Chapter one INTRODUCTION AND RATIONAL

# 1. Noise-induced hearing loss: Prevalence, degree of hearing loss and impairment criteria in South African gold miners

## 1.1. Introduction and study rational

Noise-induced hearing loss is no new phenomenon but the last two centuries has seen a significant increase in its occurrence. This can be attributed to the industrial revolution which saw the increase of mechanical equipment capable of producing hazardously loud noise and the widespread availability of gunpowder. It was noise-induced hearing loss (NIHL) which “gave birth” to the profession of Audiology in the 1940s when soldiers returned from World War II with acquired hearing loss caused by gunfire and explosions (Clark, 2000). Today it is estimated that over one-third of the 28 million Americans who have some degree of hearing loss, were affected, at least partly, by noise (American Speech-Language-Hearing Association (ASHA, 2007). Excessive noise exposure is also prevalent in developing countries, such as Africa, in the formal (e.g. mining and construction) and informal occupational sector (e.g. vehicle repair) as well as the non-occupational sector (urban, environmental and leisure) (World Health Organization (WHO), 1997). The WHO estimates that 18% of adult-onset hearing losses in the 20 southern most countries in Africa (AFR-E region), including South Africa, might be due to NIHL in the workplace (Nelson et al., 2005b).

Noise can be defined as unwanted sounds that have the potential to interfere with communication or damage people’s hearing (Franz & Phillips, 2001). Noise exposure levels related to an 8-hour working day (LEx,8h), exceeding the occupational exposure limit (OEL) of 85 dB A[1], are considered to be dangerous to the auditory system (Plontke, Zenner & Tübingen, 2004; Franz & Phillips, 2001). Excessive noise, at this limit or exceeding it, can irreversibly damage sensory hair cells of the cochlea. This results in a progressive, sensorineural, hearing loss that is predominantly noted in the high frequency region with a typical notch at 4 kHz (Śliwinska-Kowalska, Dudarerewicz, Kotył0, Zamysłowska-Szmytke, Wlaczyk-

[1] Sounds at some frequencies are more hazardous than at other frequencies. The use of A-weighted sound levels cancels these effects, so that two sounds with the same dB A level have approximately the same hazard (Dobie, 2001).

Łuszczyńska, Gadja-Szadkowska, 2006; McBride & Williams, 2001; Rabinowitz, Galusha, Slade, Dixon-Ernst, Sircar, & Dobie, 2006 & May, 2000). Significant individual variability in susceptibility to NIHL is evident and may be due to many factors including a history of exposure to noise, previous treatment with ototoxic drugs, exposure to organic solvents, long-term smoking, gender, pigmentation, age and genetic make-up (Perez, Freeman & Sohmer, 2004; Agrawal, Niparko, Dobie, 2010). Despite the variability in susceptibility to NIHL, no one is immune to the devastating effect of loud noise over a prolonged period of time. The result is a disabling condition which negatively affects a person's ability to communicate and interact socially with detrimental effects on work performance (Passchier-Vermeer & Passchier, 2000).

In the 1940s the treatment of NIHL was accentuated, but since then the emphasis has shifted from treatment to prevention. NIHL is now recognised as a preventable health effect of excessive noise in the workplace (Nelson, Nelson, Concha-Barrientos, & Fingerhut, 2005a). In the interest of prevention noise exposure in the workplace should be investigated. Review of the literature reveals that information on the level of noise exposure in the workplace is not readily available internationally. In this regard a WHO review to determine the global burden of occupationally induced NIHL stated that summary statistics on noise exposure are not available for most industrialising and non-industrialised countries (Nelson, et al., 2005a). In search for information on occupational noise exposure levels the researchers reviewed 17 studies conducted in 12 countries in South America, Africa, and Asia. The review reported on high occupational noise exposure levels (85 dB A or more) and associated hearing loss which occurred in a wide range of workplaces, including manufacturers of foods, fabrics, printed materials, metal products, drugs, watches, and in mining. Based on United States of America (USA) data the researchers estimated the proportion of workers in each occupational category with exposure to noise at or above 85 dB A in nine economic sectors. The industry with the highest estimated value was mining with an estimated 0,85 of all the production workers and labourers exposed to noise levels at or above 85 dB A (Nelson, et al., 2005a).

In South Africa mining is the country's largest industry employing 5,1% of all workers in the non-agricultural, formal sectors of the economy, a reported total of 458 600 employees in 2006 (Mwape, Roberts, & Mokwena, 2007). The processes associated with mining generate tremendous noise as a result of activities including percussion drilling, blasting and crushing of ore which is often exacerbated by confined and reflective spaces (MHSC[2], 2005). The results of a recent study investigating the profiles of noise exposure in South African mines indicate that the mean noise exposure levels in the South African mining industry range from 63.9 dB A to 113.5 dB A and that approximately 73.2 per cent of miners in the industry are exposed to noise levels of above the legislated OEL of 85 dB A (Edwards, Dekker, & Franz, 2011). In a recent study by (Phillips, Heyns, & Nelson, 2007), commissioned by the MHSC) the noise and vibration levels recorded during the operation of three types of rock drills currently used in the mining industry were compared. The researchers concluded that typical noise levels on conventional equipment are still exceeding the occupational exposure limit.

Despite the fact that NIHL is preventable and that the South African mining industry introduced hearing conservation programmes (HCP) in 1988 (Chamber of Mines Research Organisation (COMRO), 1988) a high prevalence of NIHL is still reported in South African mines (MHSC, 2007, Hermanus, 2007). Because occupational NIHL is a significant source of potentially avoidable morbidity it has been categorised as a compensable disease in South Africa in terms of Schedule three of the Compensation for Occupational Injuries and Diseases Act 1993 (COIDA, 1993). The present situation regarding compensation of this occupational disease reportedly does not reflect the exposure or burden of disease, but could be used to indicate the severity of the risk (SIMRAC, 2003). It is reported that 3 849 new cases of NIHL were submitted to the South African Mining Occupational Disease Database (SAMODD) in 2004 and compensation to the amount of ZAR 77 067 521 was paid (MHSC, 2007). An audit of the Department of Minerals and Energy in the RSA reported 1820 cases of NIHL in 2007 (as identified by medical evaluations) (Sonjica & Nogxina, 2008). It is possible that reported NIHL cases could have been inflated soon after 2001 as baseline hearing testing was only mandated after 2001. Since then a positive downward trend in the number of NIHL cases has been reported by the Chamber of Mines (since the baseline as per Instruction 171 in 2002/2003 (Chamber of Mines, 2012)). The current rate (2011) of NIHL is at 3.1 cases per 1

[2] A schematic representation of the structure and mandate of the Mine Health and Safety Council (MHSC) is included as appendix B.

000 employees. It has been stated however that the number of compensable cases will rise again in future when the threshold for compensable hearing loss is breached (Hermanus, 2007). In 2005 NIHL was reported to be responsible for ±15% of all occupational disease claims submitted to the Rand Mutual Assurance Company (RMA) who underwrites workers' compensation benefits for the mining industry in South Africa. Furthermore NIHL accounted for almost half of the compensation benefits paid out to claimants in 2005 (RMA, 2005).

In view of the high prevalence of NIHL in the mining industry the MHSC comprising representatives of state, labour and employers, signed an agreement with the mining industry in 2005 to achieve two important milestones (MHSC, 2005). Firstly, it was agreed that after December 2008, the hearing conservation programme implemented by industry must ensure that there is no deterioration in hearing greater than 10%[3] amongst occupationally exposed individuals. Secondly, parties consented that by December 2013, the total noise emitted by all equipment installed in any workplace must not exceed a sound pressure level of 110 dB A at any location in that workplace (including individual pieces of equipment). Achieving these targets is an important and significant challenge which the MHSC will reportedly continue to facilitate through its advisory function (MHSC, 2006). The difficulty in defining and calculating reliable incidence and prevalence data remains a major challenge and should be a main focus area within occupational health research according to the MHSC (2006). An evaluation of the current status of NIHL prevention practices in the small- to medium mining sector was performed in light of these milestones and results indicated that unless interventions occur the possibility of achieving the 2013 milestone is very poor (Dekker, Edwards, Franz, van Dyk, & Banyini, 2011)

Nowhere are these targets more of a priority than in South African gold mines which are a central part of the national mining industry. The first recording of a gold discovery during the modern era in South Africa was more than a century ago in 1871 (Conradie, 2007). Much has changed since then: in 2006 forty seven of South Africa's 1 212 mines and quarries produced gold, and a total of 159 984 people were employed in gold mines in that year (out of the total of 458 600 employed in the

[3] This refers to a shift in percentage loss of hearing (PLH) from the baseline audiogram or a 10% PLH for employees for whom no baseline audiogram is available. More information on this procedure follows on page eight, paragraph two of this document.

mining sector) (Mwape, et al., 2007; Conradie, 2007). The gold mine industry, as a major employer in the mining sector, has committed to the targets and milestones agreed to by the MHSC (AngloGoldAshanti, 2007; Department of Minerals and Energy, 1996).

In order to define prevalence and incidence data of NIHL in South African mines annual reports and statistical analyses of South African data provide valuable information. Reports from the South African Chamber of Mines and the MHSC describe a particularly high incidence of NIHL in gold miners (Chamber of Mines, 2009; DME, 2003) . Figure 1.1 demonstrates a prevalence rate of 11,04 per 1 000 workers with reported NIHL in 2005 and 4,32 per 1 000 workers in 2006 in South African gold mines.

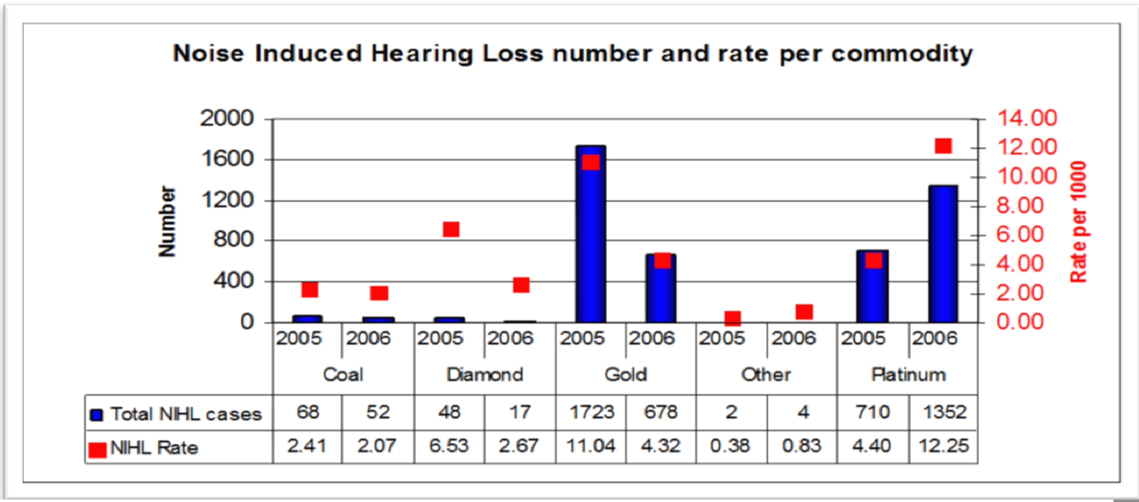


**Figure 1-1 NIHL number and rate per commodity (Randera, 2007)**

Apart from annual reports available from specific mining groups (e.g. AngloGold Ashanti), the MHSC and the Chamber of Mines very few research reports relating to NIHL in South African mines are available in current literature. Some recent studies described the utility value of certain audiological tests as part of the battery of hearing tests (De Koker, 2003), and the prediction of hearing handicap through utilisation of the audiogram configuration and a self-report handicap scale for a group of gold miners (n=339) (Vermaas, Edwards, & Soer, 2007). Another South African study described the characteristics of NIHL in gold miners of different ages and occupation types of a group of gold miners (Soer, et al., 2002). Because of relatively small sample sizes and the sampling methods (convenience sampling) these studies do not describe the prevalence of NIHL in the gold mines.

A survey study reporting on NIHL in South African gold miners completed two decades ago describes the hearing status and noise exposure of 2 667 white gold miners (Hessel & Sluis-Cremer, 1987). Although this study was not representative of the gold mining community since no black miners were included (the majority of gold miners are black (Conradie, 2007)) results from this study has been used in other prevalence studies (Nelson, et al., 2005a). For this study hearing impairment was defined as an average loss of >25 dB HL for the audiometric frequencies 0,5, 1 and 2 kHz, with five times weighting of the better ear. At age 58, 21,6% of gold miners fell in this group.

Since the Hessel & Sluis-Cremer (1987) study much has changed in the industry in terms of the legal diagnostic criteria for NIHL. A new procedure for identifying and evaluating cases of NIHL for compensation was introduced in 2001 in a guideline issued by the Compensation Commissioner, Instruction 171 (COIDA, 2001). An important change from the previous procedure is the use of a working lifetime baseline audiogram to calculate whether compensation should be provided. When a baseline audiogram is available only the deterioration from the baseline is used to calculate disablement. Instruction 171 introduced a measure of impairment termed percentage loss of hearing (PLH) which is calculated by using a series of tables based on a summation of hearing loss in each ear at the following frequencies: 500, 1 000, 2 000, 3 000 and 4 000 Hz (COIDA, 2001). Circular Instruction No. 171 of the Compensation for Occupational Injuries and Diseases Act, No. 130 of 1993 (2001) is included as Appendix C.

Because of the different ways in which hearing impairment is defined in South African mines after 2001 and prior to 2001, it is difficult to get a clear picture of or compare results on the prevalence of NIHL in mine workers. This is not only true of South African research but controversies regarding the method or measures used to estimate hearing impairment abound internationally (Dobie, 2001). When calculating hearing impairment using pure tones many questions arise relating to the frequencies that should be included. These questions include the level at which impairment begins (the low fence), the level of total impairment (high fence), the linearity of hearing impairment with increasing impairment, and finally questions relating to the weighting of the better and the worse ear (Dobie, 2001). The following figure demonstrates the audiogram (dB HL) of a typical NIHL. Table one compares the hearing impairment measured as percentage of hearing impairment for a typical noise-induced hearing loss for different criteria described in the current literature to illustrate the discrepancy between methods.

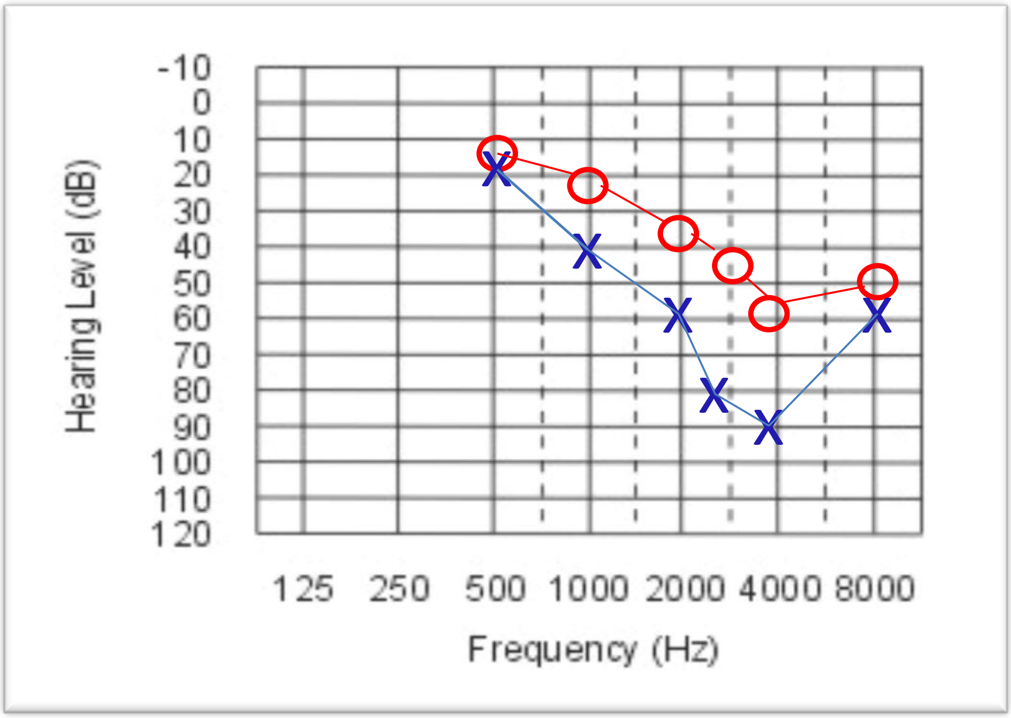


**Figure 1-2 Audiogram for a typical NIHL (values based on an illustration by Dobie (2001)**

**Table 1-1A comparison of the calculated "percentage of hearing impairment" using different criteria for the audiogram shown in figure 2**

| Method | Frequencies averaged (kHz) | Hearing Impairment/ PLH (%) |
|---|---|---|
| AMA (2000) | 0,5, 1, 2, 3 | 12,5% |
| US Department of Labor (2000) | 1, 2, 3 | 21,.25% |
| ASHA (2000) | 1, 2, 3, 4 | 41,25% |
| Instruction 171 (RSA Department of Labour, 2000, COIDA, 2001) | 0.5, 1, 2, 3, 4<br>(using weighted calculation tables) | 24,3 |

Source: American Medical Association (AMA; 2000), U.S Department of Labor (Dobie, 2001), American Speech and Hearing Association (ASHA) (Dobie, 2001) and Instruction 171 (COIDA, 2001).

From table one it is clear that the percentage of hearing impairment is very different depending on the criteria for calculating hearing impairment employed. Apart from calculation with Instruction 171, the other methods use a five: one favouring the better ear, and a 25dB HL low fence (Dobie, 2001). The ASHA method uses a two percent growth rate (with the high fence at 75 dB HL) while the other methods (Instruction 171 excluded) use a 1,5% and a 92 dB HL high fence (ASHA, 2004; Dobie, 2001). The methods using high frequencies result in a larger estimate of hearing impairment for typical cases of NIHL (or any other high frequency hearing loss). In the summation used for calculation of the PLH according to Instruction 171 the weighting of hearing loss varies from frequency to frequency. The weighting is highest for hearing loss at a frequency of 1 kHz and lowest for hearing loss at a frequency of 4 kHz (Franz & Phillips, 2001). This is contrary to what one expects as NIHL is often characterised by the "notch" in the audiogram at 4 kHz or a high frequency hearing loss (Rabinowitz, et al., 2006). This brings into question a final controversy regarding the calculation of hearing impairment percentage that is often ignored and that relates to the cause of the hearing loss and the audiometric configuration (Dobie, 2001). For example, noise and aging often interacts and it has been argued that calculation of hearing impairment should include an allowance for the hearing loss expected with advancing age (Davis, 1971 & Dobie, 2001).

Taking into account the many controversies surrounding the calculation of hearing impairment, the dearth of research describing NIHL and the rate of hearing threshold deterioration in the mining community of South Africa, the following research question was posed: What is the prevalence and degree of NIHL in a group of gold miners and is current criteria for characterising hearing impairment in South Africa valid for identifying NIHL in gold miners?