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The use of hearing protection devices in hearing conservation programs: knowledge, attitude and views of South African mine workers regarding NIHL and the use of HPD`S in the gold and non-ferrous mining subsectors.

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TITLE:

The Use of Hearing Protection Devices in Hearing Conservation Programs: Knowledge, attitude and views of South African mine workers regarding NIHL and the use of HPDs in the gold and non-ferrous mining subsectors.

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FOR THE PURPOSE OF MASTERS IN ARTS AUDIOLOGY

FACULTY OF HUMANITIES

DEPARTMENT OF SPEECH PATHOLOGY AND AUDIOLOGY

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DECLARATION

I hereby declare that I am the sole author of this research thesis and the work contained in this research is my original contribution and has not been submitted for any other degree or to any other institution.



Liepollo Ntlhakana **10th January 2014**

Date

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Abstract

Background: Hearing conservation programmes (HCPs) in South African mines have been reported to be efficient in reducing noise-induced hearing loss (NIHL). Although reduced, cases of NIHL still occur in South African mines and NIHL has been reported to be the second most common occupational medical condition in South African mines. Occupational audiologists have a critical role to play as team members in the HCPs to reduce NIHL. The one key contributing factor for occupational audiologists is to promote the appropriate use of HPDs by the South African miners in order to prevent NIHL. The current research study was conducted at two South African mines, a gold mine and a non-ferrous mine, in order to investigate HPD usage with an effective HCP.

Objective: The main purpose of the current study was to investigate the knowledge, attitude and views of South African miners regarding NIHL and the use of HPDs in HCPs in the gold and non-ferrous mining subsectors.

Study Design and Method: A non-experimental descriptive design was used for the purpose of the current research study. Structured interviews were conducted on a group of 90 participants: 65 participants from a gold mine in Gauteng Province and 25 participants from a non-ferrous mine in Limpopo Province. The participants were randomly selected from the training centre and the workplace of the gold mine and the non-ferrous mine respectively. The structured interviews were set in a questionnaire format with open and close-ended questions. Data collected were analysed using a descriptive statistical analysis test.

Results: The results of the current research study were analysed in accordance with the following sub-aims: participants' knowledge regarding hearing safety and associated NIHL; description of noise sources at the mines; participants' knowledge, attitudes and views regarding the use of HPDs; and the factors impeding and/or positively influencing the miners' use of HPDs.

The results indicated that all the participants were provided with some sort of HPD and that the majority of participants (n=88) used HPDs throughout the shift. The participants were exposed to a variety of noise sources with excessive noise levels as per different types of occupations. The participants acknowledged that an excessive noise level in their workplace was the most common cause of NIHL. The participating mines conducted compulsory annual re-induction training for all the mine employees in conjunction with medical examinations. The participants' attitudes towards and views of the use of HPDs were that "it was an enforced mine policy". The factors that affected the participants' use of HPDs included the following: lack of comfort; improper fit of HPDs associated with loose fittings, earaches and sweating during use and difficulty hearing.

The statistical test used was the chi-square test of contingency tables. The test determined the relationship between gender, level of education and years of experience and the use of HPDs. However, there is not enough evidence at the 5 % significance level to infer that gender, level of education and years of experience were related to the mine workers' use of HPDs. The insignificant statistical values obtained may be ascribed to the small sample size.

Conclusion: The results obtained indicate positive reported use of HPDs, thus confirming the effectiveness of HCPs employed by the participating mines. However, limited information on the actual use of HPDs may explain the NIHL cases that still occur in the mining sector. The current study highlights the need for imparting in-depth information on hearing safety and NIHL during HCP re-induction training as well as the importance of involving occupational audiologists in follow-up during annual medical examinations. However, the results obtained from the current study cannot be generalised to the greater mining population due to the small sample size.

Keywords: ***Hearing conservation programme, Hearing protection devices, Noise-induced hearing loss.***

List of Abbreviations

COIDA – Compensation for Occupational Injuries and Diseases Act

COP – Code of Practice

GDP – Gross Domestic Product

HCP – Hearing Conservation Programme

HPD – Hearing Protection Device

MHSC – Mine Health and Safety Council

MHSA – Mine Health and Safety Act

NIHL – Noise-induced Hearing Loss

OHC – Outer Hair Cells

OHSA – Occupational Health and Safety Act

OSHA – Occupational Safety and Health Administration

PTS – Permanent Threshold Shift

SANS – South African National Standards

TTS – Temporary Threshold Shift

WHO – World Health Organisation

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CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

1.1 Noise-induced hearing loss

Noise-induced hearing loss (NIHL) is defined as a sensorineural type of hearing loss due to damage in the organ of Corti through overexposure to different types of noise (Feuerstein, 2009). NIHL often begins at the higher frequency range of 3000 Hz to 6000 Hz and progresses gradually with chronic exposure to excessive sound levels (Rabinowitz, 2000). Intense noise exposure can cause temporary threshold shifts (TTS) and balance problems, and can later progress to permanent threshold shifts (PTS). Prolonged exposure to high noise levels over a period of time gradually causes permanent damage, referred to as NIHL. It has been indicated that the relationship between TTS and PTS is probably dependent on the extent of damage to the outer hair cells (OHCs) (Feuerstein, 2009) due to either occupational or recreational noise exposure, which is irreversible. For the purposes of the current research, the emphasis will be on the occupational noise exposure. Occupational noise exposure is defined as any type of noise produced in a workplace that is 85 dB(A) in intensity over and above an eight (8) hour working shift for a 40 hour per week time weighted average (TWA) (COIDA, 1993) and eventually leads to occupational NIHL. The noise measurement of ≥85 dB(A) TWA is used by the OSHA noise regulations 1910.95 and has been adopted as a global benchmark by many countries for occupational noise measurement (Department of Labour, 2002).

Occupational NIHL affects individuals in various occupations that are exposed to different types of excessive noise. Individuals affected by this type of hearing loss

include, for example, workers in the motor manufacturing, construction and mining industry, musicians and disc jockeys. Due to the nature of this hearing loss, it is commonly referred to as occupational NIHL. The current study focused on the effects of occupational NIHL on miners.

In the South African mining sector, various sources of noise at high intensity levels are prevalent and predispose employees to hearing loss due to noise exposure. The different sources of noise that have been linked to mining in South Africa include, but are not limited to the following: ventilation fans, drilling equipment, jackhammers, air compressors, grinding equipment, etc. within the eight (8) hour daily shift. (Edwards, 2008) The noise levels that usually exceed the stipulated A-weighted sound pressure level, $L_{aeq(8h)}$ of 85 decibels (dB) TWA in the South African mines are associated with the aforementioned noise sources (Department of Minerals and Energy [DME], 2003). The same noise measurement level of 85 dB(A) TWA as stipulated by the United States Department of Labor (OSHA, 2002) is used internationally to guide noise exposure levels in the workplace and prevent NIHL cases. According to the World Health Organisation (WHO, 1998) occupational NIHL is avoidable if adequate preventative measures are practised in the mines.

Reports by WHO dating as far back as 1998 have highlighted the insufficiency of preventative measures in mines in developing countries, which resulted in reported cases of NIHL (WHO, 1998). Recent data suggest that much of the South African workforce is still exposed to deafening noise (Hermanus, 2007). This claim is evidenced by approximately 4000 cases of NIHL reported in 2004 (Hermanus, 2007). In 2008, AngloGold Ashanti reported two (2) per 1000 cases of NIHL

(AngloGold, 2008) while, in 2011, Lonmin Platinum reported 35 per 1000 cases of NIHL (Lonmin, 2011). Annual reports from the various mining companies have shown a reduction in the prevalence of NIHL cases.

In South Africa, a study conducted by AngloGold Ashanti (2008) indicated that cases of NIHL (77/1000) were still reported, although a minor difference was shown when compared to the 78/1000 cases reported in 2007. This was attributed to the company's new set target to limit the noise of equipment to 90 dB(A) as one of its NIHL preventative measures (AngloGold Ashanti, 2008) . Anglo American Platinum mines in South Africa reported 46/1000 NIHL cases in the year 2012.

According to Azman (2011), the mining sector in the United States of America has the highest prevalence of occupational noise exposure (76 %) of all the industrial sectors. This predisposes United States miners to NIHL the most when compared to other industrial sectors. In Finland, Oksa, Palo, Saalo, Jolanki, and Makinen (2010) reported a reduction in NIHL cases of eight (8) percent in 2010, compared to the 25.6 cases per 10,000 reported in 2009. Despite the decrease in NIHL cases reported by Oksa et al. (2010), NIHL is still considered to be the most commonly reported occupational health condition. Therefore, the above international studies still show that NIHL is an occupational medical condition that should not be neglected. Recent research also shows a relationship between NIHL and tinnitus in workers exposed to occupational noise (Dias, Cordeiro, & Corrente, 2006). In a study conducted by Edwards (2008), tinnitus was one of the associated auditory effects that gold miners presented with. Edwards (2008) reported that 57.8% participants below the age of 60 years presented with tinnitus and those with 21-30

years of experience had the highest incidence of tinnitus (20.8%). Both research results suggested an investment on HCPs in order to maintain auditory health and reduce the associated symptoms.

Although there has been a reduction of NIHL cases in the mines internationally (Oksa et al., 2010), as well as in South Africa (AngloGold Ashanti, 2008), the amount of NIHL cases that are still reported remains a concern. In South Africa, NIHL is the second most compensated occupational health condition in the mining sector (Kew & Ehrlich, 2001). The Compensation for Occupational Injuries and Diseases Act (COIDA 130 of 1993, 2010) was promulgated in order to ensure the continuous reduction of NIHL.

The COIDA 130 of 1993 states that a deviation of 10 % from the baseline audiogram warrants compensable hearing loss towards which the employer has to contribute. The compensation calculation is based on the employee's current earnings coupled with the supply of hearing aids for five years (COIDA 130 of 1993, 2010).

In 2007, 4.52 cases per 1000 employees claimed for NIHL compensation and in 2009, 4 cases per 1000 employees claimed (Coutts, 2010). This shows a decrease in the cost of claims to the mining industry. Clearly a reduction in reported NIHL cases means a reduction in reported NIHL claims which creates a favourable view of mines as good corporate citizens and, in turn, could improve their profits. Since South African mines contributed 8.8 % to the country's gross domestic product (GDP) in 2011 (Chamber of Mines Annual Report, 2012) and given the importance of mining in job creation and the economy, employee welfare is critical. Current national studies on the NIHL prevalence rates will assist in determining the extent of NIHL in

the mines, the progress made by the mining companies in improving hearing conservation programmes (HCPs) and also in reducing NIHL in the mines.

A HCP is a process aimed at reducing NIHL. According to Occupational Safety and Health Administration (OSHA, 2002), HCPs require employers to monitor noise exposure levels in a way that accurately identifies employees who are exposed to noise at or above 85 dB(A) TWA over eight (8) working hours.

1.2. The Prevalence of NIHL and Hearing Conservation Programmes

Bomela (2005) conducted a study on the incidence of NIHL at a South African diamond mine. The study's aim was to determine the NIHL cases at the diamond mine by reviewing the audiological record of miners over a 5-year period in a company employing an effective HCP. The results showed more cases of NIHL among employees exposed to levels of +85 dB(A) TWA and among those with more years of experience between the ages of 35 and 45.

A similar retrospective study was conducted by Strauss, Swanepoel, Becker and Eloff, (2012), a low prevalence rate of NIHL at a South African gold mine was reported. The study cited the effectiveness of the HCP's implemented by the mine. Records of employees' audiograms over a period of 5 years were reviewed to observe the effect of noise exposure on the hearing of miners (Strauss et al., 2012). The study compared baseline and recent audiogram results from two groups of 57 714 employees. Although lower NIHL prevalence rates at the mine was noted, the authors concluded that, in order to truly substantiate the effectiveness of HCPs in South African mines, true comparisons of baseline audiograms with recent

audiograms would be a more accurate measure of HCP effectiveness. Age was stated as an added factor that tends to increase the prevalence of NIHL. As the majority of participants affected were in the age range of 36 to 45 years, the recommendation for the study was to account for age in order to obtain an accurate indication of the extent of the problem.

A review of the above-mentioned studies indicates that, there has been a reduction in NIHL cases reported in 2012 as compared to 2005. This was also supported by a reduction in NIHL claims of 4.52 claims per 1000 as compared to 4 claims per 1000 reported from 2007 to 2009 (Coutts, 2010). The positive reduction could be attributed to the HCPs currently employed by the different mines. However, accurate monitoring of the implementation of HCPs should still be addressed in order to improve the effectiveness of HCPs in the mining industry.

1.3 Hearing conservation programmes in relation to hearing protection devices

To understand the role of HCPs in South African mines in reducing NIHL, the following factors should be considered: the key elements of the HCPs, for whom they are designed, who facilitates their development, and when and how these programmes are to be implemented and monitored (DME, 2003). An effective HCP consists of three key elements, which are engineering controls, administrative controls and personal protection, as shown in Figure 1 overleaf.

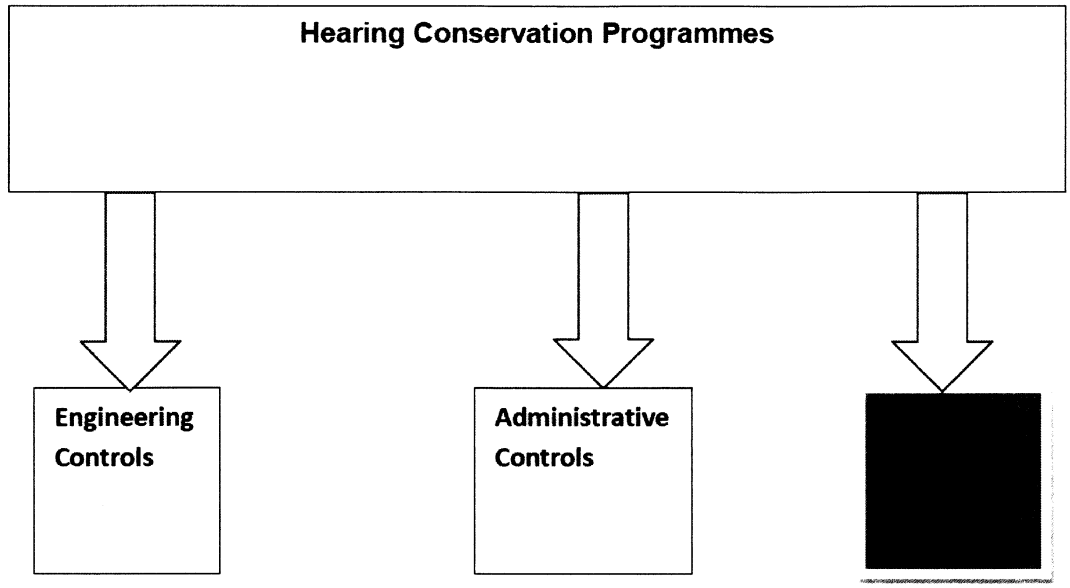


Figure 1: Hearing conservation programme framework (DME, 2003)

The first HCP was introduced in 1948 by the United States Air Force and later into the aviation and metal industries (Murdock, 1994).

In South Africa, HCPs were introduced into the mining industry much later in 1988 (Franz, Phillips, Guild, & Ehrlich, 2001), following the promulgation of the Occupational Diseases and Mines and Works Act 78 of 1973. This was followed by the Mine Health and Safety Act 29 of 1996 which was enacted following the identified and documented effects of noise on employees working in noisy environments; as well as the financial ramifications of that these threats (Franz, et al., 2001).

According to the American Occupational Safety and Health Act (OSHA, 2002), HCPs are designed to protect those workers that are exposed to significant occupational noise from hearing impairment. In the South African mining sector, HCPs have been implemented and monitored with a view to reducing the number of NIHL cases

reported, hazardous noise levels, and costs in the form of compensation pay-outs to companies (Franz et al., 2001).

According to the Mine Health and Safety Act (MHSA, Act 29 of 1996), the Department of Minerals and Energy (2003) and SANS 10083:2004, HCPs should comprise the following elements:

- Risk assessment of the noise hazard areas;
- Noise control engineering at source;
- Application of administrative control of noise, personal protection devices, noise monitoring;
- Medical surveillance; and
- Follow-up assessment.

The current South African HCP model is two-pronged; it includes the functional structure and the organisational structure as set out in the Guideline for the compilation of a mandatory code of practice for an Occupational Health Programme for Noise (DME, 2003). The functional structure focuses on risk assessments at different levels to preserve employee health and safety. The organisational structure, coordinates the HCP management committee structures for the company's implementation of HCPs. For an effective HCP as stated by the guidelines formulated by the DME (2003), the functional and organisational structures have to complement one another. Relevant to the current study, the key element of personal

protection, specifically HPDs, has been investigated in relation to both structures that inform current South African HCPs.

South African mines use the aforementioned documents as guidelines to inform their HCPs' structural frameworks and implementation practices. Current reports indicate a reduction of NIHL cases as well as noise levels that still exceed 85 dB(A). This is evident from the annual reports of companies such as AngloGold Ashanti (AngloGold, 2008), Impala Platinum (Steenkamp, 2007) and Lonmin Platinum (Lonmin, 2011). These reports state that recorded noise levels from equipment used by the miners underground has decreased. AngloGold Ashanti (2008) reported a noise reduction on all pneumatic drills and the silencing of underground ventilation fans by 2006. As a result, AngloGold Ashanti's compensated NIHL cases indicated a slight reduction for the years 2007 and 2008. They are aiming to limit noise produced by equipment to 90 dB(A) and supporting the need for an effective HCP which includes effective engineering controls, adequate use of hearing protection devices (HPDs) and appropriate medical surveillance (AngloGold, 2008).

According to the Department of Minerals and Energy (2003), medical surveillance should include monitoring of hearing through audiometric testing, ensuring the effectiveness of hearing protection devices (HPD), educating and training employees on the organ of hearing, and record keeping to track employees' audiological results for early identification of NIHL (SANS, 2003). Literature on the prevalence of NIHL in South African mines has reflected positively on the effectiveness of HCPs practiced in the mines.

HCPs in South African mines include: the reduction of noise from the source (changing or upgrading tools such as drills that are known to produce hazardous noise), the application of administrative noise controls (rotating employees to less noisy workplaces), and the use of HPDs as a preventative measure for NIHL (DME, 2003) which is the most widely applied practice (Mine Health and Safety Act 29, 1996). The use of HPDs has the lowest priority in terms of interventions recommended by the Mine Health and Safety Act Mandatory Code of Practice for an Occupational Health Programme for Noise (DME, 2003), however they are the most frequently implemented because HPDs are less costly, more measurable tools that reduces noise exposure and can be made to specifically suit a particular individual's personal and work needs (Coutts, 2010).

1.4 Hearing protection devices

In America HPDs were initially introduced to urban dwellers in the 1920s to protect them from the ambient city noise (Murdock, 1994). In the 1940s they were used in World War II as a result of extensive research showing the development of increased levels of NIHL in soldiers (Murdock, 1994).

In South Africa, HPD usage was first documented and was found to have merit in the prevention of NIHL in the mining sector due to the high noise levels that employees were exposed to (Guild, 2001). The use of HPDs in the mining industry as part of an effective HCP was first advocated early in the 19th century to the second half of the 20th Century because of miners' rapid hearing loss (Guild, 2001). However, the use of HPDs was only enforced following the implementation of the Mine Health and Safety Act (1996). The use of HPDs in South Africa has been implemented

according to international standards from developed countries such as Australia, Canada and the United States of America (Hermanus, 2007). Hermanus (2007) continues to emphasize that, although HPDs have been used for many years globally, it is the degree of use that is still not satisfactory. The current study aimed to uncover positive and negative determinants in the use of HPDs by mine workers within the South African context.

According to Steenkamp (2007), the mining industry has to adopt a best practice quality HPD system. The seal and attenuation should be verified and HPDs should be comfortable to wear, not interfere with hearing important warning signals in the work environment and enhance speech intelligibility. In South Africa, this brought about the development of the HPD TAS TOOL to address specific issues regarding HPDs (Coutts, 2010). A report on HPD usage by Coutts (2010) has contributed significantly to current debates on the relevance and value of knowledge on the use of HPDs in South African mines.

The use of HPDs in South African mines is guided by various Acts in order to protect mine workers and ensure that they work in safe and protected environments (Steenkamp, 2007). These acts include:

- Occupational Health and Safety Act No. 85 of 1993: provides for the health and safety of persons at work and for the health and safety of persons in connection with the use of plant and machinery. The protection of persons other than persons at work against hazards to work and safety arising out of or in connection with activities of persons at work. It establishes an advisory council for occupational health and safety.

- Machinery and Occupational Safety Act No. 6 of 1983: which applies to all employers at a workplace where the equivalent noise level (equivalent sound pressure level) resulting from activities at such workplace, to which any person in such workplace is exposed, is 85 dB(A) or higher. The employer should reduce the equivalent noise level or demarcate the noise zones or prohibit persons from entering unless they have HPDs provided on site free of charge.

- Mines Health and Safety Act No. 29 of 1996: protects the health and safety of persons at mines; for the employers and employees to identify hazards and eliminate, control and minimise the risks to health and safety at mines; and for employers to provide effective monitoring of health and safety conditions at mines.

- Noise-induced Hearing Loss Regulations 2003, South Africa National Standards (SANS) 10083:2004: applies to any employer or self-employed person who, at any workplace under his or her control, carries out work that may expose any person at that workplace to noise at or above the noise-rating limit of 85 dB(A).

Despite the abovementioned acts guiding the South African mines, poor and unmonitored use of HPDs has been documented by the mine as evidenced by cases of NIHL still being reported by the mines. Therefore, more studies are warranted in the area of HPD usage at the mines (Hansia & Dickinson, 2009).

A study conducted in South Africa by Hansia and Dickinson (2009) on gold miners indicated a lack of use of HPDs by lower skilled miners. This was attributed to inadequate education and training regarding the use of HPDs and the effect of noise

as a health hazard. According to the study, persistent NIHL cases could be directly related to miners not using HPDs. The content, language and delivery medium (computers) of training programmes played a role in the minimal uptake of HPDs. The current research has a similar aim; determining the use of HPDs by miners. It must be noted that Hansia and Dickinson (2009) focused only on gold miners whereas current study drew participants from gold and non-ferrous mines.

An internationally relevant study on the use of HPDs conducted by Crandell and Mills (2004) focussed on understanding and awareness of the effects of noise and hearing loss and how it affected attitudes towards the use of HPD's (Crandell & Mills, 2004). The study was conducted on college students aged 18 to 29 from different racial/ethnic groups. They were interviewed regarding their knowledge, behaviours and attitudes about hearing loss and the use of HPDs. The findings showed that while most of the participants knew about the effects of noise on hearing and the use of hearing protection devices but that they were not motivated to use hearing protection when necessary. The authors concluded that education level could not be used in isolation as a determinant for the use of hearing protection. Ethnicity and age should be considered when investigating knowledge and awareness of the use of HPDs as tools for reducing noise levels and therefore NIHL.

Based on the above reviewed literature both national (Hansia & Dickinson, 2009) and international (Crandell & Mills, 2004), the use of HPDs in the mining industry is not at satisfactory levels because cases of NIHL are still being reported. Although the reported cases of NIHL were controlled, significant measures should be implemented in order to reduce NIHL in the industry. This highlights the need and

importance of well-coordinated HCPs in South African mines. NIHL is a preventable health condition that may assist in the reduction or elimination of consequent secondary implications such as worker ill-health, premature use of hearing aids by employees, reduction in human resources and compensation pay-outs (Coutts, 2010). This forms the basis of the current study's rationale; the main aim being to investigate the knowledge, attitude and views of South African miners regarding NIHL and the use of HPDs in HCPs at a gold mine in Johannesburg, Gauteng and at a non-ferrous mine in Polokwane, Limpopo.

1.5 Rationale

Since the inception of mining on an industrial scale in South Africa in the 1880s, mines have been faced with excessive levels of risk to both health and safety (Hermanus, 2007). The United Nations HDI is an index that combines the normalised measures of life expectancy, literacy, educational attainment and GDP per capita. It is used as a standard to measure human development and combines life expectancy and levels of education measured in terms of literacy rates. It is a useful tool as it assists in forming the foundation on how age and educational levels in the mining sector could impact on adaptability and views (United Nations Human Development Index, 2011). According to these criteria South Africa is ranked as a medium developing country.

South Africa's economic growth is also measured by the HDI; and currently products yielded by the mines contribute 8.8 % to the country's GDP which is critical to this country's economy (Chamber of Mines Annual Report, 2012). The majority of South African mining houses employ people with low socio-economic backgrounds and

different cultural characteristics locally and from neighbouring countries such as Lesotho, Mozambique, Swaziland and Zimbabwe. Despite the Mine Health and Safety Act No. 29 of 1996, mines continue to have significant health and safety issues that affect human resources in comparison to other major mining countries such as Australia, Canada and the USA. According to Kew and Ehrlich (2001), noise is second only to airborne pollutants as a cause of poor health in mines in South Africa.

In 1995, the South African mining industry set up the Leon Commission of Enquiry into the mines' health and safety, which influenced the development of the Mine Health and Safety Act No. 29 of 1996. Poor health conditions in the mines were attributed to the newness of comprehensive initiatives to control health exposures (WHO, 1998). One of the problems identified by the commission was an increase in reported NIHL cases and an increase in compensation claims from ZAR52 million claimed in 2003 to ZAR77 million in 2004 (Steenkamp, 2007). In 2008, the Mine Health and Safety Council (MHSC) set goals for December 2013. It was recommended that HCPs in the mining industry should ensure that the noise levels of all equipment producing noise be below 110 dB and that deterioration in hearing greater than ten (10) percent among occupationally exposed individuals be regarded as a cause for concern (Lonmin, 2011). In compliance with this recommendation, Harmony Gold made the use of HPDs compulsory in designated noisy areas (Harmony Gold Annual Report, 2011) and AngloGold Ashanti's HCP now includes engineering controls, updated drillers with silencers, the use of HPDs and improved medical surveillance to detect early loss of hearing (AngloGold, 2008).

To date, mines have reported on the effective implementation of HCPs. However high noise levels in excess of 110 dB(A) are still reported and cases of NIHL are still recorded in occupationally exposed miners (Hermanus, 2007). Compensation pay-outs related to NIHL are still made by the mines raising questions regarding the effectiveness of implemented HCPs and the understanding of the use of HPDs. Therefore, the current research study investigated mine workers' understanding of education and training regarding noise hazards, hearing loss and HPDs. The study aimed to add to the evidence-based data for the mining industry regarding the importance of reducing NIHL by investigating the use of HPDs in HCPs specific to the South African mines. The research study further aimed to determine the miners' awareness of hearing safety and associated NIHL and attitudes towards the importance of HPD usage in reducing NIHL. Figure 2 illustrate the important aspects in addressing the current study's main aim and sub-aims thereof.

The diagram below illustrates the important areas for an understanding of the problem statement as well as addressing the sub-aims of the current study:

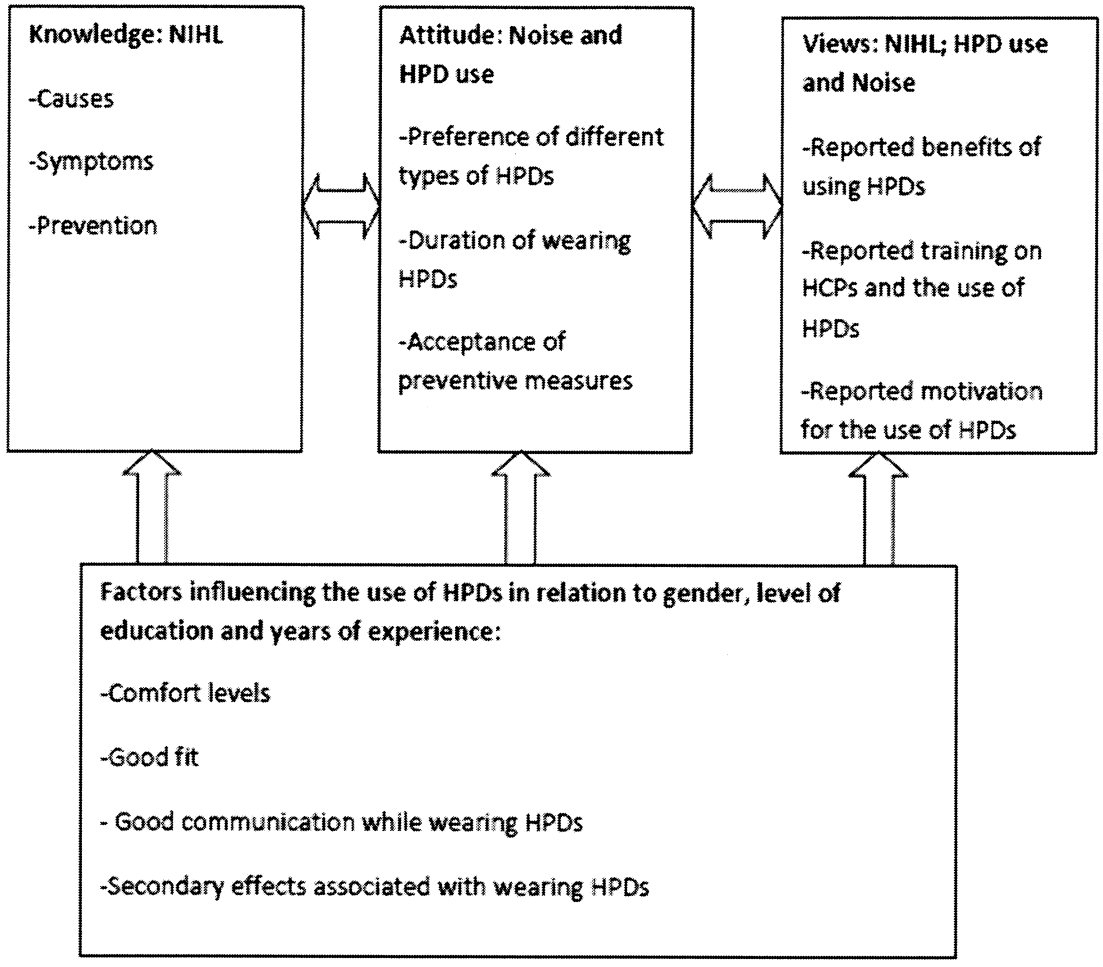


Figure 2: A summary of problem statement key elements (Varkevisser, Pathmanathan & Brownlee, 2003).

Lastly, the use of HPDs has been proven to be a measurable element of an effective HCP, is less costly, and is the method of choice preferred by the mines. Thus, the study aimed to emphasise the importance of this key element in reducing NIHL cases in the mines (Coutts, 2010).

CHAPTER 2: METHODOLOGY

2.1 Main aim of the study

The purpose of the study was to investigate the knowledge, attitude and views of South African mine workers regarding NIHL and the use of HPDs in the gold and non-ferrous mining subsectors.

2.2 Specific objectives of the study

- To investigate the understanding of a sample of South African mine workers regarding hearing safety and associated NIHL in South African gold and non-ferrous mining subsectors;
- To investigate the understanding, attitudes and views of mine workers regarding the use of HPDs in South African gold and non-ferrous mining subsectors;
- To determine the factors influencing the use of HPDs and their relationship to gender, level of education and years of experience:
    - To determine factors impeding the use of HPDs in this sample group; and
    - To determine the factors positively influencing the use of HPDs in this sample group.

2.3 Research questions

- Do mine workers know the importance of hearing protection as tools for the prevention of NIHL?

- Do mine workers' views and attitudes contribute in any way towards their use of HPDs?
- What are the negative factors that affect the use of HPDs specific to the research sample?
- What are the positively contributing factors that enhance the use of HPDs specific to the research sample?

2.4 Research design

A non-experimental descriptive research design was used for the purpose of this study in order to obtain detailed information and numeric data on the topic (Neuman, 1997). Interviews were used as method to conduct the study. The purpose of this type of research is to acquire information about a group of people regarding their opinions, attitudes and experiences by asking relevant questions about an issue (Leedy & Ormrod, 2010).

Furthermore, this type of research determines how a group of people view a specific phenomenon and provides a description and draws a comparison through the systematic and objective collection of information from a representative sample (Neuman, 1997). Face-to-face structured interviews were conducted using self-developed questionnaires as data collection instrument (Appendix A1). The use of interviews present limitations; interviews rely on self-reporting which can have distorted results, and facts can be misrepresented to create a favourable impression with the researcher (Leedy & Ormrod, 2010). The abovementioned limitations of the study were acknowledged and taken into consideration during the study.

A qualitative approach was used as the current study aimed at understanding the participants' experiences and thoughts on NIHL and HPD use (Hiatt, 2011).

2.5 Participants

2.5.1 Study sample

The participants in the study consisted of South African mine workers in the following categories: managers, supervisors and workers working for a gold mine in the Gauteng Province and a non-ferrous mine in the Limpopo Province.

2.5.2 Sampling method and sample size

A non-probability convenience sampling method was used. According to Leedy and Ormrod (2010) the researcher has no way of ensuring that each element of the population will be represented in the sample as some members of the population have little or no chance of being sampled in the study. A convenience sample was chosen purely on the basis of availability and easy access (Struwig, 2010). Permission for the study was granted by the management of the participating mines.

Informed consent was obtained from all participants prior to the interviews and the interviews were conducted using the structured self-developed questionnaire (Appendix A). Sample size depends on the accuracy of the sample in relation to the population (Bless, 2006). A small sample is less reliable but more convenient in terms of time and money, while a large sample is more accurate but also more costly (Struwig, 2010). Regarding this research study, only ninety participants from the two different mines participated, namely 65 from a gold mine and 25 from a non-ferrous mine.

The researcher was unprejudiced towards all participants included in the research study regarding their age, gender, race, work experience, work area or any element not stated.

1. Harmony Gold in Doornkop

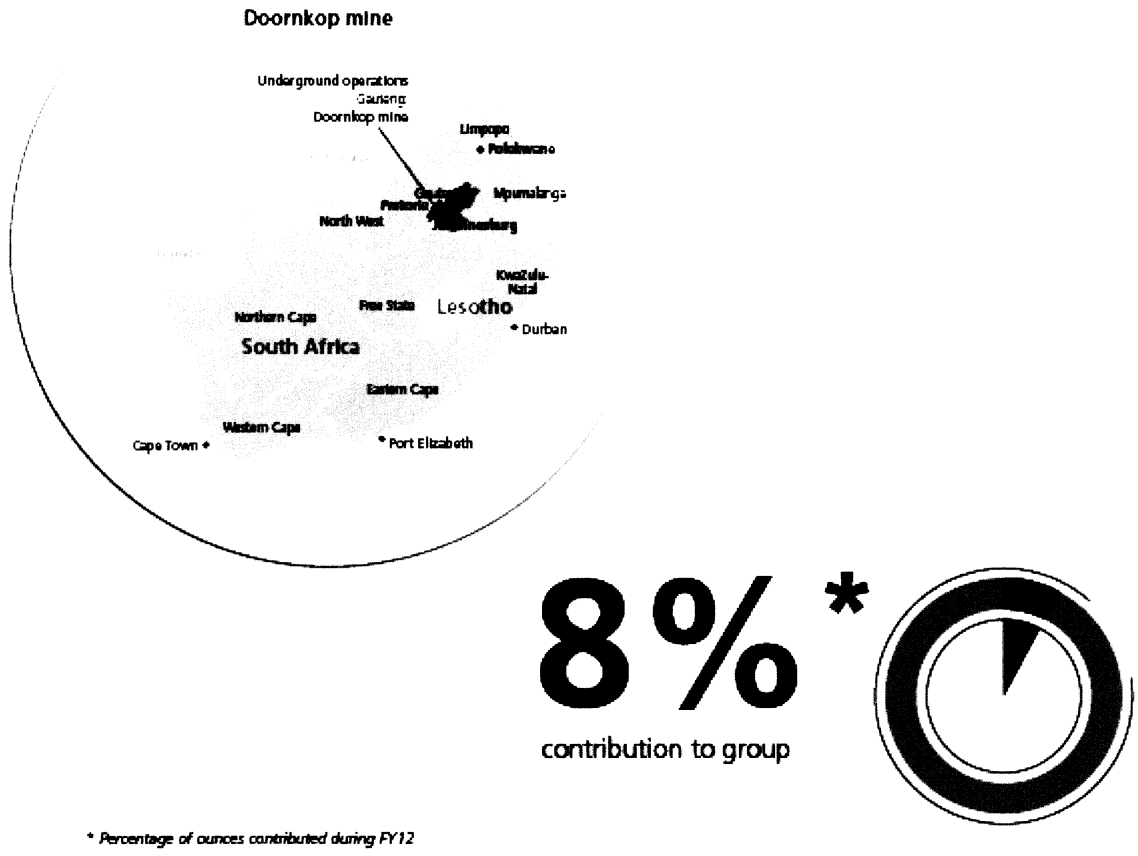


Figure 3: Harmony Gold Doornkop mine site map (Harmony Gold Annual Report, 2012)

Harmony Gold Doornkop mine is situated 30 km west of Johannesburg mining the Kimberley and South Reefs to a depth of just under 2 000 metres. It is a single-shaft operation using both mechanised board-and-pillar and narrow-reef conventional mining. It processes ore at its carbon-in-pulp plant. The mine has about 40 257 employees. The mine has reported 101 cases of NIHL for the year 2012 as opposed to 365 cases in 2011.

2. Silicon Smelter in Polokwane



Figure 4: Silicon Smelters site map (Silicon Smelters Annual Report, 2012)

Silicon Smelters is situated in Limpopo, 8 km south of Polokwane and 360 km north of Johannesburg. The first mining operations began in the 1950s at Witkop ("white hill") and consisted of clearing, extracting and crushing quartz. The Silicon plant as it now stands was commissioned in the same area in 1974. It produces high purity metallurgical and chemical silicon. The annual production capacity is 55 000 tonnes per year of silicon metal and 25 000 tonnes per year of micro silica. Silicon Smelters has about 600 employees. No cases of NIHL have been documented or reported by the company.

2.5.4 Description of noise sources at the participating mines

Table 1: Types of noise sources at the mines

Drilling machines	26	29
Grinding machines	4	0.4
Ventilation fans	9	10
Jackhammers	3	0.3
Pumps	1	0.1
Trucks	3	0.3
Forklifts	5	0.6
Air compressors	6	0.7
Ball mills	1	0.1
Winch	6	0.7
Loco	3	0.3
Shaft	1	0.1
Conveyer belts	3	0.3
Chain block	1	0.1
Crushers	9	10
Hoppers	2	0.2
Vibrators	4	0.4
Steamers	1	0.1

2.5.5 Inclusion and exclusion criteria

Initially mine workers that appeared on the mines' registries, had worked underground and had received a hearing conservation computer-based education programme during induction training were included in the study. However, due to the protest actions occurring in 2012 that destabilised the mining industry in the country, additional participants based on the surface and that were exposed to noise were also interviewed. Observations made during the pilot study indicated that whilst miners working underground were exposed to different noise sources from those working on the surface, both groups were at risk of developing NIHL thus justifying the inclusion of surface workers.

2.6 Data collection

2.6.1 Pilot study

A pilot study allowed the researcher to test the interview questions on a small sample taken from the community for which the questionnaire was planned (Bless, 2006). The pilot study was conducted in two stages to achieve the set aims. The aims of the pilot study were:

- To determine the relevance of the questions and the content covered in the interview questions;
- To determine if the chosen method of interview was acceptable to the targeted sample of participants;
- To ascertain the accuracy of the time allocated for the interview; and

- To identify any possible risks related to the current research study.

To achieve the aforementioned aims of the pilot study required two stages. In the first stage two occupational audiologists who were asked to review the self-developed interview question for content and relevance. In the second stage ten mine workers from a gold mine were interviewed to ascertain whether the participants would follow the interview questions with ease and to determine the duration of the interview. As the ten participants in the pilot study were from the same gold mine used for the main study, they were excluded from the main study. The following recommendations were then made:

1st Stage

The audiologists recommended:

- the inclusion of participants' biographical information;
- the inclusion of participants' different types of occupations; and
- the addition of noise sources at different mines.

2nd Stage

The researcher:

- decreased the interview time from 45 minutes to 15 minutes as the participants were able to complete the interview within 15 minutes instead of the anticipated 45 minutes;
- found that the interview questions were adequate and easy to understand;

- did not identify any related risks during the pilot study (Gravetter, 2009).

2.6.2 Main study

A set of self-developed questions were used as the data collection tool (Appendix A1). The interview was conducted by the researcher in order to guide the participants' responses and accommodate for varying literacy levels. The interview questionnaire included questions in checklists and rating scale formats, as this questionnaire format has been used successfully to assess respondents' attitudes and behaviours (Leedy and Ormrod, 2010).

The next steps were followed in order to conduct the interview using the questionnaire:

1. Ethical clearance for the research study was obtained from the University of Witwatersrand, Human Research Ethics Committee.

2. Permission to conduct the research study was requested from participating mines using permission letters (Appendix B) explaining the research study in detail.

3. The researcher provided individual participants with informed consent letters and forms (Appendix C).

4. On receipt of the informed consent forms, the researcher led the interview sessions going through each question with the participants.

5. Participants were asked to respond verbally to the questions in the questionnaires asked by the researcher during interviews allowing the researcher to address additional queries related to the questions.

2.7 Bias

According to Leedy and Ormrod (2010), bias is any influence, condition or set of conditions that can distort data. It is the systematic introduction of irrelevant variables that may distort or disguise the relationship among the experimental variables (Bless, 2006). It is important that the researcher recognises and acknowledges those conditions or variables that may contaminate research data in order for others to appraise the research realistically and judge its merit honestly (Leedy & Ormrod, 2010). Therefore, to minimise bias in the study, the following criteria were used:

- The researcher ensured that the questions in the interview did not lead respondents to certain answers by following a set of interview questions to the latter.
- The interviews were conducted in Sotho, Zulu, Tswana and English in order for the participants to follow and understand the interview questions.
- Two occupational audiologists were asked to review the content and relevance of the interview questions.
- The researcher also acknowledges that the mines' management could have influenced the participants' responses prior to the interviews, therefore, the researcher protected the participants' identity.

2.8 Data analysis

The data collected from the participants' interviews were analysed by employing descriptive statistics (Howell, 2004) in order to address the study's sub-aims in a more organised, summarised and presentable manner (Keller & Warrack, 2003). Frequency tables were used to determine the most frequent use of HPDs by participants, that is, in relation to the current study's stated sub-aims. Informational content relevant to the research study was also analysed using descriptive statistics, and a descriptive summary of that information was analysed by tabulating the frequency and percentage of each characteristic stated in the interview questions (Leedy & Ormrod, 2010). Tables and graphs were also formulated precisely to capture data accurately.

A statistical analysis test of chi-square contingency table was applied to the following variables: gender; level of education and years of work experience to determine the relationship between the aforementioned variables and the participants' use of HPDs. The chi-square refers to a statistical distribution procedure that produces a statistic that is approximately distributed as the chi-square distribution (Howell, 2004).

2.9 Ethical considerations

According to Neuman (1997), it is important that the researcher protects and respects the respondents' privacy by not revealing their identity and specific responses once information for the study has been gathered. This was ensured by applying the following ethical principles:

- **Informed consent** – the participants were informed of all the processes that were going to be followed in conducting the study in the form of an informed consent letter. The respondents participated in the current study only if they agreed to the processes stated in the letter by signing the letter.

- **Anonymity** – The participants' identification was only known to the researcher and the direct research supervisors. Mine management was not notified of the miners that participated. Participant codes were used instead of participant names.

- **Non-Maleficence** - the researcher ensured that the participants were protected from any physical or psychological harm during the current study's interviews. A pilot study was used to facilitate the identification of possible risks related to the current research study.

The aforementioned set of ethical guidelines assisted the researcher in making proper decisions and choosing proper action. All relevant permissions were received as stated (Gravetter, 2009).

CHAPTER 3: RESULTS AND DISCUSSIONS

3.1 Introduction

Data described in this chapter reflect the responses of participants that were interviewed from two mines, one gold mine in the Gauteng Province and one non-ferrous mine in the Limpopo Province. Ninety participants were interviewed using a self-developed questionnaire. Sixty-five of these participants were from the gold mine and twenty-five from the non-ferrous mine. The differences in the number of participants per mine were representative of the number of employees per mine. Gold mines are known to be bigger in South Africa and this was also reflected during the data collection of the study.

3.2 Participants' demographic and mining characteristics

Tables 2.1 to 2.6 below represent the participants' demographic and mining characteristics from the two mines that participated.

Tables 2.1 – 2.6: Participants' demographic and mining characteristics

Type of mine employed	N=90
Gold	65
Non-Ferrous	25

2.1

Race	N=90	Percentage
Black	86	96
White	4	0.4

2.2

Gender	N=90	Percentage
Female	13	14
Male	77	86

2.3

Age	N=90	Percentage
20 - 30	32	36
31 – 4-	31	34
41 – 5-	16	18
51 - 60	9	10

2.4

Highest level of Education	N=90	Percentage
Non	2	0.2
Primary School	18	20
High School	55	61
Tertiary	14	16

2.5

Years of experience	N=90	Percentage
1 year	10	11.4
2 years - 10years	59	67
11 years - 20years	12	13.6
21 years - 30years	6	6.8
31 years - 40years	1	1.1

2.6

From the 90 participants interviewed, 35 % were between the ages of 20 and 30 years and 34 % were between 31 and 40 years, thus suggesting that the participating mines were dominated by middle-aged individuals. The study that was conducted by Edwards (2009) reported that the 31 to 40 years category had 27 dB to 50 dB hearing thresholds with negative implications for hearing and communication skills and probably also social implications for their immediate relationships. The sample in the current study was similar with regard to age of participants.

Eighty-six (86) percent of the participants were male and fourteen (14) percent were female, thus indicating that the participating mines were still male dominated. This may be attributed to the introduction of females in the mines only being effected in 2004, in accordance with the Mining Charter of 2004 and the Employment Equity Act, 55 of 1998. Eighty-six (n=86) participants were Black and four (n=4) were White, showing that mines are still dominated by Black Africans in the manual labour departments.

More than half of the participants had attained education at a high school level (n=55), with a slight difference of 4 % between the primary school level and tertiary level. This has positive implications for the future creation of education and training materials viz the tools that can be used and the level of anticipated understanding.

A similar study conducted by Zungu (2012) indicated that the secondary level of education was the most common among the female miners in her study. The sample of the current study included both females and males but was similar with regard to the level of education of participants.

Years of experience within the mining industry ranged between 1 year and 40 years. The majority of the participants (59 %) had 1 – 10 years of experience, followed by 13 % with 10 – 20 years and 34 % with 30 – 40 years of experience. Edwards (2008) indicated a greater deterioration of hearing thresholds in participants with more years of experience.

Table 3: A summarised comparison of participants' demographic and mining characteristics between the gold mine and the non-ferrous mine

	65	**25**
	Mean: 35.5 **Median: 32** **Mode: 28**	**Mean: 38.4** **Median: 32** **Mode: 32**
	Male: 60 **Female: 5**	**Male: 22** **Female: 3**
	Black African: 62 **White: 3**	**Black African: 25** **White: 0**
	Primary School: 19 **High School: 42** **Tertiary: 4**	**Primary School: 2** **High School: 13** **Tertiary: 10**
	6 months – 30 years	**1 year – 32 years**

Gold mines in the country still dominate the mining industry in terms of capacity and the number of employees. A similar observation was made during data collection for the purposes of the current research study (Table 3). The level of education has increased overall for both males and females, as reflected in the results obtained in the current study. According to the results, more participants had a tertiary level of education (40 %) at the non-ferrous mine as opposed to the gold mine. Observations made during data collection showed that education and training contents and tools

provided by the mines were computerised and improved in order to match the employees' level of education. However, the level of understanding across all participants regarding the education tools was questionable. Data obtained from the current study clarifies the participant level of understanding regarding the education and training content.

3.2.1 Occupation vs years of exposure

Table 4 below depicts the participants' occupation and the number of years that they have worked in that occupation.

Table 4: Occupation vs years of exposure

Occupation	Number of years	N=90
Scaler assistants	2 years – 32 years	4
Metal reclaimer	30 years	1
Loco/Winch drivers	2 years – 29 years	11
Supervisors	1 year – 20 years	7
Rock and diamond drillers	2 years – 15 years	7
Pump attendants	1 year – 12 years	3
General relief	2 years – 4 years	1
Production relief	2 years – 4 years	1
Pickers	2 years – 4 years	6
Forklift drivers	2 years – 4 years	5
Generalist and Boiler makers	2 years – 6 years	12

Table 5: Occupation vs years of exposure – Non-ferrous mine

Occupation	Number of years	N=25
Scaler assistant	2 years – 32 years	4
Metal reclaimer	30 years	1
General relief	2 years – 4 years	1
Production relief	2 years – 4 years	1
Pickers	2 years – 4 years	1
Forklift drivers	2 years – 4 years	6

Table 6: Occupation vs years of exposure – Gold mine

Occupation	Number of years	N=65	Percentage
Loco/Winch drivers	2 years – 29 years	11	12 %
Supervisors	1 year – 20 years	7	0.8 %
Rock and diamond drillers	2 years – 15 years	7	0.8 %
Pump attendants	1 year – 12 years	3	0.3 %
Generalist and Boiler makers	2 years – 6 years	12	13 %

Table 6 above indicates different occupations with different exposure periods shown by of years of experience. Participants reported a working shift ranging from one to ten hours, eight hours is the legislated shift allocation when exposure levels are at 85 dB(A) but participants reported that during overtime periods a shift was extended to ten hours. The most exposed occupations in terms of years (in the order of most to least years of experience) were scale assistants, loco and winch drivers, supervisors and rock drill operators, with the rest of the occupations evenly spread between two and six years. When considering the number of hours exposed, years of exposure and noise sources per occupation, the most to the least exposed were

rock and diamond drill operators; scale assistants; loco and winch drivers; pump attendants; forklift drivers; miners; and generalists.

According to Erasmus (2009), rock drill operators in a platinum mine have been reported to be the most exposed to high levels of noise in terms of intensity levels. The current research study investigated participants' years of experience in relation to noise exposure levels, different types of noise sources and hours of exposure to noise. Rock drill operators appear to be among those participants within this category. Therefore, it can be assumed that rock drill operators in the gold mine also have high exposure levels when compared to other occupation types. A study conducted by Phillips, Heyns and Nelson (2007), identified the following rock drills to be the most commonly used in South African mines: hand-held drills (pneumatic rock drills) measuring 114dB(A) and prototype acoustically shielded self-propelled rock drill, measuring 85dB(A). The study indicated that indeed rock drill operators were exposed to excessive noise levels coupled with excessive vibration levels. Advanced engineering controls towards the use of self-propelled rock drills and administrative controls of isolating the drillers to self-propelled drills were recommended by the researchers in order to reduce NIHL.

Edwards (2008) found that different occupations present with different types of audiograms and that machine operators presented with the most hearing loss across all the frequencies. However, in the current study the majority of participants in a supervisory position had previous work experience in the areas of rock drilling, loco and winch driving. The current study shows that although occupation has an effect, the duration of exposed hours spent is more significant. Edwards (2008) found that

team leaders and shift bosses were exposed to the same levels of noise, but different frequencies were affected, which was attributed to the possible difference in the duration of noise exposure. Therefore, these occupation types can be assumed to be at risk although hearing evaluations may show that different thresholds of hearing are affected.

In addition, the rock drill operators (three) reported that at times they were exposed to noise for nine to ten hours in a shift. Participants exposed to noise of a certain type for a certain period of time, usually beyond an eight-hour shift are at risk of developing NIHL. Therefore stringent protection measures are to be applied to protect the ears of those workers and preserve hearing and in turn reduce NIHL.

Tables 5 and 6 represent different occupation types and years of experience in the gold and non-ferrous mines. Scaler assistants and a metal reclaimer from the non-ferrous mine had the most years of experience, but no studies had been conducted to determine a similarity in the results obtained from the current study. However, based on the results obtained from the current research study, the scaler assistants and metal reclaimer were at risk of developing NIHL due to exposure to noise over the reported years of experience.

Nevertheless, the selected type of HPD has to consider occupation type, noise sources and duration of noise exposure for adequate protection for all those working in noisy environments. The clinical implication is for the medical surveillance to include questions that address the occupation type and duration of noise exposure. This will also be in line with the Department of Minerals and Energy Guideline (2003) of proper hearing protection for all workers exposed to excessive noise levels.

3.3 Participants' knowledge on hearing health, safety and associated NIHL

3.3.1 Knowledge regarding exposure to noise at the workplace

From the 90 participants interviewed, 87 (97 %) acknowledged to working in a noisy environment at the workplace. Only four (0.4 %) indicated a no response. They were a supervisor, a battery-operated loco driver, a generalist and a process controller, in the age group ranging from 25 – 42 years, with 10 years, 5 years and 3 years experience respectively. The supervisor was the only one with previous mine experience. All the participants who indicated a 'no response' had at least a secondary (grade 11) level of education, with the most qualified being the process controller with a B. Tech. Degree in Chemical Engineering.

The supervisor's reason for his response was that he is based on the surface in an office and only goes underground to inspect when necessary, where he would be exposed to various noise sources for less than four hours. The supervisor further acknowledged that he used earplugs only when conducting underground inspections. Therefore, his response reflected failure to acknowledge noise as a hazard, especially when considering his previous work experience. The battery-operated loco driver's reason was that he was restricted to the loco that is very quiet upon reaching underground. The generalist's reason was that he was still undergoing induction education and has not resumed formal work.

The reasons stated may indicate a knowledge gap regarding what is understood as excessive noise exposure in the workplace. The following important criteria that constitute hazardous noise exposure may thus be neglected: duration of previous

noise exposure history; noise exposure from the lift upon entry to the mine and before entering the loco; and overall visits and/or rounds undertaken during induction at various mine points. This shows the importance of including counselling in noise hazards and proper hearing protection on an annual basis.

In spite of reports on compensation claims in the mines showing noise as the second most common health condition in South African mines after airborne pollutants (Kew & Ehrlich, 2001) and the Department of Minerals and Energy (2003), advocating education in noise hazards and clear demarcation of noise zones it is clear that accelerated education on NIHL in the mines is not happening.

3.3.2 Sources of noise

The most common sources of noise at the two mines in the current study were the drilling machines, ventilation fans and crushers. Drilling machines have been classified as one of the noisiest pieces of equipment used in a mine for which intervention is required under noise engineering controls (Erasmus, 2009). Participants reported up to five (5) drilling machines running simultaneously throughout an eight to ten hour shift. Rock and diamond drill operators are associated with extensive use of drilling machines. Therefore, as previously mentioned, when considering the types of noise source and the hours of exposure, these participants were more susceptible to developing NIHL, in addition, the use of drilling machines is associated with intense labour and hot and dusty conditions that warrant adequate education and training on the importance of hearing health and safety, especially those that worked more than eight hours per shift. Training on proper hearing protection, health and safety is therefore warranted. It is hoped that

participants' level of understanding of the types of noise source, level of noise exposure and hours of noise exposure will influence their practices regarding the use of hearing protection at work. The level of education of rock drill operators ranged from primary school to grade eleven (high school). Although, the relationship between noise sources, level of education and the use of HPDs have not been studied previously, the clinical implication is that counselling should include the type of noise source in relation to NIHL and proper HPD fit to increase awareness and in turn motivate to use of HPDs at work.

The most common sources of noise reported by the participants were drilling machines (29 %), ventilation fans and crushers (10 %), diesel-operated locos and winches as well as air compressors (0.7 %), conveyer belts and forklifts. Occupation types such as rock drill operators, boiler makers, sampling attendants and miners that are exposed to noise sources such as drilling machines, ventilation fans and grinding machines should be classified as high-risk occupations for developing NIHL. The amount of time exposed to such noise sources has negative implications on one's hearing as mentioned by Edwards (2008), and drilling machines are classified as equipment that produces excessive noise (Erasmus, 2009). The importance of education and training in engineering controls and noise hazards as well as the proper use of appropriate HPDs need to be emphasised at the HCP's functional level by clinicians during the medical surveillance, in line with the DME Guideline. (2003).

3.3.3 Awareness of noise exposure and hearing loss

All the participants indicated that they were aware that noise caused deafness and that adequate hearing protection was needed to avoid deafness. As part of the induction and re-induction training on HCPs, hearing loss due to excessive noise exposure was addressed. This is the most understood fact about noise and hearing loss regardless of the participants' age, race, level of education, occupation type and years of experience therefore it can be the positive determinant for the use of HPDs.

In a study conducted at a platinum mine 25 cases of NIHL were reported from 2008 to 2009, most of the cases being rock drill operators, followed by team leaders (Erasmus, 2009). Since the same results were obtained by Edwards (2008), the current study can also assume that those occupation types were more at risk of developing NIHL due to the types of noise source they were exposed to. Therefore, clinical implications for NIHL in relation to noise sources and lifestyle implications should be emphasised during counselling following an audiological assessment.

3.3.4 Understanding of protection from noise exposure in the workplace

Of the ninety interviewed one participant that had only been at the mine for two (2) months and therefore had no history of the use of hearing protection against mine noise. He was aware of different types of earplugs, thus indicating adequate induction education and training on the different types of HPDs, even for those without any previous mine experience. Even so the clinical implication for counselling by Occupational Audiologists during medical surveillance is warranted and should include education on different types of HPDs coupled with the medical examinations

prior to induction education and training thus improving the individual's awareness of HPDs.

3.4 Awareness of different types of HPDs and HCP scope of training

3.4.1 Awareness of the types of hearing protection

All participants were aware of earplugs and earmuffs as per education and training content provided. However, according to reports from the gold mine participants, earmuffs were mentioned in training, but not offered as a form of hearing protection at the mine. On the other hand, participants from the non-ferrous mine reported that earmuffs and earplugs were both supplied during the training sessions. Nevertheless, the most common mode of hearing protection advocated by the mines was earplugs in different forms, from disposable corded foam to custom-made earplugs. Eighty-five (97 %) participants reported awareness and use of the earplugs and only three (0.3 %) participants from the non-ferrous mine reported awareness and use of earmuffs.

Training on the different types of HPD must be covered extensively. Samples should be on display and HPDs should be supplied in order to enhance the training experience and to allow personal choice. According to Guild (2001), a choice of hearing protection should be provided based on the measure of sound pressure levels of noise to be attenuated. The two types of HPD should be known equally by the workers following education and training on HPDs (DME Guideline, 2003). The results reflect over-emphasis of one HPD (earplugs) over the other (earmuffs) and in this case the cost is assumed to be a contributing factor. However, no studies have

been conducted in South African mines that will allow a comparison with the current study. Further research to investigate the choice of HPDs available in the mines versus the miners' awareness thereof is recommended.

3.4.2 Awareness of other noise reduction preventative measures covered in the induction training of HCPs

Fifty-nine participants (66 %) knew about the hazards of noise and only 0.7 % knew about regular machine maintenance. Twenty-three participants (26 %) from the non-ferrous mine showed a lack of awareness about preventative measures mentioned in the questionnaire. It is clear that all the areas of HCPs are not emphasised equally. Training and practices should cover the basics i.e. understading of noise hazards, a summary of noise engineering controls and administrative controls practised by the mine, as well as detailed information on the use of different types of HPD. These are all critical elements to the success of an HCP. According to the Department of Minerals and Energy Guideline (2003), it is the responsibility of the employer to provide information about all aspects of HCPs during education and training in order to enhance compliance by the employees.

Table 7: Preventative measures

Awareness of other preventative measures	N=90	Percentage
Regular machine maintenance	6	0.7
Rotation of production schedules	0	0
Reduction of exposure periods	2	0.2
Training of workers on the hazards of noise	59	66

Regarding equipment maintenance, the participating mines have upgraded drilling machines by installing silencers. Some of the locos are now battery operated and reportedly so much quieter that some participants stated that it was difficult to hear them driving past while wearing HPDs. These adjustments were made to meet the target set by the commission that companies should reflect a reduction in noise levels to below 110 dB by December 2013 (Department of Mineral and Energy, 2003). Participants acknowledged noise as a hazard and it is hoped that this, together with miners' improved level of education and years of experience (Hansia and Dickinson, 2009) will promote a positive attitude towards the use of HPDs.

Most of the participants from the non-ferrous mine showed a lack of knowledge about other noise reduction preventative measures as part of the HCP practised by the mine. They were also not educated on such measures during the re-induction training. One of the reasons stated by the participants for this lack of knowledge was that production schedules were rotated only on rare occasions due to ill health or promotion to the surface. Barring this one works in the same field as long as one is

fit and employable in the industry. Whilst the same reasons for a lack of knowledge regarding other preventative measure were echoed by the participants from both mines, inconsistencies in education and training content were observed. Participants from the gold mine showed more awareness as opposed to participants from the non-ferrous mine. In South Africa, gold mines are the largest in the mining industry, followed by platinum mines (Hermanus, 2007). There is more research on the employees' medical conditions in these mines as compared to others such as non-ferrous mines. This could be a reason for the inconsistencies between the two mines in the current study and has implications for the implementation of consistent and monitored HCPs across the mines in South Africa.

3.4.3 The scope of HCP induction training

Participants reported that they received a computer-based education programme provided in four different languages: English, Afrikaans, Zulu and Fanagolo. Re-inductions occurred annually following a routine medical check-up, usually when miners return from leave. The results in Figure 5 below indicate that more than 50 % of the participants strongly agreed that the key areas of the HCP were included during the re-induction education and training.

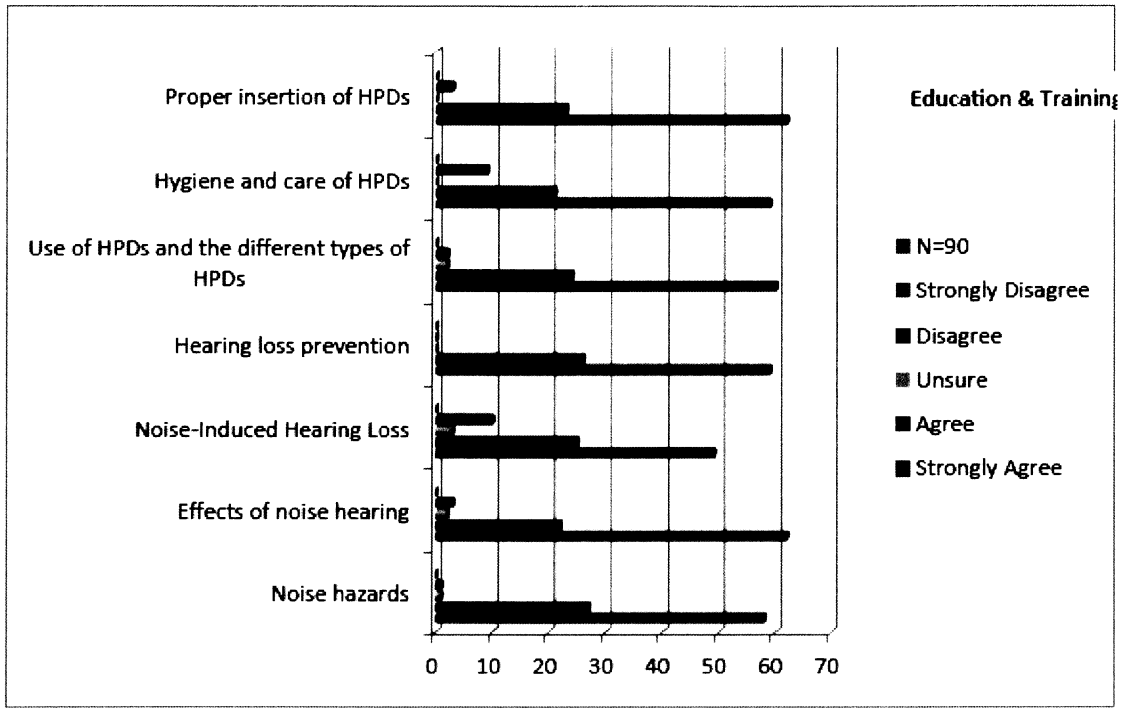


Figure 5: Education and training on HPDs

However, some participants were unsure and some disagreed about the training elements stated above. In this sample, the use of HPDs to prevent hearing loss was most commonly acknowledged. Lack of awareness regarding HCPs' education and training was attributed to the following reasons:

1. Noise hazards: only one participant indicated that noise hazards were not included at all in the induction training but confirmed the use of corded earplugs at all times. The participant had a high school education so level of education could not have been a contributing factor to the lack of understanding. However, this highlights the importance of visible signage on noise hazards.

2. Three participants did not know about the effects of noise on hearing. When considering years of experience (1-3 years) and the level of education (matric), the response could be attributed to misunderstanding the question. Contrary to the results obtained in the current study, Hansia and Dickinson (2009) noted that lower skilled miners indicated lack of knowledge on the effects of noise as a health hazard.

3. Noise-induced hearing loss (NIHL): the majority of participants reported that they were not familiar with the term NIHL, showing that it had probably not been used during the re-induction course.

4. Use of HPDs, the different types of HPD, hygiene and care and proper insertion: Fourteen participants showed a lack of knowledge in these areas. They claimed that HPDs were provided to them without any prior explanation on how to use and care for them or how to insert them correctly for a proper fit. Furthermore participants from the gold mine reported that they were not aware that there were different types of HPD to select from. This information was also echoed by one of the supervisors as well and goes against the DME Guidelines set out in Annex 6 (DME, 2003), which emphasises the importance of HPDs in improving the HCPs implemented by the mines. Annex 6 further provides for the selection, use, care and maintenance of HPDs by employers and employees.

All the areas above showing a lack of knowledge about HPDs reflect negatively on the education and training of HCPs. Participants indicated that re-inductions were offered once a year, following a medical examination at the training centre. This

could take one to five days depending on level of education and years of work experience which affects the understanding of the course content.

Training involved a computer-based software programme in the following languages: English, Afrikaans, Zulu and Fanagolo. Participants raised concerns about the medium of instruction and computer literacy which hampered understanding of the training material. This showed a gap between standard of education and training tools at employee level. The method of delivery should be reviewed by the mines (employers) so that understanding can be enhanced, this could influence the participants' level of awareness regarding noise hazards and motivation to use HPDs appropriately. Therefore, use of other training tools and methods should be explored. Similar findings were reported by Hansia and Dickinson (2009).

3.4.4 Awareness of health problems associated with noise

The interview question intended to investigate whether participants realised that the stated health problems were associated with noise exposure in the workplace. During the interviews some of participants indicated that they were aware of the secondary health problems associated with mine noise that affected the ear structures and hearing skills. The following results were obtained: five participants (0.6 %) indicated awareness of earache; fifteen (17 %) of noise in the ear (tinnitus); two (0.2 %) of ear-infection; and three (3.3 %) of hearing loss (TTS). The results indicate tinnitus to be the most common health-related problem participants experienced and associated with noise exposure followed by earache. This shows not only an awareness of the associated health problem, but also of the increased level of awareness demonstrated by participants' experiences.

Most of the participants that reported experiencing tinnitus were generalists (five) in the age group 20 to 40 years with two to three years of work experience. They reported the use of earplugs (both custom-made and corded design) for hearing protection. This result differs from that obtained by Edwards (2008) who reported that tinnitus was experienced mostly by participants in the age group 30 to 60 years with between 21 and 30 years of work experience, as well as by loco operators and team leaders. The differences in the findings could be attributed to the difference in the set of questions asked.

In the current study, rock drill operators, who were known to be exposed to excessive noise levels, did not report any case of tinnitus nor any other listed associated health problems. Since the relationship between NIHL and tinnitus has been reported (Axelsson, 1992), a similarity between the studies conducted by Edwards (2008) and Erasmus (2009) can be observed with rock drill operators and team leaders being most affected by tinnitus and NIHL. The differing results obtained in the current study may be attributed to the fact that rock drill operators had more experience in the mine, and did not consider tinnitus a cause for concern, or have adapted to the problem and therefore have mechanisms to block the effect.

In the group of participants with less than 5 years of work experience in the mine tinnitus was considered to be the most problematic health problem associated with noise exposure. This has positive implications on the part of miners in realising the relationship between tinnitus and excessive noise exposure leading to NIHL. This might indicate appropriate awareness needed for the risk-based medical examinations.

Gaps in risk-based medical examinations were identified across different levels of participants. Therefore, risk-based medical examinations should be asking relevant questions regarding tinnitus and the need for audiologists to include tinnitus management in the management of miners should be emphasised (Edwards, 2008).

3.5 Understanding, attitudes and views of mine workers on the use of HPDs in relation to noise exposure

3.5.1 Current ownership of HPDs

All the participants interviewed owned HPDs - earplugs and earmuffs. Corded earplugs being the most common and earmuffs being the least.

Table 8: Types of HPD used by miners

Types of HPD used by miners	Number=89	Percentage
Custom-made	31	35
Corded foam earplugs	55	62
Earmuffs	3	0.3

This was in line with the goal set by the commission for 2008 to provide employees with an effective HCP in order to reduce NIHL cases reported in the mines. Although the use of HPDs was listed as the last option, mines opted to use them the most, probably because earplugs are readily available and less expensive than other noise reduction measures such as engineering controls (Coutts, 2010). This suggests that cost could have been the determining factor in choosing HPDs over other noise reduction measures. Whilst the mines have undertaken a proactive role in providing

all the mine workers with some form of hearing protection, there are gaps in the selection and provision of HPDs per data previously reported. Earplugs rather than earmuffs are most widely used, thus creating a negative environment for HCP compliance. Information on a variety of HPDs should be provided equally to all employees, and employees should be allowed to select the most suitable HPD based on noise exposure level and personal preference. Therefore, in order to incorporate the code of best practice in HCPs, provision of the appropriate selection of HPDs has to be considered by the mines (Annex 6, Department of Minerals and Energy, 2003).

3.5.2 Use of HPDs specific to occupation

The majority of participants (85) used earplugs and only three participants used earmuffs. In general the mines supplied corded foam, but results from the gold mine also showed that all seven rock drill operators and ten out of eleven loco and winch drivers used custom-made earplugs. This showed the mines' intention to use adequate ear protection as these participants were the most exposed in terms of noise and years of experience. As previously mentioned, Erasmus (2009) found that most cases of NIHL reported in the platinum mine for the 2008/2009 year were from rock drill operators, followed by team leaders. The current study indicated improved hearing protection by those workers exposed to excessive noise sources. This shows the need for proper hearing protection across different occupations depending on source and duration of exposure in order to reduce occupation related NIHL cases across the spectrum (Annex 6, Department of Mineral and Energy, 2003).

3.5.3 Use of HPDs specific to years of experience

All the participants owned some form of HPD provided as part of the personal protective equipment (PPEs) used by the mines when interviewed. They reported that it was compulsory to wear HPDs for the duration of the shift. This showed that all the participants, regardless of experience were aware of the importance of using HPDs on a daily basis for the whole shift and owned personal HPDs. A trend showing that the choice of HPD changed with years of experience from corded earplugs to custom-made earplugs was noted. Loco and winch drivers with 29 years of experience preferred to use custom-made earplugs, as ten (10) out of eleven used custom-made earplugs. This indicates a positive relationship between the selection and use of an HPD and years of experience.

3.5.4 Use of HPDs in relation to the type of noise exposure

Participants employed as rock drill operators, loco and winch drivers, crashers, boiler makers, and scaler assistants reported that, due to excessive levels of noise in the workplace, they would prefer to use good quality customised HPDs, such as custom-made earplugs, in order to protect the ears efficiently. This has positive implications for the participants' motivation to use HPDs daily.

3.5.5 Frequency of HPD usage

The majority of participants (84) stated that they used HPDs at all times during the eight to ten hours shifts. However, observations conducted prior to the pilot study revealed that miners with corded foam earplugs would wear HPDs at the start of the

shift, but would not replace them should they fall out during the shift citing time wastage and discomfort as the main reasons for doing so.

A study conducted by Neitzel (cited in Hansia and Dickinson, 2009:73) indicated similar findings, with reported use of 93 % and observed use of 50 % by construction workers. However, the current research study did not obtain the exact frequencies of the actual use of HPDs, thus a limitation was noted. In order to obtain exact frequencies of the use of HPDs, employees' actual use of HPDs should be properly monitored to avoid predisposing participants to NIHL. This discrepancy between reported use and actual use of HPDs was attributed to the working conditions underground and the prolonged working hours of participants. This has negative implications for the intended application of HPDs and the compatibility with the user's needs and work situation, as stated in Annex 6 (DME, 2003). Removing the overall protection from noise places participants at risk of developing NIHL.

The participants that reported use of HPDs most of the time or half the time were mostly supervisors and health and safety officers, that usually spent less than four hours per shift in noisy areas. A process controller from the non-ferrous mine reported that he worked in a secluded quiet room and therefore only used HPDs (corded foam earplugs) when leaving the room to go into the plant. Overall, lack of actual use of HPDs and the related discomfort of HPDs may override any detailed knowledge of the effects of not wearing HPDs, especially where the discomfort may be severe (Hansia & Dickinson, 2009). Therefore, clinical implications for audiologists in counselling are to emphasise the importance of proper fit and comfort of HPDs in order to reduce NIHL cases.

3.5.6 Participants' perceived views on the benefits of HPDs

Two main benefits of HPDs were reported. The first was the reduction of the risk of hearing loss and protection from loud noise exposure. The second benefit was related to those participants exposed to dust; they reported that in the dusty humid conditions in which they worked that the earplugs protected the external ear canal from exposure to dust and kept their ears clean. This was evidenced by the sticky dusty substance apparent in the pinnae and on the periphery of the earplugs, but not inside the external ear canals. This was reported mostly by participants from the non-ferrous mine, as the majority of them worked in a dusty environment.

Most of the perceived benefits (Figure 6 below) were reported by participants in the following occupations: rock drill operators, crashers, boiler makers and forklift drivers in the non-ferrous mine.

Those participants not working in dusty places indicated "unsure" or "disagreed" with the statement that HPDs helped to keep the ears clean. Therefore, working conditions influenced the perceived benefits of HPDs. This once again shows that the appropriate selection of HPDs per employee, their work environment and their level of motivation is important. As dust particles are associated with infectious diseases, infection control measures should be emphasised by clinicians during the risk-based medical examination of employees. According to a study conducted by AngloGold Ashanti (2008) on miners, 462 cases of silicosis were diagnosed in 2007. In another study conducted by Sciencescope (2009) the co-existence of silicosis and NIHL on the miners was investigated and both were found to affect the miners' quality of life.

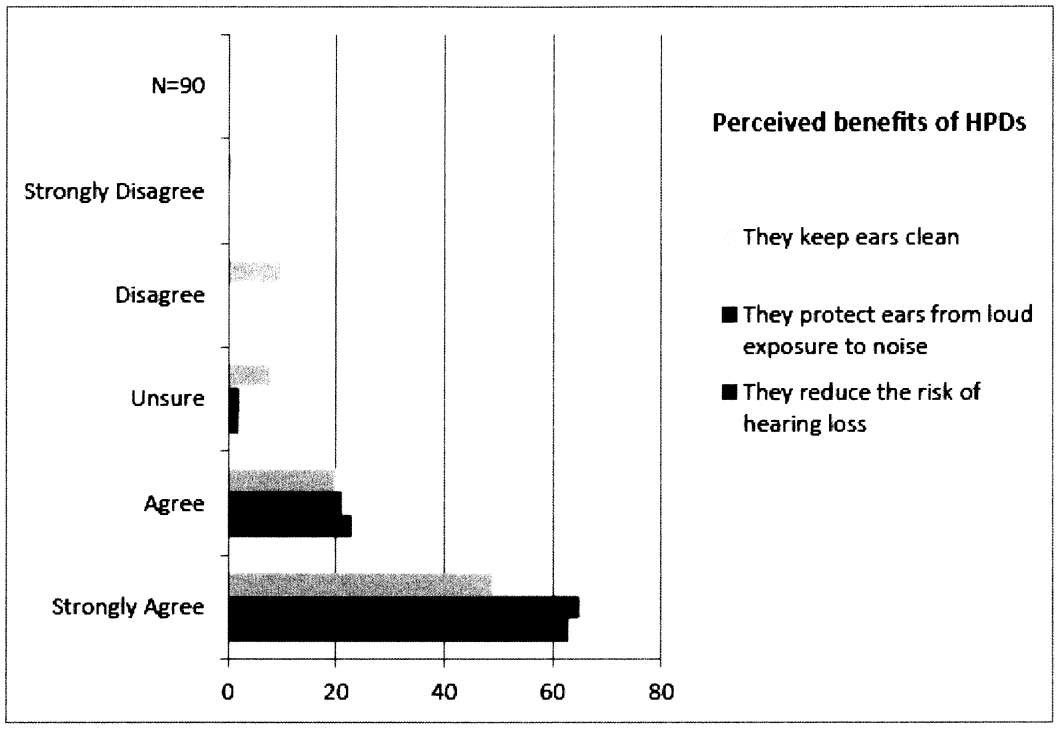


Figure 6: Perceived benefits of HPDs

3.5.7 Hearing evaluation at the mine clinic/hospital

According to the information obtained during the interviews, all mine workers across all occupations were expected to attend the annual routine medical check-up at the mine clinic, thus all the participants (100 %) had gone through the process of medical check-ups. Participants reported that medical check-up routines were conducted annually upon return from leave and were compulsory. The medical check-ups included ears, eyes, and chest, as well as an overall medical assessment and a hearing evaluation. This is in accordance with the requirements of the Mine Health and Safety Act 20 of 1996 that ensures that audiograms of all employees subject to medical surveillance are obtained annually by the employer. In addition,

audiogram monitoring is required to detect early temporary threshold shift and determine the effectiveness of HCPs.

Nevertheless, participants reported a lack of understanding the outcome of their medical results except for the pass result written on the job card at the end of the examination. They also acknowledged that they did not always report other health-related problems such as tinnitus, earache or ear infections. This lack of reporting related medical conditions and a misunderstanding of medical results may be attributed to language barriers between miners and medical professionals. This has negative implications for the risk-based medical examination, medical surveillance and audiometry elements of HCPs in reducing NIHL cases. Therefore, simplified case history interviews need to be considered by medical professionals at the mine hospitals.

3.6 Factors influencing the use of HPD

The majority of participants acknowledged that the mines provided them with HPDs free of charge and that they realised the benefits of using HPDs to preserve hearing. Factors associated with HPD usage reported by participants were in relation to comfort, design and work-related communication and warning signals. Although participants acknowledged noise as a health hazard and that hearing protection was vital, they mentioned some factors that impeded the use of HPDs. Participants that used earplugs, both corded and custom-made, reported that with prolonged use they experienced discomfort; pain and itchiness of the external ear canal. In addition, participants reported that earplugs came off during intense labour. Also in a study

conducted by Zungu (2012), the participants reported experiences of itchiness and ear infections from earplugs.

The abovementioned factors negatively affected motivation to use HPDs and led to non-compliance with HCPs. The lack of motivation can also be attributed to insufficient awareness of the different types of HPD available that suit individual preferences and anatomies. Incorrect fit could be ascribed to improper HPD size, faulty insertion, wear and tear, and incompatibility with other PPEs, for example safety glasses. All of these elements contribute to noise leaks and a lowering HPD use.

Three participants reported difficulty hearing warning signals when earplugs were worn. Some participants reported that it was difficult to hear battery-operated locos when HPDs were fitted too deep (complete seal). Consequently, when working in areas where battery-operated locos were driven, participants preferred a slightly looser fit in order to hear a hoot from a loco. In a report by Sciencescope (2009) Edwards also acknowledged diminishing ability to speak properly when wearing HPDs.

Five participants reported that they had difficulty communicating with peers at work, resulting in earplugs being removed when work instructions were given. Removing HPDs even for a few minutes reduces the rate of protection significantly (Department of Mineral and Energy, 2003), showing gaps in education and training on the use of HPDs. The removal exposed participants to noise leaks which had implications for the noise exposure levels and in turn NIHL.

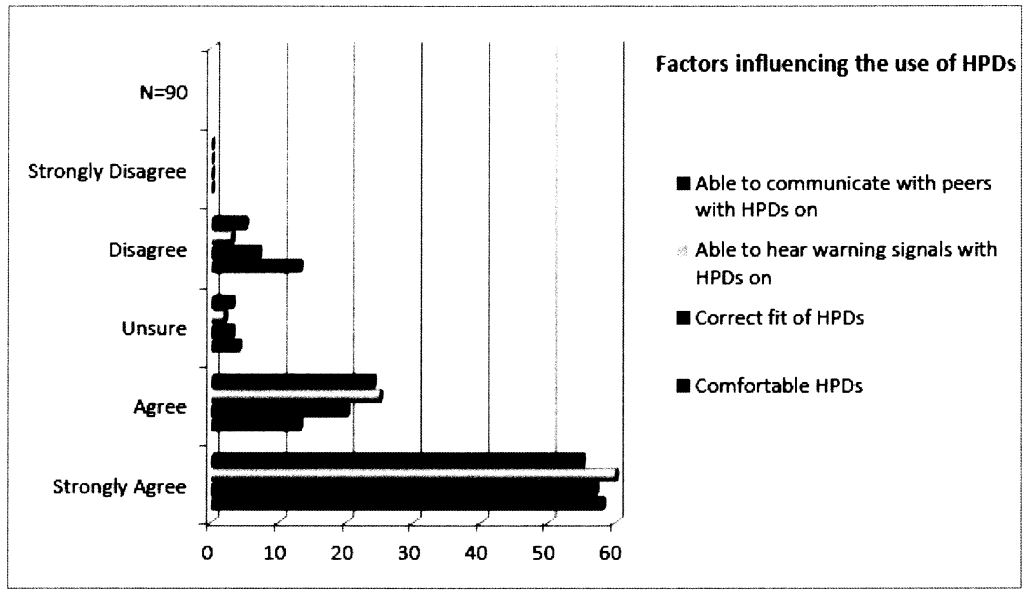


Figure 7: Factors influencing the use of HPDs

Participants also reported that proper hygiene and care of HPDs were not practised and that insufficient information was provided on the hygiene and care of HPDs during induction training. Limited information about wearing someone else's HPD, when to dispose of HPDs and the proper cleaning of custom-made earplugs when clogged with wax negatively affected their hygiene practices. When the hygiene of HPDs is compromised, it triggers other health-related problems such as ear infections. This, in turn, had negative clinical implications for the risk-based medical examination, specifically for audiological evaluation: extensive case history interviews during follow-ups that should have been incorporated within the employees' medical surveillance and audiometry.

In addition to the health problems associated with mine noise, participants reported a lack of knowledge regarding the proper use of HPDs in protecting the ears and

hearing. Therefore, participants were of the opinion that proper education and training on the different types of HPD and on the use of HPDs, during annual re-inductions and at the shaft would enhance daily use of HPDs at work.

3.7 Factors influencing the use of HPDs and the relationship between gender, level of education and years of experience

The researcher identified the factors influencing the use of HPDs as gender, level of education and years of experience. The relationship between factors influencing the use of HPDs to gender, level of education and years of experience was determined by a chi-square test. Table 9 below illustrate the results obtained.

Table 9: The relationship between gender, level of education and years of experience variables ($\alpha = 0.05$) using the chi-square test of contingency

Variables	Df	$\alpha = 0.05$	x^2	p-value	Critical value
Gender	1	0.05	0.16	0.6892	7.88
Level of education	3	0.05	2.23	0.5261	12.84
Years of experience	4	0.05	7.99	0.0919	14.87

According to the statistical test results, the slight differences in numbers obtained indicate a relationship between the use of HPDs and years of experience, although not statistically significant. However, there is not enough evidence at the 5 % significance level to infer that the following factors: gender, level of education and

years of experience were related to the participants' use of HPDs. The results therefore indicate that these factors may occur in isolation or in combination but will not influence the use of HPDs by the miners. The insignificant statistical values obtained were influenced by the small sample size. In support of the current study, a study conducted by Crandell and Mills (2004) ruled out the level of education as one of the determinant for the HPD use. In order to enhance the implementation of Track C (SIM 050501) on the use of HPDs, the miners' level of education and years of experience have to be taken into consideration (Coutts, 2010). However, no studies nationally and internationally have reported the relationship between gender, level of education and years of experience on the use of HPDs by the miners.

CHAPTER 4: CONCLUSIONS AND RECOMMENDATIONS

The current study's main aim was to investigate the understanding, attitude and views of South African mine workers regarding NIHL and the use of HPDs in HCPs in the gold and non-ferrous mining subsectors. The results proffered evidence-based information on the current practices of HCPs specific to the mines that participated in the research study. In order to address the main aim of the current study, the following sub-aims: to investigate the understanding of a sample of SA mine workers regarding hearing safety and associated NIHL in South African gold and non-ferrous mining subsectors; to investigate the secondary effects of exposure to different noise sources on participants' hearing abilities at the gold and non-ferrous mines; to investigate the understanding, attitudes and views of mine workers regarding the use of HPDs in South African gold and non-ferrous mining subsectors; to determine factors impeding the use of HPDs in this sample group; and to determine the factors positively influencing the use of HPDs in this sample group were formulated and investigated. A summary of findings obtained was as follows:

4.1 Summary of findings

- The majority of participants were from the gold mine (n=65), reflecting South Africa's dominance in this industry (Chamber of Mines Annual Report, 2012).
- A difference in understanding regarding the different types of HPDs available existed between the two mines. In the gold mine, the majority of participants were aware of three different types of HPDs: earmuffs, disposable earplugs and custom-made earplugs, whilst participants in the non-ferrous mine mostly knew about earmuffs and disposable earplugs.

- Although gender equality in the mining industry is becoming more inclusive, the majority of mine workers are still males (Zungu, 2012). In the current study 77 males and 13 females participated.

- The majority of participants had high school education, thus indicating an improved level of education among miners. This has positive implications for the provision of education and training programmes as it can by assumed there would be an improved understanding of the content material.

- Excessive noise exposure levels, years of experience, occupation type, nearby noise sources, and duration of noise exposure were the variables influencing the outcome of the study. Rock and diamond drill operators, scaler assistants, loco and winch drivers were the top three occupations with the most years of experience and highest exposure to noise for eight to ten hour shifts per day.

- Although every miner was provided with disposable corded foam earplugs, the majority of participants showed a preference for custom-made earplugs (noise clippers).

- During compulsory annual hearing assessments (as part of their annual medical examinations and re-induction and training), conditions such as tinnitus, earache and ear infections were rarely reported by the miners during these assessments.

4.2 Limitations of the study

- The current study's sample size of 90 was very small when compared to the overall mine worker population of 514 760 in South Africa (Chamber of Mines Annual Report, 2012). This was due to unrest in the South African mining sector during data collection for the research study and the researcher could not secure firm appointments to interview miners. Therefore, the results obtained cannot be generalised to the greater mining population in South Africa.

- Participants completed informed consent forms. This may have resulted in possible skewing of answers based on information contained in the informed consent.

- The questionnaire did not include a graded section on the areas that participants know the most or least about. This may have provided more relevant information.

- Although different types of noise source were identified during data collection at the mines, actual sound pressure levels of those noise sources were not recorded by the researcher. Therefore, noise source measurements could not be commented on in detail in the research study. Therefore, future research could include sound pressure levels of noise sources that miners are exposed to (Dias, Cordeiro and Corrente, 2006).

- During data collection, structured interviews were conducted with limited observations and therefore the study relied more on participants' reports.

Actual observations would have provided more reliable information and served to confirm the participants' reports, especially on the level of noise from different noise sources, HPD types and usage. Therefore, future research can include interview recordings as well as actual observations of the miners.

- In addition, interviews could have been recorded to reduce any researcher bias.

- Due to the questionnaire having been administered by the researcher, participants' responses may have been limited. They may not have always provided their true opinion as they may not have wanted to reveal certain information or may have been afraid of being penalised for providing such information. This is an acknowledged limitation of the current research study.

- The mines that participated used computer-based HCPs. Although they differed, a thorough investigation of those programmes could have assisted the researcher in understanding their content properly.

4.3 Conclusion

In the mining industry globally, the use of HPDs in the HCPs has been investigated extensively by mines. In South Africa, willingness to comply with policies on HCPs is evident. However, there are not enough current research studies to guide the mining industry, especially on the use of HPDs and the effects of NIHL on the miners. Although the sample size for the current study was very small and insignificant when

compared to the total mining population, the findings provided relevant information for use in future studies viz:

- It was evident in the research study that the level of education of miners had improved over the years thus showing that HCP/HPD education and training should match the current improved education levels of miners.

- The current research study identified and understood the practical challenges experienced by miners and mining companies, specifically HCPs and in particular the use of HPDs provided by the mines. This has positive implications for HCPs used by the mines and ways in which programmes to reduce NIHL can be improved.

- An improvement on evidence-based research regarding the positive factors and challenges in the effective application of best practice in HCPs and HPDs and recommendations for ways of overcoming these challenges.

- The important role of occupational audiologists as hearing professionals in the South African mines in improving HCPs in reducing NIHL cannot be underestimated.

- The current research study lays the groundwork for the appropriate implementation of HCPs, especially on the use of HPDs, also emphasising the importance of Track C (SIM 050501)1 (Coutts, 2010), in addressing the needs of all stakeholders in the mining industry.

South Africa is a developing country where government guidelines that regulate the mine industry have encouraged and enforced the implementation of stricter

monitoring strategies of HCPs in order to safeguard employee health and safety. The issue of NIHL should be addressed at all levels, from miners to top-level managers. This will reduce the recorded cases of NIHL. According to Edwards (2010), it is the responsibility of employers to prepare and implement a code of practice (COP) on any matters affecting the health and safety of employees, and failure to do so is a breach of the MHSA of 1996 (Mine Health and Safety Act, Act 29 of 1996).

The MHSA of 1996 (Mine Health and Safety Act, Act 29 of 1996) stipulates that the employer monitors all employees whose noise exposure is equivalent to, or exceeds eight hours, at a noise level of A-weighted sound level in decibels of 85 (85 dB(A)) or more. The mines perform compulsory annual hearing screenings on every employee and have daily recordings on underground noise levels to assist them in identifying early cases of NIHL and in order to record those areas and equipment that are still problematic for future intervention in noise reduction. (Harmony Gold Annual Report, 2011) Education and training of employees regarding the risk of excessive noise exposure in the workplace is conducted annually forming part of an HCP. However, in order for HCPs to work effectively, policies have to be understood and practised by all miners. In addition, the role of audiologists in HCPs should be clearly stated and they should be proactive in reducing NIHL.

The results obtained in the current study indicated that the participants did not link other hearing-related medical conditions such as ear infections, earache and tinnitus to NIHL. This is critical and the role of occupational audiologists in addressing hearing-related medical conditions should be emphasised.

4.4 Recommendations

- Due to the limited sample size of the current study, future research should replicate the current study using a larger sample size.

- The current research study should be replicated with the addition of actual observations and recordings of the use of HPDs by the miners during their normal working shifts. This will allow the researchers to document the actual benefits of the HPDs to the miners.

- Many research studies on the prevalence of NIHL as a major indicator of the effectiveness of HCPs have been conducted in the South African mines. However, limited research has been conducted on the use of HPDs in HCPs in South African mines. Therefore, more research is recommended, as the improper use of HPDs has a direct link to the effectiveness of HCPs practised by the mines in South Africa.

- Future research should investigate HCPs practised by mine subsectors other than the gold, diamond and platinum mines.

- An in-depth investigation of the content of HCPs and the mode of training at different mines should be done in future. Both these elements are critical in the understanding of HCPs provided by the mines, which in turn will improve effective practices.

- As stated in the Department of Minerals and Energy Guideline (2003), the selection of HPDs should be considered based on the miner's individual preference, the miner's work environment as well as other personal protective

devices used by the miner, for example a helmet. Therefore, involving the miners in the selection of HPDs might encourage the use of provided HPDs.

- All the mines were mandated to provide HCPs annually to all employees as evidenced by annual induction and re-induction programmes. Such programmes should emphasise the importance of a good fit, infection control measures and wear-and-tear of HPDs, these areas were found to be lacking during the current research study.

- The mines do have medical clinics as well as stores above ground that provide medical and safety materials. However, it would be advisable to have the same services on a smaller scale underground in order to provide for eventualities such as the replacement of HPDs on site.

- The audiologist's role in medical surveillance was identified as a limitation during the current study. Occupational audiologists should actively be included in HCPs provided by the mines; in the selection of HPDs, follow-up visits on hearing-related medical conditions, and the use of HPDs and their role should be clearly identified and understood by all parties.

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Appendix A: Interview Questions

APPENDIX A:

QUESTIONNAIRE

SECTION A: BIOGRAPHICAL INFORMATION

A.1 Age:

A.2 Gender:

A.3 Ethnic Group:

A.4 Highest Qualification:

Section B: EMPLOYMENT HISTORY

B.1 Previous work experience:

B.1.1 Please state the type (gold/platinum) of the mine you worked for previously: _____

B.1.2 Please state your job description at the previous mine: _____

B.2 How long did you work there?

1. Less than 2years		**2.** 2yrs – 5yrs		**3.** 6yrs – 8yrs		**4.** 9yrs +	

B.3 Current work experience information.

B.3.1 Please state your current job description by placing an **[X]** next to it.

1. Rock drill operator	
2. Timber-man	
3. Winch and Loco Driver	
4. Miner	
5. Underground Supervisor/Miner	
6. Other (please specify)	

B.5 How long have you worked in the present area? Please indicate with **[X]** next to the answer.

1. 6mths – 1yr		**2.** 1yr – 2yrs		**3.** 3yrs – 5yrs		**4.** 6yrs – 8yrs		**5.** 9yrs +	

B.6 Please indicate on average your working hours per day with **[X]** next to the answer.

1. 4hrs – 6hrs		**2.** 7hrs – 9hrs		**3.** 9hrs – 11hrs		**4.** 12hrs – 14hrs		**5.** 15hrs +	

SECTION C: KNOWLEDGE ON THE USE OF HPDs AND NIHL

C.1 Do you think you are exposed to loud noise of any kind at work? Please indicate with an **[X]** underneath your answer.

1.Yes	**2.No**

If **Yes**, please proceed to C.2

If **No**, please move to C.4

C.2 If your answer is yes for C.1, please indicate with an **[X]** the source.

Source	**[X]**
1. Drilling machines	
2. Ventilation fans	
3. Jackhammers	
4. Riveting machines	
5. Grinding machines	
6. Air-compressors	
7. Ball mills	
8. Other(please specify)_____	

C.3 If yes, for how long? Please indicate with an **[X]** underneath your answer.

1. 4hrs – 6hrs		**2.** 7hrs – 9hrs		**3.** 9hrs – 11hrs		**4.** 12hrs – 14hrs		**5.** 15hrs +	

C.4 Are you aware that exposure to noise can cause deafness ?

1.Yes	2.No

If **Yes**, please proceed to C.6.

C.5 If **No**, what do you think causes deafness in your working environment? Specify_____.

C.6 Are you aware that you can be protected from noise?

1.Yes	2.No

If **Yes**, please proceed to C.7.

If **No,** please proceed to C.9.

C.7 State the method of protection

Method of protection	**Mark with a cross [X]**
1. Use of Earplugs	
2. Use of Earmuffs	
3. Isolation from noisy machines	

C.8 Knowledge of other preventative measures

Preventative measures	**Mark with a cross [X]**
1. Regular machine maintenance	
2. Noise engineering controls	
3. Rotation of production schedules	
4. Reduce exposure period	
5. Training workers on hazard of noise	

C.9 Have you heard of education and training on prevention of deafness from mine noise?

1.Yes	**2.No**

If **Yes**, please proceed to C.10.

If **No**, please proceed C.11

C.10 If the answer at C.9 is yes, did education and training on the HPDs include the following: Indicate the appropriate statement below with an **[X]**.

Statement	**1. Strongly Agree**	**2. Agree**	**3. Unsure**	**4. Disagree**	**5. Stro y Disa e**
1. Noise hazards					
2. Effects of noise on hearing					
3. Noise-Induced Hearing Loss					
4. Hearing loss prevention					
5. Use of HPDs and the different types of HPDs.					
6. Hygiene and care of the HPDs.					
7. Proper insertion of the HPDs.					

C.11 Have you heard of health problems from mine noise?

1.Yes	2.No

If **Yes**, please proceed to C.12

If **No**, please proceed to C.13

C.12 State the health problems caused by the mine noise.

Health Problems	Mark with a cross [X]
1. Hearing loss	
2. Noise in the ear	
3. Headache	

C.13 Do you have any hearing protection devices (HPDs)?

1.Yes	2.No

If **Yes,** please proceed to C.14.

If **No**, please proceed to C.19.

C.14 Please select with an **[X]** the type of HPDs you use below.

Type	**1. Yes**	**2. No**
1. Earmuffs		
2. Corded Earplugs		
3. Cordless Earplugs		
4. Custom-made plugs		
5. Head-band inserts		
6. Other (please specify)_____		

C.15 How often do you wear HPDs when you are working? Please indicate with an **[X]** underneath your answer.

1. Never	**2. Not often**	**3. About half the time**	**4. Most of the time**	**5. Always**

C.16 Was education and training performed at the mine on how to wear and care for your HPDs?

1.Yes	**2.No**

C.17 Do you think you benefit from using HPDs? Please indicate with an **[X]** underneath your answer.

1.Yes	**2.No**

C.18 If yes in C.17, what do you think the benefits are? Please indicate with an **[X]** the appropriate statement.

Statement	**1. Strongly Agree**	**2. Agree**	**3. Unsure**	**4. Disagree**	**5. Strongly Disagree**
1. They reduce the risk of hearing loss.					
2. They protect my ears from loud exposure to noise.					
3. They keep my ears clean.					
4. Other (please specify)					

C.19 Have you checked your hearing ability in the mine hospital/clinic?

Yes	**No**

If **Yes**, please proceed to C.20.

If **No**: **Thank you for completing the questions.**

C.20 What were the reasons for a hearing check? Please indicate your answer with an **[X]**.

Reason for hearing check	**Indicate with an [X]**
1. Routine annual medical check-up	
2. Due to hearing loss	
3. Due to noise in the ear	
4. Due to other ear pathologies	

SECTION D: FACTORS INFLUENCING THE USE OF HPDs

D.1 I am motivated to use HPDs.

Yes		**No**		**Unsure**	

D.2 If the answer above is **yes** state the reason. Indicate the appropriate statement below with an **[X]**.

Statement	**1. Strongly Agree**	**2. Agree**	**3. Unsure**	**4. Disagree**	**5. Strongly Disagree**
1. My HPDs are comfortable.					
2. My HPDs fit me correctly.					
3. I can hear warning signals properly when I have my HPDs on.					
4. I am able to communicate well with my peers.					
5. Other reasons, if any.					

D.3 If the answer above is **No** state the reason. Indicate the appropriate statement below with an **[X]**.

Statement	**1. Strongly Agree**	**2. Agree**	**3. Unsure**	**4. Disagree**	**5. Strongly Disagree**
1. My HPDs are uncomfortable.					
2. My HPDs do not fit me correctly					
3. I cannot hear warning signals properly when I have my HPDs on.					
4. My HPDs fall off regularly when I am working.					
5. My ears sweat more when I have my HPDs on					

at work.					
6. I struggle to communicate well with my peers.					
7. Other reasons, if any.					

THE END

THANK YOU FOR COMPLETING THE QUESTIONS

Appendix B: Permission Letters

APPENDIX B

Mine: Harmony Gold

Date: 23rd August 2012

Dear Sir/Madam

Re: Permission to carry out a research study with mine workers employed by the mine.

I am currently a Masters student in the Department of Speech Pathology and Audiology at the University of Witwatersrand. I am registered in Masters in Audiology by dissertation. A requirement for the completion of the Masters degree by dissertation is to conduct a research study.

The purpose of the study is to investigate the use of hearing protection devices in hearing conservation programmes in South African mines and the factors that positively and/or negatively influence the use thereof. The study would enable me to determine whether mine workers are aware of the importance of hearing protection devices for their ears and hearing and whether they understand the importance of using the hearing protection devices whenever they are exposed to noise at work.

The method of data collection is a structured interview with the mine workers in my presence, of which will take a few minutes of their time. Details of the study are contained in the proposal, which is enclosed. Upon completion of the study, the research report will also be made available to the mine.

Information obtained from the mine workers will be treated with strict confidentiality. Mine workers' anonymity is also guaranteed.

Your assistance will be greatly appreciated.

Yours truly,

_____

Mrs L. Ntlhakana

APPENDIX B

Mine: Silicon Smelters

Date: 8th January 2013

Dear Sir/Madam

Re: Permission to carry out a research study with mine workers employed by the mine.

I am currently a Masters student in the Department of Speech Pathology and Audiology at the University of Witwatersrand. I am registered in Masters in Audiology by dissertation. A requirement for the completion of the Masters degree by dissertation is to conduct a research study.

The purpose of the study is to investigate the use of hearing protection devices in hearing conservation programmes in South African gold, platinum and other ferrous mines and the factors that positively and/or negatively influence the use thereof. The study would enable me to determine whether mine workers are aware of the importance of hearing protection devices for their ears and hearing and whether they understand the importance of using the hearing protection devices whenever they are exposed to noise at work.

The method of data collection is a set of questions structured in the form of a questionnaire whereby the research will interview the mine workers using the questionnaire. This is expected to take about 20 minutes of their time. Details of the study are contained in the proposal, which is enclosed. Upon completion of the study, the research report will also be made available to the mine.

Information obtained from the mine workers will be treated with strict confidentiality. Mine workers' anonymity is also guaranteed.

Your assistance will be greatly appreciated.

Yours truly,

_____

Mrs L. Ntlhakana

Appendix C: Informed Consent Letters

APPENDIX C

PARTICIPANT INFORMATION SHEET

You are invited to participate in a research study conducted by Liepollo Ntlhakana for the purpose of pursuing a Masters Degree in Audiology at the University of Witwatersrand. You are invited to participate in the research study because you are a mine worker, working underground at this mine and you are exposed to high levels of noise at work. Your participation is voluntary. Please read the information below, and ask questions about anything you do not understand before deciding whether to participate. Please take as much time as you need to read the consent form. If you decide to participate, you will be asked to sign this form at the end. You will be given a copy of this form.

PURPOSE OF THE STUDY

The purpose of the study is to find out if mine workers use hearing protection devices well when they are working in the mines. The title of the research study is to investigate the use of hearing protection devices in hearing conservation programmes in South African mines and the factors that positively and/or negatively influence the use thereof. The study would allow me to understand whether you are aware of the importance of using hearing protection devices to protect your ears and hearing as well as the importance of using the hearing protection devices whenever you are exposed to noise at work.

STUDY PROCEDURES

If you volunteer to participate in this study, you will be asked to complete a questionnaire. The questionnaire will take about 45minutes of your time to complete. You will complete the questionnaire in a quiet room allocated by the mine. After completing the questionnaire you will fold it and drop it in the box placed next to the door. There are no risk factors anticipated regarding your participation in the

research study. However, when you feel some discomfort at responding to some questions, please feel free to avoid the question.

POTENTIAL BENEFITS TO PARTICIPANTS

The research study will provide anticipated benefit to you. As the overall goal of the research study is to find out if mine workers use hearing protection devices and that they are aware of the importance of hearing protection devices for their ears and hearing. Therefore, as a mine worker you will eventually benefit from the research study when its recommendations are implemented of reducing noise induced hearing loss.

PAYMENT/COMPENSATION FOR PARTICIPATION

You will not receive any form of payment for your participation in this research study.

CONFIDENTIALITY

Any identifiable information obtained in connection with this study will remain confidential and will be disclosed only with your permission or as required by law. Only members of the research team will have access to the data associated with this study. The information will be coded and stored in numbers in the place researcher's unidentifiable place, locked up in a filing cabinet and some on a protected computer. When the results of the research are published or discussed in conferences, no identifiable information will be used.

PARTICIPATION AND WITHDRAWAL

Your participation is voluntary. Your refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may withdraw your consent at any time and discontinue participation without penalty.

INVESTIGATOR'S CONTACT INFORMATION

If you have any questions or concerns about the research, please feel free to contact me (Liepollo Ntlhakana) on 084 257 0938 and Ms Amisha Kanji, Research Supervisor, on (011) 717 4551.

INFORMED CONSENT

I have read the information provided above. I have been given a chance to ask questions. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

_____

Name of Participant

_____ _____

Signature of Participant Date

SIGNATURE OF INVESTIGATOR

I have explained the research to the participant and answered all of his/her questions. I believe that he/she understands the information described in this document and freely consents to participate.

_____

Name of Person Obtaining Consent

_____ _____

Appendix D: Medical Ethics Committee Clearance Certificate

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON MEDICAL)
H120622 Ntlhakana

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER H120622**
PROJECT TITLE	The Use of Hearing Protection Devices in Hearing Conservation Programs: use, awareness and views of South African mine workers.
INVESTIGATOR(S)	Ms L Ntlhakana
SCHOOL/DEPARTMENT	Speech Pathology and Audiology
DATE CONSIDERED	22 June 2012
DECISION OF THE COMMITTEE	Approved Unconditionally
EXPIRY DATE	30 June 2014

DATE 10 October 2012 **CHAIRPERSON** (Professor T Milani)

cc: Ms. A Kanji

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10005, 10th Floor, Senate House, University.

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** 26 / 11 / 12

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES