NOISE INDUCED HEARING LOSS AND FACTORS AFFECTING IT AMONG THE VECTOR CONTROL WORKERS IN SARAWAK

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# TABLE OF CONTENTS

ACKNOWLEDGEMENTS .................................................................................................................. iii  
TABLE OF CONTENTS ................................................................................................................... iv  
ABSTRACT ........................................................................................................................................... ix  
ABSTRAK .............................................................................................................................................. x  
CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW ............................................................ 1  
  1.1.1 Introduction ......................................................................................................................... 1  
  1.1.2 Background of the Study Population ............................................................................... 5  
  1.1.3 Significance of the Study ................................................................................................. 7  
  1.2 Literature Review ................................................................................................................... 8  
  1.2.1 Introduction ....................................................................................................................... 8  
  1.2.2 Epidemiology of Hearing Loss ....................................................................................... 14  
  1.2.3 Hearing Conservation Program ...................................................................................... 16  
  1.2.4 Associated Factors ......................................................................................................... 20  
  1.3 Problem Statement ................................................................................................................ 22  
  1.4 Research Objectives ............................................................................................................ 23  
  1.4.1 General Objective .......................................................................................................... 23  
  1.4.2 Specific Objectives ........................................................................................................ 23  
  1.5 Research Hypotheses .......................................................................................................... 23  
  1.6 Research Questions ............................................................................................................ 24  
  1.7 List of Variables .................................................................................................................. 24  
  1.8 Conceptual Framework ....................................................................................................... 25  
CHAPTER 2: METHODS AND MATERIALS ............................................................................... 26  
  2.1 Research Study Design ........................................................................................................ 26  
  2.2 The Study Population .......................................................................................................... 26  
  2.3 Place of Study ...................................................................................................................... 26  
  2.4 Sample Design .................................................................................................................... 27  
  2.5 Inclusion and Exclusion Criteria ....................................................................................... 27  
  2.5.1 Inclusion Criteria ........................................................................................................... 27  
  2.5.2 Exclusion Criteria .......................................................................................................... 27  
  2.6 Data Collection Procedure ............................................................................................... 28  
  2.6.1 Instrument Developments ............................................................................................ 28  
  2.7 Ethic Committee Approval ................................................................................................. 29  
  2.8 Operational Definitions ..................................................................................................... 29  
  2.9 Data Entry and Analysis .................................................................................................... 30
2.10 Working Framework ................................................................. 31

CHAPTER 3: RESULTS .................................................................... 32

3.1 Introduction ............................................................................... 32

3.1.1 Socio-demographic and personal characteristics .................... 32
3.1.2 Occupational characteristic .................................................. 35
3.1.3 Exposure to occupational hazards and its sources .................. 36
3.1.4 Workers’ Personal and Family Medical history ....................... 38
3.1.4 Specific Medical Complains ................................................... 39
3.1.5 Exposure to ototoxic drugs .................................................... 39
3.1.6 High risk behaviour .............................................................. 40
3.1.6 Use of Personal Protective Equipment (PPE) ......................... 41
3.2 Audiogram ............................................................................... 41
3.3 Hearing Loss ........................................................................... 42
3.4 Relationship between hearing loss and socio-demographic characteristics .... 44
3.5 Relationship between hearing loss and occupational characteristics .... 46
3.6 Relationship between hearing loss and exposure to hazards, sources of noise and duration of exposure ......................................................... 47
3.7 Relationship between hearing loss and medical history and complaints .... 50
3.8 Relationship between hearing loss and exposure to ototoxic drugs .... 52
3.9 Relationship between hearing loss and risk taking behaviour .......... 52
3.10 Relationship between hearing loss and use personal protective equipment ... 54

CHAPTER 4: DISCUSSION, IMPLICATION AND RECOMMENDATION .......... 56

4.1 Noise Induced Hearing Loss ..................................................... 56
4.2 Factors affecting noise induced hearing loss among vector control workers .... 58
4.2.1 Sociocultural and demographic factors ................................... 58
4.2.2 Occupational characteristics of noise ...................................... 59
4.2.3 Exposure to hazards, sources of noise and duration of exposure .... 60
4.2.4 Medical history and family history illnesses ............................ 60
4.2.5 Exposure to ototoxic drugs .................................................. 61
4.2.6 Risk Behaviour ................................................................. 61
4.2.7 Personal Protective Equipment ............................................. 62
4.3 Limitation of the study ............................................................. 63
4.4 Policy Implication and recommendation .................................... 63

CHAPTER 5: SUMMARY AND CONCLUSIONS .................................. 65

REFERENCES ............................................................................... 66
Appendix

Appendix I: Checklist for data collection from medical record

Appendix II: Ethical Approval Letter from UNIMAS Ethics Committee

Appendix III: Ethical Approval Letter from MREC

Appendix IV: Ethical Approval Letter from Jabatan Kesihatan Negeri Sarawak (JKNS)

Appendix V: Ethical Approval Letter from NIH

Appendix VI: Gantt chart
Table of Contents

Table 3.1 Percentage distribution of the workers by socio-demographic characteristics (n=166)..................................................................................................................................... 34

Table 3.2 Percentage distribution of the workers by occupational characteristics......... 36

Table 3.3 Percentage distribution of the workers by exposure to hazards and sources of noise ........................................................................................................................................... 37

Table 3.4 Percentage distribution of the workers’ personal and family medical history .... 38

Table 3.5 Percentage distribution of the workers by exposure to ototoxic drug .............. 40

Table 3.6 Percentage of Personal Protective Equipment Provided and Usage .................... 41

Table 3.7 Mean distribution of audiogram in dB.................................................................. 41

Table 3.8 Percentage distribution of workers by hearing loss and socio-demographic characteristics ........................................................................................................................ 45

Table 3.9 Percentage distribution of the workers by hearing loss and occupational characteristics ................................................................................................................... 47

Table 3.10 Percentage distribution of the workers by hearing loss and medical history and complaints ............................................................................................................................. 51

Table 3.11 Percentage distribution of hearing loss and exposure to ototoxic drug.............. 52

Table 3.12 Percentage distribution of workers by hearing loss and high risk behaviour........ 54

Table 3.13 Percentage distribution of workers by hearing loss and using personal protective equipment ........................................................................................................................ 55
LIST OF FIGURES

Figure 3.1 Percentage distribution of the workers by their medical complaints .......39

Figure 3.2 Percentage distributions of the workers by risk taking behaviour ..........40

Figure 3.3 Mean distribution of audiogram in dB ......................................................42

Figure 3.4 Percentage distributions of workers by degree of hearing loss in both ears .........................................................................................................................43

Figure 3.5 Percentage distribution of hearing loss .....................................................43
ABSTRACT

Noise Induced Hearing Loss (NIHL) is known as the most common occupational disease in industrial countries. In Malaysia, Hearing Conservation Programme (HCP) was introduced under Noise Regulation 1989 (Factories and Machinery (Noise Exposure) Regulations, 1989) and it is to protect workers from noise exposure and hence preventing NIHL. Cases of NIHL investigated by Department Occupational Safety and Health (DOSH) had increased from 120 cases in 2007 to 427 cases in 2009 for all categories except for military personnel. However, there is no established data of NIHL among medical personnel in Sarawak. This study aims to determine the proportion of noise induced hearing loss (NIHL) among vector control worker and factors associated with NIHL. This was a retrospective study to evaluate the medical record of workers who involved in vector control using fogging machine who attended occupational health clinic in Klinik Kesihatan Kota Sentosa. The total of 166 records with PTA (Pure Tone Audiometry) result between January 2007 and December 2012 were obtained and collected using the checklist. The proportion of NIHL was 56% among this group of workers. Noise Induced Hearing Loss was significantly associated with the age group of 40 years and older, being married, duration exposed to noise 9 years and above, with personal and family medical history and specific medical symptoms (p<0.05). Although providing and usage of Hearing Protective Device (HPD) did not show significant result, but it is proven by many other studies. Therefore, education towards the importance of proper usage of HPD among workers must be implemented thoroughly.

Keyword: Noise induced hearing loss, vector control worker, workplace safety
ABSTRAK

Tajuk: Hilang Pendengaran Akibat Kebisingan Dan Faktor-Faktor Yang Berkaitan Di Kalangan Pekerja Kawalan Vektor Di Sarawak.

Penyakit akibat pekerjaan yang paling kerap di negara-negara perindustrian adalah penyakit Hilang Pendengaran Akibat Kebisingan (HPAK). Di Malaysia, Program Pemuliharaan Pendengaran (HCP) telah diperkenalkan di bawah Peraturan Bunyi 1989 (Kilang dan Jentera (Pendedahan Bising), 1989) dan ianya adalah untuk melindungi pekerja daripada pendedahan bunyi bising dan seterusnya mengurangkan HPAK. Kes-kes HPAK yang disiasat oleh Jabatan Keselamatan dan Kesihatan Pekerjaan (JKKP) telah menunjukkan peningkatan daripada 120 kes pada 2007 kepada 427 kes pada tahun 2009 bagi semua kategori pekerjaan kecuali anggota tentera. Di Sarawak, maklumat berkaitan dengan HPAK di kalangan pekerja kesihatan tidak ada buat masa kini. Oleh yang sedemikian, kajian ini bertujuan untuk menentukan bilangan kes HPAK di kalangan pekerja kawalan vektor dan faktor-faktor yang berkaitan dengan HPAK. Ini adalah satu kajian retrospektif yang menilai rekod perubatan pekerja-pekerja yang terlibat dalam kawalan vektor menggunakan mesin kabut yang telah melalui saringan kesihatan pekerjaan di Klinik Kesihatan Kota Sentosa. Sebanyak 166 rekod kesihatan yang mempunyai keputusan audiometri dari Januari 2007 ke Disember 2012 telah diperolehi dan dikumpulkan dengan menggunakan senarai semak. Hasilnya, prevalens HPAK adalah 56.7 peratus di kalangan pekerja kawalan vektor. HPAK amat berkait rapat dengan kumpulan umur 40 tahun dan lebih tua, berkahwin, tempoh terdedah kepada bunyi bising 9 tahun dan ke atas, yang mempunyai sejarah perubatan peribadi dan keluarga dan gejala perubatan tertentu (p <0.05). Walaupun penyediaan dan penggunaan alat
perlindungan pendengaran (HPD) tidak menunjukkan hasil yang ketara, tetapi ia telah dibuktikan oleh banyak kajian lain. Oleh itu, pendidikan terhadap kepentingan penggunaan yang betul HPD kalangan pekerja perlulah ditekankan.

Kata kunci: Hilang pendengaran akibat kebisingan, pekerja kawalan vector, keselamatan tempat kerja
CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

1.1.1 Introduction

The healthcare workers are being exposed to a complex variety of health and safety hazards including biological hazards, chemical hazards, physical hazards, ergonomic hazards and psychological hazards. They need protection from these workplace hazards just as much as do the mining or construction workers. Protecting the health of the workers is critical to having an adequate workforce of trained and healthy health personnel. Among those health care workers, those workers that involved in vector control by using fogging machine are being exposed not only to chemical hazards of the pesticides but as well to physical hazards of noise from fogging machine.

In Sarawak, control of vector borne disease is being handled by the Sarawak State Health Department together with co-operation from the Sarawak State Local Authority. In combating this vector borne disease, a large number of human resources are needed apart from physical and financial needs. Therefore, it is vital to protect this worker’s health to ensure the activities of the program become successful. Eventually, this will help in reducing the morbidity of the disease that can arise from the exposure of work hazards.

In Malaysia, the burden of vector borne diseases are dengue with an incidence rate of 180/100,000 population followed by 2.01/100,000 population for malaria disease (Ministry of Health, 2008). In view of the high burden of dengue disease, the vector control workers have to work harder to ensure the disease is being controlled in short time of period. One of the scopes of work that the vector control worker need to do especially during the outbreak is space spraying. Space spraying is the spreading of
microscopic droplets of insecticide in the air to kill adult mosquitoes and is used in emergency situations when an outbreak of dengue fever is already in progress. Two forms of space spray are generally used for Aedes aegypti control: thermal fog and ultra-low volume (ULV) aerosols (cold fogs) and mists. The frequency of application of this space spraying is 3 cycles for every case notified. The fogging machine not only release chemical such as organophosphate pesticides and diesel, but it does produce noise that more than 90 dB (A) at a distance of 0.5m (Masilamani et al., 2012).

Although vector control workers have been specifically assigned to control the vector borne disease, when there is a peak season of outbreak happens, other units of workers will help. Therefore, in this study not only vector control worker is being selected, other unit of workers that help with fogging activity being included. They have been exposed to noise hazards that emitted from the fogging machine that hazardous to their ear and subsequently can result in hearing loss.

Hearing loss is a common problem caused by noise, aging, disease, and heredity. Hearing is a complex sense involving both the ear's ability to detect sounds and the brain's ability to interpret those sounds, including the sounds of speech. One of the most common causes of hearing loss is loud noise. Loud noise can permanently damage the inner ear. Loud noise also contributes to tinnitus, which is a ringing, roaring, clicking, hissing, or buzzing sound in the ears. Approximately 17% (26 million) of Americans between the ages of 20 and 69 have high frequency hearing loss due to exposure to loud sounds or noise at work or in leisure activities (Niskar et al., 2001; National Institute on Deafness and Other Communication Disorders, 2008).

Noise Induced Hearing Loss (NIHL) is a gradual loss of hearing caused by exposure to loud noise over an extended period of time, such as in an individual who
works in a noisy environment. The hearing loss is sensorineural in nature and greatest in the higher frequencies. Although an early hearing loss may be temporary, it becomes permanent with increased exposure to noise (Mosby's Medical Dictionary, 2009). The other definition of NIHL is a loss of hearing threshold of a subject by the result of a given period of time and specific intensity level sound exposure (American National Standard, 1995). Hearing loss also referred to any hearing threshold level (HTL) of 25 dB (A) or more at 500, 1000, 2000, 4000, 6000 or 8000 Hz during the audiometric test (WHO, 2010).

The mechanism of noise induced hearing loss is when there is a situation of exposure to a specific time period of sound intensity, the middle ear and inner ear of auditory system would be overloaded by sound transmission of exceeding energy to an electronic signal. The exceeded sound received by the tympanic membrane hammering against the oval window (which is a known component of the cochlea) would cause strong fluctuation of endolymph and perilymph. The repetition of transmission could make the hair cells of stereocilia push against its direction, accumulative the burden of hair cells in transmitting the wave signal into an electronic signal (Beranek, 1957). These processes need to produce some amount of reactive oxygen species that would lead to the overload of stereocilia which causes the death of oxidative cells, a subgroup of hair cells. There can be other forms of damage with hair cell such as the exhaust of metabolism or degeneration which causes noise induced hearing loss due to long term loud noise exposure. The damage of hair cells would cause distortion and attenuation of stimulating auditory, resulting in sensible hearing loss (Bies, 1961).

Prolonged exposure to sound in excess of 85 dB (A) is potentially hazardous although the important factor is the total amount of sound exposure i.e., both the level
and length of exposure are important and the two are interrelated. After exposure to a
typical hazardous industrial sound, for an 8-hour work day, the ear fatigues and
develops a Temporary Threshold Shift (TTS). The hair cells become exhausted from
the excessive metabolic stress placed upon them and hearing becomes less acute. This
is usually transient and after appropriate rest, recovery ensues (Sataloff and Sataloff,
2006). If TTS occur day after day, the recovery becomes less complete and a
permanent threshold shift occurs because with persistent exposure to such sounds
some hair cells do not recover. First to fail permanently are the outer hair cells in the
basilar part of the cochlea, in the area which responds to 4000 Hz and the adjacent
areas of 3000 and 6000 Hz. This is where the ear is most sensitive, in part because of
the harmonic amplification of the ear canal and in part because of an absolute
sensitivity.

Once the hair cells degenerate they do not recover and a permanent hearing
loss develops. Typically, following noise exposure, hearing loss is shown as an
audiometric notch, usually maximal at 4000 Hz but may also be based anywhere
between 3000 and 6000 Hz. With higher noise exposure for longer periods, the loss
extends into adjacent frequencies (Sataloff and Sataloff, 2006). This has been proven
by studies done on rats where they found the hair cells of the high frequency would be
diminished but the low frequency hair cells would be spared (Chen et al., 1999; Chen
and Fechter, 2003).

Hearing loss has been associated with age due to ageing affects many parts of
the auditory system. Histopathological studies report that degeneration of the auditory
system begins early in life and continues insidiously throughout life (Nondahl et al.,
2004; Rosenhall and Pedersen, 1995). Epidemiological studies have supported a clear
trend of an annual decline in hearing ability (Lee et al., 2004; Cruickshanks et al.,
Hearing deterioration may become more rapid for both men and women after the fourth decade (Danner and Harris, 2003).

The NIHL hearing loss is also multiplicative by smoking due to reduction of oxygen and increase carbon monoxide to the hair cells, age and ototoxic solvents in industries (Noorhassim and Rampal, 1998; Chen, 2002; Fadzli, 2005; Hodgkinson and Prasher, 2006; Campo and Maguin, 2007).

The NIHL is highly preventable via hearing conservation program. Therefore, the Occupational Safety and Health Administration (OSHA) mandate that employers provide hearing conservation programs for their employees in workplaces where noise levels equal or exceed 85 dB (A) for an eight-hour time-weighted average. An occupational hearing conservation program includes engineering and administrative controls to reduce noise exposures, employee training in the use of hearing protection and annual audiometry for all workers who are exposed to noise. The usage of hearing protection devices such as earplug was found to be protective to NIHL (Yuzhang, 2012). Although NIHL is a highly potential preventable disease, it remains an important occupational health problem.

1.1.2 Background of the Study Population

The population of interest in this study is those vector control workers who are using the fogging machine for space spraying to control adult mosquito. They also responsible to control seven vector borne diseases – malaria, dengue, filariasis, Japanese Encephalitis, plague, scrub typhus and yellow fever. In Malaysia, both Ministry of Health and State Local Authority works together for vector control activities in their respective area. Therefore workers who are involved in vector
control using fogging machine either working under the Divisional Health Office (DHO) of Ministry of Health and local authority are the main subject of this study.

Many workers throughout the world experience excessive noise exposure which is ≥85 decibels (dB) (Seter, 1998). In this study, the source of noise is from the fogging machine that generates sound levels more than 90 dB (A) (Masilamani et al., 2012). There are 2 types of fogging machines used by the workers, which are the thermal fogging machines and ultra low-volume fogging machines. The workers generally perform fogging activities around 5 pm to 8 pm, and the frequency of fogging for a worker depends on the incidence of dengue fever in their area. Fogging is done in the residential areas where dengue fever is reported. Workers are provided with personal protective equipment such as respirators, goggles, gloves, and earmuffs.

The noise emitted from fogging machines, together with the chemicals exposed may be the addition factors that can contribute to their hearing impairment. The fogging machines emitted noise levels of more than 90 dB (A) at a distance of 0.5 m. In their line of work, they were exposed to organophosphate pesticides and diesel, which are used as diluents. Organophosphate exposure is associated with higher risk of hearing loss (Teixeira et al., 2003; Hoshino et al., 2008; Masilamani et al., 2012). Diesel also contains organic solvents that have been shown to affect hearing (Kim et al., 2005; Sliwinski, 2007; Masilamani et al., 2012). Therefore, workers who are involved in vector control are at higher risk of developing NIHL because of exposure to noise and ototoxic chemicals.

Since the NIHL is caused by high intensity noise and the fogging machines is the source of noise when operating using it; this study was designed to find the proportion of NIHL and the associated factors among vector control workers in...
Sarawak. Previous study done by Masilamani (2012) shows that the prevalence of NIHL among vector control workers was 26.5% which was done in the Negeri Sembilan state.

1.1.3 Significance of the Study

Fogging machine that has been used for controlling vector borne disease is known to produce high noise levels which required a noise monitoring report being done according to FMA 1967 (Noise Exposure Regulation 1989) but so far limited local study done to establish the NIHL and the associated factors among the vector control workers. The studies done in other industries, locally or abroad, have shown a high prevalence of NIHL (Maisarah and Said, 1993; Çelik et al., 1998; Nizam et al., 2004; Fadzli, 2005; Ferrite and Santana, 2005; Guerra et al., 2005; Rachiotis et al., 2006; Razman et al., 2008; Phillips et al., 2010).

Noise Induced Hearing Loss is a preventable disease through HCP (Hearing Conservation Programme) (NIOSH, 1998), therefore the outcome of this study will identify the magnitude of hearing loss among vector control workers in Sarawak. Among the associated factors identified were age, being smoker, intensity of noise exposed, duration of working, poor practice in using HPD (Hearing Protective Device) and ignorance (Fadzli, 2005; Ferrite and Santana, 2005; Masilamani et al., 2012). By identifying specific factors that associated with NIHL, the need to strengthen the implementation of hearing conservation program will be more acknowledged by the management.
1.2 Literature Review

1.2.1 Introduction

Mechanism of hearing is when the sound waves are transmitted through a medium from the source to the middle ear. Then the signal is directed to the inner ear and finally to the brain to be perceived as a sound. The functions of the outer ear are amplifying the sound, direction, and protection. Meanwhile, the middle ear has the functions of sound transmission, pressure equalization and also protection function (Emanuel and Letowski, 2009).

Noise is usually defined as undesired random sound signals. But in the scope of audiology and the view of the physicist, there are no differences between sound and noise while they were just the fluctuation of distinctive pressure. As the expansion of industry in all over the world, the collective expose to noise an uprising, particularly among workers of noise related occupation. Noise is possibly the most common occupational and environmental hazard. Outside of work, many persons pursue recreational activities that can produce harmful noise.

There are two major types of noise as steady noise and non-steady noise, where depending on the difference between variations in the pressure level of sound (ANSI, 1991). Steady noise is defined as the sound with small fluctuations of pressure levels, where non-steady sound represented as a sound with different sound pressure levels in a period time (ANSI, 1991). Noise is one of the major risk factors in the current occupational factors, and there is no any effective treatment to reverse noise-induced hearing impairment, the only way to keep NIHL away is prevention of noise, including the ear protection.
Approximately 14% of industrial workers worldwide were exposed to noise more than 85 dB (A) (WHO, 1995). Some of the noises were unavoidable. Study by Malaysia Environment Department showed that most common sources of noise pollution were road traffic, industrial and building construction activity. Sound levels of less than 75 dB(A) are unlikely to cause damage to hearing. However, sound levels of 85 dB(A) and above causes damage to hearing after many years of exposure (Nasir and Rampal, 2012). The undesirable increase in noise would lead to an epidemic of hearing loss which is incurable, but surely preventable.

An adverse effect or implication of noise is defined as a change in the morphology and physiology of an organism that results in impairment of functional capacity, or an impairment of capacity to compensate for additional stress or increases the susceptibility of an organism to the harmful effects of other environmental stress (WHO, 1999). Noise exposure also has been known to induce tinnitus, hypertension, vasoconstriction, and other cardiovascular adverse effects.

The effect of noise to health can be divided into non auditory and auditory. There are several non-auditory physiological effects of noise exposure including a possible increase in cardiovascular disease from elevated blood pressure and physiological reactions involving the cardiovascular endocrine system (Talbott, 1995). In addition, community noise has been shown to adversely affect sleep, communication, performance and behaviour, reading and memory acquisition, and mental health (Talbott, 1995). Studies of occupational and environmental noise exposure suggest an association with hypertension, whereas community studies show only weak relationships between noise and cardiovascular disease (Stansfeld and Matheson, 2003). Exposure to high intensity noise in the industry has been linked in
some studies to raise levels of noradrenaline and adrenaline (Cavatorta, Falzoi, and Romanelli et al., 1987).

The direct implication of noise for individual health is hearing impairment or hearing loss. This impact to the hearing can be in the sort of ear discomfort, ear discomfort, ear ringing, ear pains and hearing loss. Hearing loss or deafness furthermore would lead to abnormal behaviour such as anxiety disorders, mood disorders, personality disorders and schizophrenia; and communication breakdown (Scheetz, 2004).

Hearing loss is categorized based on the causes; conductive, sensorineural and mixed hearing loss. Conductive hearing loss occurs when the sound waves are not transmitted to the inner ear because of some interference in the external ear such as in the external ear canal, eardrum, ossicular chain, middle ear cavity, oval window or Eustachian tube. On the other hand, sensorineural hearing loss refers to hearing loss caused by the damage in the inner ear. When the damage is in the auditory nerve, it is termed neural hearing loss, and when damage is localized in the inner ear, it is termed sensory hearing loss.

Mixed hearing loss referred to a conductive followed by sensorineural hearing loss (Sataloff and Sataloff, 2006). An example of the conductive hearing loss is an injury to the ear drum or blockage at the external canal. The most two common causes of sensorineural hearing loss are presbycusis i.e. hearing loss due to aging; and NIHL (Konings et al., 2009). There is no certain age of presbycusis to occur, but in the United States approximately 25-30% of people aged 65-74 years are estimated to have impaired hearing and for people aged 75 years and older, this incidence is thought to rise to 40-50% (Roland et al., 2010).
Other causes of sensorineural hearing loss are diseases to inner ear such as Miniere’s disease or tumours (Emanuel and Letowski, 2009). The other type of classification is based on the grade or degree of hearing loss. According to (WHO, 2010), hearing loss is graded into normal, mild, moderate, severe and profound based on the HTL on the pure tone audiometry (PTA).

Table 1.1 Grades of hearing impairment [adapted from WHO (2010)]

<table>
<thead>
<tr>
<th>Grade of impairment</th>
<th>Corresponding audiometric ISO value</th>
<th>Performance</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - No impairment</td>
<td>25 dB or better (better ear)</td>
<td>No or very slight hearing problems. Able to hear whispers.</td>
<td></td>
</tr>
<tr>
<td>1 - Slight impairment</td>
<td>26-40 dB (better ear)</td>
<td>Able to hear and repeat words spoken in normal voice at 1 metre.</td>
<td>Counselling. Hearing aids may be needed.</td>
</tr>
<tr>
<td>2 - Moderate impairment</td>
<td>41-60 dB (better ear)</td>
<td>Able to hear and repeat words spoken in raised voice at 1 metre.</td>
<td>Hearing aids usually recommended.</td>
</tr>
<tr>
<td>3 - Severe impairment</td>
<td>61-80 dB (better ear)</td>
<td>Able to hear some words when shouted into better ear.</td>
<td>Hearing aids needed. If no hearing aids available, lip-reading and signing should be taught.</td>
</tr>
<tr>
<td>4 - Profound impairment including deafness</td>
<td>81 dB or greater (better ear)</td>
<td>Unable to hear and understand even a shouted voice.</td>
<td>Hearing aids may help understanding words. Additional rehabilitation needed. Lip-reading and sometimes signing essential.</td>
</tr>
</tbody>
</table>

Grades 2, 3 and 4 are classified as disabling hearing impairment.
The audiometric ISO values are averages of values at 500, 1000, 2000, 4000 Hz.
The audiogram is a graph showing the results of the pure-tone hearing tests. It illustrates the type, degree, and configuration of hearing loss. The frequency or pitch of the sound is referred to in Hertz (Hz). The intensity or loudness of the sound is measured in decibels (dB). The responses are recorded on a chart called an audiogram that shows intensity levels for each frequency tested. Each vertical line from left to right represents a pitch, or frequency, in Hertz (Hz). The graph starts with the lowest pitches on the left side and moves to the very highest pitches (frequencies) tested on the right side. The ranges of frequencies tested by the audiologist are 0.5 KHz, 1 KHz,
2 KHz, 3 KHz, 4 KHz, 6 KHz and 8 KHz. Each horizontal line on the audiogram from top to bottom represents loudness or intensity in units of decibels (dB). Lines at the top of the chart (-10 dB and 0 dB) represent soft sounds. Lines at the bottom of the chart represent very loud sounds. On the audiogram, the pattern of hearing loss (configuration) and degree are recorded. The audiologist uses a red O to indicate the right ear and a blue X to record the left ear. The farther down the audiogram the Xs and Os appear, the worse the hearing.

Figure 1.2 A high-frequency notch in the audiogram, typical of noise-induced hearing loss