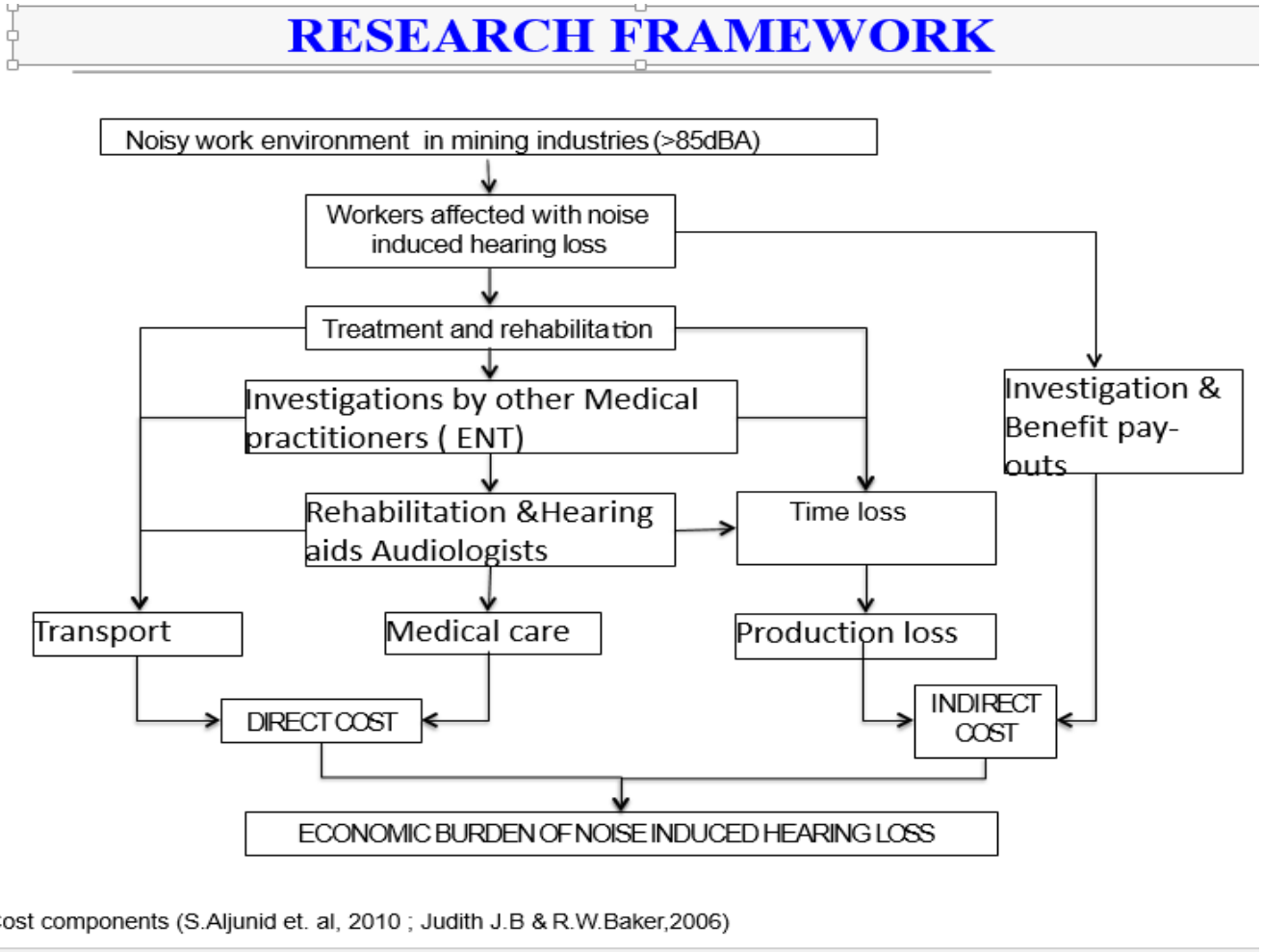

Figure 3: Cost components (Aljunid et al., 2010)

1.11 Rationale for the study

Economically, the mining sector remains one of the biggest contributors to the South African economy with an estimated worth of R20.3 trillion (US$2.5 trillion) (Statistics, 2017). It is the world's fifth largest mining sector in terms of GDP, contributing 8% to South Africa's GDP (Statistics, 2017). According to the government, there are 35 large-scale gold mines operating in South Africa, while the country accounts for 11% of the world's gold reserves (Editor, 2018). South Africa also accounts for 96% of known global reserves of platinum group metals, and is the second largest palladium producer (Editor, 2018). Furthermore, South Africa is the biggest producer of chromium and vanadium ores, and a leading supplier of their alloys, a significant producer of iron and manganese ores (Editor, 2018). Mining also has a multiplier effect on the rest of the economy, which, when taken into consideration, raises the contribution of mining to the GDP to close to 12% (Statistics, 2018). But the same industry has created a legacy which includes disease,

environmental damage, poor occupational health and safety and political hostility (Editor, 2018) . The legacy of poor occupational health and safety has been discussed in the current study. The main focus of the study is on the economic burden of NIHL on the affected individual, the sector and the state at large.

As mentioned earlier, in South Africa NIHL is the most reported occupational health condition and its prevalence remains high in the mining sector (Edwards, Dekker, Franz, van Dyk, & Banyini, 2011; Kanji,et al., 2017; Ntlhakana, Kanji, & Khoza-Shangase, 2015; Strauss et al., 2012; van Coller, 2015). This could be attributed to the fact that NIHL is invisible, slow progressing and not life threatening as opposed to conditions such as human immunodeficiency virus (HIV)/ acquired immunodeficiency syndrome (AIDS) and tuberculosis (TB) which are also known to be prevalent in the mining sector (Stuckler, Basu, McKee, & Lurie, 2011; Stuckler, Steele, Lurie, & Basu, 2013). Moreover according to Chadambuka, Mususa, & Muteti (2013) 80% of individuals affected by NIHL live in low and middle income countries and the burden of NIHL is much heavier than in developed countries of the worlds. Hence NIHL is known as the main and most direct health effect of noise exposure, which marks it as a significant and continuing health concern with economic consequences (Agrawal, Niparko, & Dobie, 2010; Hong, Kerr, Poling, & Dhar, 2013; Lie et al., 2016). Additionally, the prevalence of NIHL in South Africa should not be startling, as South Africa is a developing country faced with challenges related with developing countries. South Africa is challenged with an increased burden of diseases, increased unemployment rate, and political and economic instability (Gray & Vawda, 2016; Leboea, 2017; Lehohla, 2017) Therefore, ignoring NIHL may have negative impact to the mining sector's economy due to the enormous costs that come with management and non-management of NIHL. Thereby adding to the national economic burden in a country already experiencing high volumes of unemployment. It is concerning that despite mining in South Africa being one of the biggest contributors to the South African economy, little is known regarding the impact NIHL has on the financial well-being of this industry.

Regardless of the possible reasons why there is scarcity of research in South Africa on economic impact of NIHL, the fact remains that NIHL as an occupational disease does affect the economy of the mining sector, affected individual and that of the country. Dearth of current research on economic cost of NIHL begs the following questions: Does the South African government and the mining sector have adequate knowledge about the economic effects of NIHL? Are the economic effects of NIHL not of significant to call the attention of the

professionals and researchers as advocates for individuals affected by NIHL? While the impact of NIHL on individuals and families has been established, there have been relatively few attempts to assess its economic costs, especially in low and middle income countries (like South Africa) and at the global level. Therefore drawing from the above discussion the current study was based under the cost finding analysis as it aimed to investigate the economic cost of NIHL in individuals exposed to excessive occupational noise within the South African mining sector. In line with the cost finding analysis the study sought to determine:

1. What were the direct costs of investigation associated with NIHL?
2. What were the direct cost of management of NIHL?
3. What were the compensation costs related to NIHL?

CHAPTER 2: METHODOLOGY

This chapter describes the research approaches and research design choices made in the present study. Discussion on sampling procedures used, methods used for data collection, research instrument and operationalization of research variables are presented. Further, procedures used for testing the research instrument reliability and validity are discussed. At each stage, rationale for each action is discussed explaining the reason behind those actions and specific design choices.

2.1 Objectives of the study

2.1.1 Main Aim

To investigate the economic cost of NIHL in individuals exposed to excessive occupational noise within the South African mining sector.

2.1.2 Specific objectives

In line with the conceptual framework depicted in Figure 3, the specific objectives of the current study were:

1. To determine direct costs associated with investigation of NIHL as perceived by the Occupational Audiologists as the service provider.
2. To determine the direct costs associated with management of NIHL as reported by the Occupational Audiologists as the service provider.
3. To determine the compensation costs related to NIHL as reported by the workmen's compensation scheme.

2.2 Research design

A research design can be described as 'a plan that describes how, when and where data are to be collected and analysed' as well as the researcher's complete plan to answering the research question (Parahoo, 1997; Cooper & Schindler, 2003). The current study adopted the economic evaluations approach as it was concerned with finding the costs incurred during investigation of NIHL. There are several types of economic evaluation and each approach offers different

measures of the economic features of a health intervention (Anderson, Reinhardt, Hussey, et al., 2003; Drummon, Mark, Karl, et al., 2015). Irrespective of the type of analysis chosen, reliable intervention cost data forms the foundation of all economic evaluations (Chapel & Wang, 2019). In the current study cost analysis approach, specifically micro costing analysis was adopted. Cost analysis approaches assesses the net monetary impact of an intervention to a payer or other perspective, in other words, the costs of resources consumed in the process of developing, implementing, operating and delivering the intervention (Anderson, Reinhardt, Hussey, et al, 2003 ; Catlin & Cowan, 2013). Therefore this approach seem deemed for the current study as it was concerned with establishing the costs (how much in monetary value) incurred during the investigation and management of NIHL.

Specifically micro- costing analysis was adopted for the current study as it can provide the most accurate method of determining intervention costs as it contains direct details and costing of each intervention input (Chapel & Wang, 2019). Additionally, micro-costing entails determining the total cost by assigning a unit cost value to the inputs and grouping those (Chapel & Wang, 2019). Similarly in the current study the researcher sought to determine the cost of each service rendered (unit cost) by the service providers by assigning monetary costs on procedures conducted while investigating and managing NIHL. In addition micro-costing comprises five primary steps however other investigators have specified methods from 3 to 6 steps Charles, Edwards, Bywater, et al., (2013) ; Xu, Yonkers, Ruger, (2014) but the key principles remain the same. These steps are: 1) define the intervention production processes and the study perspective; 2) identify the intervention inputs; 3) quantify the units of each input; 4) assign a cost value to each input unit and aggregate and 5) conduct sensitivity analysis. Also costs can be measured at different levels of analysis depending on the study question (Smith & Barnett, 2003). In the current study 5 of the steps were applied as follows:

1. Define the intervention production processes and study perspective- the study was concerned with investigating the costs incurred during the investigation and management of NIHL,
2. Identify the intervention inputs- these were the tests and procedures conducted by Audiologists while investigating and managing NIHL,
3. Assign a cost value for each unit - the service providers were requested to state the cost of each test and procedure conducted in monetary value,
4. Quantify the units of each unit- the researcher made use of a statistician services to quantify the costs,

5. Conduct sensitivity analysis- the researcher highlighted the costs of units (investigation and management costs) and the consequences of non-management of NIHL (costs incurred by the individual, company and state).

Additionally, Chapel & Wang, (2019) enumerate 5 major data collection methods in economic evaluation studies, which are:

1. Standardised comprehensive templates (e.g., web-based cost assessment tool, standardised data collection instrument),
2. Targeted questionnaires and interviews (e.g., survey of participants, manager's survey, and staff interviews),
3. Activity logs (e.g., staff time sheet, time diary),
4. Direct observation (time and motion study),
5. On-site databases and routine records (e.g., intervention database, cost accounting system, financial records)

As stated above by Chapel& Wang (2019), there are different data collection methods in economic evaluation studies, the method of data collection is determine by the aim of the study. Thus the current study adopted the questionnaire as the data collection tool as it allowed no pressure or manipulation from the researcher (Cooper & Schindler, 2003). Also, this study was statistical in nature and it was designed for breadth rather than depth. It attempted to highlight the insights of the economic costs of NIHL in the South African mining sector and made numeric implications based on the data obtained (Cooper & Schindler, 2003).

2.3 Sampling Strategy and sample size

A non-probability purposeful and snowball sampling approaches were employed to recruit participants who shared similar characteristics such as - knowledgeable in the field of occupational audiology, assessed and managed individuals who presented with NIHL from the mining sector, availability at a given time, or the willingness to participate - were included in this study (Dörnyei, 2007; Etikan, Musa & Alkassim, 2016; Story et al., 2019). Although a probability unrestricted simple random sample approach would have been ideal for the current study, this was not practical considering the already limited number of Occupational Audiologists. In 2020 the Health Professions Council Association in South Africa's database had a total number of 3266 registered Audiologists, Speech Therapists and Speech Therapists

and Audiologists (Pillay, Tiwari, Kathard & Chikte, 2020). Majority (1548) were registered as dual Speech Therapist-Audiologist, followed by 1087 as Speech Therapist and 617 as Audiologist (Pillay, Tiwari, Kathard & Chikte, 2020). This is considered the smallest profession within the board (HPCSA, 2018). Audiologists specializing in occupational audiology were invited and owing to the small number of these professional, recruited Occupational Audiologists, were further requested to refer fellow colleagues in order to increase the number of participants. Additionally a workmen's compensation scheme, which was responsible for handling the administration of claims for occupational injuries and diseases according to the Compensation for Occupational Injuries and Disease Act was invited to participate in the study. This scheme was to provide the researcher with compensation paid-aid to compensate NIHL in the period specified by the researcher. Furthermore this workmen's compensation scheme was responsible for the management of compensation claims in 80% of the mines in South Africa.

Therefore, a non-probability sampling approach, specifically, purposive and snowball sampling was thus applied (Cooper & Schindler, 2003). Since this study did not sought to generalise the results of the study to specific mining commodities but to highlight the insights of the economic costs of NIHL, these approaches were deemed suitable. In addition, the researcher sought to identify and select professionals who had experience and were knowledgeable in the management of NIHL in the mining sector (Etikan et al, 2016). Possible participants were identified from the mining sector as well as private and public organizations affiliated to the mining sector.

2.4 Target population defined for the study

In order to achieve the aim of the study, both direct and indirect costs were targeted. However, due to COVID-19 pandemic and lockdown regulations in place during data collection phase, challenges were encountered with recruiting occupational health and safety (OHS) personnel or any personnel tasked with the implementation of HCP in the mines. These personnel were targeted as they were in constant contact and were responsible for managing individuals exposed to excessive noise at work. In order for these personnel to participants in the study, permission from the mine (as the employer) was required. Majority of the mines denied access for the study. The mines that were willing to participant had to be withdrawn from the study

due to access being restricted in the mines during data collection phase. Table 1 below details the responses from the mine commodities.

Mining commodity	Response
Gold commodity	The researcher was initially granted verbal permission to access the OHS/ personnel tasked with implementing HCP. The manager who granted permission later retired before the written permission was issued. The newly appointed manager also granted verbal permission, however indicated that the letter would only be released at a later stage as the mine was focusing on containing the increasing number of workers who were testing positive for Covid-19, thus stricter measures implemented in all of the mine shafts. The manager further stated that a permission letter would only be issued once the board had been informed of the study. However limited number of essential departments were allowed in the mines in order to assist contain the virus, thus the board had not reviewed the request. Therefore data collection would not be feasible with the current state of the mine. Follow up emails were sent to the mine and it was reported that the situation had not improved and to wait for the lockdown to be eased to level 1. Due to time constrains the researcher with the advice from the supervisor concluded on finalising the study without data from these mines, as prediction could not be made on when the lockdown would be eased.
Diamond commodity	The response from the mine was: "after careful consideration and engagement with the mine's management your request has been regrettably not been considered". No further explanation was given.
Platinum commodity	Verbal telephonic permission given, however the researcher was informed that written permission could only be granted post covid-19 peak as the mines were focusing on containing the increasing number of workers who were testing positive for Covid-19, thus stricter measures implemented in all of the mine shafts. Also only limited number of essential departments were allowed in the mines in order to assist contain the spread of the virus. Therefore data collection would not be feasible with the current state of the mines. Follow up emails were sent to the mine and it was reported that the situation had not improved and to wait for the lockdown to be eased to level 1. Due to time constrains the researcher with the advice from the

	supervisor concluded on finalising the study without data from these mines, as prediction could not be made on when the lockdown would be eased.
Coal commodity	The company firstly reported that the application will be considered by the relevant managers. On follow up it was reported that a decision was not finalised, further information would be communicated once a decision was made. No further communication was received from this commodity, follow up emails were not responded too.
Chrome and Platinum	The response from these mines was: "Feedback from management with regard to your application is that we can unfortunately not accommodate any students for research at this time".

Table 1: Responses from the mines commodities

Ultimately, only the following stakeholders were included in the study:

1. Occupational Audiologists – these professionals were involve in the diagnosis and management of NIHL as a result of occupational exposure.
2. Compensation analysis report from Workmen's compensation scheme.

2.4.1 Occupational Audiologists

A total of 30 Occupational Audiologists participated in this study, both from the private sector and the state sector across the nine provinces in South Africa. These participants were regarded as knowledgeable in the field of NIHL as they were responsible for managing individuals with NIHL at their place of work.

2. 4.2 Compensation scheme report

A compensation analysis report from the workmen's compensation scheme was obtained. The report detailed compensation pay-outs for the past decade (2008-2018) per mining commodity (gold, diamond, coal and platinum) for each year. It further detailed compensation costs per age and gender. This compensation scheme was selected as it was responsible for managing compensation process in 80% of South African mines.

2.5 Method of data collection

In economic evaluation studies data may be collected in different forms as mentioned earlier and the current study adopted the use of questionnaire as a tool of measurement. As the aim of this study was to quantify the economic cost of NIHL, the study was thus classified as a quantitative study. Further support for classifying this study as following a positivist approach is provided by Bryman and colleagues (Ritchie & Lewis, 2003). These authors note that beliefs and practices associated with positivism usually demonstrates reliability and validity in the processes of research. As this study followed to the above mentioned practices, it would be appropriate to state that a positivist framework was followed mainly. In the development of the questionnaire, no provision was made for open-ended responses, and in this respect the study design was purely quantitative. In order to ensure improved controls of the data collection process, the study questionnaire link was emailed to the participants. This process assisted the researcher to maintain minimal interaction with the participants during data collection (Wilson, 2010). No personal face to face contact occurred with the participant during data collection. Data was collected using a structured questionnaire which was compiled in using English language. Participants were emailed the questionnaire link and were given time to complete the questionnaire at their convenient time.

2.6 Design of the questionnaire

There are various guidelines, checklists, questionnaires and standards that have been developed for conducting, reporting and reviewing economic evaluations. However, few have provided adequate focus on methods for intervention cost estimation Ridyard & Hughes,(2010) ; Chapel & Wang, (2019), and of the developed guidelines none have been developed with sufficient detail for comprehensive direct measurement techniques such as micro-costing (Ruger & Reiff, 2016). Therefore a questionnaire was developed and served as the measuring instrument for the study. The specific measurement scales that comprised the questionnaire were as follows: The aim of this study was to quantify the cost effects of NIHL in individuals exposed to excessive occupational noise. As alluded earlier, research evidence suggest that NIHL has negative effects on the economic wellbeing of individuals exposed to excessive occupational noise. A customised scale was developed for the study (see questionnaire in appendix A, and

B) (Cooper & Schindler, 2003). Simple category, multiple choice single-response, as well as multiple choice multiple-response scales were used in the final questionnaire to investigate economic cost of NIHL.

2.7 Pilot study

In order to increase the reliability of the questionnaire, a pilot study is conducted prior to data collection. A pilot study allows the researcher to test variables such as data collection methods, and the time frames of the investigation process (Van Teijlingen & Hundley, 2001). Moreover, it assist the researcher to iron out any problems before preparing the broad plan that will direct the entire research project (Polit et al., 2001). Thus revisions should be made accordingly from the pilot study so that the actual study is of better quality. Furthermore, the pilot study enables the researcher to obtain assessment of validity of questionnaire (Saunders et al., 2011). According to Cooper & Schindler, (2003) participants do not have to be statistically selected. Mugenda and Mugenda (2003); Orodho (2003) stated that a pilot study is conducted when a questionnaire is distributed to a small number of people with an intention of pre-testing the questions. Hence it should draw subjects from the target population and imitate the procedures and protocols that have been designed for data collection.

There are a number of variations on pilot testing. Some are intentionally restricted to data collection activities. One form, pre-testing, may rely on colleagues, participant surrogates, or actual participants in order to refine a measuring instrument. Pre-testing may be repeated several times to refine questions, instruments or procedures (Cooper & Schindler, 2003).

The pilot study was conducted with one participant who was first to respond to the researcher's request to participate in this study after the researcher had sent out the information letters to the possible participants. The participant was an Audiologist who met the criteria of the current study. The participant was given time to complete the study questionnaire at their convenient time. The questionnaire was in English language.

2.7.1 Findings and design alterations

The participant seemed to understand the questions and responded appropriately. No suggestions were made to the study tool. Because the current study had a small sample size, the pilot study was also included in the main study. According to Teijlingen and Hundley,

(2001, p. 3), generally, there is a common concern with the inclusion of the pilot study participants in the main study as those participants may already be exposed to an intervention and therefore may respond differently from other participants who were not included in the pilot sample. However, in some cases, "it is simply not possible to exclude these pilot-study participants because to do so would result in too small a sample in the main study". This was the case with the current study. The sample size of the participants was very limited and it became necessary that the pilot study participant be included in the main study. Also, the current study did not involve any intervention procedures or subsequent interviews.

Furthermore this study followed a single phase method with regards to pre-test of the study instrument. The questionnaire was pretested by five audiology colleagues experienced in the field of NIHL in the mining sector. These Audiologists were selected as they have been working close with the mine commodities targeted by the study, have over 5 years of experience working in the field of NIHL, are tasked with implementation and monitoring the effectiveness of HCP in these mine commodities. No major problems were detected and only minor comments in relation to the style and grammar of the questionnaire were received (Appendix A: questionnaire for Audiologists). These comments were taken into account and the questionnaire was amended accordingly.

With regards to Appendix B questionnaire for workmen's compensation scheme, the following changes were suggested:

1. A "per commodity" option had to be added, in order to simplify information given
2. A differentiation between "reported, acceptable and compensable" claims needed to be explained more clearly
3. A " per year, per commodity" option needed to be added to simplify the data given

These aspects were addressed and the final questionnaire amended accordingly (refer to Appendix A and B for an example of the final questionnaire). The actual data for this study was collected, using this questionnaire, during the period of October 2019 to July 2020.

2.8 Data collection procedures

Data for the study was collected using a questionnaire as a tool. The questionnaire link was emailed to the identified research participants as they are described above. Below is the procedure on how data was collected for each of the participants:

2.8.1 Occupational audiologists

The distribution of self-administered questionnaire to the Occupational Audiologists was conducted to estimate the direct health care cost incurred through investigation, management of NIHL. Occupational Audiologists who diagnosed and managed individuals with NIHL from the mining sector across all nine provinces of South Africa where invited to participate in the study. Upon obtaining Ethics clearance from the University of Witwatersrand ethics board protocol number H19/05/26. The researcher conducted a desktop search to identify Audiologists practicing in the occupational audiology field. Potential participants were emailed in order to requesting them to participate in the study, these potential participants were further requested to refer fellow colleagues in the field. The researcher further requested assistance from National Speech and Audiology forum colleagues in audiology to circulate study email in order to recruit participants. The link to the study questionnaire, study information letter and request to participants were included on the email (Appendix A). Occupational Audiologists who were willing to participate in the study did so by completing an online questionnaire anonymously and at their convenience. The participants were required to complete and send the questionnaire online. Information such as the participants email addresses and identification information were not collected to ensure and protect participants' identity. The questionnaire allowed for participants to omit questions which they did not want/ feel comfortable to answer. Finally, the link sent to the participant only allowed the participants to complete the questionnaire once to avoid duplication. Once the participants completed the questionnaire, the researcher collected the responses into a comma-separated values file (CSV) format for statistical analysis.

2.8.2 Report from Workmen's compensation scheme

The distribution of self-administered questionnaire to the workmen's compensation scheme representative was conducted to determine the compensation pay-outs, in relation to cost to the worker's and residual employment time frame. This compensation scheme was selected as it was responsible for compensation claims in 80% of the South African mines. The researcher contacted the compensation manager of the company to request permission for the study. An appointment was made for the researcher to meet with the manager. During the meeting the

researcher explained the purpose of the study, the required data, data collection tool and process. Once permission was granted for the study, the researcher emailed the study questionnaire which sought to gather data on the number of reported cases of NIHL from each mining commodity in the last decade (2008- 2018) and compensation costs for NIHL per mining commodity. The compensation scheme was given time to gather the required information and the report was formulated and provided in an excel sheet.

2.9 Method of analysis and statistical techniques

The focus of any analysis note that it takes one of three basic forms, namely, description, estimation and hypothesis-testing (Diamantopoulos & Schlegelmilch, 2000). The current study followed a descriptive focus. The aim of the descriptive focus, is to paint a summary picture of the sample (or population) in terms of the variables of interest. There are a number of statistical techniques that can be used to undertake descriptive analysis and these are referred to as descriptive statistics (Diamantopoulos & Schlegelmilch, 2000). The starting point in a descriptive analysis is the construction of a frequency distribution for each variable of interest. This indicates in absolute or relative (that is, percentage) terms how often the different values of the variable are actually encountered in the sample (Diamantopoulos & Schlegelmilch, 2000).

During the analysis of the study, the responses from the online questionnaire were converted into a CSV format in preparation for analysis. The CSV report together with the excel report from the workmen's compensation scheme were given to the independent statistician. The data was analysed electronically using the Statistical Analysis Software (SAS) package (Version 8.2). Results were presented in the form of graphs and tables by the statistician.work

2.10 Validity and reliability of data

The need to ensure validity and reliability in research affects all aspects of the research design. Various strategies were used in this study to ensure that the conclusions were warranted by the data.

To ascertain the validity of the study questionnaire, the researcher utilised theoretical contrast content validity. Content validity pertains to the degree to which the instrument fully assesses

or measures the construct of interest (Polit & Beck 2006; Sangoseni & Hellman, 2013). The development of a content valid instrument is typically achieved by a rational analysis of the instrument by raters (experts) familiar with the construct of interest or experts on the research subject (Polit & Beck 2006; Sangoseni & Hellman, 2013). The questionnaires were appropriately pre-tested as reported in the pilot study section. Removing bias from a study ensured validity. The use of a link to send the questionnaire to the participants ensured independence. As mentioned earlier, the questions initially did not have a "please specify" option but the Audiologists colleagues experienced in the field of NIHL in the mining sector recommended the inclusion of this option to enable a comprehensive and correct completion of the questionnaire. The researcher used closed ended questions to ensure that most questions were completed comprehensively and correctly. In addition the use of a link ensured the elimination of any sampling bias in the sample selection.

Reliability is an extent to which a questionnaire, test, observation or any measurement procedure produces the same results on repeated trials (Bolarinwa, 2015). It is the degree to which an individual's responses (their scores) on a survey would stay the same over time (Bolarinwa, 2015). In short, it is the stability or consistency of scores over time or across raters (Bolarinwa, 2015; Kimberlin & Winterstein, 2008).The study adopted the Inter-rater reliability, where the researcher compared how the participants responded to the same question. The participants were able to respond to the questions in the same manner thus assuring reliability of the study tool.

2.11 Ethical Considerations

The current study involved people as participants. A study that involves human and animal subjects needs to take into account ethical implications. The core purpose of ethics in research is to ensure that no one is harmed or suffers adverse consequences from research activities (Cooper & Schindler, 2003). It is vital to respect people, in particular their rights, as well as details of their lives (Pickard, 2007). This current study adhered to the Helsinki Declaration of 1975 as revised in 2008 (World Medical Association, 2008). Brief discussion on the due care taken in the present study is presented below:

- Permission to carry out the study was obtained from the University of the Witwatersrand non-medical research Ethics committee, protocol number: H1905/26.

The said committee scrutinised the instruments to ensure that all the questions adhered to ethical issues for human research and are not offensive.

- Permission to carry out the study was also obtained from the prospective mining companies and Audiologists in South Africa.
- Protection from harm- A questionnaire link was emailed to the participants to complete the questionnaire at their convenient time at work (familiar and safe environment).

Participants' information document contained the following information:

- This letter was drafted on a letterhead which included the name and address of the department (Speech therapy and Audiology) and the institution (University of the Witwatersrand).
- The letter stated the name of the researcher, the title of the study and the purpose of the study.
- It was noted that the study was conducted to investigate economic cost of NIHL in individuals exposed to excessive occupational noise in the South African mining sector in order to contribute towards the prevention and management of NIHL strategies. It was emphasised that the researcher was only interested in understanding the costs incurred during investigation and management of NIHL.
- The letter also stated the estimated time it would take to complete the questionnaire.
- Risks and discomforts (if applicable) - This aspect was not applicable to this study as the participants completed the questionnaire in their own place of work.
- Benefits- As noted above that the study would be of value to strategic planning of management of NIHL. It will also assist in translating the adverse effects of NIHL into monetary terms, the universal language of decision makers.
- Participants' rights- It was stressed that participation in the study was voluntary.
- Confidentiality - It was stated that the questionnaire was anonymous, confidential and that the participants' identity was not required. The study data would be stored in a password encrypt Google drive in which only the researcher would have access. This addressed the need to ensure the right of privacy and confidentiality, and the right of participants to withdraw at any stage.

CHAPTER 3: RESULTS

This chapter entails the findings of the study based on the data collected from the field. The study sought to investigate the economic cost of NIHL in individuals exposed to excessive occupational noise within the South African mining sector: practitioner's perspective. The study targeted Occupational Audiologists who assessed and managed individuals with NIHL and workmen's compensation report. The data was analysed and presented in form of pie charts, bar graphs and tables. The results will be presented according to the objectives of the study and per general findings which were observed from the data collected.

3.1 To determine the direct costs of investigation of NIHL

In this section the study sought to establish direct costs of health care treatment for NIHL and further determine who (employer, individual or state) was liable for the service rendered. To calculate the costs incurred, the analysis made used of the average cost of audiology evaluation session and the average number of sessions needed for diagnosis (information derived from the Audiologists responses and compensation report provided by the workmen's compensation scheme). Supporting tables and figures are provided.

3.1.1 Payment of service rendered

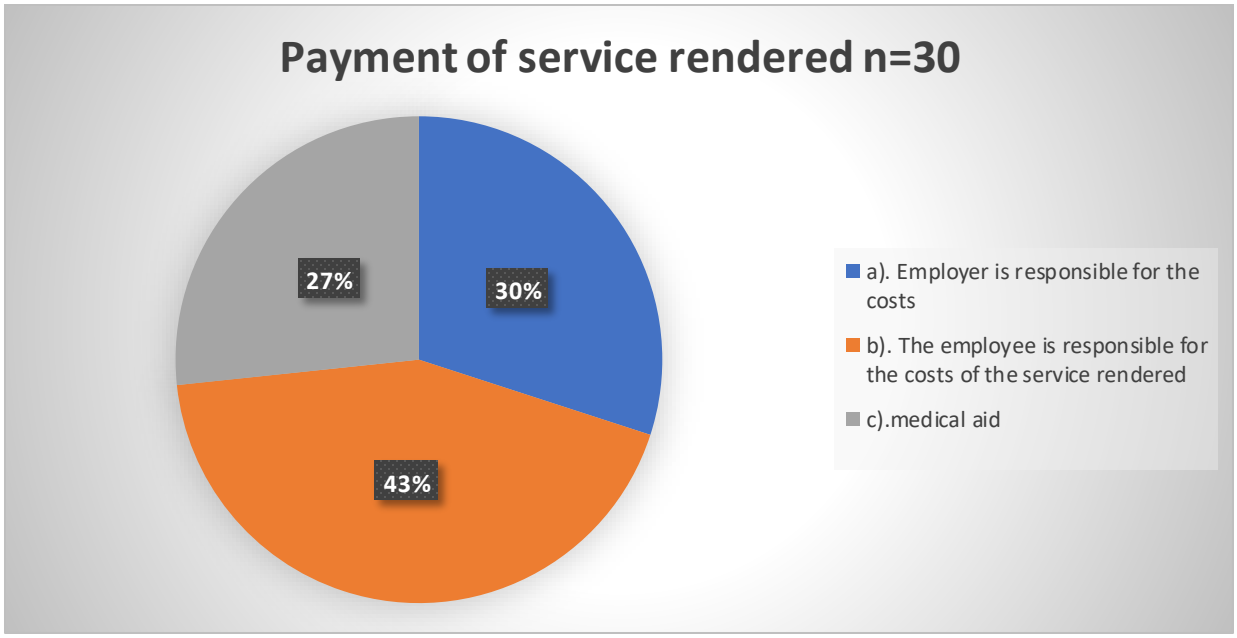

Figure 4: Payment of service rendered

Participants were asked to state who was responsible for consultation costs. The results (Figure 4) revealed n=13 (43%) of the participants indicated that the employee/individual was responsible for the costs of services rendered, n= 9 (30%) indicated that the employer covered the costs, a further n= 8 (27%) indicated that the medical scheme covered the costs. According to the analysis, it indicated that individuals with NIHL were mostly responsible for the costs of the services rendered.

3.1.2 Number of audiological investigation

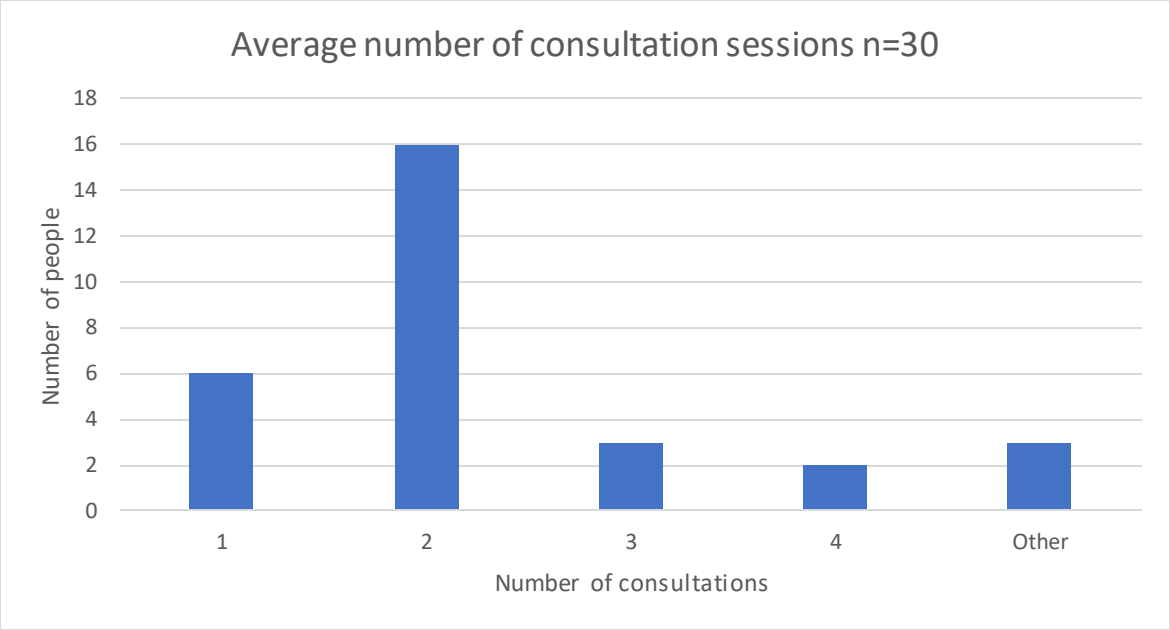

Figure 5: Number of audiological investigations

In order to estimate the average cost of investigation, the audiologists were asked to state the average number of sessions required for diagnosis purposes. There were variations with the average number of investigation session required for NIHL, with a majority of participants n= 16 (64%) indicating that 2 sessions were required for investigation purpose, This was followed by n=6 (10%) participants indication that only 1 session was required, further n= 3 (10%) of the participants indicated that 3 sessions were required and the other responses (varying from 2 sessions with an Audiologist and 1 session with the doctor, 1 session with the Audiologist and 1 session with the ENT, 2 diagnostic sessions and 1 re-test session to confirm results) as listed above in figure 5.

3.1.3 Cost of diagnostic test

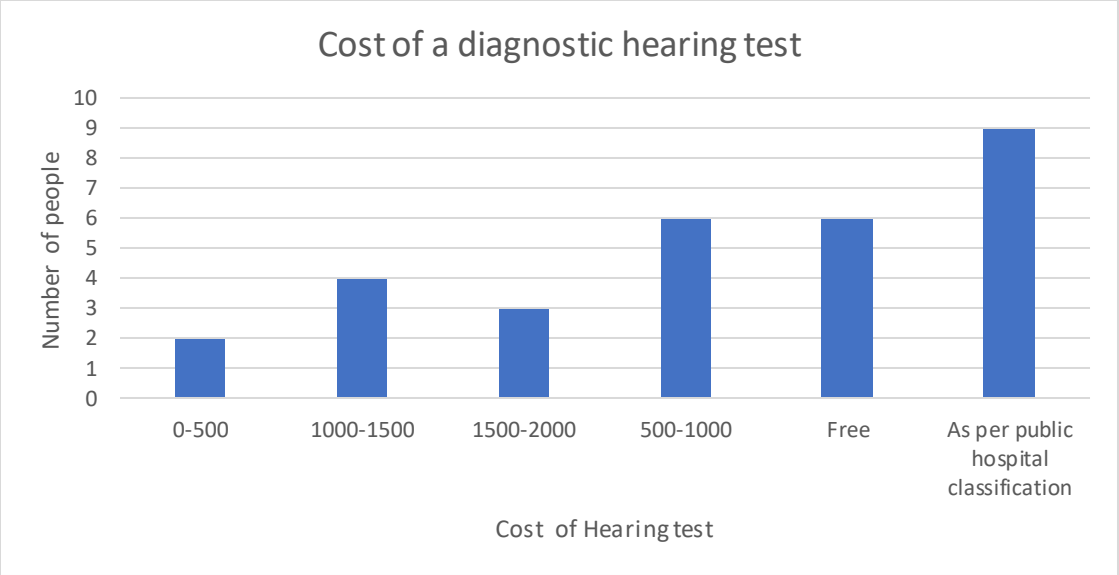

Figure 6: Cost of diagnostic test

This question aimed to determine the cost of assessment in order to estimate costs incurred during investigation of NIHL. There were significant variations in cost of audiological assessment based on the participants' place of work. Majority of the participants n= 9 (27%) of the participants reported that individuals were billed as per public hospital billing system based on their income/affordability, followed by n=6(18%) cost between R500- R1000 per session, followed by n=4 (12%) cost between R1000-R1500 and the rest of responses (ranging from less than R500 per assessment, free assessment and R1500-2000 per assessment) as listed in figure 6 above.

3.1 To determine the direct cost of management of NIHL

In this section the study sought to establish direct cost of management of NIHL and further determine who (employer, individual or state) was liable for the service rendered. . To calculate the costs incurred, the analysis made used of the average cost of hearing aids, average cost of aural rehabilitation therapy and the average number of sessions needed for aural rehabilitation therapy (information derived from the Audiologists responses and compensation report provided by the workmen's compensation scheme). Supporting tables and figures are provided.

3.1.1 Fitting of hearing aids

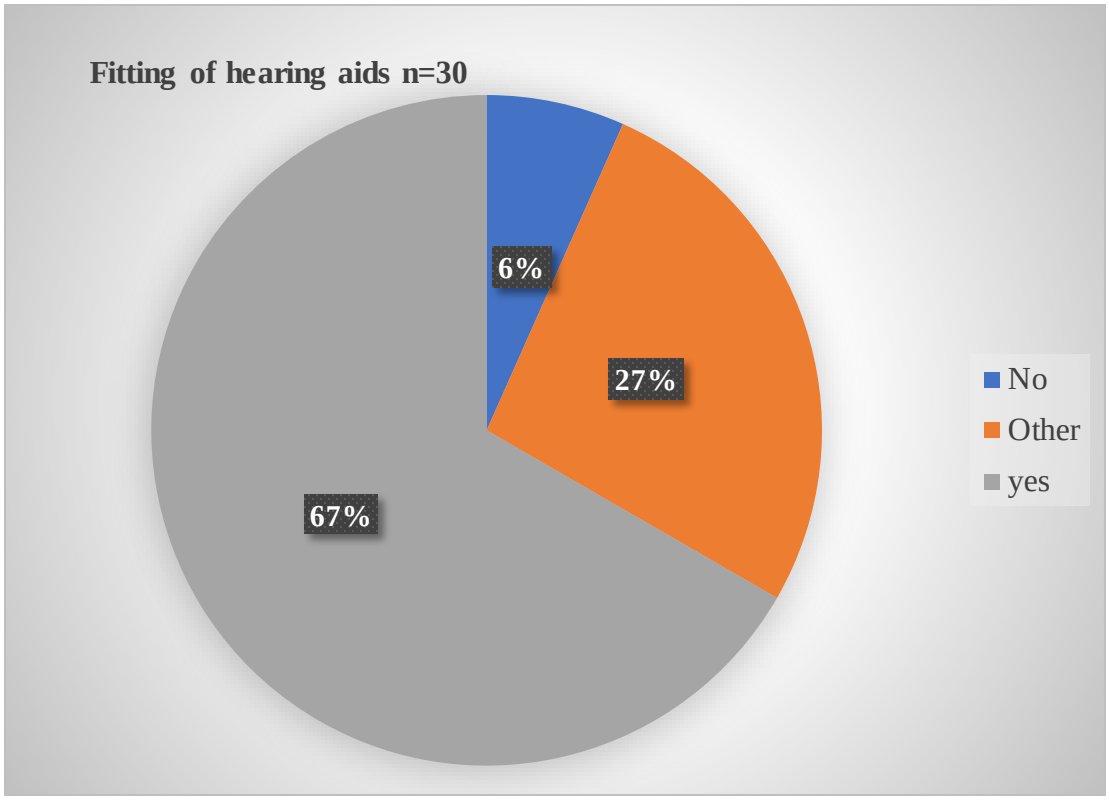

Figure 7: Fitting of hearing aids

This question sought to determine whether individuals diagnosed with NIHL were fitted with hearing aids post diagnosis. Majority of participants n= 20 (67%) indicated that individuals diagnosed with NIHL were fitted with hearing aids post diagnosis, while n=2(6%) indicated that individuals were not fitted with hearing aids and n=8(27%) indicated that hearing aid fitting depended on the availability of funds and clinical presentation of these individuals.

3.2.2 Cost of Hearing aids

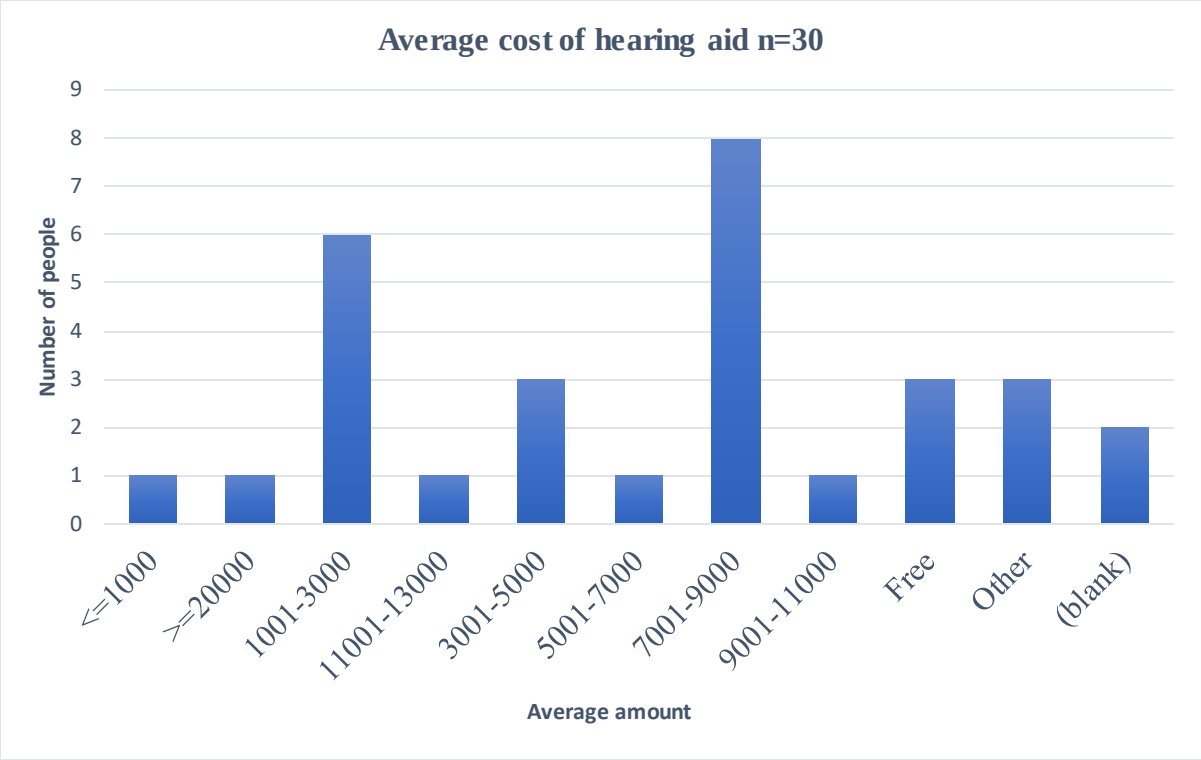

Figure 8: Cost of hearing aids

Audiologists were asked to state the average cost of a hearing aid in order to estimate costs incurred during treatment of NIHL. There were significant variations regarding the cost of a hearing aid based on the participants' place of work. Majority of the participants n= 8 (23%) charging between R7000- R9000 per hearing aid, followed by n=6 (16%) which stated that the costs were between R1000- R3000 per hearing aid and the other responses (hearing aids were free of charge, less than R1000 per hearing aid, R2000 per hearing aid, R3000-R5000 per hearing aid, R5000-R7000 per hearing aid and over R9000 per hearing aid) as listed in figure 8 above.

3.2.3 Aural Rehabilitation

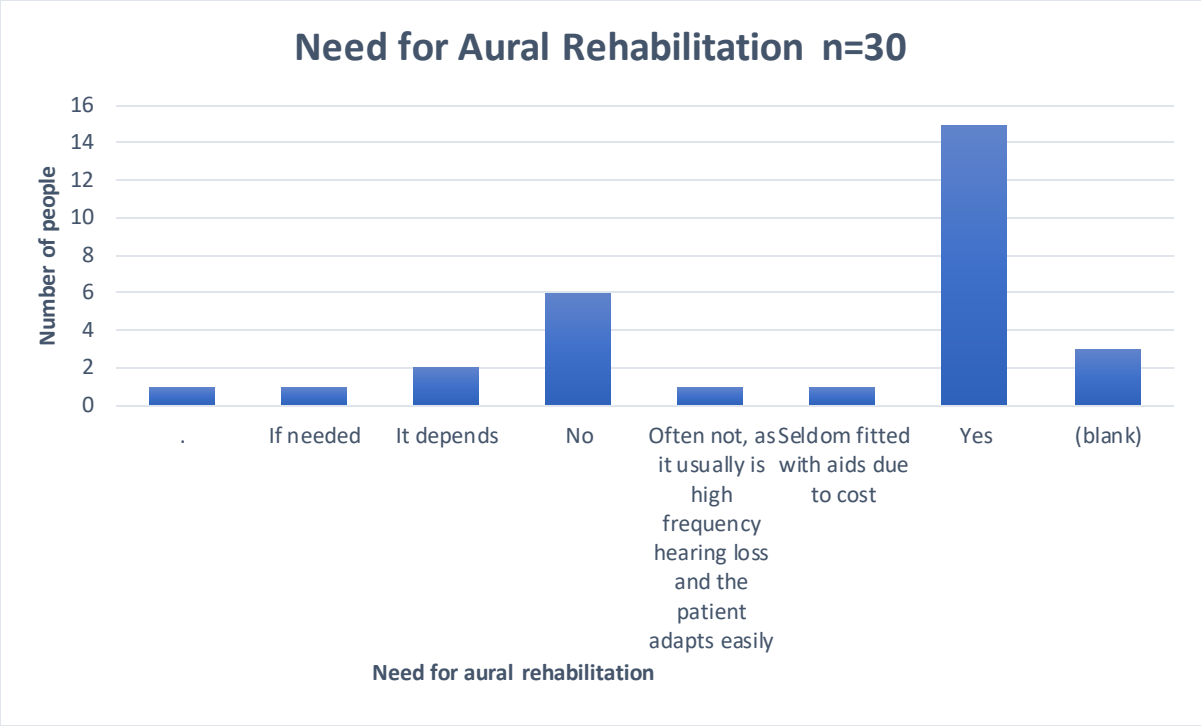

Figure 9: Aural Rehabilitation

Participants were asked to indicate whether individuals diagnosed with NIHL required aural rehabilitation therapy post diagnosis. N15= (50%) of the participants indicated that yes, there was a need, while n=6 (21%) indicated that there was no need and the remaining participants n=9 (30%) indicated that the need was determine by availability of funds, communication difficulties and availability as seen above in figure 9.

3.2.4 Number of Aural rehabilitation therapy

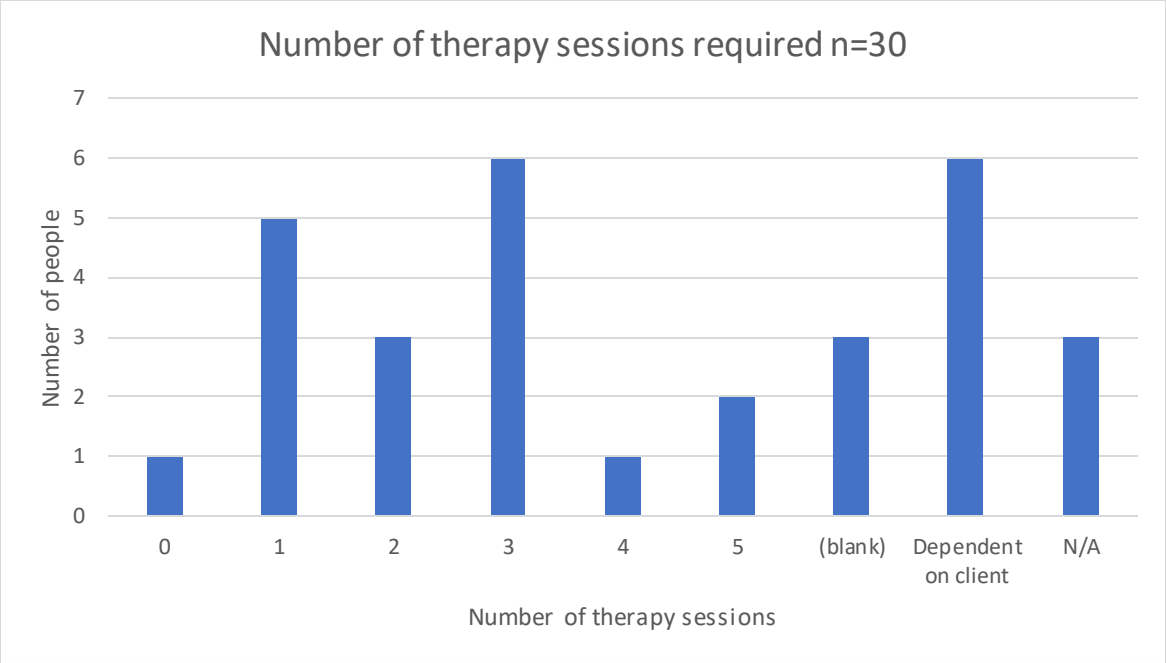

Figure 10: Number of Aural Rehabilitation sessions

In order to estimate the average cost of rehabilitation, the participants were asked to indicate the average number of aural rehabilitation sessions needed. Similar to investigation sessions, there were differences with the average number of aural rehabilitation sessions required for individuals diagnosed with NIHL, at least n=5 (16%) indicated that 3 sessions were required, n=3(14%) reported no need for therapy, a majority of participants n=21 (67%) of the participants indicated that the number of therapy sessions were determine and influenced by various aspects such as: progress in therapy, individual's needs for therapy, availability of funds and time as illustrated above in figure 10.

3.2.5 Cost of Aural rehabilitation therapy

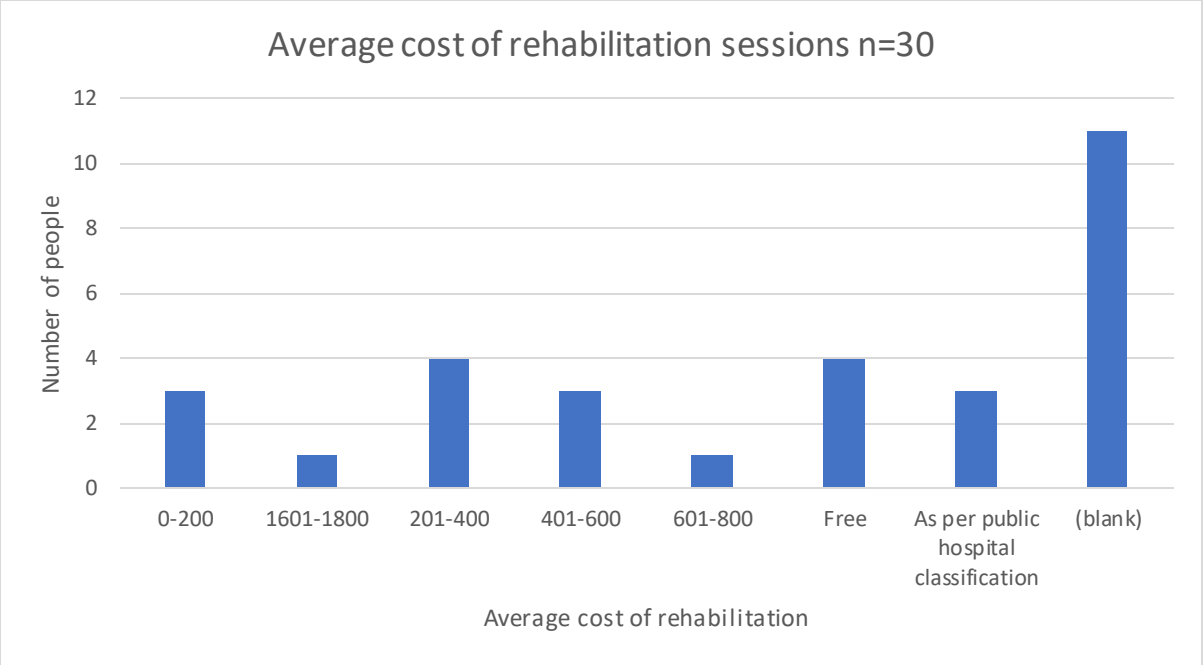

Figure 11: Cost of Aural Rehabilitation

The participants were requested to state the average cost of Aural Rehabilitation in order to estimate costs incurred during management of NIHL. There were variations in costs of aural rehabilitation based on the participants' place of work as seen in figure 11 above. N=4 (13%) of the participants indicated that individuals did not pay for aural rehabilitation, further n=4 (13%) indicated the cost were between R200-R400, an additional n=3 (10%) indicated that the cost were between R400-R600 and the other responses n=8(26%) (Ranging from less than R200 per session, R600-800, above R8000) as listed in figure 11 above.

3.3 To determine the compensation paid out for NIHL

This section of the study sought to determine compensation paid-out for NIHL in the four common mining commodities mentioned earlier, further evaluate compensation per mining commodity, per year and age group in the period of 2008-2018. The analysis took into consideration the number of reported claims for compensation, claims acceptable for compensation and claims which were compensated. It further evaluated the compensation costs per commodity.

3.3.1 Acceptable versus reported claims in the mining sector

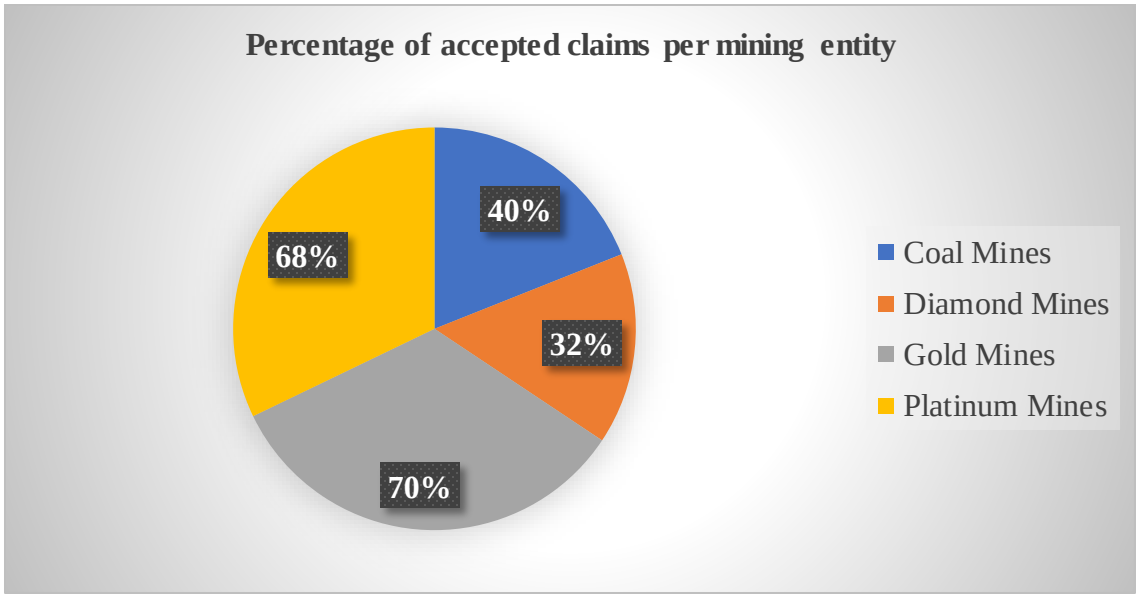

Figure 12: Acceptable versus reported claims

This question aimed to determine the number of claims which were acceptable for compensation from the reported claims in the period of 2008 – 2018. During the period of 2008-2018 the scheme received n=11993 claims from the mining sector as a whole and n= 7860 (66%) of those reported claims were acceptable for compensation. Figure 12 illustrate the distribution of the claims per mining commodity. The most claims were reported from gold mines n=6593 and n=4803(70%) were acceptable for compensation, followed by platinum mines with n= 3343 reported claims and n=2232(68%) were acceptable for compensation, thirdly was coal mines with reported claims of n= 1964 and n=796(40%) were accepted for

compensation. The least mines with reported and acceptable claims were from diamond mines, reported claims at n= 93 and accepted being n=29 (32%).

3.3.2 Accepted claims versus reported claims per year

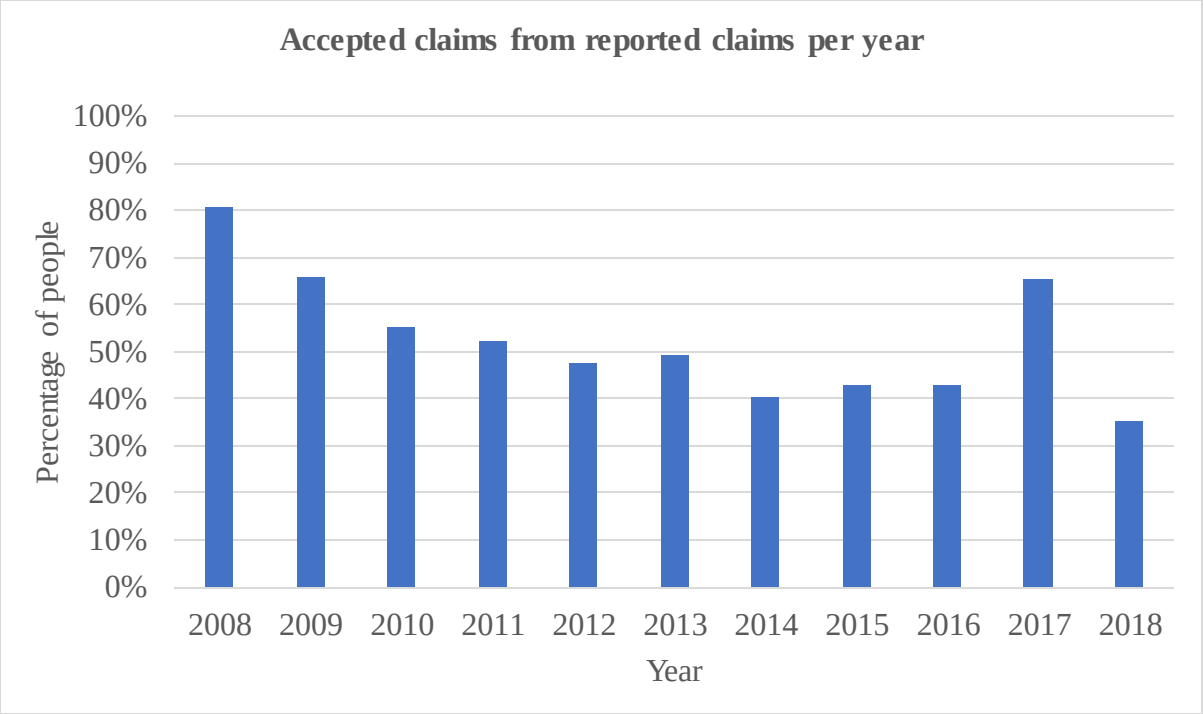

Figure 13: Acceptable versus reported claims in the mining sector

The study sought to determine how many claims were reported for compensation versus the number of claims who were acceptable for compensation in the period concerned in the mining commodities mentioned earlier. Figure 13 illustrates the number of claims which were reported to the scheme and the number of claims which were acceptable for compensation in the period of 2008-2018 across the mining sector. In 2008 there were n= 1445 reported claims and n= 1156 (80%) were acceptable for compensation, this was the year with the highest number of reported claims and acceptable claims for compensation for the period discussed. It is of note that year 2018 was a year were the least claims were reported n= 762 and only n=267(35%) acceptable claims and the rest of the years as displayed above in figure 13.

3.3.3 Acceptable versus reported claims per mining commodity per year

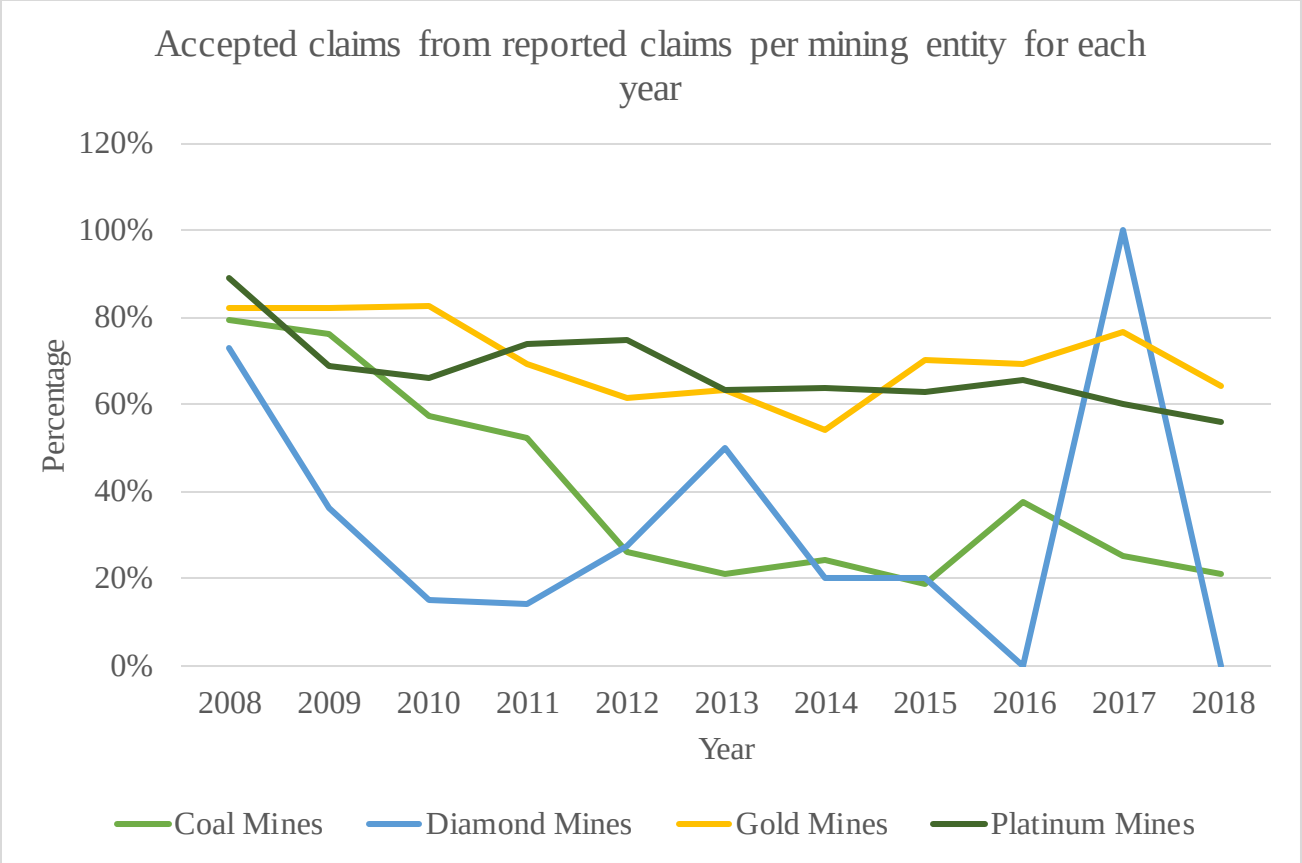

Figure 14: Acceptable versus reported claims per mining commodity per year

This question aimed to determine the number of claims which were reported versus the number of claims which were acceptable for compensation per mining commodity per year in the period of 2008-2018. Figure 14 displays the number of claims which were reported to the scheme and the number of claims which were accepted by the scheme for compensation per respective commodity per year. As observed in figure 12 above, gold mines had the highest number of reported claims per year and the highest acceptable claims when compared to counterpart mines across the decade. In 2008 gold mines reported the most claims at n=1065 and n=873(82%) were acceptable for compensation by the scheme. In 2018, this was a year with the least reported and accepted claims across all commodities. Gold commodity in 2018 reported n=289 and acceptable claims were n=185(64%). The mines which reported the least claims across the decade were diamond mines with the highest reported claims at n=11 and of the reported only n= 8 (73%) were accepted in 2008. In 2018 diamond mines reported n= 5 and none of the reported claims were accepted for compensation. The rest of the commodities and respective years are displayed in figure 14.

3.3.4 Total number of acceptable claims paid by the scheme

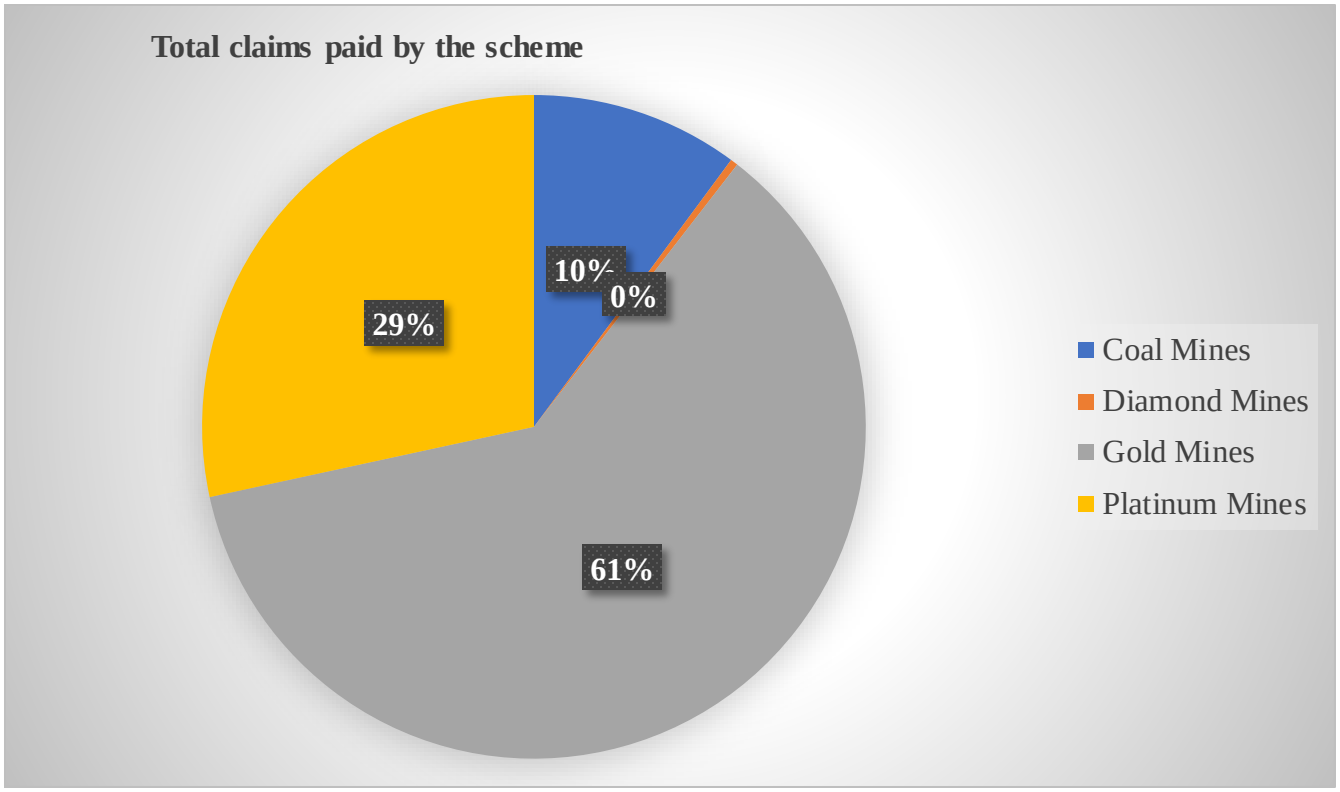

Figure 15: Total number of acceptable claims

The aim of this question was to determine which commodity incurred the most costs in compensation of NIHL. Figure 15 demonstrates the distribution of claims paid across the mining commodities over the period of 2008-2018. With reference to figure 15 above, n=7199 of the claims were paid by the scheme for compensation of NIHL in the mining sector. The highest claims paid by the scheme were from gold mines n= 4823 (61%), followed by platinum at n= (29%), thirdly were from coal mines n=643 (10%) and lastly acceptable paid claims were from diamond mines n=22(less that 1%).

3.3.5. Total number of claims paid per commodity per year

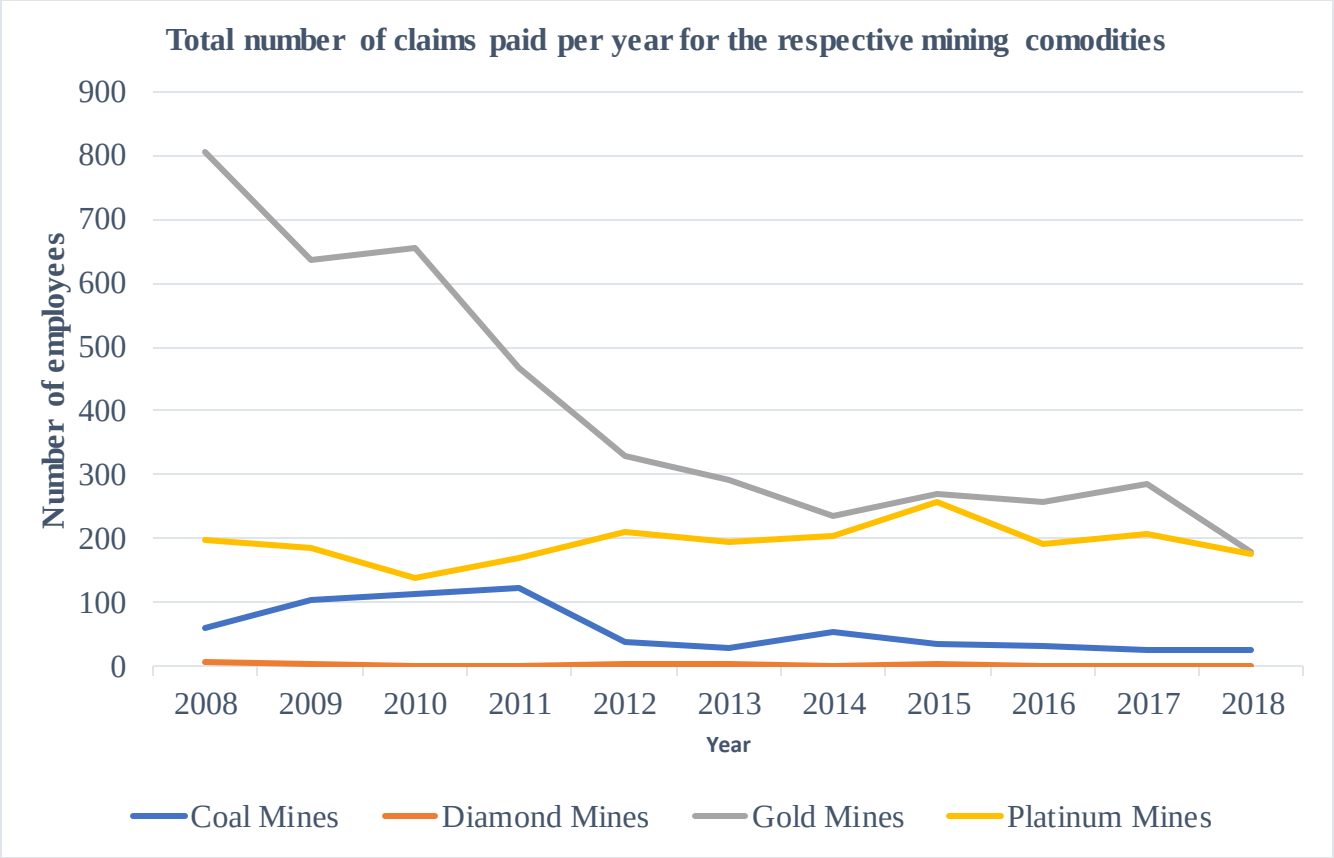

Figure 16: Total number of claims paid per commodity per year

This question analysed costs incurred on claims for NIHL by each respective mine commodity per year. With reference to figure 16 above, the highest claims compensated were from gold mine. In 2008 was the year with the highest claims, there were n=804 claims paid by gold mines. Platinum mines was the second commodity with the highest claims, having compensated n>300 in each year. In third place was coal mines with n>100 compensated claims per year. The least compensated claims were from diamond mines having paid less than 10 claims per year across the decade as displayed above.

3.3.6 Total cost of compensation per mining commodity

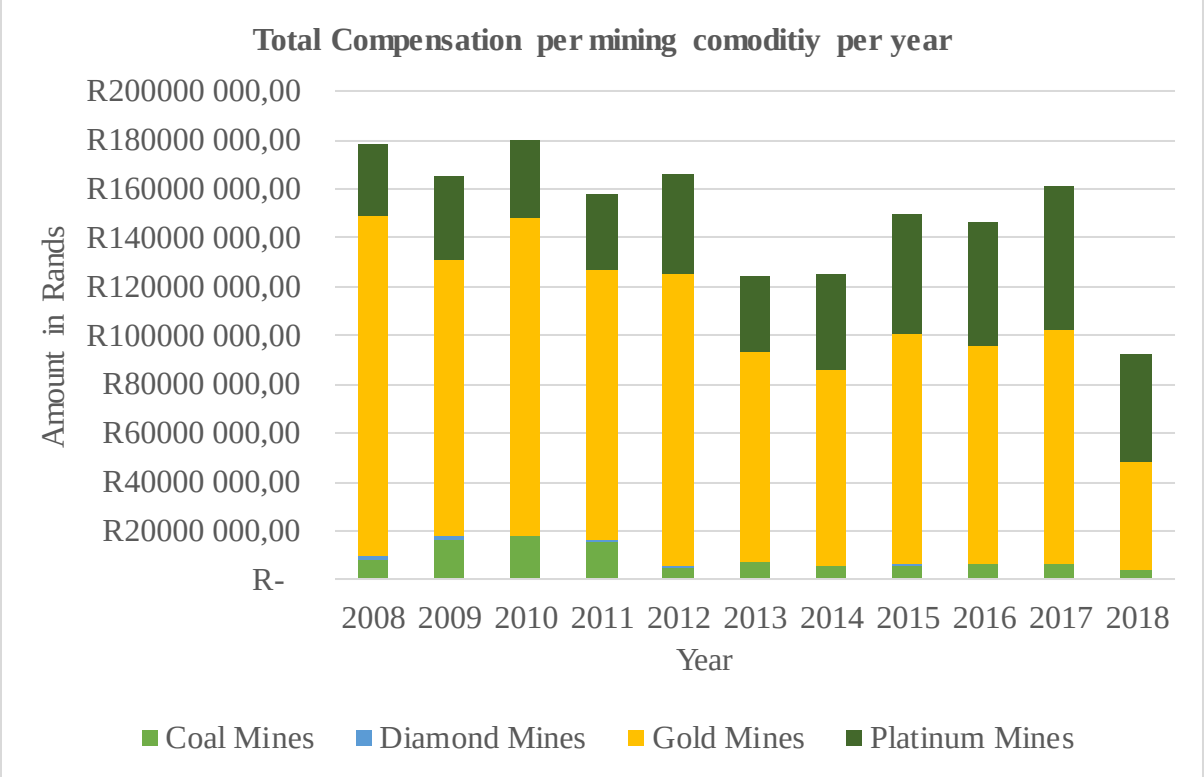

Figure 17: Cost of compensation per mine commodity per year

In this question the study sought to determine the amount paid-out on claims to compensate NIHL per mining commodity per year. As demonstrated above in figure 17, the highest compensation costs were from platinum mines, at no less than R60 000 000 yearly and having paid R180 000 000 in 2010 and was the year with the highest compensation costs. Gold mines followed at no less that R60 000 000.00 yearly and having paid-out over R120 000 000.00 in other years. In third place was the coal commodity, having paid less than R20 000 000 yearly, across the decade. The least compensated claims were from diamond mines, majority of the years having paid no claims for compensation and the years where there were claims paid, having paid just under R20 000 000.00 on compensation as illustrated on figure 17 above.

3.4 Direct costs incurred in the different mining commodities

In this section the study analysed and estimated the direct costs incurred by the mining sector during the period of 2008-2018, the costs will be presented in the form of direct cost during investigation, direct costs during management of NIHL. These costs will further be analysed per respective commodity per year.

3.4.1 Direct costs incurred during investigation

In this section the study sought to estimate direct costs incurred during investigation of NIHL. Direct investigation costs for this study were the cost of diagnostic hearing test and the number of session/s required for diagnosis (information derived from the Audiologists responses). To calculate the estimated costs incurred, the analysis took into account the average cost of diagnostic hearing test and the number of accepted claims per mining commodity (information derived from the compensation report provided by the workmen's compensation scheme). Direct cost of investigation will be discussed for the mining sector as a whole, per commodity and per age group.

3.4.1.1 Total direct costs of investigation in the mining sector

Figure 18: Direct costs of investigation per mining commodity.

In order to estimate costs incurred during investigation of NIHL in the period of 2008-2018, in the mining sector, the average cost of investigation and the number of accepted claims per mining commodity were used to derive the costs (Figure 18). In the period discussed in the study, the most costs of investigation were incurred in gold mines at just above R6 000 000, 00, followed by platinum mines at just under R3 000 000, 00, coal at under 1 000 000, 00 and with diamond mines being the least that incurred investigation costs, as demonstrated above in figure 18.

3.4.1.2 Direct costs of investigation per mining commodity per year over a 10 year period (2008-2018)

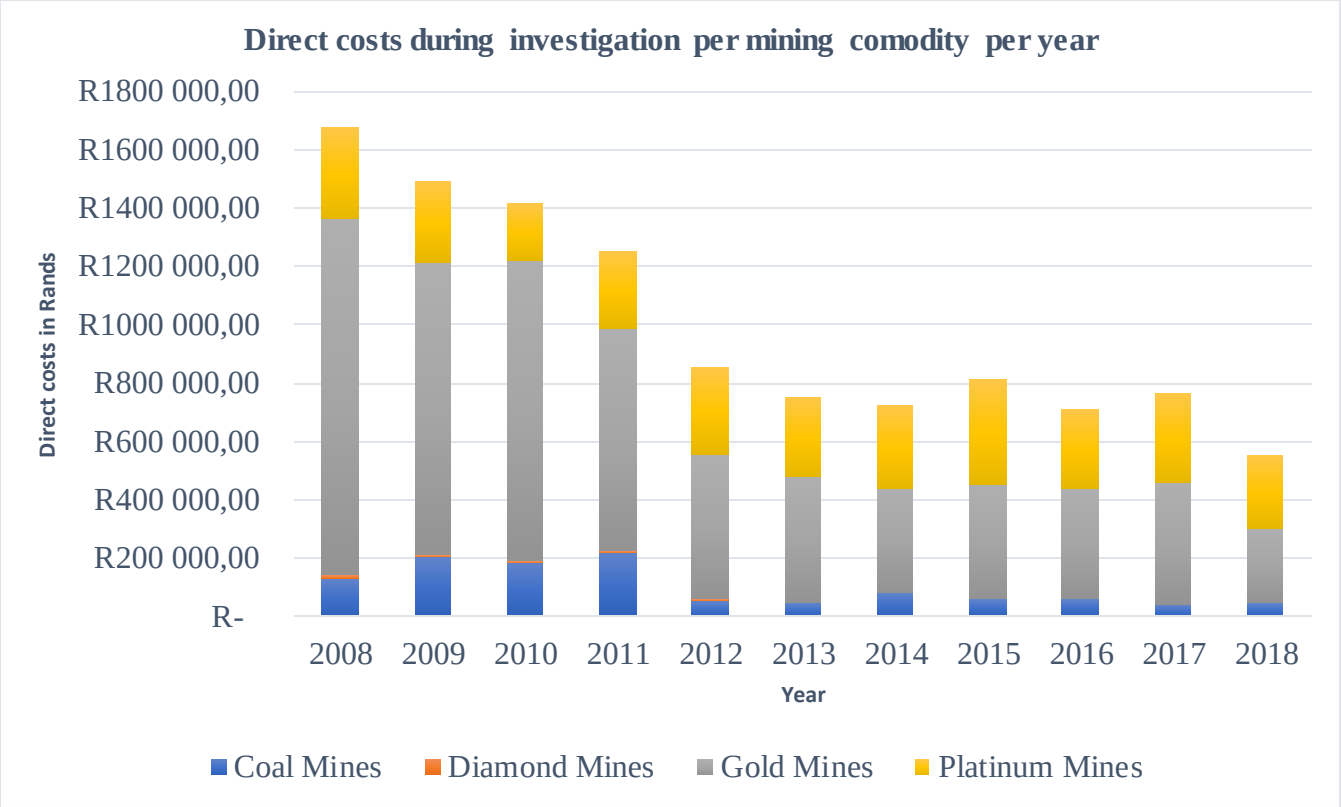

Figure 19: Cost of investigation per mining commodity

This question was aimed to estimate average investigation costs incurred by each mining commodity per year amongst the 4 mining commodities discussed in the current study in the period of 2008-2018. In order to estimate these costs the study analysis made used of the average cost of investigation (derived from figure 6) and the number of all accepted claims for compensation , in each commodity per year (as per report from workmen's scheme). Diamond mines and coal mines incurred the least costs on investigation having incurred less than R200 000, 00 across the decade, followed by gold mines fluctuating between the regions of R200, 000, 00 and R1.3 million across the decade and platinum mines being the one commodity which incurred the highest costs on investigations across the decade, 2008 was the year with the highest costs at over R1.6 million.

3.4.1.3 Costs incurred per age group

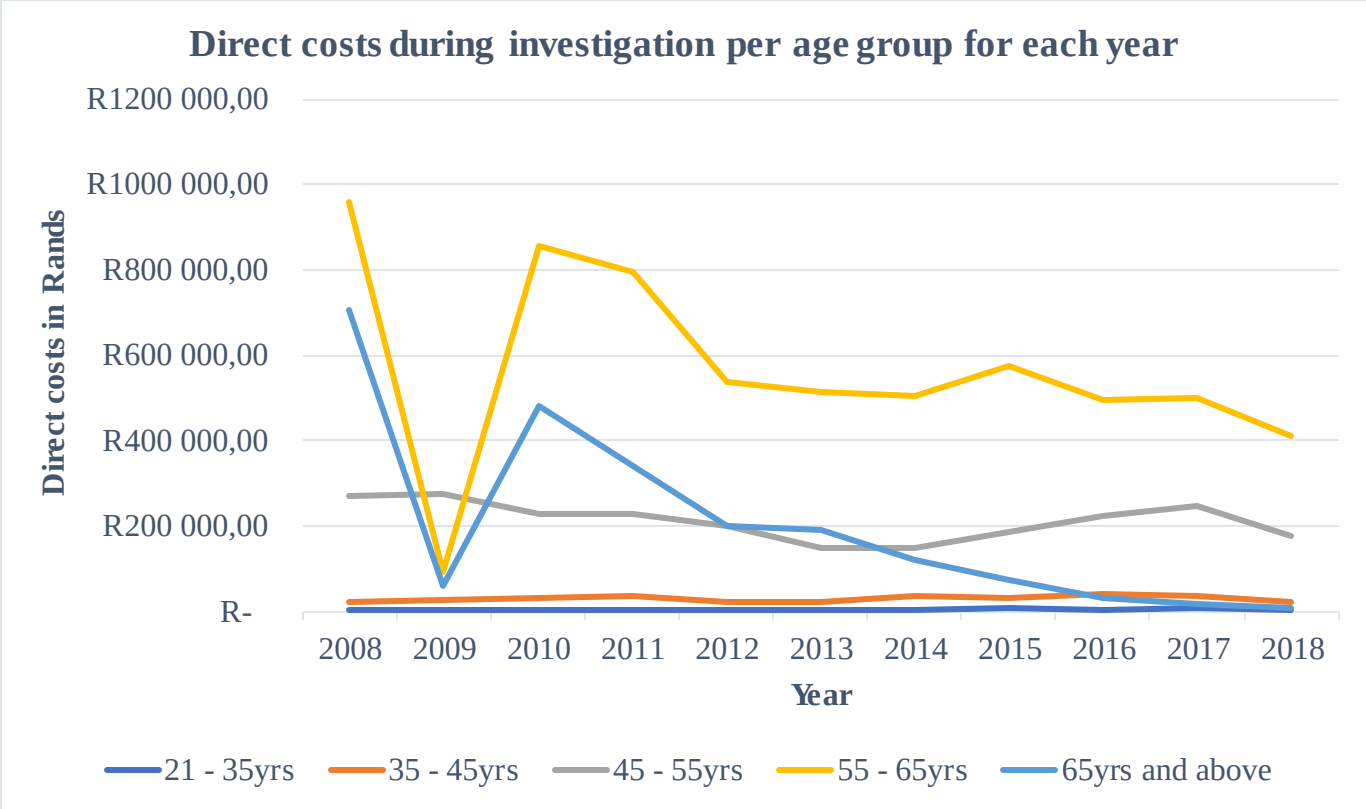

Figure 20: Direct costs incurred per age group

In order to determine which age group incurred the most costs on investigation, the study analysis took into account the number of accepted claims for compensation, per age (as per works- men scheme report) and the estimated investigation cost (in figure 6). The age group with the least investigation costs was the 35-45 age group at less than R200 000, 00, followed by the 45-55 age group in the region of R200 000, 00 to R400 000, 00. The age group 21-35 was in the region of R200 000, 00 to R800 000, 00. Lastly the age group that incurred the most investigation costs was the 55-65 age group in the region of R200 000, 00 to R 10000 000, 00.

3.4.2 Direct costs incurred during management of NIHL

This section of the study investigated the direct costs incurred during management for NIHL. For the purpose of study, direct management costs were considered to be the cost of hearing aids and aural rehabilitation therapy (as in figure 8 and 11). To calculate the costs incurred, the analysis made used of the average cost of hearing aids, cost of aural rehabilitation therapy, the average number of therapy sessions and the number of compensated individuals per mining

commodity (information derived from the compensation report provided by the workmen's compensation scheme). The direct costs incurred during management f NIHL will be discussed as per mining sector, per commodity and per age group. These costs are based on the compensation data of 2008-2018 period.

3.4.2.1 Direct costs incurred during management

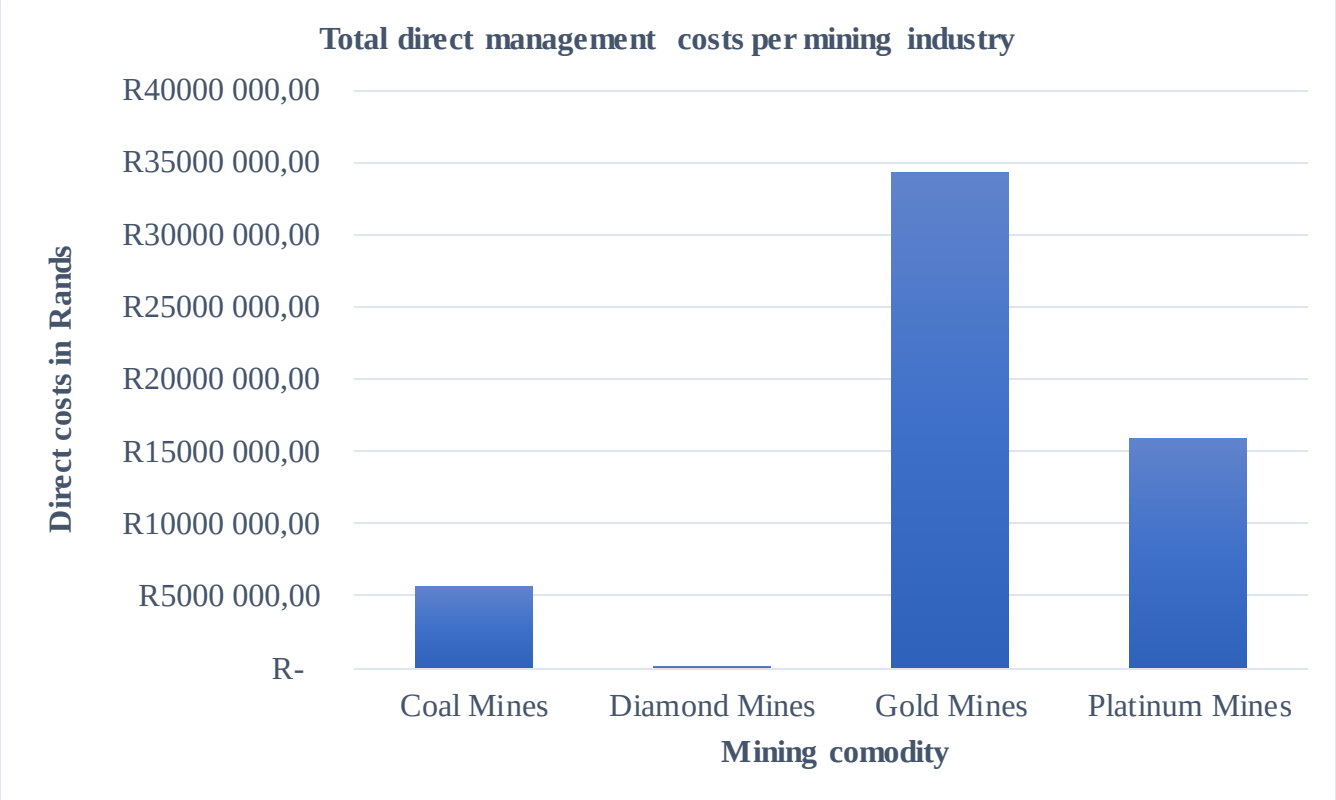

Figure 21: Direct costs incurred through management

The average costs spent on management of NIHL were calculated using the average costs of management as derived in figure 8 and 11 and the number of compensated individuals per mining sector. In the period of (2008- 2018) gold mines incurred the most costs on management at just under R35 000 000, 00 (35 million), followed by platinum mines at R16 000 000, 00 (16 million), coal mines at R6 000 000, 00(6 million) and with diamond mines being the least that incurred management costs, at 1million, figure 21. This pattern of costs was observed earlier on, on costs incurred during investigation, where gold mines incurred the most costs due to the number of claims received from this commodity as compared to the rest of the sector.

3.4.2.2 Direct management costs per mine commodity

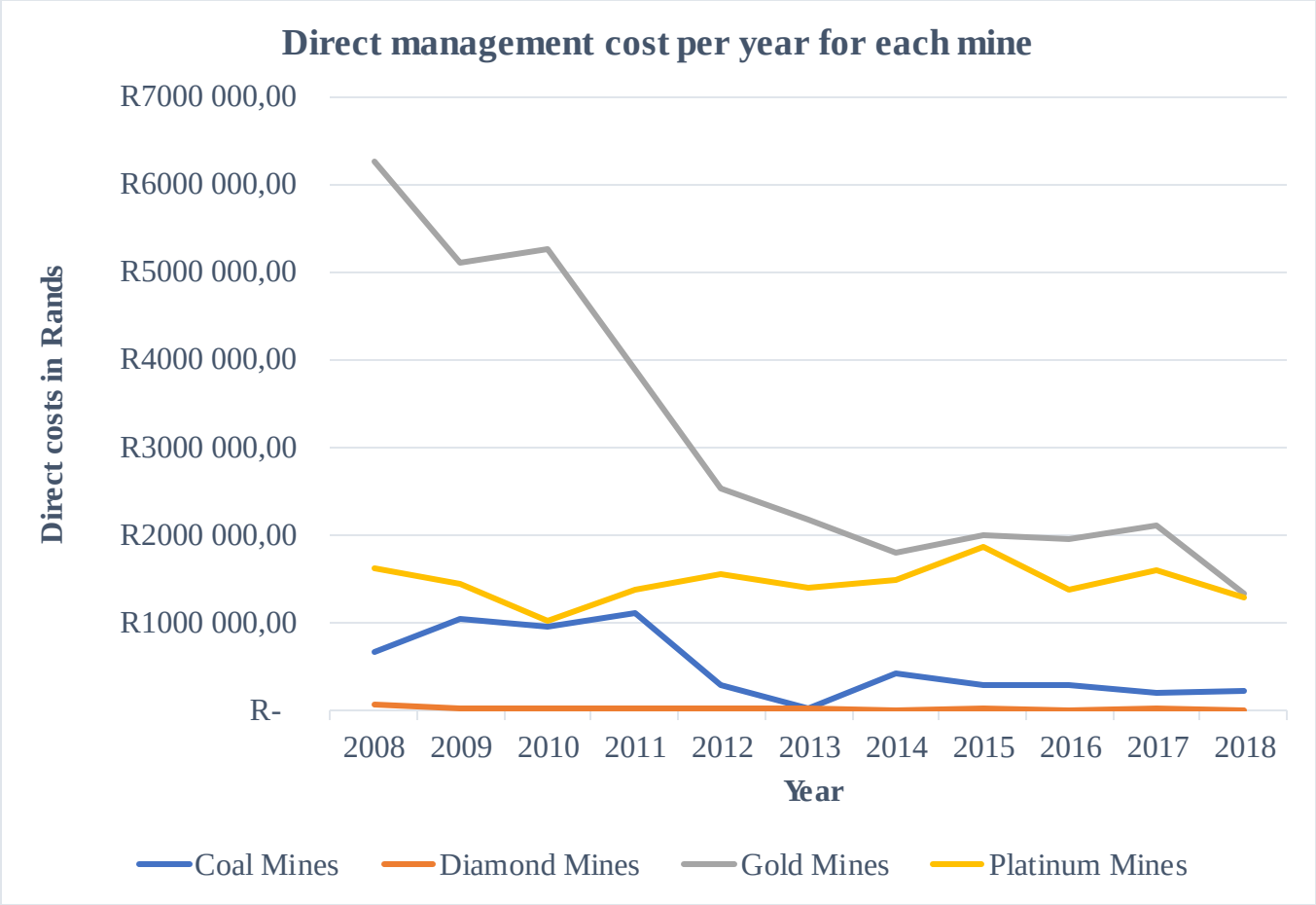

Figure 22: Direct management costs per mine commodity

To estimate direct costs incurred during management of NIHL in the 4 mining commodities discussed in this study in the period of 2008-2018. The average costs were calculated using the average cost of hearing aids (as a form of treatment for the purpose of the study), cost of aural rehabilitation (as in figure 8 and figure 11) and the number of individuals which were compensated by each commodity per year. Diamond mines incurred the least costs having spent less than R100 000, 00, followed by coal at just under R1000, 000, 00 as well, platinum mines being just under R200, 000, 00 and gold mines was the commodity which incurred the highest costs on management across the decade with costs over R600 000 000.00 at one year as presented above in figure 22.

3.4.2.3 Direct management costs per age group

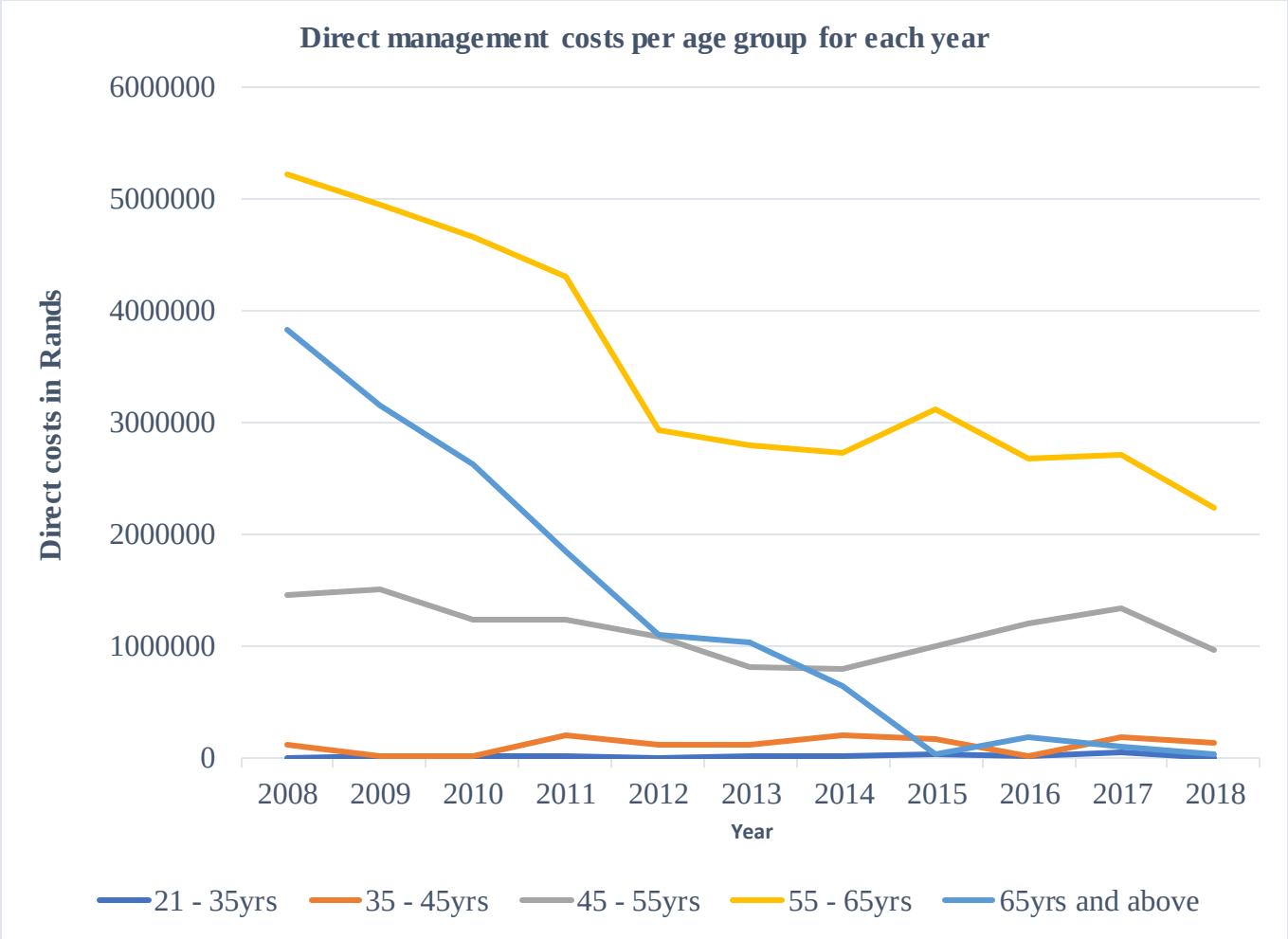

Figure 23: Direct costs incurred during management per age group

In order to determine which age group incurred the most costs on management of NIHL, the analysis took into account the number of individuals compensated per age group (as per workmen's scheme report) and the estimated management cost (in figure 8 and figure 15). The group which incurred the least costs was the 35-45 age group at less than R1 000 000, 00, followed by the 45-55 group at just under R2 000 000, 00, The age group 21-35 being in the region of R0-R4 000 000, 00, and lastly the age group which incurred the most costs on management was the 55-65 age group in the region of R2 000 000, 00 to R 5 000 000, 00 as displayed on figure 23 above.

3.5 Observation from the data collected

During data collection there were additional information collected which was not the aims of the study initially but worth reporting on as it contributed to the study being comprehensive. These results will be presented below in a form of graphs and pies.

3.5.1 Source of referral

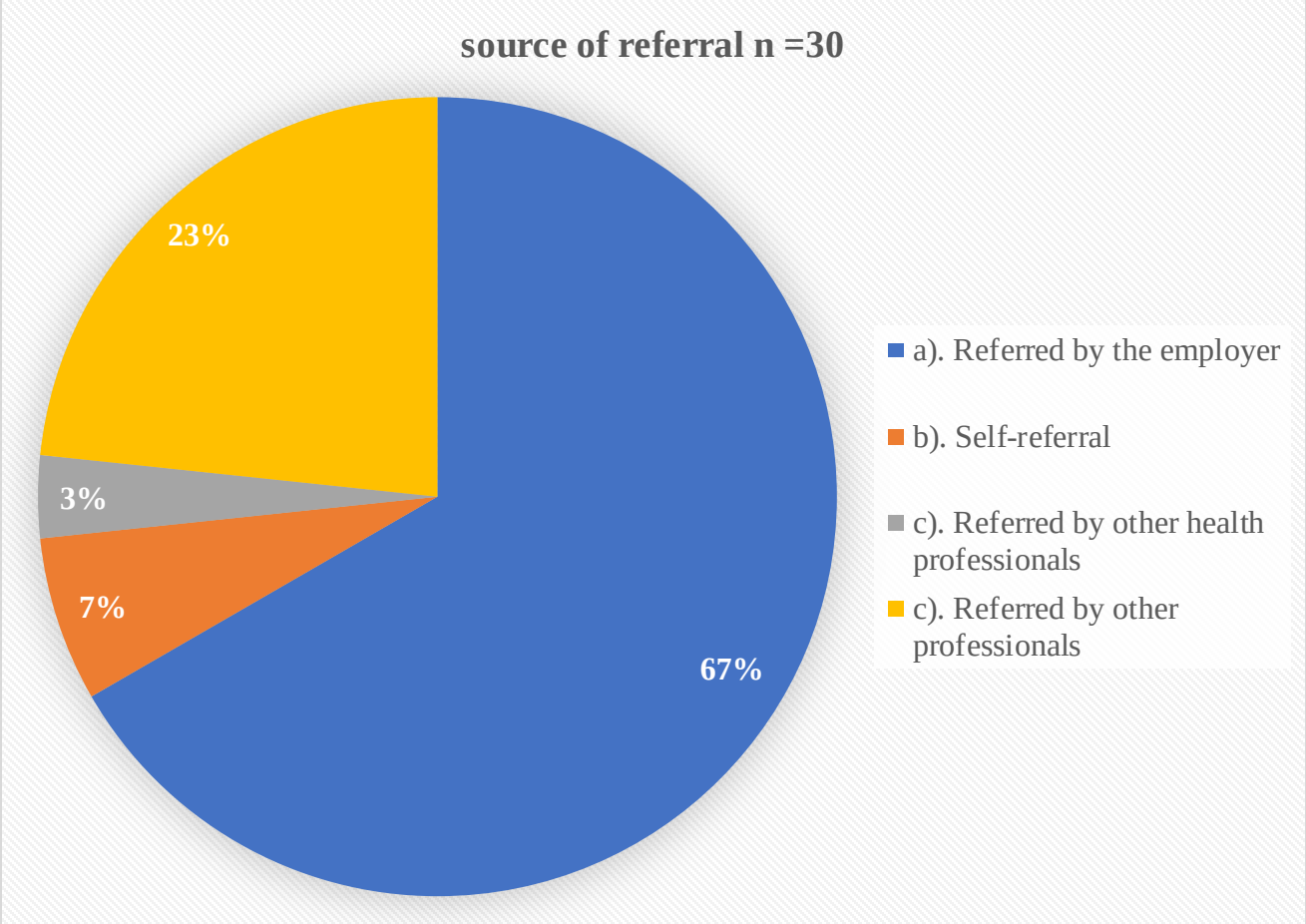

Figure 24: Source of referral

Regarding the source of referral for individuals exposed to excessive occupational noise in the mining sector, the study sought to determine the primary source of identification and carried the referral through for these individuals. In figure 24, it appears that majority of participants n=20 (67%), indicated the employer as a source of referral, n=7 (23%) indicated non health professionals as a source of referral, n=2 (7%) indicated that individuals with NIHL themselves would seek medical help (self-referrals) and lastly n=1 (3%) indicated other health professionals as source of referral.

3.5.2 Additional Costs

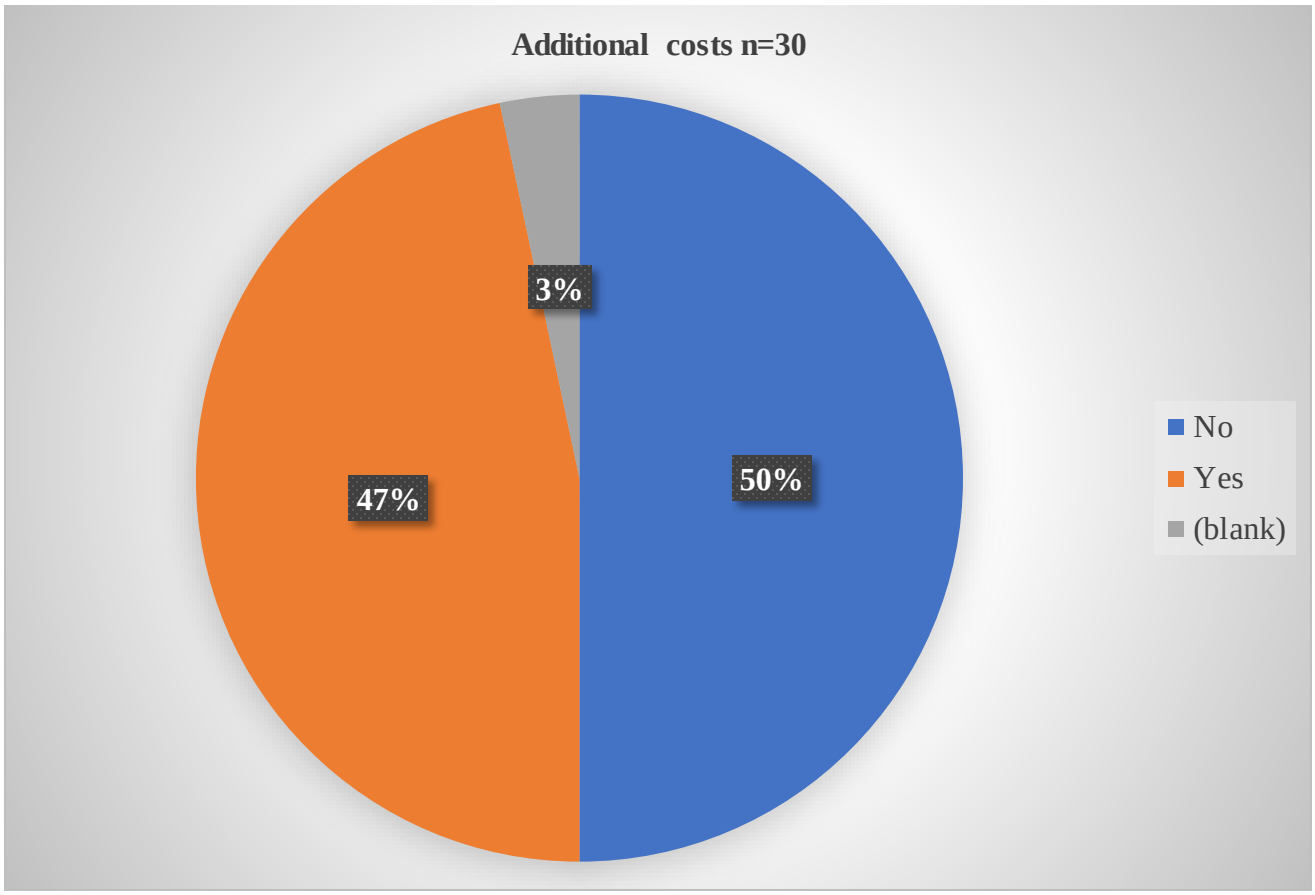

Figure 25: Additional costs

The purpose for this question was to determine if there are any known additional costs incurred during the investigation and management of NIHL. N=15(50%) participants indicated that there are no known additional costs incurred during investigation and management of NIHL, n=14 (47%) indicated that there are known costs incurred during the investigation of NIHL and n=1 (3%) did not indicate whether there are known/unknown additional costs incurred.

3.5.3 Known services with additional costs

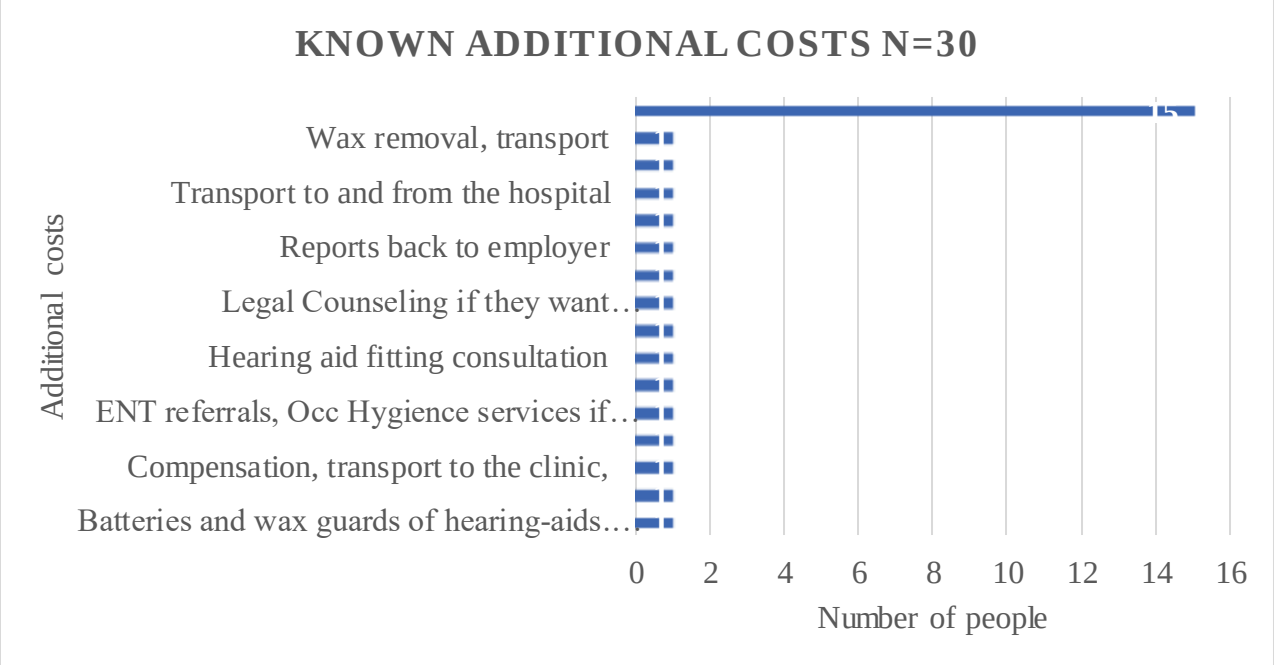

Figure 26: Known additional costs

This question was aimed to determine additional services known to add on costs incurred during investigation and management of NIHL. Different services were mentioned varying from hearing aid accessories, legal counselling, wax removal, hearing aid batteries, referrals to other professionals, report writing, hearing aid repairs, with a majority of the participants n=5 (16%) indicated transport a service with additional costs as listed in figure 26 above.

3.5.4 Referral for further investigation

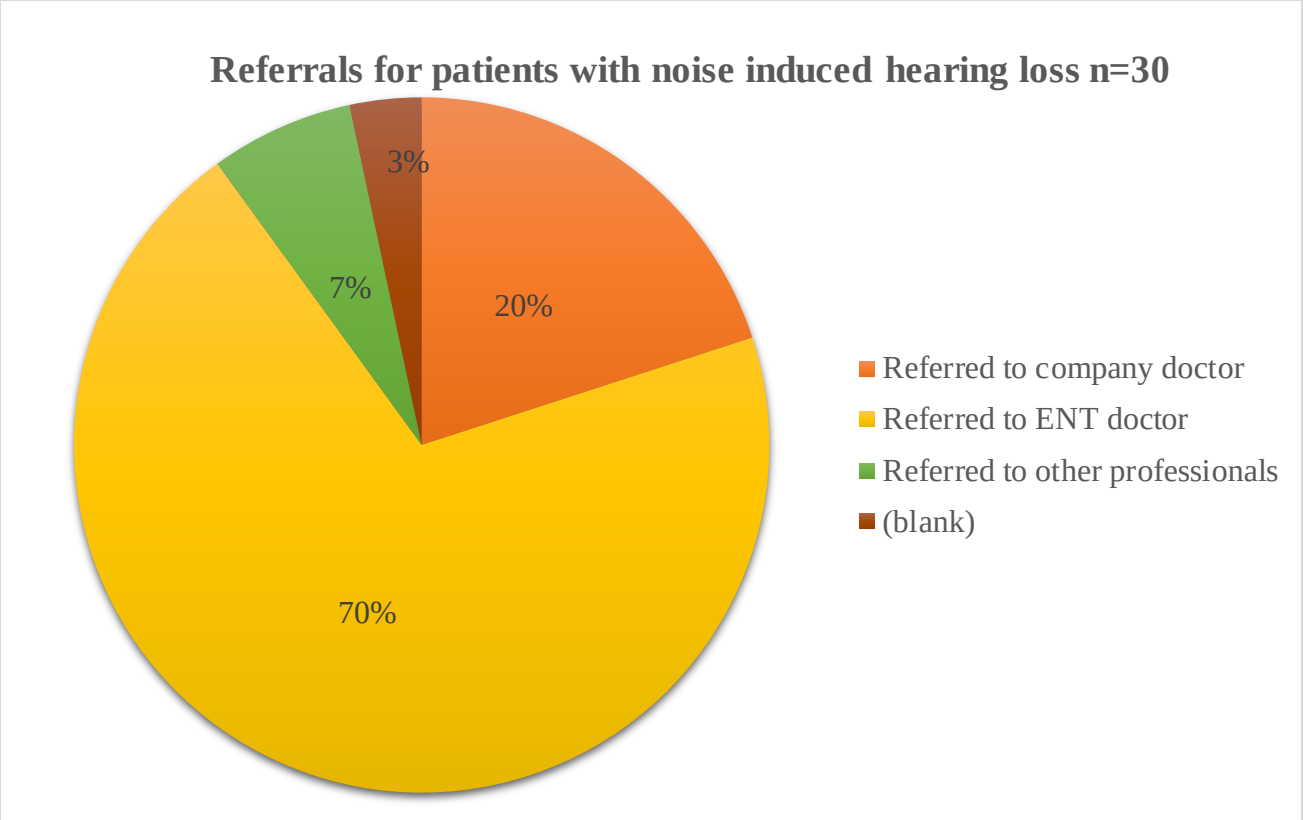

Figure 27: Referrals for further investigations

This question aimed to determine whether individuals with NIHL are referred for further investigations post audiological assessment. In figure 27, n= 21(70%) of participants indicated that a referral to an Ear Nose and Throat (ENT) specialists was made for further investigation, n= 6 (20%) indicated that a referral to company doctor was made and n= 2(7%) of the participants indicated that a referral to other professionals was indicated for further investigation.

3.6 Conclusion

To address the costs associated with investigation and management of NIHL. The results clearly indicated that NIHL is a costly occupational disease as evident by the high costs incurred by the employee, employer and the state. In terms of the direct costs incurred during investigation of NIHL, the results revealed that in the period of 2008-2018 the costs incurred were estimated at just over R9 000 000.00 (9million) and it cost R56 284 924.00 (56 million) to manage 7199 individuals. With regards to compensation paid-out to individuals with NIHL, the results indicated that only 60% of the reported cases for compensation were successfully compensated and R1 711 951 577.01(R1.7 billion) was paid in a form of compensation in the period stated. These results highlighted the burden NIHL has on the country's economy.

CHAPTER 4: DISCUSSION

This chapter presents the general discussion of the findings of this study in relation to the aims presented in section 3. This study investigated the economic cost of NIHL in individuals exposed to excessive occupational noise and the sample comprised of 30 participants. As mentioned earlier in the methodology section, this study had a small sample because it aimed to target participants who are experienced in the management of individuals with NIHL. This study sought to highlight the cost associated with the management of NIHL and not generalise the findings to a large population, therefore the findings of this study may not be generalized to the greater population of mining industry.

The main aim of the study was investigate the economic cost of NIHL and the specific objectives which were raised as follows: direct costs of investigation, direct costs of management and analysis of compensation paid-out.

4.1 Direct Costs of investigation for NIHL

In terms of the direct costs incurred during investigation of NIHL, the results revealed that in the period of 2008-2018 the costs incurred were estimated at just over R9 000 000.00 (9million) during investigation of individuals who presented with NIHL. The findings further indicated that gold mines accounted for most costs incurred at just above R6 000 000 00 (6 million). Also for each individual to be investigated for NIHL the costs were approximated at R1250.17. In comparing the two years with the highest number of reported individuals with NIHL (2008), versus the year which had the lowest number of reported individuals (2018). In 2008 the burden of investigating NIHL was at R1 806 495.65 (1.8 million) to the country's GDP of 2 trillion which translated to 0.0000036% to the mining sector for 1445 individuals. In 2018 the burden was at R952 629.54 to the country's GDP of 6 trillion which translated to 0.0000054% to the mining sector for 762 reported individuals with NIHL.

The majority of participants indicated that these costs at usually are incurred by the employees. However according to the researcher's experience and observations this could be due to the following reasons: firstly some private sector Audiologists work on cash consultation and the client/ individual would be responsible to claim from their medical scheme. Secondly small percentage of occupational audiologists are contracted to the mines (employer) where a claim can be made directly to the employer and lastly in some state hospital the individual with NIHL

is responsible for payment of any occupational health related assessments as it is not regarded as medical illness/disease. Therefore depending where the individual decides/being referred to for medical care, they would be liable/not liable for costs. Additionally it was of interest to observe the difference in cost between private and state practices. In private practices the costs are calculated based on the sub tests conducted and the report is billed separately. Which means the employer or employee will be liable for all the costs. Whereas in public sector all outpatient services are billed at a fixed rate regardless of which test are being conducted. In public sector individuals are only expected to pay a portion of the cost based on their income (up to 30% of the cost) as services are subsidised. Also some institutions within the public sector are free health care services thus individuals nor the employer will incur these costs, but will be incurred by the state. This will results in drainingg the already scarced resources thereby burdening the health system. This implies that not only is the brunt of non-management of NIHL felt by the company or individual but extended to the entire country as the state institutions are being funded by the tax payers.

The dangers in the mining industry have been well documented by different authors (Teke, 2017; National Institute for Occupational Safety and Health [NIOSH], 1996; Cullinan, 2018; Nkosi, Claassen, & Voyi, 2015). One of the author who described the dangers of mining through the eyes of the workers was Plaatjie, (1914), who described the miners as "Two hundred thousand subterranean heroes who, by day and by night, for a mere pittance lay down their lives to the familiar 'fall of rock' and who, at deep levels, ranging from 1 000 to 3 000 feet in the bowels of the earth, sacrifice their lungs to the rock dust which develops miners' phthisis and pneumonia." That is the realities of mining, it was and still remains a dangerous job. For instance, a century later, "South Africa's mining sector is controversial, exciting, empowering and a painful contradiction when seen through the eyes of the miner" (Teke, 2017, p. 1).

The current study findings echoed the observations made by Tahir et al., (2014) in a study where the researchers investigated the economic burden of NIHL among manufacturing workers in Malaysia, these authors indicated that it cost 608 Malaysian ringgit (MR) per individual for NIHL medical care investigations. These authors further stated that NIHL is a costly occupational disease and posed a huge economic burden to the Malaysian country. Later in 2017 Neitzeles, Swinburn, Hammer & Eisenberg, (2017) estimated a range of $58 billion to $152 billion annually, with a core estimate of $123 billion for management of NIHL. These

authors believed this was a conservative estimate, because consideration of additional costs of hearing loss, including health care, would likely further increase the benefits associated with hearing loss prevention. Similarly, additional services with additional costs were also observed in the current study which were not accounted for in the cost estimates of managing NIHL. Thus it is the researcher's opinion that the current costs are conservative estimate. Moreover an Australian study estimated the national cost burden attributable to hearing loss to be AUD 33.3 billion in 2017. Approximately half of the cost burden was estimated to be due to financial costs, including direct health system costs and lost productivity, while the remaining half was due to the loss of well-being (quantified using disability adjusted life-years) (Hearing Care Industry Association, 2017). Even though the above example is not specific to NIHL it however paints a picture of how costly are the investigation of hearing loss including NIHL.

The above examples are from countries considered to be developed countries when compared to South Africa in terms of the economy and resources. Therefore with South Africa being a developing country and with its challenges such as poverty, low levels of education and employment, as well as an urgent need for economic growth, it is imperative to reduce costs. In South Africa, NIHL is known to be an occupational disease with high prevalence (Edwards, Dekker, Franz, van Dyk, & Banyini, 2011; Kanji, Khoza-Shangase, & Ntlhakana, 2017; Ntlhakana, Kanji, & Khoza-Shangase, 2015; Strauss, Swanepoel, Becker , Eloff, & Hall, 2012; van Coller, 2015). With approximately 73.2% of South African miners exposed to excessive noise above the legislated occupational exposure limit of 85 dBs, despite the implementation of HCPs in the mining sector (Edwards et al., 2011; Strauss et al., 2012). Furthermore Chadambuka, Mususa, and Muteti (2013) stated that 80% of individuals affected by NIHL live in low and middle income countries where the burden of NIHL is much heftier than in developed countries and South Africa is such country. Thus, there is high possibility of ever increasing number of individuals with reported NIHL who would require medical investigation which comes with costs. In this way creating significant economic burden, which could be carried out past discharge from the mining sector (Cooper, 2014). In addition NIHL have been shown to be associated with secondary diagnoses, which potentially drive costs for medication and health care (Yankaskas & Prelude, 2013). It is for these reason that NIHL is regarded as one of the major threats to the country's economy as well as public health.

This is contrary to the South African Mine Health and Safety Council (MHSC) which stated one of its goals as "every mine worker returning from work unharmed everyday: Striving for

zero harm" (Mine Health and Safety Council, 2016). Sadly mining is probably one of the most hazardous peacetime occupations in South Arica. With the annual death toll on all mines fluctuated at around 800, 30 years later in 1983, the figure was still a high 831, and 20 years after that it had dropped to 246, Chamber of mines, (2017). Till this day, deaths still occur as a result of non-compliance by employees and management as individuals try to take short cuts (Editor, 2018). Furthermore, the pressure to reach production targets is huge, even though this sometimes means that miners remain in unsafe workplaces. Thus safety still remains an issue in the mines (Coulson, 2019). Thereby the ever increase occupational disease such as NIHL.

4.2 Direct costs incurred during management of NIHL

The study explored the direct costs incurred during management of NIHL. Predominant finding emerging from the study was that it cost R56 284 924.00 (56 million) to manage 7199 individuals, using the acceptable figures for compensation derived from the compensation scheme report of 2008-2018. Majority of the costs incurred where from the gold mines at R 34 393 955.00 (34 million) based on 6539 individuals with acceptable claims from this commodity. The results further indicated that on average it cost R7 818.43 to manage an individual with NIHL. Thus the costs of management of NIHL were 5 times the costs of investigations. In comparing the two years with the highest number of acceptable individuals for compensation (2008), versus the year which had the lowest number of acceptable individuals for compensation (2018).In 2008 the burden of treating and rehabilitating NIHL was at R9 366 479.14 (9.3 million) to the country's GDP of 2 trillion which translated to 0.0000186% to the mining sector for 1198 individuals. In 2018 the burden was at R3 088 279.85 (3million) to the country's GDP of 6 trillion which translated to 0.000018% to the mining sector for 395 individuals. Similar to costs of investigations, there were significant variations in the costs of management of NIHL. As stated in the section above, this could be due to the fact that all costs in private are paid in full by the individual or employer where else in state institutions they are subsidised. Fact is NIHL still occur and is a costly condition to manage as illustrated by the findings in the current study.

The current study findings were echoed by a study conducted in Australia by Radi, Benke, Schaafsma & Sim (2010) on the costs and determinants of compensation claims for NIHL between 1998-99 and 2008-09. Even though the study might be outdated it is of benefit to illustrate how costly was/is to manage NIHL as it mirrors the findings of the current study. The results of this study indicated that over the eleven-year period, the median cost for hearing aids

provision and management was $5,845 and did not vary greatly over time. However, it is worth mentioning that the majority of claimants were provided with a single hearing device, had it been two hearing aids provided the costs would have doubled. Furthermore the price of a hearing aid in private market in 2005 was estimated to be $2,500 and the estimated cost of batteries and device maintenance was $137 per person per year (Access Economics 2006).

In this study both the Government Hearing Services Program and WorkSafe Victoria scheme publish a fee schedule for the provision of hearing services by contracted providers. However, description of services by item were different from one scheme to the other. Thus difficult to compare them. For example in the WorkSafe scheme, hearing review and/or device maintenance is payable to the audiologist or Audiometrist on an hourly basis with a maximum of 7 hours paid over a period of 5 years. The Government Hearing Program includes rehabilitation in fitting services. The above discrepancies are similar to the findings of the current study were certain individuals with reported NIHL would consult in the private sector where all costs are paid fully to the audiologist (assessment, fitting of hearing aids and accessories and rehabilitation thereafter). Also in private sector, service costs were different from one Audiologist to another, resulting in difficulties in comparing the services. Contrary individuals who consulted in state facilities would receive all services at a subsidise cost based on their income and some even at no cost. Therefore these costs would be incurred by the state, straining a system with already constrained resources where issues such as minimum wage are still in the public address. Moreover with South Africa's credit rating status being downgraded to junk status fully Bloomberg, (2020), the country's weak economic growth, constrained fiscus and the ailing state-owned companies, it is imperative to contain costs where possible.

Furthermore Alamgir et al., (2016) reported that the Centers for Disease Control and Prevention (CDC) estimated the disability cost of occupational hearing loss to be $242.4 million per year nationally. Based on a report from Washington State in 1991, hearing-related conditions cost about $4.8 million in workers' compensation disability settlements (CDC, 2014). The authors further stated that, despite a high prevalence of hearing loss and NIHL injury and the associated high economic burden, there are no recent, comprehensive, and reliable estimates of costs incurred by the Department of Defense (DoD). In addition, published estimates exclude additional expenses related to hearing loss that are not as transparent. These include outpatient expenditures (ear examinations), travel expenses, productivity losses (reduced income, work

absences, reduced lifetime earnings, reduced working hours, early retirement, unemployment, underemployment), support services (special education classes, interpreters, note takers), assistive devices, cost of communication devices (telephone, speech aids), vocational rehabilitation, and out-of-pocket expenses. As mentioned earlier under direct costs of investigation, in the current study there were known additional costs that individuals with reported NIHL are likely to incur. The fact is the actual economic cost of hearing loss is likely to be higher than what is reported in published estimates. As it is difficult to quantify some of the costs which are associated with NIHL.

4.3 Analysis of compensation

4.3.1 Reported versus Accepted versus Compensated claims

In relation to compensation paid-out to individuals with NIHL, the study results indicated that 11993 cases were reported for compensation in the period of 2008-2018, out of the 11993 cases reported only 7860(65.5%) cases were acceptable for compensation and only 7199 (60%) cases were compensated for NIHL. Majority of cases reported were from gold mines sector (with 6593 reported, 4803 were accepted and 4406 were compensated claims). The above results indicates that on average only 60 % of the reported cases were successfully compensated by the scheme in the period stated above and only 719 cases on average were compensated annually by the scheme. Thus not only does these individuals develop a work induced condition (NIHL) but further suffer financial costs and misery of going through the compensation process only for their application to be considered unsuccessful, while living with the effects of a permanent hearing loss and most likely to suffer the consequences of a condition which could have been avoidable.

Also the 11993 reported claims to the scheme in the 10 year period is of concern as it is reported that mining in South Africa gives employment to 4.5 million people Teke, (2017) and the fact that there are 73.2% of South African miners exposed to excessive noise above the legislated occupational exposure limit of 85 dBs Edwards et al., (2011); Strauss et al.,(2012) and likely to develop a hearing loss. Thus, these figures could be an underestimation and not a true reflection of the situation in the South African mines. As a result, there could be a larger percentage of individuals with reported NIHL but not aware of their rights to claim and the procedure to follow when lodging a claim. This could be attributed to the fact that South Africa has two worker compensation acts, namely, Compensation for Occupational Injuries and Diseases Act (COIDA) and the Occupational Diseases in Mines and Works Act (ODMWA). These acts differ in the administration and benefits provided. Furthermore these compensation frameworks mirrors theoretical knowledge of what establishes work induced hearing loss, etiology factors responsible for work induced hearing loss as well as measure and manage employees hearing (Warren, Manning & Pillay, 2020). Pillay, (2011); Pillay and Kathard, (2018) argue that such knowledge is usually blurred, hidden and not well understood by audiologists outside of a few basic references to South African National Standard (SANS) guidelines or COIDA. Therefore this impact on the individual rights as these are the laws that mandate occupational hearing protection. These authors further raises a question of how adequately, in this legal predicament of acts and regulations, is the state recognising South African employees' rights as per Sections 9 and 27 of the Bill of Rights ? Ncube and Kanda, (2018) shared similar sentiments when these authors stated that the disintegrations of the South African OHS laws have been resulting in duplication of law enforcement roles; a costly waste of scarce resources; and discrepancies and lack of consistency in the implementation of enforcement functions. Thus the main outcome is a hindrance of advancement regarding to safeguarding employees health.

Moreover, a study by Si, Lewkowski, Fritschi, Heyworth, et al., (2020) shared related findings to the current study with regards to the number of compensated claims versus the number of reported claims. The authors stated that in Australia, more than 16,000 successful compensation claims for industrial deafness involving hearing loss were made between 2002 and 2007, which equates to more than 3000 workers annually (Safe work Australia Occupational NIHL in Australia, 2020). However, it is likely that the number of successful compensation claims is an underestimation of the true number of workers affected (Safe work

Australia Occupational NIHL in Australia, 2020). These authors assumed various reasons for underestimation. The first reason was that despite the high prevalence of occupational NIHL and significant health and economic burden of hearing loss, studies investigating the amount and extent of occupational NIHL are scarce, particularly at a population level. The authors further stated that according to Australian national standards, workplace noise levels should not exceed 85 dB. However, only workers who are deemed to be exposed above 90 dB are required to have hearing tests (Safe work Australia Occupational NIHL in Australia, 2020). In addition, there is no national-level surveillance of the prevalence of occupational noise exposure, neither have there been ongoing direct measurements of existing or new cases of ONIHL in Australia (Safe work Australia Occupational NIHL in Australia, 2020). Hence the under reporting of affected employees. Adversely it is the affected individuals who are disadvantaged by lack of consistence in the laws that governs hearing care, lack / death of prevalence of occupational exposure data and evidence-based strategies to eliminate excessive noise. Hence Moroe et al., (2018) argues that in order for the South African mining industry to succeed in management of occupational NIHL there is a need for new, inventive and evidence based methods of managing excessive exposure to unsafe noise. These authors stressed the point that these approaches should holistically focus on understanding why HCPs are not successful in the South African mining industry while their counterparts in developed countries have reported success. The authors further stated that holistic investigation suggests a comprehensive, in-depth evaluation of the policies and regulations concerned with the safety of the mineworkers who are exposed to excessive noise in their place of work, as well as the perspectives and opinion of various stakeholders on the management of this condition (Moroe et al., 2018).

4.3.2 Cost of compensation

With regards to costs spent by the mining sector in compensation of NIHL, the results of the analysis indicated that R1 711 951 577.01(R1.7 billion) was paid in a form of compensation in the period of 2008 -2018. Moreover gold mines accounted for 90 % of the compensation claims paid at R1 102 648 004.90 (R1.1 billion) and on average an individual was compensated at 237 804.08 which is double the maximum of R140 506.00 paid by the state compensation scheme. In comparing the two years with the highest number of compensated individuals (2008) versus the year which had the lowest number of compensated individuals (2018). In 2008 the burden

of NIHL compensation was at R254 450 365.6(254 million) to the country's GDP of 2 trillion which translated to 0.000048% to the mining sector for 1070 individuals compensated for NIHL by the compensation scheme. In 2018 the burden was at R90 365 550.4(90 million) to the country's GDP of 6 trillion which translated to 0.000054% to the mining sector for 380 individuals compensated for NIHL by the compensation scheme. On the other hand the state is said to have paid out R1.4 billion over the past 30 years to nearly 97 000 beneficiaries. This means on average the state compensated 323 individuals per year and an average of R14432.98 was paid per individual. The vast differences between the state compensation scheme and the private compensation scheme is appalling. Does this mean that miners whom are regarded as contract workers, working under the same environment , being exposed to the same toxins as their counterpart miners who are regarded as permanent workers (being covered by the private compensation scheme), will be disadvantage by the system based on their work status? Also could these variation be due to the disintegrations of the South African OHS laws as stated above? Sadly this could have dire impact on the application outcome for the affected individual. It may, work for or against the applicant depended on the assessor's interpretation of the law.

The complexity of compensation process is not only limited to the South African context but a global concern. A report on tackling the compensation culture: noise induced hearing loss claims in the United Kingdom was compiled by the British insurers, where the aim was to understand the problems of compensation. The findings of this report were that the majority of NIHL claims are not successful whilst there is a significant increase in the number of NIHL claims being reported and these claims are often not successful. The industry average claims failure rate was 65% in 2013 ABI analysis of NIHL, (2013), and this rate is now on the increase, with one insurer reporting a claims failure rate of 85% in 2014 (ABI analysis of NIHL, 2014) . Various reasons were stated for NIHL claims fails, including the total absence of any NIHL element, a lack of evidence that the hearing loss was due to exposure to noise in the claimant's workplace or because the claim falls outside the limitation period for making a claim. The report further stated that the high failure rate highlights two key issues: Firstly, a significant number of NIHL claims that are submitted are of poor quality and are cultivated by claimant lawyers without any real prospect of success; Secondly, insurers and compensators are being forced to incur costs in terms of employing additional staff to consider the significant increase in the volume of claims, the vast majority of which fail. Time spent considering a claim that will eventually fail is time taken away from settling a genuine claim. These key issues could be applicable to the South African context considering there are apparently 90 000 claims that have been approved but not yet paid, and

up to 700 000 still to be assessed by the state compensation scheme (Editor, 2018). Moreover the lack of consistency in the implementation of enforcement functions of the OHS laws as mentioned earlier could be contributing to the failure rate of compensation in the South African context and further contribute to the longer waiting list.

The costs associated with NIHL compensation have be discussed in several studies, amongst these studies is a study in the United States of America where it is estimated that the annual compensation for NIHL is approximately $242.4 million (Basner, Babisch, Davis, Brink, Clark, Janssen, et al., 2014). The authors added that this economic burden is extremely high and continually increasing. In the same year, same country, same authors reported similar findings as above, however these were specific to the military services. They reported that in 2012 alone there was $1.2 billion of entitlement for compensation and care of hearing loss and auditory system injuries despite efforts to emphasize and improve military HCPs. There were 10% to 18% of Service Members enrolled in HCP and have been diagnosed with significant threshold shifts in their hearing, representing a prevalence of two to five times higher than rates in comparable civilian, industrial HCPs. Therefore if the mining sector is to combat this costly public health condition called NIHL, new innovative ways are to be developed as mentioned earlier.

It seems the average age for compensation was 55-60 for individuals compensated by the compensation scheme concerned in the current study as majority of compensated individuals were in this age group. Therefore it is clear that individuals exposed to excessive occupational noise are mostly likely to notice symptoms of NIHL later in their career life (could be post discharge from the mine). This is in line with the fact that NIHL is insidious in onset and therefore many workers may be unaware that they are losing their hearing (NIOSH, 2010). An earlier study by Edwards and Kritzingert, (2012) mirrors the findings of the current study. These findings were: there seems to be claimants for NIHL compensation under 40 years of age in all of the main commodity sectors. Also, in the age groups where miners have longer service, the number of claims were significantly higher. These long service miners have hearing loss far beyond what would be expected for their age as a result of the normal age-related hearing loss. The authors further stated that the reasons for these claims might be the years when little or no hearing conservation practices were implemented have left a legacy of hearing loss. Additionally, the HCPs in process currently are not effective enough to prevent all hearing loss.

Furthermore it seems the average age of compensation for NIHL is between the ages of 50-59 globally. This is supported by estimates conducted by NIOSH (2012) which states that 1.7 million workers between the ages of 50 and 59 with various occupations in the U.S. have compensable NIHL and that 10% of all employees exposed to noise levels of 90 dB(A) or above will experience a disabling hearing loss. In addition a Swedish population-based study found that 31% of the working population and 36% of the non-working population, aged 16 to 64 years, had hearing loss and/or tinnitus using self-report. In those aged 40 years and younger, n=37 of the participants , every fifth individual reported either tinnitus or hearing loss, with severe hearing problems already present in those who reported exposure to work-related noise. It has been estimated that worldwide, 16% to 24% of hearing impairment is work-related with quantification of the health impact estimated to be over 4 million DALYs. The DALYs is a measure of the years lost from the ideal lifespan due to morbidity and premature death, and therefore represents the gap between the current and ideal situation where everyone achieves standard life expectancy in perfect health. However, some studies have reported surprisingly high NIHL prevalence rates among young workers suggesting that NIHL may already be present even before employment. A Dutch survey of construction workers found that 7.6% of workers under age 25 were diagnosed with NIHL, while other studies reported prevalence rates ranging from 14.4% to 16.0%. In a large scale retrospective study (n ¼ 29,644) of Dutch construction workers in which hearing thresholds of workers (noise-exposed and none-exposed) were compared with ISO-1999 predictions, the authors found that NIHL was present at the start of employment and increased at the same rate as predicted for longer exposure durations. It may be that leisure noise exposure is a contributing factor to NIHL in young workers as well as in workers of all ages.

In addition, the time lag that occurs between work-related hearing damage and the presentation of symptoms can be several years, depending on the duration and intensity of the noise exposure. In South African mines detection of mine induced disease may occur very late in a day, if at all due to migratory labour system. It is known that the mining sector have a high number of migrant workers working in the South African mines. Therefore migrant workers who return to rural areas in South Africa or to neighbouring states, after completing their years of service on the mines and do not have easy access to testing facilities, let alone treatment are particularly disadvantaged in this regard. Unfortunately many Migrant workers or their bereaved dependants may be ignorant of their rights and be disadvantaged in this regard.

Also earlier, under investigation, management costs we noticed the age group 25-35 was not the group with the least costs incurred. However when looking at compensation they are seen to be the least compensated group even though they developed a hearing loss that warranted to be treated and rehabilitated. This has implication for future employment opportunities particular for this group, as research shows that individuals with hearing loss have less opportunities of employment and underemployment than their counterpart individuals with normal hearing Emmett & Francis (2015); Hogan et al.(2009); Jung & Bhattacharyya (2012) and higher odds of low income (Jung and Bhattacharyya 2012). Research has revealed that there is low level of education attainment amongst the miners in South Africa (as discussed earlier), this means when these individual lose their jobs at an early age (employable age) the likelihood of reemployment is reduced not only by their level of education but further by the hearing loss itself. Likewise when these individuals loses their income the effects are not only limited to the individual who is affected but also extend to their families, as in most cases these individuals are the sole breadwinners for their families. Subsequently, these individuals and their dependants are forced to rely on state resources for their upkeep.

4.3.3 Occupation with the highest claims

The results of the study further revealed occupation groups with the highest claims for NIHL, which were the drill operator, fitter, boilermaker, miner, foremen, loco driver, stope team and scraper winch operator to mention a few. The driller operator seems to be amongst the top compensated occupation for NIHL across all the mentioned mine commodities. These occupations mentioned above utilises equipment/ machinery which produce noise at high intensity. Thus predisposes employees to NIHL. Similar findings to the current study were echoed by Edwards, (2008) were the author stated that the various sources of noise in the mining industry include, but are not limited to, noises produced by ventilation fans, drilling equipment, jackhammers, air compressors, grinding equipment, etc; all within the 8-h daily shifts. These sources of noise have been reported as the main culprits producing noise levels that usually exceed the stipulated A-weighted sound pressure level, LAeq, 8h, of 85 dB TWA within South African mines (Department of Minerals and Energy, 2003).

This reality raises significant implications for the ear and hearing health of miners who are exposed to these sources of noise in shifts longer than 8 h daily while trying to earn a living. It further highlights the importance of HCPs within the South African mining industry, which could assist eliminate and or reduce NIHL. According to (NIOSH,2015), NIHL from work is

avoidable if adequate preventative measures are put in place in the mines, for example: removal of hazardous noise from the workplace, and through the use of hearing protectors where hazardous noise exposure has not been controlled or eliminated. However even though the use of hearing protectors has been reported within the South African setting, but factors such as comfort, design and work-related communication have been found to have an influence on their effective use (Ntlhakana , Kanji , Khoza-Shangase, 2015). Also there seems to be a lack of commitment from professional with regards to awareness training for people exposed to excessive noise at work. As echoed in a study by Edwards et al., (2015), the authors conducted a descriptive survey to evaluate NIHL due to occupational exposure. These authors' findings indicated that there is dearth in commitment by management pertaining to prioritising awareness training for NIHL. Moreover majority of the mines lacked concrete theoretical foundation for their awareness training programmes. Lastly, these authors highlighted that there were challenges with the choice of language used during these training. However, a study by Moroe & Khoza-Shangase, (2018) on the management of occupational NIHL in the mining sector, indicated success in awareness training of mineworkers, recognised by the mining sector. These authors attributed these findings to the implementation of the revised 2014 Mine Health and Safety Council milestones on the elimination of NIHL in the mining sector may had perhaps supported a change as the mining sector shifted their attention on awareness training and education on NIHL and its effects. Moroe and Khoza-Shangase , (2018) further stated that the efforts in commitment by the mining sector pertaining to awareness training programmes might be unnoticed due to the increasing burden of diseases, such as HIV/AIDS and TB, which are known to be prevalent in the mining sector (Stuckler, Basu, McKee, & Lurie, 2011; Stuckler, Steele, Lurie, & Basu, 2013).

Therefore if the mining sector where to eliminate or reduce the high prevalence of NIHL, they need to consider in investing in buying quite machinery, which is an initiative that adopts and promotes the use of quieter machinery as an approach of controlling noise at its source. There is published evidence regarding the success of buying quite as strategy for reducing and elimination NIHL. Firstly, in a study by Gumede et al., (2014) the researcher highlighted that the mining sector does acknowledge buying quite as practical approach that will significantly reduce NIHL and improve the management of noise at its source. The second study though outdated is of relevance to the current study, this was a study conducted by Burger et al. (2004), where these researchers focused on developing a low noise blast hole drilling system in order to reduce the risk of NIHL in the mining procedures. The motivation for this study painted the

benefits of using this drill, such as removing the operator from the areas of excessive noise and minimizing the need for operators to support the drill therefore eliminating the risk of vibration-induced injury. Results from this study showed that the developed low-noise rock drill reached the noise level as specified and stipulated in the legislation, thereby aiding the mining industry to be compliant with the NIHL regulations.

4.4 Conclusion

The current chapter indicated that the inadequate prevention of NIHL has profound negative effects not only on workers and their families but also on society at large due to the tremendous costs that it generates, particularly, in terms of loss of productivity and burdening of social security systems.

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CHAPTER 5

The findings of the current study, which provide an overview of costs associated with NIHL in the South African mining sector, add to the evidence base, which can be consulted in planning future studies and in formulating policies around NIHL. These findings raise important implications for the South African mining sector in terms of areas needing attention to enhance the sector's GDP contribution. Therefore this chapter discusses the concluding remarks, the implications and limitations of the study and recommendations for future studies.

5.1 Conclusion

To answer the question regarding what are the costs incurred by the individual exposed to excessive occupational noise within the South African mining sector. The study attempted to investigate the direct cost incurred during investigation, the direct cost incurred during management and compensation pay-outs. In its attempt to investigate direct costs incurred during investigation and treatment of NIHL, the study revealed that majorities of the costs were incurred by the individual who presented with NIHL. The study further revealed that it in 2018 the costs incurred for managing an individual case of NIHL were estimated at R246 872.68, (these are investigation, management and compensation costs added together).

Historically in South Africa mines most mineworkers, particularly black South Africans, had low levels of education and literacy mentioned earlier subsequently, being restricted to performing manual labour jobs since such work does not require any form of education and there by resulting in low paid employment. Therefore incurring additional costs with already low wage have a potential of increasing these individuals debts. Thus indirectly increase their credit and forced to borrow for basic necessities such as food, clothes and school fees for their children. In addition NIHL may lead to career-ending disability thus adding to the economic burden as these individuals will now be forced to access public services for their up keeps and further adding strain to the already limited state resources. This is seen to be true in the current study as it was discovered that individuals with NIHL not only seek help in the private sector where all costs are liable to the individual or the company but further seek help in the public sector. This has negative effects on the resources of state as most services in the state are

subsidised by the tax payers' money. Therefore the presence of noise in any country, irrespective of whether it is developed or not, has dire effects, more so in South Africa , a country faced with challenges such as quadruple burden of disease such as HIV/AIDS and TB which is known to be high in the mining sector, the impact becomes even more burdensome. Thus NIHL with the presence of low education, low wage and presence of disease have intense effects in South African country not only in the economy sphere but to the public health sphere too.

Furthermore, NIHL has impact on the mining companies as they incur costs through compensation. As alluded in the current study, in a decade the mining sector incurred R 1.9 billion in the form of compensation pay-outs. Furthermore the study indicated that an average age for compensation in South Africa is 55-65 years. Thus loosing +/- 10 years of their career lives. This scenario mirrors the findings by Matetic (2005) who indicated that, according to the Center for Disease Control, 49% of male miners are likely to acquire a hearing loss by age 50 and further rise by 70% by the age of 60 as compared to the 9% in the general public. These findings strongly indicate that the mining sector in general represents the heaviest burden on the economy. Additionally these high compensation pay-outs demonstrates the costly impacts and magnitudes of inadequately managed NIHL in a place of work. Importantly, these effects of NIHL should not be taken lightly as they have a potential to extend beyond compensation in particular to developing countries such as South Africa where poverty levels are high. In addition the impact of NIHL on one's health and quality of life cannot be quantified in tangible measures or standards. Thus NIHL may be considered one of the greatest threats to the country's economy and public health systems.

In the current study gold mines incurred highest costs of compensation paid out at R 1.1 billion in the period stated. There could be various reasons that contributes to the highest number of compensation paid by this commodity. Some of the reasons include the fact that the working environment in these mines can be up to two kilometres underground and up to ten kilometres into the mine on a vertical plane. In this environment miners are known to work on the rock face for several hours a day, frequently beyond the usual 8 hour working day, in the presence of high levels of noise from machinery such as drilling equipment, ventilation equipment and transportation equipment, in restricted areas which might also impact on the acoustical effects that the noise has on the these miners (Franz, Janse van Rensburg, Marx, Murray-Smith & Hodgson, 1997; Edwards et al, 2009). Moreover the Chamber of Mines has that underground

and surface mining equipment used in these mines such as jackhammers, pneumatic drills, ball mills, air compressors, drilling equipment, stoping and developing equipment and equipment for bending, riveting, grinding and cutting steel plate, are known to emit noise levels of up to 120 dBA. Noise exposure levels linked with several types of jobs in the South African gold mining setting have been reported as far beyond the legislated level of 85dBA (Kielblock, Van Rensburg, Franz & Marx, 1991; Mdaka, 2015). Similarly in the current study the most compensated occupation groups were the drill operator, stopes, jackhammer, winch driver and loco to mention a few. Thus the main culprit for accelerating NIHL in these individuals in this study could be the type of equipment used.

Finally, NIHL poses huge economic burden to the country, as evident by the costs highlighted in the current study which were incurred due to non-management of NIHL. In comparing the two years with the highest number of compensated individuals (2008), versus the year which had the lowest number of compensated individuals (2018). In 2008 the burden of NIHL was at R265 881 876.36 (265 million) to the country's GDP of 2 trillion which translated to 0.000053% for 1077 individuals compensated. In 2018 the burden was at R93.811.618.4 (93 million) to the country's GDP of 6 trillion which translated to 0.0000558% for 380 individuals. Most of these costs were borne by the employer in the form of compensation. Though the number of compensated individuals have significantly decreased by at least 65% in a decade, the costs associated with management of this preventable condition are still high. Also the impact it has on the country's GDP is concerning considering the number of individuals which were compensated by the scheme as demonstrated above. Therefore it is for this reason that NIHL is considered one of the greatest threats to the country's economic and public health systems. The South African context paints a true picture of the effects of NIHL in a developing country.

The findings of this study suggest an urgent need for strategic planning of management of NIHL in order to avoid/curb these costs. In South Africa, the government mandate the implementation of HCP for management of NIHL. Sadly there is limited data available on the effectiveness of HCP. Moreover the limited published data indicates HCPs are not yet successful (Edwards et al., 2011; Edwards et al., 2015; Edwards & Kritzinger, 2012). Moroe et al., (2018) argues that this could be due to the following reasons: 1 targeting of individual pillars at the expense of neglecting certain other pillars; 2. lack of prioritising the hierarchy of control in the management of noise, 3. the absence of Audiologists in the implementation and

evaluation of HPCs. Thus new innovative and comprehensive ways of managing NIHL are needed.

5.2 Strength of the study

Currently, this may possibly be the first study conducted on the costs incurred during investigation and management of NIHL in South Africa. Thus, this study may potentially add to the dearth of research in the cost evaluation in South Africa in the field of occupational health specifically, on work related NIHL. Moreover the data and the findings of this study are based on quantitative procedures which firmly addressed the issue of the results being consistent, precise and reliable. Additionally, results from this research project will draw much needed attention to this critical issue, encouraging initiatives to improve the auditory health and well-being of individuals exposed to excessive occupational noise in the mining sector and aiding in the development and implementation of prevention measures.

Given the current economic challenges, it is imperative to contain costs. Economic burden data from the study assisted into translating the adverse effects of NIHL into momentary terms, which is the universal language of decision makers and the policy arena. These estimates are of value when defining the magnitude of NIHL and justify intervention programs. Moreover these values will be of great benefit for policy makers in planning new evidence based focused and thoughtful effort towards the management of hazardous occupational noise in the mining industry. As previous/ current strategies have failed to prevent and manage NIHL within the mining sector as evident by the high costs associated with NIHL.

5.3 Limitation of the study

These findings should be considered with an awareness of the limitations of the study. Firstly, the small sample size, which was recruited through purposive and snowball sampling, restricts the ability to generalise the findings beyond the study sample. However, as was stated, this study aimed to highlight the impact NIHL has of the economy (at an individual level, company level and the state). Secondly the data collection tool allowed for participants who did not meet the study criteria to proceed with the study, thus these participants' responses had to be eliminated from the analysis. The study tool allowed for participants who selected the option "other" to proceed without specifying what "other" referred to. Within economic analysis, there

are different types of analysis that can be used in health economic studies, the current study only focused on cost findings and did not look at the cost of intervention. Therefore comparison between cost of prevention and the cost of disease (cost of doing nothing) were not possible. Also indirect costs associated with NIHL could not be measured due to covid-19 restriction prescribed during data collection as mentioned earlier which affected the study sample. Thus the overall economic burden of NIHL could not be measured.

5.4 Further Research

Future research on a larger representative sample, perhaps on including the indirect costs incurred due to NIHL, the mining personnel responsible for managing HCP and the individuals affected by NIHL in South African mines, may allow the issues uncovered in this study to be further explored. There is now evidence to prove that NIHL is costly and has an ability to impact the economy. Therefore research on cost effectiveness (or benefit) of engineering control (buying quite machinery) compared to hearing protection. Over and above an attempt to highlight the costs of NIHL in the South African mining sector, this study provides an opportunity for the mining sector to consider investing in cost effective analysis of NIHL conservation program to the employers. Farquhar et al. (2001) stated in their book "Public health has, for many years, been concerned with efforts to increase the efficiency of health care delivery, to measure changes in health care resource utilization and associated costs, and to link these changes to different types of interventions." From this viewpoint, research on the socioeconomic impact of NIHL is important for decision makers in occupational health and safety to implement preventive measures, service and policy.

5.5 Policy Implications

The main objective for conducting cost evaluation studies is to gather evidence-based information to be used by policymakers when planning the implementation of comprehensive program in managing NIHL at the place of work. Findings from this study could therefore be used to motivate the mining sector to invest in prioritising engineering controls over hearing protective devices as research evidence has indicated that prevalence of NIHL is high in the South African mining sector despite the government mandate the implementation of HCP. Thereby assist in reducing or possibly eliminating NIHL in the South African mining sector.

6. REFERENCES

Africa, C. o. M. o. S. (2017). *The state of mining in South Africa* Paper presented at the Parliamentary Portfolio Committee on Mineral Resources. file:///C:/Users/Tee/Downloads/the-state-of-mining-in-south-africa-2017-09-11.pdf

Agarwal, G., Nagpure, P., Sindhu Pal, K., & et al. (2015). Audiometric notching at 4 kHz: Good screening test for assessment of early onset of occupational hearing loss. *Indian Journal of Otology, 21*(4), 270-273. doi:16 October 2015

Alamgir, H., Tucker, B., Sun-Young, K., & et al. (2016). Economic Burden of Hearing Loss for the U.S. Military: A Proposed Framework for Estimation *Military Medicine, 181*(4), 301-306.

Alberti, P. W. (1991). Occupational Hearing Loss. In e. Balleng-er JJ (Ed.), *Diseases of the Nose, Throat, Ear, Head and Neck:* (pp. 1053).

Ali Jadoo, A. S., Aljunid, M. S., Sulku, S. N., & et al. (2013). Review health sustems reform from the people's point of view: development of reliable and valid questionnaire. *Malaysian Journal of Public Health Medicine 13*(2), 65-76.

Aljunid, M. S., Baguma, D., & Qusheri, A. M. (2017). Global economic burden Of asbestos related diseases in comparison with the costs of production and consumption. *Malaysian Journal of Public Health Medicine, 17*(1), 111-125. doi:10 May 2017

Allooef, M. M. (2017). The Effectiveness of Hearing Conservation Program in the Workplace. *Global Journal of Otolaryngology, 5*(4).

Amedofu, G. K. (2007). Effectiveness of hearing conservation program at a large surface gold mining company in Ghana. *African Journal of Health Sciences, 14*(1), 49-53. doi:18 June 20208

Amedofu, G. K., & Fuente, A. (2011). Occupational hearing loss in developing countries. *Audiology in developing countries*, 189-221.

Anjorin, S. A., Jemiluyi, A. O., & Akintayo, T. C. (2015). Evaluation of Industrial Noise: A case study of two Nigerian industries. *European Journal of Engineering and Technology, 3*(6).

Anna, V., Kontsevaya, O. M., Drapkina, Y. A., Balanova, A. E., Imaeva, E. I., Suvorova, M. B., ... (2018). Economic Burden of Cardiovascular Diseases in the Russian Federation in 2016. *Rational Pharmacotherapy in Cardiology*

Arenas, J. P., & Suter, A. H. (2014). Comparison of occupational noise legislation in the Americas: an overview and analysis. *Noise & Health, 16*(72), 306-309.

Arthur, J. (2016). *The effects of occupational noise evels on hearing among cement factory workers in Tema* Master of Science Occupational Hygiene Degree. University of Ghana , Legon. Retrieved from http://ugspace.ug.edu.gh/handle/123456789/21174

Azizi, M. H. (2010). Occupational noise-induced hearing loss. *International Journal of Occupational and Environmental Medicine 1*(3), 116-123.

Azmi, S., Aljunid, S. M., Maimaiti, N., & et al. (2016). Assessing the Burden of Pneumonia using administrative data from Malaysia, Indonesia and the Philippines. *International Journal of Infectious Diseases 49*, 87-93. doi:August 2016

Balfour-Kaipa, T. (2014). *Occupational health milestones and Chamber's response to key health issues*. Paper presented at the Mine medical professionals association 17th annual congress, Muldersdrift South Africa. https://slideplayer.com/slide/9226050/

Barrion M. (2015). *Exploring factors associated with potential hearing loss in Namibian class A mines*. Stellenbosch University. Retrieved from Stellenbosch University https://scholar.sun.ac.za

Basner, M., Babisch, W., Davis, A., & et al. (2014). Auditory and non-auditory effects of noise on health. *Lancet, 383*(9925), 1325–1332. doi:12 April 2014

Bloom, D. E., Cafiero, E. T., Jané-Llopis, E., & et al. (2012). *The Global Economic Burden of Non-communicable Diseases*. Retrieved from file:///C:/Users/Tee/Desktop/reserch/articles/s18806en.pdf

Bolarinwa, O. A. (2015). Principles and Methods of Validity and Reliability Testing of Questionnaires Used in Social and Health Science Researches. *Nigerian Postgraduate Medical Journal, 22*(4), 195-201.

Brand South Africa. (2017). Manufacturing in South Africa. Retrieved from https://www.brandsouthafrica.com/investments-immigration/business/economy/sectors/manufacturing-in-south-africa

Brand South Africa. (2018). South Africa's economy: key sectors [Press release]. Retrieved from https://www.brandsouthafrica.com/investments-immigration/business/investing/economic-sectors-agricultural

Butjie, B. (2017). *The effect of the Marikana events on the collective bargaining process in South Africa*. Degree in Magister Legum. Law. Nelson Mandela Metropolitan University. Retrieved from http://vital.seals.ac.za:8080/vital/access/manager/Repository/vital:26482?site_name=GlobalView

Caldart, A. U., Adriano C F., Terruel, I., & et al. (2006). The prevelance of noise induced hearing loss among textile industry workers. *International Archives of Otorhinolaryngology, 10*(3), 192-196.

Campbell, R. (2019). Mantashe highlights challenges facing South Africa's mining sector. In C. media (Ed.).

Cantley, L. F., Galusha, D., Cullen, M. C., & et al. (2015). Association between ambient noise exposure, hearing acuity, and risk of acute occupational injury. *Scand J work Environ Health, 41*(1), 75-83.

Carvalho, F. P. (2018). Mining industry and sustainable development: time for change. *Food and Energy Security, 6*(2), 61-77.

Cavalcante, F., Ferrite, S., & Meira, T. (2013). Exposure to noise in the manufacturing industry in Brazil *Epub, 5*(5).

Changik, J. O. (2014). Cost-of-illness studies: concepts, scopes, and methods. *Clinical and Molecular Hepatology, 20*(4), 327-337.

Chapel, M., & Wang, G. (2019). Understanding cost data collection tools to improve economic evaluations of health interventions *Stroke and Vascular Neurology, 4*(4).

Chen, K. H., Su, S. B., & Chen, K. T. (2020). An overview of occupational noise-induced hearing loss among workers: epidemiology, pathogenesis, and preventive measures. *Environmental Health and Preventive Medicine, 25*(65).

Chibba, S. (2018). A history of mining in South Africa. Retrieved from https://www.southafrica.net/za/en/travel/article/a-history-of-mining-in-south-africa

concha-Barrientos, M., Campbell-Lendrum., D., & Steenland, K. (2004). Assessing the burden of disease from work-related hearing

impairment at national and local levels *Environmental Burden of Disease*

Cooper, S., Alamgir, H., Whitworth, K., & et al. (2014). The Department of Defense Epidemiologic and Economic Burden of Hearing Loss Study. *Military Medicine, 179*(12), 1458.

Crandell, C., Mills, T. L., & Gauthier, R. (2004). Knowledge, behaviors, and attitudes about hearing loss and hearing protection among racial/ethnically diverse young adults. *Journal of National Medical Association, 96*(2), 176-186.

Crocker, L., & Algina, J. (1986). *Introduction to classical and modern test theory. Orlando, FL:*

Harcourt Brace Jovanovich; 1986:1-527. New York: Holt, Rinehart, and Winston.

Cunningham, L., & Tucci, D. (2017). Hearing Loss in Adults. *Engl J Med, 377*(25), 2465-2473.

Daniell, W. E., Swan, S. S., McDaniel, M. M., & et al. (2006). Noise exposure and hearing loss prevention programmes after 20 years of regulations in the United States. *Occupational Environment Med, 63*(5), 343-351.

Dawes, P., Richard Emsley, R., Cruickshanks, K. J., & et al. . (2015). Hearing Loss and Cognition: The Role of Hearing Aids, Social Isolation and Depression. *Plos one 10*(3).

Dawoud, D. M., & Baines, D. L. (2017). Economic Evaluation and Its Types. *Science Direct*, 99-119.

de Sequeira Filha, N. T., de Fatima Pessoa Militao deAlbuaquerque, M., Legood, R., & et al. (2018). The economic burden of Tuberculosis and latent Tuberculosis in patients living with HIV in Brazil: a cost study from the patient perspective. *Pubmed, 158*, 31-36.

Deaf, T. N. F. f. t. (2016). *Social and economic costs of hearing loss in New Zealand* Retrieved from New Zealand: file:///C:/Users/Tee/Desktop/reserch/articles/social-economic-cost-hearing-loss-new-zealand-021216.pdf

Department of Labour. (2019). *Compensation for occupational injuries and disease act, 1993 (ACT NO 130 OF 1993)*. Retrieved from https://www.mm3admin.co.za/documents/docmanager/editor/34/UserFiles/nihl%20document.pdf.

Devleesschauwer, B., Havelaar, A. H., Maertens de Noordhout, C., & et al. (2014). Calculating disability-adjusted life years to quantify burden of disease. *International Journal of Public Health, 59*(3), 565-569.

Ding, T., Yan, A., & Liu, K. (2019). What is noise-induced hearing loss? *British Journal of Hospital Medicine, 80*(9), 525.

Dobie, R. A. (2008). The burdens of age-related and occupational noise-induced hearing loss in the United States. *Eear hear, 29*(4), 565-577.

Edelson, J., Neitzel, R., Meischke, H., & et al. (2009). Predictors of hearing protection use in construction workers. *Annals of Occupational Hygine, 53*, 605-615.

Editor. (2018). The impact of mining on the South African economy and living standards. Retrieved from http://fse.org.za/index.php/item/593-the-impact-of-mining-on-the-south-african-economy-and-living-standards

Edwards, A., Dekker, J. J., & Franz R, M. (2011). Profiles of noise exposure levels in South African Mining. *J. S. Afr. Inst. Min. Metall., 111*(2).

Edwards, A., Geldenhuys, P., & Grové, T. (2011). *Noise-Induced hearing loss and Silicosis prevention audit tools for use in the South African mining industry*. Retrieved from https://mhsc.org.za/sites/default/files/public/research_documents/SIM%20100601%20Report_0.pdf

Edwards, A., & Kritzingert, D. (2012). Noise-induced hearing loss milestones: past and future. *J. S. Afr. Inst. Min. Metall, 112*(10December 2012).

Edwards, A., Milanzi, L. A., Khoza, N. N., & et al. (2015). Evaluation of the current practices of noise-induced hearing loss (NIHL) awareness training in the South African mining industry. *Occupational Health South Africa, 21*(1), 11-17.

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of Convenience Sampling and Purposive Sampling. *American Journal of Theoretical and Applied Statistic, 5*(1), 1-4.

European Agency for Safety and Health at Work. (2005). Reducing the risks from occupational noise *White chlorine -free paper*. Retrieved from file:///C:/Users/Tee/Downloads/TE6805535ENC_-_Reducing_the_risks_from_occupational_noise%20(1).pdf

Feder, K., Michaud, D., & McNamee, J. (2017). Prevalence of Hazardous Occupational Noise Exposure, Hearing Loss, and Hearing Protection Usage Among a Representative Sample of Working Canadians. *Journal of Occupational and Environmental Medicine, 59*(1), 92-113.

Finneran, J. (2015). Noise-induced hearing loss in marine mammals: A review of temporary threshold shift studies from 1996 to 2015. *J Acoust Soc Am, 138*(3), 1702-1726.

Gholamreza, P., Ramin, M., & Saeed, P. (2017). Noise-Induced hearing loss among professional musicians. *Journal of occupational health, 59*(1), 33-37.

Gilles, A., Van Hal, G., De Ridder, D., & et al. (2013). Epidemiology of Noise-Induced Tinnitus and the Attitudes and Beliefs towards Noise and Hearing Protection in Adolescents. *Plos one, 8*(7).

GroblerI, L., Swanepoel, D., Strauss, S., & et al. (2020). Occupational noise and age: A longitudinal study of hearing sensitivity as a function of noise exposure and age in South African gold mine workers. *S. Afr. J. Commun. Disord, 67*(2), 687.

Halperin, D. (2014). Environmental noise and sleep disturbances:

A threat to health. *Sleep Science, 7*(4), 209-212.

Healey, K. (2017). More than meets the eye: deafness and in/visible disabilitie. *CMAJ.JAMC, 189*(13), 506-507.

Hermanus, M., Coulson, N., & Pillay, N. (2015). Mine Occupational Safety and Health Leading Practice Adoption System (MOSH) examined - the promise and pitfalls of this employer-led initiative to improve health and safety in South African Mines. *J. S. Afr. Inst. Min. Metall, 115*(8), 717-727.

Hermanus, M. A. (2007). Occupational health and safety in mining—status, new developments, and concerns. *The Journal of the Southern African Institute of Mining and Metallurgy, 107*(8), 531-538.

Hong, O., Madeleine, F., Kerr, J., & et al. (2013). Understanding and preventing noise induced hearing loss. *Disease a-Month, 59*(4), 110-118.

Hume, K. (2010). Sleep disturbance due to noise: Current issues and future research. *Noise & Health, 12*(47), 70-76.

Institute of Medicine. (2006). Noise and military service implications for hearing loss and tinnitus. Retrieved from https://www.nap.edu/catalog/11443/noise-and-military-service-implications-for-hearing-loss-and-tinnitus

Jabbari, K., Nassiri, P., Esmaeelpour, M. R. M., & et al. (2016). The Relationship between Occupational Noise Exposure and Noise Induced Hearing Loss (NIHL) in Small-Scale Industries: A Case Study in the City of Damavand, Iran. *Biotech Health Sci, 3*(4), 49-56.

Jo, C. (2014). Cost-of-illness studies: concepts, scopes, and methods. *Epub, 20*(4), 327-337.

Jose, P., & Szabo, A. (2017). *Handbook of Educational Research* (Vol. 1). New Zealand: Sage Editors.

Kahan, E., & Ross, E. (1994). Knowledge and attitudes of a group of South African mine workers towards noise induced hearing loss and the use of hearing protective devices. . *South African Journal of Communication Disorders, 4*, 37-47.

Kanji, A., Khoza-Shangase, K., & Ntlhakana, L. (2019). Noise-induced hearing loss: what South African mineworkers know. *International Journal of Occupational Safety and Ergonomics, 25*(2), 305-310. doi:10.1080/10803548.2017.1412122

Kanji A., Khoza-Shangase K., & Ntlhakana L. (2019a). Noise-induced Hearing Loss: What South African Mineworkers Know. *International Journal of Occupational Safety and Ergonomics, 25*(2).

Kanji A., Khoza-Shangase K., & Ntlhakana L. (2019b). Noise-induced hearing loss: What South African mineworkers know. *Pubmed, 25*(2), 305-310.

Khoshakhlagh, A. H., & Ghasemi, M. (2017). Occupational Noise Exposure and Hearing Impairment among Spinning Workers in Iran. *Iranian Red Crescent Medical Journal, 19*(5), e42712.

Khoza-Shangase, K., & Moroe, N. F. (2020). Risk versus benefit: Should not audiologists assess this in the context of occupational noise-induced hearing loss in the mining industry? *S Afr J Commun Disord, 67*(2), 671.

Khoza-Shangase, K., Moroe, N. F., & Edwards, A. (2020a). Occupational Hearing loss in Africa: An interdisciplinary view of the current status. *S Afr J Commun Disord, 67*(2), 700. doi:3 March 2020

Khoza-Shangase, K., Moroe, N. F., & Edwards, A. (2020b). Occupational Hearing loss in Africa: An interdisciplinary view of the current status. *S Afr J Commun Disord, 67*(2).

Kimberlin, C. L., & Winterstein, A. L. (2008). Validity and reliability of measurement instruments

used in research

Am J Health-Syst Pharm, 65, 2267-2284.

Kistnasamy, B., Yassi, A., Yu, J., & et al. (2018). Tackling injustices of occupational lung disease acquired in South African mines: recent developments and ongoing challenges. *Globalization and Health, 14*(60).

Koskinen, H. L., Kauppinen, T., & Tenkanen, L. (2011). Dual role of physical workload and occupational noise in the association of the metabolic syndrome with risk of coronary heart disease: findings from the Helsinki Heart Study. *Occupational Environment Med, 68*(9), 666-673.

Kou-Huang, C., Shih-Bin, S., & Kow-Tong, C. (2020). An overview of occupational noise-induced hearing loss among workers: epidemiology, pathogenesis, and preventive measures. *Environmental Health and Preventive Medicine, 25*(65).

Leather, P., Beale, D., & Sullivan, L. (2003). Noise, psychosocial stress and their interaction in the workplace. *Journal of Environmental Psychology, 23*(2), 213-222. doi:https://doi.org/10.1016/S0272-4944(02)00082-8

Lie, A., Skogstad, M., Johannessen, H., & et al. (2016). Occupational noise exposure and hearing: a systematic review. *Int Arch Occup Environ Health 89*(3), 351-372.

Litchfield, P., Cooper, C., Hancock, C., & et al. (2016). Work and Wellbeing in the 21st Century. *Int J Environ Res Public Health., 13*(11), 1065.

Litwin, M. (1995). *How to Measure Survey Reliability and Validity*. City of California: Sage Publications.

Mahendra-Prashanth, K. V., & Sridhar, V. (2008). The relationship between noise frequency components and physical, physiological and psychological effects of industrial workers. *Noise Health, 10*(40), 90-98.

Mailu , J. M. (2016). *Establishing employees perception on occupational health and safety concerns at East African portland and cement*. (Master of Science

(Occupational Safety and Health)), Jomo Kenyatta University of Agriculture and Technology Retrieved from file:///C:/Users/Tee/Desktop/reserch/articles/Mailu,%20%20bb%20Judith%20Mutindi.%20MSc%20occupation%20safety%20and%20health,%202016.pdf

Manufacturing Indaba. (2018). *Manufacturing sector proves to be job creation engine of South Africa*. Paper presented at the 5th Annual Manufacturing Indaba to highlight sector's impact on job creation, Sandton Convention Centre Johannesburg. http://manufacturingindaba.co.za/manufacturing-sector-job-creation-engine-south-africa/

Marcellusi, A., Capone, A., Mennini, F. S., & et al. (2015). The economic burden of HCV-induced diseases in Italy. A probabilistic cost of illness model. *European review for medical and pharmacological sciences 19*(9), 1610-1620.

Masaka, E. (2009). *THE PREVALENCE OF NOISE INDUCED HEARING LOSS AT A NICKEL MINE IN ZIMBABWE*. . (Masters of Public Health (Occupational Hygiene)), University of the Witwatersrand. Retrieved from /C:/Users/Tee/Desktop/reserch/literature%20review/MPH%20RESEARCH%20PROJECT%20REPORT%20THE%20PREVALENCE%20OF%20NOISE%20INDUCED%20.pdf

Masterson, E. A., Tak, S., Themann, C. L., & al., e. (2013). Prevalence of hearing loss in the United States by industry. *American Journal of Industrial Medicine, 56*(6), 670-681.

Masterson, E. A., Themann, C. L., Luckhaupt, S. E., & al., e. (2016). Hearing difficulty and tinnitus among U.S. workers and non-workers in 2007. *American Journal of Industrial Medicine, 59*(4), 290-300.

Mazlana, A., & Yahyab, K. (2015). Compensation Process for Noise Induced Hearing Loss. *Jurnal Teknologi, 74*(4), 13-17.

McReynolds, M. C. (2005). Noise induced hearing loss. *American Journal of Medicine, 24*(2), 73-78.

Mdaka, T. (2015). *Assessment of noise levels in work areas at the Polokwane platinum smelter, South Africa* Master of Science in Physiology. Faculty of Science and Agriculture (School of Molecular & Life Science). University of Limpopo, Turfloop Campus. Retrieved from http://ulspace.ul.ac.za/bitstream/handle/10386/1296/mdaka_tc_2015.pdf?sequence=1&isAllowed=y

Mizan, G. E., Abrahams, O., Sekobe, G., & et al. (2014). Noise-induced hearing loss and hearing conservation in the iron and steel industry in South Africa. *Occupational Health Southern Africa 20* (6).

Mohammed, R. H., & Dickinson, D. (2010). Hearing protection device usage at a South African gold mine. *Occupational medicine, 60*(1), 72-74.

Mohapi, G., & Zaiske, R. (2018). *Health and Safety on South African mines: A best practice report*. Retrieved from http://cellit.co.za/ccmr/Health_Safety_SA_Mines_singles.pdf

Morata, T. C., Themann, C. L., Randolph, R. F., & et al. (2005). Working in noise with a hearing loss: perceptions from workers, supervisors, and hearing conservation program managers. *Ear Hear, 26*(6), 529-545.

Moroe, N. F. (2018). Occupational noise-induced hearing loss in South African large-scale mines: exploring hearing conservation programmes as complex interventions embedded in a realist approach. *International Journal of Occupational Safety and Ergonomics, 26*(4), 753-761

Moroe, N. F., & Khoza-Shangase, K. (2018a). Management of occupational noise induced hearing loss in the mining sector in South Africa: Where are the audiologists? *Journal of Occupational health 60*(5), 376-382.

Moroe, N. F., & Khoza-Shangase, K. (2018b). Research into occupational noise induced hearing loss in South African large-scale mines: Access denied? *AAAS open research, 1*, 1-4.

Moroe, N. F., Khoza-Shangase, K., Kanji, A., & et al. (2018). The management of occupational noise–induced hearing loss in the mining sector in Africa: A systematic review – 1994 to 2016. *Noise & Vibration Worldwide, 49*(5), 181-190. doi:10 July 2018

Moroe, N. F., Khoza-Shangase, K., Madahana, M., & et al. (2019). A proposed preliminary model for monitoring hearing conservation programmes in the mining sector in South

Africa. *The Journal of the Southern African Institute of Mining and Metallurgy, 119*(7), 671-679.

Moroe, N. F., Khoza-Shangase, K., Madahana, M., & et al. (2020). Feedback-based noise management matrix in action. *S Afr J Commun Disord, 67*(2).

Morris, M. (2017). The dangerous world of South Africa's deep-level mining. *News24*. Retrieved from https://www.news24.com/Columnists/GuestColumn/the-dangerous-world-of-south-africas-deep-level-mining-20171229

Mpinga, S. (2018). The Mine Health and Safety Report: Assessing the Functioning of the Occupational Diseases in Mines and Works Fund. Retrieved from http://www.mlia.uct.ac.za/news/mine-health-and-safety-report-assessing-functioning-occupational-diseases-mines-and-works-fund

Münzel, T., Sorensen, M., Schmidt, E., & et al. (2018). The Adverse Effects of Environmental Noise Exposure on Oxidative Stress and Cardiovascular Risk. *Antioxid Redox Signal., 28*(9), 873–908.

Narlawar, U. W., Surjuse, B. G., & Thakre, S. S. (2006). Hypertension and hearing impairment in workers of iron and steel industry. *Indian Journal of Physiology and Pharmacology, 50*(1), 60-66.

National Institute of Occupational Health and Safety. (2009). *Noise and hearing loss prevention*. Retrieved from www.cdc.gov/niosh/.

Neitzel, R., Swinburn, T., Hammer, D., & et al. (2017). Economic Impact of Hearing Loss and Reduction of Noise-Induced Hearing Loss in the United States. *Journal of Speech, Language, and Hearing Research, 60*(1), 182-189.

Nelson, D. I., Nelson, R. Y., Concha-Barrientos, M., & et al. (2005). The Global Burden of Occupational Noise Induced Hearing Loss. *American journal of industrial medicine, 48*(6), 400-408.

Nkosi, V., Claassen, N., & Voyi, K. (2015). Occupational noise-induced hearing loss prevalence and noise abatement techniques in a steel-making plant. *Occupational Health Southern Africa, 21*(5).

Ntlhakana, L., Khoza-Shangase, K., & Nelson, G. (2020). Estimating miners at risk for occupational noise-induced hearing loss: A review of data from a South African platinum mine. *S Afr J Commun Disord, 76*(2), 677.

Ologe, F. E., Tanimola, M., Olajide, A., & et al. (2005). Noise exposure, attitudes and use of hearing protection in a steel rolling mill in Nigeria. *Occupational Medicine, 55*(6), 487-489.

Ose, S. O. (2005). Working conditions, compensation and absenteeism. *Health economics, 24*(1), 161-188.

Pallarito, K. (2013). Work-Related Hearing Loss Claims: Conclusive Data Prove Elusive *The hearing journal, 66*(4), 28-30.

Paoli, P., & Merllié, D. (2000). *Third European survey on working conditions* Retrieved from Ireland: https://www.eurofound.europa.eu/publications/report/2001/working-conditions/third-european-survey-on-working-conditions-2000

Polit, D. F., & Beck , C. T. (2006). The content validity index: Are you sure you know what's being reported? Critique and recommendations. *Res Nurs Health, 29*(5), 489-497.

Potter, S., Davies, C., Davies, G., & et al. (2020). The use of micro-costing in economic analyses of surgical interventions: a systematic review. *Health Economics Review, 10*(3).

Prevention, C. f. D. C. a. (2017). Worker hearing loss. Retrieved from https://www.cdc.gov/features/worker-hearing-loss/index.html

Protect ear, U. (2012). Work related hearing loss in manufacturing industry. https://www.protectear.com/us/blog/2012/06/05/work-related-hearing-loss-in-the-manufacturing-industry/.

Rabinowitz, P. M. (2000). Noise induced hearing loss. *American Family Physician, 61*(9), 274 279 – 256, 2759 – 2276.

Rachiotis, G., Alexopoulos, C., & Drivas, S. (2006). Occupational exposure to noise, and hearing function among electro production workers. *Auris Nasus Larynx, 33*(4), 381-385.

Radi, S., Geza Benke, G., Schaafsma, F., & et al. (2016). Compensation claims for occupational noise induced hearing loss between 1998 and 2008: yearly incidence rates and trends in older workers

Samia Radi,1 Geza Benke,1 Frederieke Schaafsma,2,1 Malcolm Sim1. *Australian and New Zealand Journal of Public Health, 40*(2).

Raghunath, G., Suting, L. B., & Maruthy, S. (2012). Vestibular symptoms in factory workers subjected to noise for a long period. . *International Journal of Occupational Environmental Medicine, 3*(1), 36-44.

Rayan, A., Kujawa, S., Hammill, T., & et al. (2017). Temporary and Permanent Noise-Induced Threshold Shifts: A Review of Basic and Clinical Observations. *Otol Neurotol, 37*(8), 271-275.

Rikhardsson, P. L. (2019). Corporate Social Responsibility and Environmental Management. *Accounting for theCost of Occupational Accidents, 11*, 63-70.

Roberts, S. L. E., Healey, A., & Sevdalis, N. (2019). Use of health economic evaluation in the implementation and improvement science fields—a systematic literature review. *Implementation Science volume, 14*(72).

Sanghavi, S. (2016). Predictive Maintenance: Marrying Safety With Productivity. Retrieved from https://www.manufacturing.net/article/2016/12/predictive-maintenance-marrying-safety-productivity

Sangoseni, O., Hellman, M., & Hill, C. (2013). Development and validation of a questionnaire to assess the effect of online learning on behaviors, attitude and clinical practices of physical therapists in United States regarding of evidence-based practice. *Internet J Allied Health Sci Pract 11*(2), 1-12.

Saremi, M., Rohmer, O., Burgmeier, A., & et al. (2008). Combined effects of noise and shift work on fatigue as a function of age. *International Journal of Occupational Safety and Ergonomics, 14*(4), 387-394.

Sayler, S. K., Rabinowitz, P. M., & Cantley, L. F. (2018). Costs and Effectiveness of Hearing Conservation Programs at 14 US Metal Manufacturing Facilities. *Int J Audiol., 57*(1), S3-S11.

Schokry, A. (2015). Evaluation of Noise Levels in Different Industrial Sectors within the Gaza Strip: A Pilot Study *Journal of Materials Science and Engineering 5*(6), 202-208.

Seabi, J. M. (2014). *Chronic Aircraft Noise Exposure Effects on Children's Learning and Development*

(Doctor of Philosophy), University of the Witwatersrand, Johannesburg. Retrieved from http://wiredspace.wits.ac.za/handle/10539/15850

Seixas, N. S., Neitzel, R., Stover, B., & et al. (2011). A multi-component intervention to promote hearing protector use among construction workers. . *International Journal of Audiology, 50*(Suppl1 (0 1)), S46-56.

Shield, B. (2006). *Evaluation of the social and economic costs of hearing impairment* Retrieved from https://www.hear-it.org/sites/default/files/multimedia/documents/Hear_It_Report_October_2006.pdf

Si, S., Lewkowski, K., Heyworth, J., & et al. (2020). Productivity Burden of Occupational Noise-Induced Hearing Loss in Australia: A Life Table Modelling Study. *Int J Environ Res Public Health, 17*(13), 4667.

Staff Writer. (2018). The biggest economies in Africa. *Bisiness Tech*. Retrieved from https://businesstech.co.za/news/finance/257337/the-biggest-economies-in-africa/

Starkey Hearing. (2017). HearingFactFriday: Hearing loss is America's most common work-related injury. Retrieved from https://www.starkey.com/blog/2017/06/Most-common-workplace-injury-in-America

Statistics, S. (2014). *Manufacturing and Construction industries*. Retrieved from file:///C:/Users/Tee/Desktop/reserch/Manufacturing%20SA/Manufacturing_And_Construction_2014_MediaPresentation.pdf.

Stocks, S. J., McNamee, R., Van der Molen, H. F., & al., e. (2015). Trends in incidence of occupational asthma, contact dermatitis, noise-induced hearing loss, carpal tunnel syndrome and upper limb musculoskeletal disorders in European countries from 2000 to 2012. *Occupational Environment Med, 72*(4), 294– 303.

Strauss, S., Swanepoel, D. W., Becker, P., & et al. (2018). Noise and age related hearing loss-A study of 40123 South African gold miners *Journal of communication disorders 4*(10), 11-38.

Ta-Yuan, C., Chiu-Shong, L., Li-Hao, Y., & et al. (2012). Noise frequency components and the prevalence of hypertension in workers. *Scince of the total environment, 416*, 89-96.

Tahir, N., Aljunid, M. S., Hashim, H. J., & et al. (2014). Burden of Noise Induced Hearing Loss among Manufacturing Industrial Workers in Malaysia. *Iranian journal of public health, 43*(3), 148-153. doi:21 October 2015

Tak, S., Davis, R. R., & Calvert, G. M. (2009). Exposure to hazardousn workplace noise and use of hearing protection devices among US workers—NHANES, 1999–2004. *Am J Ind Med, 52*(5), 58-71.

The Provincial Review. (2016). *The real economy bulletin* Retrieved from file:///C:/Users/Tee/Desktop/reserch/articles/The_REB_Provincial_Review_2016_Gauteng.pdf

Themann, C. L., Suter, A. H., & Stephenson, M. R. (2013). National research agenda for the prevention of occupational hearing loss—part 1. *Semin Hear, 34*(3), 208-252.

Themanna, C., & Masterson, E. (2019). Occupational noise exposure: A review of its effects, epidemiology, and impact with recommendations for reducing its burden. *The Journal of the Acoustical Society of America 146*(5), 3879.

Thorne, P., Ameratunga, S. N., Stewart, J., & al., e. (2008). Epidemiology of noise-induced hearing loss in New Zealand. *The New Zealand medical journal, 121*(1280), 33-44.

Treasury, G. P. G. (2016). *Socio-Economic Review and Outlook*. Retrieved from http://www.treasury.gov.za/documents/provincial%20budget/2016/3.%20Provincial%20Appropriation%20Acts/5.%20Guide%20to%20the%20Budget/GT/Gauteng%20-%20Social-Economic%20Review%20and%20Outlook.pdf

Trung, N., Straatman , L. V., Lea, J., & et al. (2017). Current insights in noise-induced hearing loss: a literature review of the underlying mechanism, pathophysiology, asymmetry, and management options. *Journal of Otolaryngology Head and Neck Surgery, 46*(41).

Tshoose, C. (2014). Placing the right to occupational health and safety within a human rights framework: trends and challenges for South Africa. *The Comparative and International Law Journal of Southern Africa, 47*(2), 276-296.

Tufts, J. B., Weathersby, P. K., & Rodriguez, F. A. (2010). Modeling the Unites States government's economic cost of noise-induced hearing loss for a military population. *Scand J work Environ Health, 36*(2), 242-249.

Van Dijk, F. J. (1986). Non-auditory effects of noise in industry. II. A review of the literature. *International Archives of Occupational and Environmental Health, 58*(4), 325-332.

Vos, T., Flaxman, A., & Naghavi, M., et al. . (2012). A systematic analysis for the Global of Disease Study. *Lancet, 380*(216), 3-96.

Vos, T., Flaxman, A. D., Naghavi, M., & et al. (2012). Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet, 380*(9859), 2163-2196.

Wang, L., Lei, S., Cocker, F., & et al. (2018). A Systematic Review of Cost-of-Illness Studies of Multimorbidity. *Pubmed*.

Worl Health Organization. (2005). *Guidelines for estimating the economic burden of diarrhoeal disease, with focus on assessing the costs of rotavirus diarrhoea*. Switzerland Retrieved from www.who.int/vaccines-documents/.

Worl Health Organization. (2009). *WHO Guide to identifying the economic consequences of disease and injury* Retrieved from file:///C:/Users/Tee/Desktop/reserch/articles/d_economic_impact_guide%20(2).pdf

Worl Health Organization. (2011). *Burden of disease from environmental noise*. Retrieved from file:///C:/Users/Tee/Desktop/reserch/articles/environmemntal%20noise%20burden%20of%20disease.pdf

Worl Health Organization. (2015). *Hearing loss due to recreational exposure to loud sounds*. Retrieved from https://apps.who.int/iris/handle/10665/154589.

Worl Health Organization. (2017). *Global costs of unaddressed hearing loss and cost-effectiveness of intervention*. Retrieved from file:///C:/Users/Tee/Desktop/reserch/articles/global%20cost%20of%20unaddressed%20hearing%20loss.pdf

World Health Organization. (2017). *Protecting workers' health*. Retrieved from https://www.who.int/news-room/fact-sheets/detail/protecting-workers'-health

Xu, X., Grossetta Nardini, H. K., & Ruger, J. P. (2014). Micro-costing studies in the health and medical literature: protocol for a systematic review. *Pubmed*.

Yankaskas, K. (2013). Prelude: noise-induced tinnitus and hearing loss in the military. *Hearing Research, 295*, 3-8.

Zare, S., Baneshi, M. R., Hemmatjo, R., & et al. (2018). The Effect of Occupational Noise Exposure on Serum Cortisol Concentration of Night-shift Industrial Workers: A Field Study. *Saf Health Work, 10*(1), 109-113.

7. APPENDICES

Appendix A: Audiologists study Questionnaire

Section 1

Work Environment

1. In your practice/ place of work do you see individuals who work in the mining sector and are exposed to excessive noise?
   [ ] a). Yes [ ] b). No

2. Who refers these individuals to you?
   [ ] a). Referred by the employer [ ] b). Self-referral
   [ ] c). Referred by other health professionals (please specify)
   _____
   [ ] d. Other (please specify)
   _____

3. Who is responsible for paying the costs of the service rendered?
   [ ] a). Employer is responsible for the costs
   [ ] b). Costs claimed from medical aid and covered in full
   [ ] c). The client is responsible for the costs of the service rendered
   [ ] d). Other (please specify)
   _____
   _____

4. On average how many sessions does the client have to consult before diagnoses of noise induced hearing loss are made?
   _____

5. On average what is the cost of diagnostic hearing test?
   _____

6. Are Individuals diagnosed with noise induced hearing loss fitted with hearing aids?
   [ ] a). Yes [ ] b). No
   [ ] c). Other (please specify)
   _____
   _____

7. What is the average cost of each hearing aid?

_____

_____

8. Do these individuals need to attend aural rehabilitation?
   [ ] a). Yes [ ] b). No
   [ ] c). Other (please specify)
   _____
   _____
   _____
9. On average how many sessions of therapy do these individuals have to attend?
   _____
10. On average what is the cost of aural rehabilitation session?
    _____
11. Are there any known additional costs incurred during noise induced hearing loss diagnosis and management?

[ ] a). Yes [ ] b). No

[ ] c). Other (please specify)

_____

12. If yes, what are those costs?
    _____
    _____
    _____
    _____
13. Are clients who presents with noise induced hearing loss referred to other health professionals for further investigation

    [ ] a). Referred to ENT doctor
    [ ] b). Referred to company doctor
    [ ] c). Other referrals (please specify)
    _____
    _____
    _____
    _____

The End

Appendix B: Workmen's Compensation Questionnaire

1. What is the total number of reported claims for noise induced hearing loss in the last decade in the mining sector (2008-2018)?

   _____

2. Please state the total number of reported claims per year for noise induced hearing loss in the last decade in the mining industry

Mining entity	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gold											
Diamond											
platinum											
Coal											

3. What is the total number of acceptable claims for noise induced hearing loss from the reported claims in the mining sector in the last decade (2008 -2018)?

   _____

4. Please lists the total number of acceptable of claims per mining commodity in the last decade

Commodity	Number of acceptable claims for noise-induced hearing loss
Gold mines	
Diamond mines	
Platinum mines	
Coal mines	

5. Please list the number of acceptable claims for noise induced hearing loss per mining commodity in the last decade

Mining commodity	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gold											
Diamond											
platinum											
Coal											

6. Please list the top five occupational groups from which claims were receive from per commodity per year

Mining commodity	Occupational groups	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gold	1. 2. 3. 4. 5											
Diamond	1. 2. 3. 4. 5.											
Platinum	1. 2. 3. 4. 5.											
Coal	1. 2. 3. 4. 5.											

7. Please state the number of acceptable claims according to gender per commodity

Mining commodity	2008		2009		2010	2011	2012	2013	2014	2015	2016	2017	2018
	F	M	F										
Gold													
Diamond													
platinum													
Coal													

8. How many acceptable claims were received per year according to age group?

Age group	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
21-35											
35-45											
45-55											
55-65											
65+											

9. Please state the compensation pay-out per year in the last decade per mining commodity

Mining entity	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gold											
Diamond											
platinum											
Coal											

10. Please list the number of compensated claims per mining sector in the last decade?

Mining commodity	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gold											
Diamond											
platinum											
Coal											

The End

Appendix C: Request Letter to Conduct Study at Workmen's Compensation scheme
To delete

SPEECH PATHOLOGY & AUDIOLOGY
THE SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT (SHCD)

Private Bag 3, Wits, 2050 • Tel: 011 717 4577 • Fax: 011 717 4572 • E-mail: sppa.SHCD@wits.ac.za

Dear Sir/ Madam

RE: Permission to Conduct Research Study

My name is Thandeka Radebe and I am an Audiologist at Charlotte Maxeke Johannesburg Academic Hospital. I am currently enrolled in the department of Speech Language Pathology and Audiology at the University of Witwatersrand and am in the process of writing my master's dissertation. I hereby request permission to conduct my research study at Rand Mutual Assurance (RMA) (compensation of noise induced hearing loss division). The study is entitled: The economic cost of noise induced hearing loss in individuals exposed to excessive occupational noise within the South African mining industry, practitioner's perspective.

I hope that the CEO of RMA will allow me to recruit the medical manager tasked with handling claims for occupational injuries and diseases to anonymously complete a questionnaire (copy enclosed). The medical manager will be requested to complete a questionnaire about compensation processes for employees diagnosed with noise induced hearing loss. The medical manager may omit answering questions which they do not feel comfortable or/and are not allowed to respond to. The questions should take no longer than 60 minutes to answer. Completing and submitting the questionnaire will be taken as consent given. The medical manager would be requested to complete a self-administered questionnaire at work at their convenient time.

Costs: Participation in this study is voluntary. Participant/s will also be informed that they can withdraw from the study at any point without negative consequences. There will be no costs incurred for both participants and RMA at any point during the study.

Confidentiality and Anonymity: Every effort will be made to keep personal information confidential. No identifying information for the company or the participant will be used; instead participant numbers will be used in the research study (e.g. 0001). Raw information (i.e. questionnaire) will be kept in a locked cabinet where only the researcher and her supervisors can access. The researcher will not include any information in any report that may be published that would make it possible to identify the participant and the company.

Your permission to conduct the research at your company will be greatly appreciated. Evidence from this proposed study will contribute towards prevention and management of noise-induced hearing loss in individuals exposed to excessive occupational noise.

Should permission be granted, kindly email a signed letter of permission acknowledging your permission for my study to be conducted at your company. After the completion of my study, I will provide you with a copy of my complete research report upon request. If you have any enquiries, concerns or complaints regarding the ethical procedures of this study you are welcome to contact the University Human Research Ethics Committee (non-medical), telephone 011 717 108, email shaun.schoeman@wits.ac.za

For any further details about the study, please do not hesitate to contact me or my supervisors on the details below:

Student and researcher Thandeka Radebe

Email: thandeka.gpr@gmail.com

Tel: 011 488 3044 / 073 224 4695

Supervisor: Dr. N. Moroe (supervisor)

Email: nomfundo.moroe@wits.ac.za

Tel: 011 717 4501

Supervisor: Dr. D. Pillay

Email: dhanashree.pillay@wits.ac.za,

Tel: 011 717 4581

Appendix E: Participants Information Sheet for Audiologists

SPEECH PATHOLOGY & AUDIOLOGY
THE SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT (SHCD)

Private Bag 3, Wits, 2050 • Tel: 011 717 4577 • Fax: 011 717 4572 • E-mail: sppa.SHCD@wits.ac.za

Participant Information Sheet

Dear Sir/Madam

My name is Thandeka Radebe and I am a Postgraduate student at the University of Witwatersrand. I am conducting research on the economic cost of noise-induced hearing loss in individuals exposed to excessive occupational noise within the South African mining industry- practitioner's perspective.

As part of this project, I would like to invite you to participate in answering a questionnaire or an online survey. You will be requested to complete a short questionnaire/ survey about diagnoses process, treatment process and costs incurred during the management of individuals with noise induced hearing loss. The questions should take no longer than 15 minutes to answer. Completing and submitting the questionnaire/ online survey will be taken as consent given.

Participation is voluntary, there are no penalties for you should you not wish to participate or wish to withdraw from the study at any stage. You will not receive any benefits from participating in this study. You may withdraw at any time or not answer any question if you do not want to. The questionnaire will be completely confidential. The researcher will not be collecting or retaining any information about your identity. The records of this study will be kept strictly confidential. Research records will be kept in a locked file, and all electronic information will be coded and secured using a password protected file. The researcher will not include any information in any report that may be published that would make it possible to identify you.

If you require any further information or have any questions regarding the research, feel free to contact me on the details below. A research report will be written from the information obtained in this study. If you wish to receive a summary of this report, I will be happy to send it to you upon request.

If you have any queries, concerns or complaints regarding the ethical procedures of this study you are welcome to contact the University Human Research Ethics Committee (non-medical), telephone 011 717 108, email shaun.schoeman@wits.ac.za

Your participation in this study will be highly appreciated.

Yours sincerely,

Thandeka Radebe

Email: thandeka.grp@gmail.com, Tel: 0732244695
Dr. N. Moroe (supervisor), email: nomfundo.moroe@wits.ac.za, Tel: 011 717 4501
Dr. D. Pillay (supervisor), email: dhanashree.pillay@wits.ac.za, Tel: 011 717 4581

Appendix F: Participants Information Sheet for Compensation Scheme Representative

SPEECH PATHOLOGY & AUDIOLOGY
THE SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT (SHCD)

Private Bag 3, Wits, 2050 • Tel: 011 717 4577 • Fax: 011 717 4572 • E-mail: sppa.SHCD@wits.ac.za

Participant Information Sheet

Dear Sir/Madam

My name is Thandeka Radebe and I am a Postgraduate student at the University of Witwatersrand. I am conducting research on the economic cost of noise-induced hearing loss in individuals exposed to excessive occupational noise within the South African mining industry- practitioner's perspective.

As part of this project, I would like to invite you to participate in answering a questionnaire. You will be requested to complete a short questionnaire about the compensation process followed for compensating individuals with noise induce hearing loss. The questions should take no longer than 60 minutes to answer. Completing and submitting the questionnaire be taken as consent given.

Participation is voluntary, there are no penalties for you should you not wish to participate or wish to withdraw from the study at any stage. You will not receive any benefits from participating in this study. You may withdraw at any time or not answer any question if you do not want to. The questionnaire will be completely confidential. The researcher will not be collecting or retaining any information about your identity. The records of this study will be kept strictly confidential. Research records will be kept in a locked file, and all electronic information will be coded and secured using a password protected file. The researcher will not include any information in any report that may be published that would make it possible to identify you or your employer.

If you require any further information or have any questions regarding the research, feel free to contact me on the details below. A research report will be written from the information obtained in this study. If you wish to receive a summary of this report, I will be happy to send it to you upon request.

If you have any queries, concerns or complaints regarding the ethical procedures of this study you are welcome to contact the University Human Research Ethics Committee (non-medical), telephone 011 717 108, email shaun.schoeman@wits.ac.za

Your participation in this study will be highly appreciated.

Yours sincerely,

Thandeka Radebe

Email: thandeka.grp@gmail.com, Tel: 0732244695
Dr. N. Moroe (supervisor), email: nomfundo.moroe@wits.ac.za, Tel: 011 717 4501
Dr. D. Pillay (supervisor), email: dhanashree.pillay@wits.ac.za, Tel: 011 717 4581

Appendix G Non-Medical Human Research Ethical committee

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Radebe

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H19/05/26**
PROJECT TITLE	Economic cost of noise-induced hearing loss in individuals exposed to excessive occupational noise in mining industry, South Africa
INVESTIGATOR(S)	Miss T Radebe
SCHOOL/DEPARTMENT	Human and Community Development/
DATE CONSIDERED	24 May 2019
DECISION OF THE COMMITTEE	Approved
EXPIRY DATE	03 September 2022

DATE 04 September 2019 **CHAIRPERSON** _____
(Professor J Knight)

cc: Supervisor : Dr N Moroe

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University. Unreported changes to the application may invalidate the clearance given by the HREC (Non Medical)

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to completion of a yearly progress report.**

_____ _____/_____/_____
Signature Date

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES