THE EFFECTIVENESS OF APPLYING DIFFERENT PERMISSIBLE EXPOSURE LIMITS IN PRESERVING HEARING THRESHOLD LEVEL AMONG AUTOMOBILE INDUSTRY WORKERS: AN INTERVENTION STUDY

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ABSTRACT

Introduction

The occurrence of occupational noise-induced hearing loss has doubled from 120 million to 250 million in a decade. Countries such as Malaysia, India and the US are adopting 90 dBA as the permissible exposure limit. The aim of this study was to assess the effectiveness of applying 85 and 90 dBA in preserving hearing thresholds and preventing the development of temporary threshold shifts.

Methodology

In this intervention study, 203 participants from two factories in an automobile industry were exposed to noise levels above the action level of 85 dBA in Factory 1 and 80 dBA in Factory 2, where the permissible exposure limits were 90 and 85 dBA, respectively. The exchange rate of 5-dB was used in both study locations. Noise levels were measured using personal exposure noise dosimeters and a sound level meter. The hearing threshold levels were measured at baseline and then followed up at the first month (post-shift exposure) and again, at the sixth month (pre-shift exposure). Data on hearing threshold levels were measured using a manual audiometer. Hearing protection devices with appropriate noise reduction rate were used to reduce noise exposure among participants. The data analysis was carried out using SPSS version 20.0 for Windows. Data for participants were then imputed as per-protocol analysis and based on the intention-to-treat principle. Independent *t*-tests, Chi-square tests, Fisher's exact tests, McNemar's and repeated measures ANOVA were used in the statistical analysis.

Results

As per-protocol analysis, mean hearing threshold levels on right ear of participants at 3000 and 4000 Hz were statistically significantly lower in Factory 2 with exposure limit at 85 dBA compared to Factory 1 at 90 dBA, (3.17; 95% CI, 0.04-6.30 dBA, p = 0.048, partial η^2 = 0.045) and (4.45; 95% CI, 0.05-8.84 dBA, p = 0.047, partial η^2 = 0.045), respectively at the sixth month. At the first month analysis, hearing threshold levels of more than 25 dBA of the right ear at 3000 Hz was significantly higher among participants in Factory 1, as per-protocol analysis, χ^2 (1) = 5.25, φ = 0.203, p = 0.022 (moderate association), and also at the sixth month, at 4000 Hz (right ear), with a continuing level of deterioration; χ^2 (1) = 4.73, φ = 0.232, p = 0.030 (moderate association). According to the National Institute of Occupational Safety and Health recommended standard, the standard threshold shifts on left ear of participants at 1000 Hz was markedly lower in Factory 2 at the sixth month, as per-protocol analysis, χ^2 (1) = 3.93, φ = 0.211, p = 0.047 (moderate association). There were no differences in mean scores of knowledge, belief, feeling, judgment and practice domains between participants from the two factories.

Conclusion

The adoption of 85 dBA as a permissible exposure limit has preserved the hearing threshold among participants compared to those who embraced the 90 dBA. Countries adopting 90 dBA as the permissible exposure limit should review their policy, as the limit adoption of 85 dBA may lower the risk of noise-induced hearing loss.

Key Words: Effects 85 or 90dBA; Noise; Threshold shift

ABSTRAK

Pengenalan

Kejadian kehilangan pendengaran bunyi yang disebabkan oleh pekerjaan telah bertambah sebanyak dua kali ganda, iaitu dari 120 juta ke 250 juta dalam tempoh sepuluh tahun ini. Negara-negara seperti Malaysia, India dan Amerika Syarikat menjadikan 90 dBA sebagai had pendedahan yang dibenarkan. Tujuan kajian ini dijalankan adalah untuk menguji keberkesanan had pendedahan yang dibenarkan yang berlainan dalam memelihara ambang pendengaran dan mencegah pembangunan anjak ambang sementara.

Metodologi

Dalam kajian intervensi ini, seramai 203 orang peserta dari dua buah kilang industri automobil telah terdedah kepada tahap bunyi yang melebihi tahap tindakan 85 dBA di Kilang 1 dan 80 dBA di Kilang 2, di mana had pendedahan yang dibenarkan adalah 90 dan 85 dBA masing-masing. Kedua-dua kilang tersebut telah menggunakan 5-dB *exchange rate*. Tahap bunyi bising telah diukur dengan menggunakan *dosimeter* pendedahan bunyi peribadi dan meter paras bunyi. Tahap ambang pendengaran adalah diukur pada garis dasar dan kemudiannya disusuli pada bulan pertama (pendedahan selepas peralihan) dan berulang kali dalam tempoh masa enam bulan. Data tahap ambang pendengaran adalah diukur dengan menggunakan *audiometer manual*. Peranti perlindungan pendengaran dengan bunyi kadar pengurangan yang sesuai digunakan untuk mengurangkan pendedahan bunyi bising dalam kalangan peserta-peserta penyelidikan ini. Data kajian dianalisis dengan menggunakan perisian SPSS versi 20.0 *for Windows*. Data untuk peserta kemudiannya dimasukkan untuk analisis per-protokol dan berdasarkan prinsip tujuan merawat. *Independent t-tests, Chi-square tests, Fisher's exact tests, McNemar's and repeated measures ANOVA* telah digunakan dalam analisis statistik.

Dapatan

Analisis menunjukkan bahawa min tahap ambang pendengaran di telinga kanan peserta pada 3000 dan 4000 Hz adalah jauh lebih rendah di Kilang 2 dengan had pendedahan pada 85 dBA berbanding dengan Kilang 1 pada 90 dBA, (3.17; 95% CI, 0.04-6.30 dBA, $p = 0.048$, *partial* $\eta 2 = 0.045$) dan (4.45; 95% CI, 0.05-8.84 dBA, $p = 0.047$, *partial* $\eta 2 = 0.045$), masing-masing pada bulan keenam, melalui analisis per-protokol. Dalam analisis bulan pertama, tahap ambang pendengaran lebih daripada 25 dBA di telinga kanan pada 3000 Hz adalah jauh lebih tinggi di Kilang 1, χ^2 (1) = 5.25, $\varphi = 0.203$, $p = 0.022$ (perhubungan sederhana), dan juga bulan yang keenam, pada 4000 Hz (telinga kanan) dengan tahap kemerosotan yang berterusan; $\chi^2(1) = 4.73$, $\varphi = 0.232$, $p = 0.030$ (perhubungan sederhana), melalui analisis per-protokol. Menurut standard yang disyorkan oleh Institut Keselamatan dan Kesihatan Pekerjaan Kebangsaan, anjakan ambang standard pada telinga sebelah kiri peserta pada 1000 Hz secara jelasnya adalah lebih rendah di Kilang 2 pada bulan yang keenam, χ^2 (1) = 3.93, $\varphi = 0.211$, $p = 0.047$ (perhubungan sederhana), melalui analisis per-protokol. Analisis menunjukkan bahawa tiada perbezaan dalam skor min pada domain pengetahuan, kepercayaan, perasaan, penilaian dan amalan antara peserta-peserta dari kedua-dua buah kilang tersebut.

Kesimpulan

Adopsi 85 dBA sebagai had pendedahan yang dibenarkan telah mengekalkan ambang pendengaran dalam kalangan peserta berbanding dengan mereka yang mengandungi 90 dBA. Negara-negara yang menerima pakai 90 dBA sebagai had pendedahan yang dibenarkan perlu mengkaji semula dasar mereka kerana had sebanyak 85 dBA boleh mengurangkan risiko kehilangan pendengaran disebabkan bunyi bising.

Kata Kunci: Kesan 85 atau 90dBA; Bunyi bising; Anjakan ambang

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LIST of SYMBOLS and ABBREVIATIONS

ANOVA	Analysis of variance
ANCOVA	Analysis of covariance
DOSH	Department of Occupational Safety and Health
DPOAE	Distortion product otoacoustic emissions
IDDM	Insulin-dependent diabetes mellitus
NIDDM	Non-insulin dependent diabetes mellitus
NIOSH	National Institute of Occupational Safety and Health
NRR	Noise reduction rate
OSHA	Occupational Safety and Health Administration
PC	Production Control
QC	Quality Control
Scuba	Self-contained underwater breathing apparatus
SPSS	Statistical Package for the Social Sciences
TTS_2	Temporary threshold shifts after two minutes of noise-exposure
CI	Confidence interval
dB	decibel
dBA	decibels, A-weighted
dBC	decibels, C-weighted
dBHL	decibel hearing level
Hz	Hertz
OR	Odds ratio
SD	Standard deviation

CHAPTER 1

INTRODUCTION

Occupational hazards have been recognized in various countries for many centuries. The debilitating condition was first recognized during the industrial uprising. The data obtained may be limited due to a long latency period between exposure to and occurrence of disease. The inadequacy of data may also due to other factors such as poor occupational history, low awareness, incomplete documentation and lax reporting. The prevalence of occupational noise-induced hearing loss has been increasing globally. More noise-induced hearing loss have been emerging in developing countries recently, compared to developed countries due to rapid industrialization with poor protective measures (Concha-Barrientos, et al., 2004). Occupational noise-induced hearing loss, a type of sensorineural hearing loss, is the development of hearing loss due to exposure to high levels of noise (Rutka, 2011).

1.1 Physics of sound and its mechanics

1.1.1 Physics of sound

Sound produces waves which travel in a straight line. The waves produced are due to vibration and are transmitted through a medium (Robertson & Diskin, 2003). A ‘period’ is referred to as time needed to complete a cycle of vibration; a cycle is completed when one repetition of the vibratory pattern has been accomplished. The number of cycles that has been achieved within a second is referred to as *frequency* (Robertson & Diskin, 2003) and denoted as Hertz (Hz), where *pitch* is designated as high if the frequency is high. The range of normal human hearing is between 20 to 20000 Hz (Raichel, 2006).

The frequencies below this range are known as *infrasonic*, and *ultrasonic* if it is above the range. Higher frequency sounds are noted to have less bending on approaching an object.

The speech frequencies commonly used during communication are 500, 1000, 2000 and 3000 Hz. If these frequencies are permanently affected, it would lead to hearing impairment (Laws of Malaysia, 2010). *Presbycusis* is a condition where the higher frequencies (3000 Hz and above) are usually affected as age advances. These high frequencies are also commonly involved in occupational noise-induced hearing loss (Kirchner, et al., 2012). The wavelength is the distance between two spots of the corresponding sound waves, as high frequencies have lower wavelength compared to lower frequency sounds (Robertson & Diskin, 2003). The degree of displacement, where the highest voltage point of positive to highest negative point of the vibratory waves, is referred to as *amplitude* (Robertson & Diskin, 2003). The sound is considered to be loud if the amplitude or intensity is high. The intensity of sound is denoted in the decibel (dB) scale (Gelfand, 2009) and measured using a sound lever meter or by personal exposure noise dosimeter. The scale used compares against a reference value (Gelfand, 2009), and so the dB scale is a relative value. The reference value, also known as *acoustical zero* dB, is taken as an average value of normal hearing when using an audiogram to detect hearing loss. This scale is in a logarithmic ratio and it does not hinge on the additive principle.

There are three filter networks, i.e., A, B and C (Gelfand, 2009); filter network A is used primarily to measure sound especially in the industries. Noise from industries usually affects the higher frequencies. And hence, filter network A is most accurate when the lower frequencies are excluded. The dB hearing level (dBHL) is a scale referring to hearing sensitivity for pure tones. A normal person is able to detect between 125 and 8000 Hz (Gelfand, 2009). The dBHL is measured using an audiometer. The threshold of hearing is the faintest sound a person is able to hear. If the frequency tested is beyond 8000 Hz, there is a possibility that the person examined may not detect any sound since the wavelength would be the same, and can be annulled at these frequencies. This condition is known as 'standing wave' where the waves can be cancelled out. Changes may not be detected in noise-induced hearing loss if measured using a high-frequency audiometer (American Academy of Audiology, 2009).

A person may be exposed to a few types of noise. A steady and continuous noise is a sound level that does not vary significantly, i.e., less than 3 dB (Koh, et al., 2001; Laws of Malaysia, 2010). If these sound levels vary considerably, more than 3 dB, then it is termed as fluctuating noise (Koh, et al., 2001). These are the two types of noise that are commonly elicited in the factories. Impulsive noise is a sound level that rises instantaneously and it attains the greatest level of more than one in a second (Laws of Malaysia, 2010). The levels may give rise to severe damage of the tympanic membrane and hearing. The other types of noise are steady intermittent and fluctuating intermittent noise. In the former, the levels may reach an ambient level and remain constant for at least a second; whereas in the latter, the levels may fluctuate after reaching the ambient value (Laws of Malaysia, 2010).

1.1.2 The mechanics of hearing

Hearing is one of the essential human senses. Its functions vary from mere hearing for pleasure, such as music, to communication. The factors required for hearing are (Antonelli, 2013):

- sufficient sound,
- transmission of sound waves to the inner ear,
- neural conduction of impulses and
- central auditory processing in the brain.

The ear is divided into three parts, i.e., outer, middle and inner ear (Rutka, 2011). The outer ear extends from pinna or auricle to the tympanic membrane. Sound waves travel through this external auditory canal to the tympanic membrane (Antonelli, 2013). They undergo vibration and then travel to the middle ear. The middle ear consists of ossicular bones, i.e., malleus, incus and stapes. Besides these ossicular bones, the Eustachian tube runs in the air-filled middle ear. The tube stabilizes pressure in both ears. The middle ear is connected to the inner ear through an oval window. The vibrations of sound waves continue to travel through the middle ear and are transmitted to a fluid-filled cavity in the inner ear. The inner ear consists of vestibular labyrinth and cochlea. The former is required for balancing, while the latter is a coiled-shaped structure and is responsible for transmitting impulses to the brain.

Besides the oval and round window, the cochlea has an organ of Corti with sensory and non-sensory cells. The sensory cells appear to be hair-like structures which can be either outer or inner cells. The outer sensory cells are not only more abundant but arranged in three rows compared to the inner cells occupying only one row (Rutka, 2011). The outer hair cells are more prone to damage from noise and ototoxic drugs. Prolonged exposure to sounds above 3000 Hz may damage these cells. The vibration of the sound waves in the inner ear is transmitted to the brain as impulses for interpretation via the acoustic nerve (Antonelli, 2013). This acoustic nerve is known as the eighth cranial nerve or vestibulocochlear nerve. The cerebral cortex of the brain is responsible for converting impulses received to a distinguishable sound.

1.1.3 Air conduction and bone conduction

Sound waves from an external source are heard through air conduction and bone conduction (Henry & Letowski, 2007). In air conduction, these sound waves travel via an external auditory canal. The tympanic membrane quivers in response to these sound waves. These vibrations are conveyed to the malleus, incus and stapes and are transmitted through the oval window. The air conduction is affected if there is damage either in the outer or middle ear. Isolated air conduction losses result in conductive hearing loss.

Sound waves can also be transmitted through skull bones. This type of conduction is known as bone conduction. The sound waves are transmitted directly to the cochlea and if there is any damage to the inner ear or the auditory nerve, bone conduction are likely to be affected. If transmissions of sound waves are affected through this conduction, it usually leads to sensory or neural hearing loss. The masking of noise is required to test bone conduction, since sound is felt or heard by the opposite ear or a non-test ear through the skull bone (British Society of Audiology, 2011).

1.2 Types of hearing loss

There are two types of hearing loss, i.e., conductive and sensorineural hearing loss.

1.2.1 Conductive hearing loss

Conductive hearing loss occurs when there is an interruption of sound waves from the external to middle ear (Hussain, 2008). The inner ear is spared in this type of hearing loss. In conductive hearing loss, bone conduction is more effective than air conduction. Air conduction tends to be reduced due to blockage in the pathway through the external auditory canal. The conductive hearing loss may be unilateral or bilateral. There are few characteristics features of this hearing loss which distinguishes it from sensorineural hearing loss. One of the common features is the presence of discharge (Maharjan, et al., 2009), indicating infection of the ear (Hussain, 2008). Besides discharge, a sensation of fullness or presence of tinnitus may be felt.

Other probable features are the presence of obstruction in ear such as wax or foreign bodies (Isaacson & Vora, 2003). Those with conductive hearing loss tend to speak softly especially in bilateral hearing loss, but may be able to hear well since bone conduction is not affected.

The findings may even be normal on otoscopy examination. The lateralization to the affected ear on tuning fork assessment is another feature of conductive hearing loss. *Air-bone gaps* are elicited and the features are seen especially in the lower frequencies through audiometry assessment (Gelfand, 2009). Hearing losses that are recorded may not exceed 70 dB. Generally the prognosis for conductive hearing loss is favorable (Hussain, 2008) since the corrective measures (hearing aid) for this type of hearing loss is available. Surgeries may be helpful in this type of hearing loss.

1.2.2 Sensorineural hearing loss

Unlike conductive hearing loss, sensorineural hearing loss occurs due to the interruption of sound waves in the inner ear (American Speech-Language-Hearing Association, 2005). Neural loss is the disruption of sound waves in the vestibulocochlear nerve whereas if the eighth cranial nerve is spared, it is referred to as sensory loss. When both the components are involved, it is known as sensorineural hearing loss. Occupational noise-induced hearing loss is a type of sensorineural hearing loss (Amirabadi, 2012). Unlike conductive hearing loss, the prognosis of this hearing loss is poor. This is because the nerve fibers which are affected cannot be reversed. Performing surgery as in the conductive hearing loss may not be very helpful. This explains the importance of taking measures to prevent occupational noise-induced hearing loss, as this malady is irreversible and permanent. There are conditions that may be reversible in sensorineural hearing loss; those who are exposed to excessive noise for a brief period leading to development of temporary threshold shift.

There are many different characteristics in sensorineural hearing loss compared to conductive hearing loss. The sensorineural hearing loss usually involves both ears. This irreversible hearing loss may take a long time to occur. However, there are conditions whereby this sensorineural hearing loss may occur unilaterally. One of the conditions is the Meniere's syndrome (Dinces & Rauch, 2013; National Institute on Deafness and Other Communication Disorders, 2010a). This syndrome disrupts the inner ear without affecting the auditory nerve, causing sensory hearing loss. Other conditions that may trigger hearing loss unilaterally are by engaging in shooting activities or exposure to excessive noise adjacent to one ear. Eventually, bilateral hearing loss may ensue over a period of time. The other feature of the sensorineural hearing loss is that air conduction and bone conduction is reduced. This is contrary to conductive hearing loss where only air conduction is reduced. This reduced conduction may be appreciated in an audiogram by eliciting a no obvious 'air-bone gap' reading (Gelfand, 2009). The reduced conduction can also be demonstrated using a tuning fork. The tuning fork usually lateralizes with the ear that hears well (Thiagarajan & Arjunan, 2012).

Another characteristic feature that distinguishes sensorineural hearing loss from conductive hearing loss is that the subject tends to speak louder during a conversation (Roeser, et al., 2007). This can be distinguished from otosclerosis (conductive hearing loss) where one tends to speak more softly. The person has a reduced capability of hearing fainter sounds since bone conduction is affected in sensorineural hearing loss, making it difficult to communicate in a noisy environment. The other distinctive feature is reduced *discrimination* ability (Roeser, et al., 2007). The *discrimination* is the ability of the individuals to understand words spoken in a conversation. The ability to repeat these words can be scored. Scores above 90% are considered to have a good *discrimination* capability. *Discrimination* testing depends on the level of one's speech reception threshold. The speech reception threshold is the lowest level of intensity of sound required by a person to reproduce it verbally. The frequencies tested ranged from 500 to 3000 Hz. The ability to discriminate depends on lists of words to be repeated. The *discrimination* test is conducted in a soundproof room and the results of *discrimination* are based only in a quiet environment. Since poor *discrimination* involves the speech frequency, the conditions affecting high frequencies are not involved. The person may also have difficulty in differentiating certain consonants that are almost similar when uttered. In long standing noise-induced hearing loss, both high and low frequencies are affected.

Recruitment is another feature may be present in sensorineural hearing loss (Baguley, 2002; Roeser, et al., 2000). This may not be at characteristic feature in this hearing loss, but it is not present in conductive hearing loss. It is present only if the sensory component of hearing is affected. Here the subject may recognize the sound quality as being louder in the affected ear than the normal ear. This feature can be illustrated by using a tuning fork of 512-Hz type. The affected person usually has the capability to detect small changes in sound quality. If the person with an affected ear has the ability to perceive sound tones better than the normal ear, the person may have a condition known as *hyperrecruitment*.

Another unique feature of sensorineural hearing loss is hyperacusis. The person may experience pain due to the sound tone over the affected ear. The loudness that one perceives causes this uncomfortable sensation over the ear (Baguley, 2002; Gothelf, et al., 2006). The presence of abnormal tone decay is another distinctive feature in sensorineural hearing loss (Roeser, et al., 2000); the sound tone is experienced for a short while only, and then it disappears. This phenomenon may be present in the neural type of sensorineural hearing loss. This is an important feature to diagnose a tumorous condition known as acoustic neuroma (Chung, et al., 2002). The distortion of pitch is invariably present in neural type of hearing loss (Jansen, et al, 2009; Knight, 2004), which can be illustrated with a vibrating tuning fork.

In sensorineural hearing loss, generally the findings are normal on otoscopy examination. The involvement is in the inner ear and eighth cranial nerve, and hardly recognizable merely by using tuning fork. The features mentioned may not be experienced in occupational noise-induced hearing loss, especially in the early stages.

1.2.2.1 Occupational noise-induced hearing loss

There are few conditions that may lead to sensorineural hearing loss. One of the causes is occupational noise-induced hearing loss (Rutka, 2011). Occupational noise-induced hearing loss is the development of hearing loss due to exposure to high levels of noise. There are different views with regard to noise levels leading to this slow and irreversible malady. According to the U.S. Occupational Safety and Health Administration (OSHA), the permissible exposure limit is 90 dBA (decibels, A-weighted) with a 5-dB exchange rate, where an employee should not be exposed to noise above the level for more than 8-hour duration (Franks, et al., 1996). The U.S. National Institute of Occupational Safety and Health (NIOSH) recommends an exposure limit of 85-dBA. The exchange rate suggested is 3 dB (Franks, et al., 1996). The lower level recommended by the U.S. NIOSH was based on a study conducted on material hearing impairment; the excess risk was lower with the adoption of 85 dBA compared to 90 dBA as the permissible exposure limit (National Institute for Occupational Safety and Health, 1998).

The progression to sensorineural hearing loss is dependent on few factors, i.e., frequency, intensity and duration of noise exposure (Kirchner, et al., 2012). Cumulative and repetitive exposure with high noise intensity and long duration of contact to noise above the permissible exposure limit may aggravate the development of this occupational threat (Haboosheh & Brown, 2012). Intensity is known as loudness, where dB indicates the logarithmic ratio for any minute change in the intensity. The doubling effect occurs with every increment of 3 and 5 dBA, according to the U.S. NIOSH and U.S. OSHA, respectively. This effect is known as 'exchange rate'.

Noise-induced hearing loss is a slow and progressive condition. The duration for an employee to have this irremediable condition depends on several factors. Besides being influenced by high levels of noise, the degree of hearing loss of an employee is dependent on the institution of the hearing conservation program (Kirchner, et al., 2012) in an industry. This program is vital in curbing noise exposure through various approaches.

Noise-induced hearing loss displays a few characteristic features in an audiogram. The presence of a permanent threshold shift in comparison with the baseline findings (Rutka, 2011) usually occurs in both ears and involves frequencies ranging from 3000 to 6000 Hz (Haboosheh & Brown, 2012; Kirchner, et al., 2012). There is usually a dip in these frequencies in the early phases of the plight with recovery at 8000-Hz. In a long-standing affliction, the lower frequencies are also involved. The features found in noise-induced hearing loss are different from *presbycusis* which also causes sensorineural hearing loss. In *presbycusis*, there is no recovery at 8000 Hz.

There is another condition that contains features of occupational hearing loss but only temporarily. This condition is known as *acoustic trauma* (Amirabadi, 2012), where it is triggered, due to exposure to high-noise levels in a short space of time. Due to high-impact noise, temporary threshold shifts may occur and recovery takes place as long there is no further noise intrusion (Haboosheh & Brown, 2012). The findings of acoustic trauma in the audiogram are similar to that of noise-induced hearing loss, but on follow-up the recovery of the hearing threshold ensues. This condition is seen in bomb blasting, explosions and firing of guns or similar ammunition.

1.3 Symptoms and signs of hearing loss

Hearing loss may occur suddenly or of gradual onset disrupting the daily activities. The history of hearing loss may. The cause of a sudden onset of hearing loss is due to penetrating trauma to the ear, whereas occupational noise-induced hearing loss is of gradual onset (Kirchner, et al., 2012). The hearing loss may be unilateral as in Meniere’s disease (Sajjadi & Paparella, 2008) or even bilateral as in occupational noise-induced hearing loss (Kirchner, et al., 2012). The fullness sensation of the ear suggests the Meniere’s disease (Sajjadi & Paparella, 2008). Fluctuation of hearing (diurnal variation) may occur during stress and also in Meniere’s disease. Symptoms such as alteration of pitch and loudness of sound usually occur in sensorineural hearing loss. Ear discharge may be unilateral or bilateral suggesting a condition known as otitis media (World Health Organization, 1996). A medical history such as diabetes may also contribute to hearing loss (Kakarlapudi, et al., 2003). Histories of surgery or penetrating trauma to the ear may also add to hearing loss. The family history is also of significant, as otosclerosis which is a conductive hearing loss may run in family (Hussain, 2008). The social history is vital since listening to loud music (Sataloff, 1991), self-contained underwater breathing apparatus (scuba) diving (Parell & Becker, 1993) and smoking (Kumar, et al., 2013) may all increase the risk of hearing loss. Drug intake, such as consuming aspirin and aminoglycosides for a prolonged duration, may also contribute to hearing loss (Cianfrone, et al., 2011).

Current and past occupational history may give a clue to the cause of hearing loss. Industrial workers are likely to be exposed to loud noise for a long period of time and increase the risk of sensorineural hearing loss.

In otosclerosis, a conductive hearing loss, words are articulated softly as bone conduction in these individuals is normal. This group of individuals may not be able to hear conversations appropriately while chewing food. Another feature among these individuals is that they tend to hear better in noisy places (Hussain, 2008). This particular condition is known as *paracusis of Willis*. In contrary, those with sensorineural hearing loss tend to speak louder especially in a noisy environment. They may have a difficulty in understanding speech since higher frequencies are required to understand the consonants during communication.

Tinnitus may also be associated with hearing loss. This particular symptom may occur in many conditions. It may be experienced as age advances or it may occur due to ingestion of drugs such as aspirin and aminoglycosides. Tinnitus may indicate early injury to the vestibulocochlear nerve as in the consumption of these drugs. Tinnitus may occur in one or both ears. If it is unilateral, acoustic neuroma needs to be ruled out (Wiegand & Fickel, 1989), which is a benign tumor on cerebellopontine angle. The consumption of ototoxic drugs triggers tinnitus bilaterally. The sudden onset of tinnitus is brought about by explosive noise without hearing protectors, while the gradual onset is seen in presbycusis. Tinnitus in the ear is classified into subjective or objective (Rutka, 2011). In the former the subjects can appreciate tinnitus, while in the latter the examiner or tester is also able to hear the sounds. The subjective tinnitus is more common to occur. One of the causes for objective tinnitus is the presence of a tumor in the ear. The roaring type of tinnitus is very typical of Meniere's disease (Han, et al., 2009). The characteristics of tinnitus are usually not associated with sensorineural hearing loss. Physical examination and audiometry assessment (ranging 500 to 8000 Hz) may not reveal any findings; high frequency audiometry assessment (above 8000 Hz) maybe of helpful for these individuals by detecting hearing loss

(Yildirim, et al., 2010). Symptoms such as vertigo and nausea may also be associated with hearing loss.

1.4 Investigations of hearing loss

1.4.1 Tuning fork and its findings

The tuning fork assessment is a basic test to determine hearing loss. There are various ranges of frequencies in a tuning fork. Generally, the 512-Hz tuning fork is used to determine the type of hearing loss. It can distinguish conductive from sensorineural hearing loss by detecting the defect in air conduction or bone conduction (Thiagarajan & Arjunan, 2012). This test is cheap; it does not require much training to carry out the procedure and also to interpret the results. There are few limitations with the use of this test. This test is unable to quantify hearing loss unlike the gold standard test of audiometry assessment. Another limitation is that the response of the opposite ear may be heard. This is true especially in bone conduction testing as the vibration from tuning fork may be felt by the opposite ear. Consequently, masking is required for more accurate results.

The procedure for conducting this test is to strike the tuning fork on a firm surface. This vibrating tuning fork is initially placed near the test ear. The "better" hearing ear is tested first. The vibrating handles of the tuning fork should not be parallel to the ear. This procedure is to test air conduction. Once the tone is not appreciated, the vibrating tuning fork is then placed near to the examiner's ear to compare the tone. This comparison can be made provided the examiner's hearing is normal. Next, the other ear is tested. For bone conduction, the tuning fork is again struck on a firm surface and then it is placed over the mastoid of the "better" hearing ear. Later, the procedure is repeated on the opposite ear. Instead of the mastoid, the forehead and upper incisor may be used (Thiagarajan & Arjunan, 2012).

There are various tests that can be used with the vibrating tuning fork to distinguish conductive from sensorineural hearing loss. One of the tests is the Rinne test (Thiagarajan & Arjunan, 2012). The 512-Hz tuning fork (Burkey, et al., 1998) is struck against a firm surface and placed on the mastoid of the "better" hearing ear initially. Once the vibration is not appreciated, the tuning fork is placed in front of the same ear, near the external auditory canal. In an individual with normal hearing, the air conduction is better than bone conduction, as sound is still appreciated on placing in front of the ear. In conductive hearing loss, sound is not appreciated while in sensorineural hearing loss, air conduction is better than bone conduction. This procedure should be repeated on the opposite ear as well. This test should not stand alone, but complemented by other tests (tympanometry and audiometry assessments).

The other type of test that can detect the type of hearing loss is the Weber test (Thiagarajan & Arjunan, 2012). The tuning fork is struck against a firm surface and placed over the forehead. In the individual with normal hearing, the vibration is equally appreciated in both ears. In other words, there is no lateralization to either ear. The findings may be similar if the person has hearing damage in both ears. This is the limitation of conducting this test. If air conduction is better than bone conduction on the Rinne test and vibration is better appreciated over the left ear with the Weber test, then the sensorineural hearing loss occurs on the right ear and vice versa. In other words, if the Rinne test is normal while the Weber test lateralizes to the ear, then sensorineural hearing loss occurs on the opposite ear. If the Rinne test shows bone conduction is superior to air conduction on right ear, and the vibration also felt more on right ear with the Weber test, then there is conductive hearing loss on right ear and sensorineural hearing loss of left ear. In other instances, where both ears show that air conduction is worse than bone conduction on the Rinne test, but with the Weber test the vibration is appreciated on left side, then there is conductive hearing loss on both ears and sensorineural hearing loss on right ear. The Rinne and Weber tests are screening tests and it should be confirmed by an audiometry assessment.

Another test may be illustrated using the tuning fork is the Schwabach test. The tuning fork is struck against a firm surface and placed over the mastoid area of the examinee and then over the examiner's mastoid. The person is having sensorineural hearing loss of the ear if the vibration felt falls short compared to that of examiner's. In contrast, if the vibration appreciated is longer than the examiner's, then the examinee is said to have conductive hearing loss of the ear. This test can be carried out if the examiner has normal hearing. In the Bing test, the vibrating tuning fork is placed over the mastoid (Thiagarajan & Arjunan, 2012) and the ear of the same side is occluded. If there is no change in the vibration, then there is conductive hearing loss of the ear. If change in vibration is experienced, then the examinee has either normal hearing or sensorineural hearing loss. All these tests are not confirmatory as they are bed-side screening procedures.

1.4.2 Tympanometry

The impedance audiometry supplements the otoscopy and audiometric findings and it also adds new capabilities to hearing evaluation. It is an objective method for evaluating the integrity and function of the auditory mechanism. One of the procedures most often used is the tympanometry. The tympanometry measures the mobility of transfer of vibrating energy through the eardrum connecting the ossicular bones. The compliance or impedance of the middle ear system is measured by its response to variations in air pressure on the eardrum. As controlled degrees of positive and negative air pressure are introduced into the sealed ear canal, the resulting movement of the mechanism is plotted on a chart: a tympanogram. The types of tympanogram are (Mikolai, et al., 2006):

i. Tympanogram Type A – Normal middle ear function and normal compliance.
ii. Tympanogram Type As – Normal middle ear pressure but limited compliance, seen in otosclerosis and a scarred tympanic membrane.
iii. Tympanogram Type Ad – Excessive compliance, seen in discontinuity of the ossicular chain and thinly healed tympanic membrane.
iv. Tympanogram Type B – Little or no compliance, seen in otitis media, congenital middle ear malformation and perforation of tympanic membranes.
v. Tympanogram Type C – Near normal compliance and negative air pressure, seen in poor Eustachian tube function and otitis media (early stage).

1.4.3 Audiometer

The gold standard to determine hearing loss is by measuring using an audiometer. The audiometer is electronic equipment capable of quantifying hearing loss in either ear. The success of employing this equipment relies on operator and the examinee as full cooperation is required. In order to obtain this support, the operator must develop a good rapport with the examinee to obtain a valid result. The pure tone audiometer is capable of detecting hearing loss at various frequencies. The frequencies range from 250 to 8000 Hz (British Society of Audiology, 2011). These frequencies cover both the speech frequencies and high frequencies. The speech frequencies range from 500 to 3000 Hz, on which the diagnosis of hearing impairment is based (Laws of Malaysia, 2010). Presbycusis and occupational noise-induced hearing loss usually affects higher frequencies. Among the frequencies, 2000 to 3000 Hz is known to be the most sensitive range of frequencies in humans due to ear-canal resonance (National Health and Nutrition Examination Survey, 2003). The audiometers have sensitivity of 92 percent and specificity of 94 percent in detecting sensorineural hearing loss (Walker, et al., 2013). Pure tone audiometry was efficient in detecting minor temporary statistically significant changes in auditory thresholds following exposure to loud noise (Barros, et al., 2007).

There are various types of audiometers being used on the market. One of them is the manual audiometer. The manual audiometer has a wide range of frequencies and can be controlled by adjusting the frequency dial (British Society of Audiology, 2011). It has also an attenuator that controls the intensity of sound transmitted to the subjects being examined. There is a switch that can be adjusted, on the side of ear to be examined, delivering the tone required. The audiometer is connected to the earphones for both ears (Franks, 1995; National Health and Nutrition Examination Survey, 2003). The earphones have two colors, i.e., red and blue. The red-colored earphone is worn on right ear whereas the blue on left side. These earphones are connected to a spring headband. A button is pressed when a tone is appreciated. The earphones and the button are usually placed in an audiometric booth. The examinee needs to sit in the audiometric booth while the operator is outside. The audiometer is commonly used in industrial areas to detect hearing loss among workers who are exposed to noise. In an industrial setting, usually air conduction is performed. The bone conduction is usually done in a specialized institution where audiologists are available.

Another type of audiometer available is a microprocessor audiometer (Franks, 1995). This electronic audiometer has the capability to detect the hearing loss on a large number of workers exposed to noise. This audiometer is connected to a computer recording data and assessing the threshold shifts where hearing impairment can be detected quickly. It also saves time by avoiding double recording unlike in the manual audiometer where the operator needs to register the findings on the audiogram initially and then re-enter them in a computer for further evaluation.

There are audiometers that test frequencies above 8000 Hz (Ahmed, et al., 2001). These audiometers are known as ‘high frequency audiometers’. They may be useful in differentiating presbycusis from occupational noise-induced hearing loss. Early losses from the ototoxicity may be detected from this audiometer.

The Békésy audiometry (Franks, 1995) is able to record hearing thresholds without assistance from the operator. This audiometer which functions in a similar way to the manual audiometer, as a button is activated once the tone is heard. This is done separately for both ears. The Békésy audiometer produces continuous and interrupted tones. Based on these tones, five types of interpretations can be made (Roeser, et al., 2007). In Type I, both the continuous and interrupted tracings in the audiogram overlay each other. This condition is seen in individuals with normal hearing levels and also found in those having conductive hearing loss. In Type II, the cochlear involvement is expected. The continuous tracing overlaps with the interrupted tracings at low frequencies and then separates from the latter at above 1000 Hz. In Type III and Type IV, the vestibulocochlear nerve is involved. In Type III, the continuous tracing is separated from the intermittent and continues to levels below the maximum intensity. In Type IV, the continuous tracing is separated but does not reach to levels similar to that of Type III. In Type V, as seen in pseudohypacusis, the continuous tracing is above the pulsed tracing. Besides diagnosing the various disorders and measuring hearing threshold, this type of audiometer can also measure the abnormal tone decay to diagnose acoustic neuroma.

The audiometric booth is sound-proof and there is a limit for allowable octave-band sounds for various frequencies. The allowable upper limits are shown in Table 1.1 (Laws of Malaysia, 2010). The booth has a door, window and a seat. The window is created to unable the examinee to see the audiometer being operated in order to produce valid results on the hearing measurement.

Table 1.1: Allowable upper limit of sound pressure levels

Octave-band frequency (Hz)	500	1000	2000	4000	8000
Sound pressure level (dB)	27	30	35	42	41

{Source: (Laws of Malaysia, 2010)}

Calibration is required to be carried out at regular intervals (Laws of Malaysia, 2010), i.e., once a year. Calibration is done on the audiometer, earphones and audiometric booth. The calibration on audiometer tests the hearing threshold level at each frequency. The calibration within the booth is conducted using an octave band analyzer.

Before testing, the purpose of the examination and the requirement by law is explained (Laws of Malaysia, 2010). The particulars of the subject such as name and identification number are recorded. Histories such as hearing loss, trauma to ear, and hobbies such as listening to loud music, ear discharge and 'a period of quiet' (exposure to noise below 80 dBA for at least 14 hours) before examination are obtained from the examinee. This procedure may not be carried out among claustrophobics.

The operator needs to have special training to maneuver the audiometer. Audiologists are trained in operating the audiometers. In an industrial setting, usually the trained audiometer technician mans the audiometer. In Malaysia, these technicians are trained in NIOSH, Malaysia (Department of Occupational Safety and Health, 2013).

1.4.4 Distortion product otoacoustic emissions

Distortion product otoacoustic emissions (DPOAE), two pure tone frequencies presented simultaneously, measures the functional status of the outer hair cells where identification of cochlear dysfunction can be detected much earlier compared to the gold standard audiometry assessment. Besides being an objective evaluation, the drawback of DPOAE, if used alone, is that the degree of hearing loss cannot be determined. (Guida, et al., 2012).

1.5 Prevention of occupational noise-induced hearing loss

One of the causes of hearing loss is due to exposure to high levels of noise in industries. There are no medications available to reverse occupational noise-induced hearing loss. The hair cells within the cochlea that are damaged due to high levels of noise are not replaceable (Dancer, 2004). As a result, all preventive measures are needed to be taken to avert noise-induced hearing loss. The approaches should prevent standard threshold shifts, a precursor to permanent threshold shifts or permanent hearing loss, from occurring.

There are few measures to control and avoid excessive noise (Franks, et al., 1996; Kirchner, et al., 2012; Timmins, et al., 2010). One of the measures is to reduce the emission of noise from the source (Concha-Barrientos, et al., 2004; World Health Organization, 1997). The employers need to purchase machines that produce the least noise through stipulations of machinery. This can be achieved by constant communication with the engineers. The employers may also find alternative procedures or processes that do not require machines to produce the output. By reducing the vibration of the machines, the noise emitted is also decreased. The vibration is unlikely to be increased if the parts in machines are heavy. Another way to reduce these vibrations from the equipment is by a damping process. By adopting this procedure, the amplitude of vibration is further reduced. Furthermore, after damping, noise that produced affects only low frequencies which are at less risk of producing noise-induced hearing loss. The procedure of damping may be costly, but the claims made from noise-induced hearing loss are much higher. Besides the damping procedure, vibration can also be isolated using materials such as rubber as a secondary exterior layer. By replacing the parts of the machine regularly, the vibration produced may also be reduced. So maintenance of the machines is of utmost importance; supervisors have to ensure this maintenance is done in a specified time-frame to reduce noise levels.

The other engineering method besides controlling at the source is controlling noise along the path can be adopted (Franks, et al., 1996). Engineers may advise on barriers such as steel sheets which can be created around the noise source. The thickness of these barriers will depend on the noise levels emitted from the source. Generally, the thicker the barrier, the higher the reduction of noise transmitted. These barriers created may fully enclose the noise source if the high levels of noise are found to have been transmitted. For further reduction of noise levels, a noise-absorbing substance may be planted in these barriers. These substances, such as fiberglass and gypsum board, are usually porous in nature and have the capability to absorb sound. Finally, the noise source may be placed further from the workers since distance may also have an effect on the noise level. For every twofold increase in distance, noise levels are reduced by 6 dB (Ouis, 1999).

If the above measures fail to reduce excessive noise, then administrative methods are advocated (Franks, et al., 1996). In this approach, the management has to ensure that the employees are not exposed to excessive noise beyond the specified duration as per the First Schedule of Factories and Machinery (Noise Exposure) Regulations 1989 (Laws of Malaysia, 2010). In other words, job rotation should be encouraged so that the duration of exposure to the excessive noise is shortened among the employees. The drawback with this approach is that the factory needs more workers for job rotation. It costs the management as they have to pay for more workers and train new workers. Other measures such as regular noise monitoring, audiometry testing, health education and training need to be carried out to support this approach. The participation of employees is imperative to ensure this approach meets with success.

Finally, the last alternative to prevent hearing loss due to noise is by wearing hearing protection devices (Concha-Barrientos, et al., 2004). Though it is the final option; it is the cheapest and a basis for reducing noise exposure in most industries. It is also favored by the management since wearing these hearing protection devices is the quickest way to reduce noise exposure among employees.

1.6 Hearing protection devices

Hearing protection devices are the final option to reduce noise exposure above the permissible exposure limit. The benefit of using this approach is that these devices can instantly reduce the noise exposure among employees when worn appropriately and regularly. These devices have different reduction levels of noise. The levels are known as noise reduction rate (NRR), where it is denoted as dBC (decibels, C-weighted) on hearing protection devices. In order to convert to dBA, the level has to be subtracted by 7 and later on derated by 50% for the optimum hearing protection for workers (Jones, 2007; Occupational Safety & Health Administration, 2012). The conversion is required since the noise measurement and monitoring are in dBA. Education and training is very imperative to the workers. They must endeavor to create and maintain a reliable ‘locking’ device to prevent infiltration of sound when wearing these devices. During this exercise, the employees need to be enlightened that communication is not affected when wearing these protective gadgets. This is sorely to block high frequency noise unless the high levels of noise affect frequencies of speech range.

There are many types of hearing protection devices available for the workers (Hudak, 2005; USACHPPM, 2006). The most commonly used are earplugs. Earplugs are favored among employers and employees in the industries since they are cheap and more convenient to wear in humid conditions. There are different forms of earplugs available such as formable, custom-molded and premolded. Of these types, the preferred ones are a custom-molded since they are made according to the shape and size of the ear canal. The premolded model, which is reusable and also available in different varieties are preferred than the formable ones. These earplugs are available in different colors to ensure their continuous usage. The technique of wearing these devices needs to be taught so that the earplugs are placed appropriately in the ear canal. The disadvantage using these devices is that employees may complain of complete deafness on wearing them. This is probably due to the presence of impacted wax which can be removed. Another disadvantage is that infection may be introduced due to regular use of the earplug. It can be prevented by taking proper care of them before reuse. This care should be taught to the employees at consistent intervals. The employees are also advised during health education that they should not wear earplugs when having discharge from the ears. For these employees, earmuffs would be a better substitute.

The other type of hearing protection available is earmuffs (Hudak, 2005) which are generally more expensive than earplugs. Earmuffs have two ear cups with a headband. These devices are made according to a size; most employees can use them. The disadvantage of using the earmuff is that it is not comfortable in moist, humid conditions. The use of earmuffs may also hinder the performance of employees' especially when they are required to wear spectacles or goggles.

The next type of protection available is canal caps (USACHPPM, 2006). This device has also two caps with a headband. The reduction of noise level using these canal caps are not superior to the other hearing protection devices and subsequently, are not used frequently in industries. At times, two hearing protection devices may be needed to reduce the noise levels, especially when the levels are above 100 dBA.

1.7 Legislation of occupational noise-induced hearing loss

In Malaysia, the safety, health and welfare of workers are protected under the Factories and Machinery Act 1967 (Act 139) (Laws of Malaysia, 2010). Employees under this Act are those working as manual laborers in Trade. There should be more than five workers involved in operating machinery within a factory or working premises. The machines in the office or that function manually are not included as the part of machinery in this Act. There are 14 regulations and 1 rule under this Act.

The regulation for noise exposure in Malaysia was initiated in 1989. The main aim of this regulation is to preserve the hearing threshold and avoid further loss among workers who are exposed to loud noise in a workplace. The objectives maybe achieved by reducing the noise levels to a level below the permissible exposure limit.

The noise regulation is in 10 parts and two schedules (Laws of Malaysia, 2010). An employee is not allowed to be exposed to more than 90 dBA (permissible exposure limit) for a period of eight-working hours. If they are exposed above this level, then the working duration should be shortened according to the First Schedule. However, employees are not allowed to be exposed to a noise beyond 115 dBA or sound levels which are greater than one per second of 140 dB (Laws of Malaysia, 2010). ‘Action level’ is a gauge where the Hearing Conservation Program should be instituted; the dose is half the permissible exposure limit, 85 dBA (Laws of Malaysia, 2010).

Noise exposure should be monitored and conducted by skilled personnel. Noise monitoring is measured using a sound level meter and personal exposure noise dosimeter which is approved by the Department of Occupational Safety and Health (DOSH) and calibrated regularly. If the initial exposure monitoring does indicate the noise levels are above the action level, then the exposure monitoring should be repeated within six months. Within this period, the employer is expected to reduce noise through various approaches. The personal exposure noise dosimeter is conducted on at least one other worker doing the same job. The results should be reported within a two-week period (Laws of Malaysia, 2010).

In order to reduce noise exposure to the employees, various engineering methods should be adopted. If the noise level is still high despite the engineering method employed, the duration of noise exposure among employees should be shortened. The last alternative to reduce noise exposure is by wearing a hearing protection device. These devices should be supplied to the employees for free and should be replaced once damaged. The noise exposure reduction required depends on the presence of standard threshold shifts and hearing impairment. If the average levels are more than 10 dB temporary shifts from 2000 to 4000 Hz (standard threshold shift) or 25 dB of permanent shifts from 500 to 3000 Hz (hearing impairment) (Laws of Malaysia, 2010), then the noise exposure levels need to be reduced to levels below the action level. If the levels are otherwise, then the noise levels need to be reduced to levels below the permissible exposure limit. These changes can be noted by performing regular audiometry assessment. This assessment should be carried out by a skilled person yearly if the need to reduce noise below 85 dBA or otherwise once in 2 years if the target is below 90 dBA (Laws of Malaysia, 2010). The results of the audiogram should be notified to the employees once diagnosed as permanent threshold shift. The warning signs indicating high levels of noise should be displayed for employees to take precautionary measures. The entry to these areas should be restricted to authorized personnel only. The importance of the signs and also high levels of noise with its effect should be transferred to employees by proper training at least once in two years. The records of the training conducted and assessment done should be kept for at least five years after the employee has retired or resigned.

An authorized person from the DOSH may inspect the premises at any time if required to do so. This licensed person may enter with or without a warrant for further investigation if the employees are found to be exposed to occupational hazards. The employers may be fined or imprisoned or both if there is negligence on their part to reduce noise exposure among their employees (Laws of Malaysia, 2010).

1.8 Compensation

Occupational noise-induced hearing loss is a compensatory disorder under the Fifth Schedule (Section 28) of Employees Social Security Act 1969 (Laws of Malaysia, 2006). Employees who have been diagnosed as having hearing impairment are able to claim from the Social Security Organization. These employees should also provide a history of exposure to noise above 85 dBA over an 8-hour period in the workplace. Hearing is required for communication and its loss affects the activities of daily living. This disability would compromise the safety and performance of employees at the workplace. The amount that can be claimed depends on the severity of hearing loss calculated from frequencies ranging 500 to 3000 Hz (Cocchiarella & Andersson, 2000). Hearing loss should be calculated separately for both ears once permanent impairment is diagnosed. This is otherwise known as maximal medical improvement achieved. The age correction is not generally taken into account for the compensation in hearing impairment. Assistive devices such as hearing aids should not be used during audiometry examination for compensatory purposes.

1.9 Effects of hearing loss

Hearing is one of the five human sense-organs and plays a vital role through sensory receptors by transmitting the impulses to brain for interpretation. Hearing is as essential as the other senses especially during interaction (Plack, 2005). Hearing makes it possible for humans to perceive and understand verbal communication. Through this organ, the two ears, meaningful sounds are detected, distinguished and interpreted from the environment besides the ability of identifying the source and whereabouts of the sound. The hearing ability plays a vital role in the daily life of a person. If we lose this faculty, there will be difficulty in recognizing sounds such as background noise and warning signs which may pose a danger to the safety and health of employees and others in the surrounding environment. These negative effects are further exaggerated if the degree of losing this ability is high. Hearing loss due to various causes; noise-induced hearing loss is largely being ignored as it is perceived as not life threatening. The effects as a consequence of hearing loss may be economic, psychosocial, or biological. The prevalence of occupational noise-induced hearing loss has been increasing worldwide (Nelson, et al., 2005). Job opportunities for employees with noise-induced hearing loss may be affected constantly.

1.9.1 Economic impact

Hearing loss may lead to loss of income for the affected person and indirectly to the employer. A cross-sectional study was done on income and degree of hearing loss (Kochkin, 2007). It was found that there was an inverse association between these two variables: the income per year of an employee decreases as the degree of hearing loss increases. However, the salary tends to be much higher in the group with hearing aid compared to that of employees not wearing any form of assistive technologies.

New job opportunities for an employee having hearing loss are very slim. The affected employee may not even have the opportunity to continue in the current position as it may endanger him or others during work. This employee may not be able to follow the instructions as clearly as those who are not suffering from hearing loss. This can be worsened in a factory setting, where noise may be above the permissible exposure limit, resulting in faulty carrying out of tasks. There is also a high risk of accidents occurring in persons with hearing loss. There were many fatalities involving forklifts (WorkSafe Victoria, 2006) which may have been prevented. If an employee with hearing loss is tasked with a job, the person may be unaware of the cautionary device such as horn from the forklift and there is a risk of jeopardizing himself or others when it heads his way. Consequently, this employee may be hospitalized, productivity is slowed; also compensation has to be paid and damaged property repaired resulting in economic losses for the employer. Sometimes, the smallest of all accidents may have most detrimental domino effect leading to the ultimate closure of the factory.

The employee may be underemployed or the salary or promotion may be affected. The affected person is not assigned to the job that he is qualified for, due to hearing loss and as a consequence, will not be paid a sufficient amount to support himself or his family. The affected person may need to purchase a hearing aid in order to assist his hearing to the pre-injury level. To purchase these assistive devices is very pricey (North Carolina Division of Services for the Deaf and the Hard of Hearing, 2010) and it may need to be replaced at constant intervals, besides paying medical bills for a follow-up care.

In severe conditions, the perforation of the tympanic membrane may occur due to high-impact noise (Ritenour, et al., 2008) in certain industries. Activities such as blasting may cause perforation and surgical intervention such as myringoplasty may consequently be required. This procedure will incur further cost. It is difficult to estimate the cost for an affected person to have a regular life-style, but it is sufficient to deduce that there is definitely economic loss for the individual as well as the employer. The problems faced by these individuals are very serious as one may have to lose the current job or give up a career that cannot be pursued further due to the stress of hearing loss. This may cause workers to neglect even basic treatment. However, the consequences can be dire to the affected person as he may not be able to respond well enough to his surroundings. This may jeopardize him in public spaces where there are obvious dangers such as passing vehicles or, under unlucky circumstances, falling objects. The injury the person may face due to hearing loss again will require costs for the treatment, etc. This could have been easily evaded if the hearing level is at the optimum condition with the assistance of a hearing aid. It is obviously sensible in investing in a hearing aid, but the person who does not have the means to purchase one, will usually take their chances and go about their lives without any thought for the consequences, even though these consequences may be dreadful. The fact is that hearing loss may lead to more expenditure in the resultant, necessary treatment.

Even in the simplest of situations, it is difficult for an employer to communicate with the employee having hearing loss (Ross, 2011). The employee with hearing loss may be reluctant to be present for meetings or discussions. The employer or supervisor concerned needs to spend more time repeating directions to the employee with hearing loss. This leads to a fall in productivity as the employee concerned feels more stressed and less likely to perform at his best, while the supervisor concerned is also equally tense since more attention is needed to be given to the employee with hearing loss. This is a loss of time and has an impact on both the employer and employee.

1.9.2 Psychosocial impact

The ability to speak and hear is the most important characteristic required for effective communication. When a person has sensorineural hearing loss such as noise-induced hearing loss, the person would have difficulty to engage in a normal conversation (Morata, et al., 2005). The affected person would have to raise his voice due to bone conduction loss. This scenario usually happens in a noisy industry with employees suffering from this type of hearing loss. There was a study conducted (Giordano, et al., 2008) evaluating problems related to noise-induced hearing loss. The common problems detected in the study were that they had difficulty in comprehending softer sounds and words had to be repeated. Among the 180 male participants in the study, 97% of them were convinced that hearing aids were useful but only 4% of the subjects wore them or had tried before. From the findings of the study, those who had noise-induced hearing loss would usually opt to withdraw from engaging in any form of communication to avoid wearing hearing aids. They may prefer to be left alone and avoid attending any gatherings including meetings conducted by the factory or the company, thereby probably affects their performance in the workplace. As a consequence, they may end up in a depressive phase as their other colleagues may be getting a higher pay or promotion. In hearing loss, as the severity increases, the likelihood of depression is higher (Shield, 2006).

The person with hearing loss may also feel very irritable and apprehensive. In a case-control study (Joshi, et al., 2003), about 40% of 150 respondents felt agitated and fatigued from the effect of noise. Besides irritation, the participants felt decrease in attention and disturbances in speech. Their performance in the workplace is definitely affected. There is a possibility of marital glitch since misunderstanding may occur between couples (Shield, 2006), as they have difficulty to engage in a meaningful dialogue. They are worried about their job; this adds further stress to an already-unstable relationship in the family. Daily activities at home such as watching television may add to the problem in a relationship since a higher volume is preferred by one person, irritating the other family members. The affected person may also feel exhausted in trying to understand discussions and end up ignoring them. It is not uncommon for this affected person to harbor negative feelings towards colleagues, friends and family.

The affected person may also have a sense of denial due to embarrassment. Besides this, the person may become the target of ridicule. It is undeniable that there is a huge negative social impact on those with this hearing loss. The person may be violent or obsessive or even resort to self-imposed seclusion due to hearing loss as he finds the social aspect of his life fading. The impact may reduce his quality of life (Morata, et al., 2005). He is unlikely to enjoy the same relationship he used to have with his colleagues or family members.

1.9.3 Biological effect

The biological effect of noise can be either auditory or non-auditory. Besides hearing loss, the person may have tinnitus or vertigo (Koh, et al., 2001). The non-auditory effects are increase in blood pressure (Marchiori, et al., 2006), increased incidence of diabetes mellitus (Diniz & Guida, 2009) and peptic ulcers (Koh, et al., 2001).

1.10 Statement of problem

The prevalence of occupational noise-induced hearing loss is on an increasing trend globally. There are 16% of adults suffering from this irreversible condition primarily due to occupational origin (Nelson, et al., 2005). The prevalence of this occupational disease has doubled in the past decade from 120 million in 1995 to 250 million in 2004 globally (Nelson, et al., 2005). There are countries where the prevalence of this occupational malady is increasing at a quicker rate than in others, primarily due to rapid industrialization. More than 30 million workers in the US were exposed to excessive noise; around 26 million of them have hearing loss affecting high frequencies (National Institute on Deafness and Other Communication Disorders, 2011). The prevalence of hearing impairment in India varies from 5% to 17% (Mishra, et al., 2011). There were a total of 663 cases of occupational diseases which have investigated in Malaysia for the year 2010. From this total, around 70% of them were diagnosed to have noise-induced hearing loss, making it the most common occupational disease (Department of Occupational Safety and Health, 2013). Countries such as the US, India (Madison, 2007) and Malaysia (Laws of Malaysia, 2010) are adopting 90 dBA as the permissible exposure limit for noise.

1.11 Rationale of study

In an experimental study (Yates, et al., 1976), there were more temporary threshold shifts upon adopting 90 dBA as the permissible exposure limit compared to 85 dBA. The temporary threshold shift is a precursor of permanent threshold shift (Lawton, 2001). According to Lawton (Lawton, 2001), the temporary threshold shifts occurring at levels above 85 dBA may result in some degree of permanent hearing loss. The continuous exposure to high levels of noise may lead to noise-induced hearing loss. The purpose of this study is to assess the mean hearing threshold levels, the development of hearing threshold levels above 25 dBA and standard threshold shifts on adoption of 85 dBA as the permissible exposure limit compared to 90 dBA. It is of utmost importance to determine the adoption of the permissible exposure limit scientifically as a legal limit, since it will impose cost and enforcement issues, besides introducing mandatory hearing protection among workers.

1.12 Research questions:

1. Is 85 dBA as permissible exposure limit more effective in preserving hearing threshold levels as compared to 90 dBA?
2. Is 85 dBA as permissible exposure limit more effective in preventing standard threshold shifts as compared to 90 dBA?
3. Are levels of knowledge, attitude and practice of noise-induced hearing loss different between participants from two factories adopting different permissible exposure limits, 85 and 90 dBA?

1.13 Study objectives:

1.13.1 General objective:

The general objective of this study is to compare the effectiveness of applying different permissible exposure limits in preserving hearing threshold level.

1.13.2 Specific objectives:

Primary objectives:

1. To determine the effectiveness of adopting 85 dBA as a permissible exposure limit compared to 90 dBA in preserving hearing threshold levels.
2. To ascertain the effectiveness of adopting 85 dBA as a permissible exposure limit compared to 90 dBA in preventing standard threshold shifts.

Secondary objective:

1. To compare levels of knowledge, attitude and practice of noise-induced hearing loss between participants two factories adopting different permissible exposure limits, 85 and 90 dBA.

1.14 Research hypotheses:

1. There are changes in mean hearing threshold levels when adopting 85 or 90 dBA as permissible exposure limit.
2. There are changes in development of standard threshold shifts when adopting 85 or 90 dBA as permissible exposure limit.
3. There are differences in levels of knowledge, attitude or practice of noise-induced hearing loss between participants from the two factories adopting different permissible exposure limits, 85 and 90 dBA.

1.15 Public health implications

The cases of noise-induced hearing loss investigated in Malaysia and the US are on increasing trend. These countries are adopting 90 dBA as the permissible exposure limit. Therefore, by lowering the exposure limit to 85 dBA, the prevalence of this malady may be reduced.

1.16 Summary

Occupational noise-induced hearing loss, a sensorineural hearing loss, is a permanent and irreversible malady. The prognosis is poor and hence, it is important to take measures to prevent this condition. The progression of noise-induced hearing loss depends on frequency, intensity and duration of exposure to noise. The characteristic features in an audiogram are the presence of a permanent threshold shift in comparison with baseline findings at 3000 to 6000 Hz bilaterally (both ears), with recovery at 8000 Hz. It is of gradual onset and activities such as scuba diving, listening to loud music and smoking may increase the risks of hearing loss.

The gold standard to determine hearing loss is by measuring using an audiometer. There are various methods to prevent hearing loss such as engineering and administrative methods, but hearing protection devices are preferred as they are the cheapest and swiftest way to reduce noise exposure. The most commonly used hearing protection devices are earplugs.

The workers are protected from noise-induced hearing loss under the Factories and Machinery Act 1967 (Act 139) in Malaysia. It is a compensatory malady. According to the U.S. OSHA, the permissible exposure limit for noise is 90 dBA, while the U.S. NIOSH recommends 85 dBA. The countries adopting the former level as the permissible exposure limit are the U.S., India and Malaysia. The effects as a consequence of hearing loss may be economic, psychosocial, or biological. The prevalence of noise-induced hearing loss is increasing globally including in Malaysia. Hence, this study was conducted to assess the effectiveness of applying different permissible exposure limits, 90 and 85 dBA in preserving hearing thresholds and preventing the development of temporary standard threshold shifts, in order to reduce the prevalence of this irreversible occupational malady.

CHAPTER 2

LITERATURE REVIEW

In this chapter, a more detailed discussion of systematic review of comparison between 85 and 90 dBA as the permissible exposure limit is presented. The prevalence, pathogenesis and risk factors of hearing loss, hearing conservation program and also knowledge, attitude and practice of noise-induced hearing loss are narrated.

2.1 Prevalence of noise-induced hearing loss

There has been an increased prevalence of occupational noise-induced hearing loss globally. This occupational malady brings the total of sufferers to over 4 million attributable Disability Adjusted Life Years (Nelson, et al., 2005), where the Western Pacific region contributes to more than a quarter of the total. In the US alone, there were around 30 million workers exposed to noise levels above the permissible exposure limit (Concha-Barrientos, et al., 2004), where 26 million of them had noise-induced hearing loss (National Institute on Deafness and Other Communication Disorders, 2010b). In Germany there was one sixth of the working population who were exposed to noise levels above the permissible exposure limit (Concha-Barrientos, et al., 2004). The countries in the East were not spared either. Noise-induced hearing loss was the most common occupational disease in Malaysia (70% of the total occupational diseases investigated) (Department of Occupational Safety and Health, 2013).

2.2 Pathogenesis of noise-induced hearing loss

There are two possible mechanisms that have been postulated on pathogenesis of noise-induced hearing loss (Dancer, 2004). Mechanical damage of stereocilia is one of them. There is initially disarticulation of stereocilia on noise insult. On exposure to high noise intensity, the rigidity of stereocilia is reduced and later it gets detached. This detachment takes place since there is a presence of depolymerization of actin filaments. This ultimately leads to a reduction of ion channels and sensitivity of the cochlea verging on to temporary threshold shift. If continuously exposed to noise, the stereocilia would be permanently damaged and this would lead to permanent threshold shift (Dancer, 2004). There are two types of hair cells in the organ of Corti, i.e., outer and inner hair cells. The former is more sensitive to noise and ototoxic drugs. These hair cells transmit acoustic stimuli to the inner hair cells. Once the outer hair cells are damaged, a 40-dB hearing loss may ensue. If the inner hair cells are also damaged, then there will be a permanent threshold shift on hearing threshold. The other mechanism to explain noise-induced hearing loss is metabolic damage of the cells (Dancer, 2004). Due to loud noise insult, a bulge is formed within the afferent synapses, which later may burst. The recovery process takes around five days and is known as temporary threshold shift. If there is a continuous exposure to noise, the afferent fibers are constantly damaged leading to a permanent threshold shift.

2.3 Permissible exposure limit

Australia is adopting 85 dBA as the permissible exposure limit since the year 2000 as shown in Table 2.1. The claims for hearing loss have reduced from 5755 in 1998/1999 to 4510 in 2001/2002. The claims have dropped dramatically to 19.0% of all-disease related claims. The fall of claims can be mainly attributed to the manufacturing industries (Morris, 2006). New Zealand has been adopting the same permissible exposure limit as Australia since 1995 (Madison, 2007). A cross-sectional study was done to show the claims made on noise-induced hearing loss in the country. There were 2823 claims in 1995 compared to 5580 in 2006 (Thorne, et al., 2008). The claims were mainly from the agriculture and fisheries department (15%), plant and machinery operators (14%) and also building and machinery trades (12%). The claims due to noise-induced hearing loss are different in the two neighboring countries though they have been adopting 85 dBA as the permissible exposure limit. The claims in fact were higher among the New Zealanders who have been adopting the exposure limits much earlier than the Australians. Hence, studies comparing the effectiveness of 90 and 85 dBA as permissible exposure limit on preserving hearing threshold need to be carried out.

Table 2.1: Permissible exposure limit

Country, Year	PEL	Country, Year	PEL
Argentina, 2003	85	India, 1989	90
Australia, 2000	85	Israel, 1984	85
Brazil, 1992	85	Italy, 1990	85
Canada, 1991	87	Mexico, 2001	85
Chile, 2000	85	New Zealand, 1995	85
China, 1985	85	Norway, 1982	85
Colombia, 1990	85	Spain, 1989	85
European Union, 2003	87	Sweden, 1992	85
Finland, 1982	85	UK, 1989	85
France, 1990	85	US, 1983	90
Germany, 1990	85	Uruguay, 1988	85
Hungary, -	85	Venezuela, -	85

PEL, Permissible exposure limit

Source: (Madison, 2007)

2.4 Comparing 85 and 90 dBA as the permissible exposure limit: A systematic review

2.4.1 Literature search

Researchers (Balachandar S. Sayapathi and Anselm Ting Su) considered observational studies, trials and any other comparative designs. We used medical subject headings with keywords, i.e., “Effects 85 or 90dBA AND Noise AND Threshold shift” for all the databases searched. The outcome measures were temporary threshold shifts on the audiogram.

2.4.1.1 Search strategy

Researchers conducted search in 3 major databases, i.e., PubMed, Embase and Lippincott Williams & Wilkins Journals@Ovid for studies published up till 1 May 2013. We applied no language restrictions. A few inclusion criteria needed to be met for the papers to be encompassed in this systematic review. The studies were required to include exposure information regarding the noise source, such as industrial or experimental noise, noise levels and outcomes of threshold levels. Initially the titles of the papers were reviewed for applicability in this review. Later, the abstracts were studied to further ascertain whether the studies fulfilled the requirements of the review. Finally, full texts of the papers were appraised to confirm the contents achieved the primary objectives of this review. On evaluation of the full text, once a paper was accepted for this review, information was gathered from it such as the name of the authors, year of publication, country where the study was conducted, the setting (experimental or industrial), number of participants or subjects, exposure information including the sources of noise, duration of exposure and usage of hearing protection devices, the noise levels in dB and finally, the outcome of the hearing threshold level in the subjects. Unpublished works, such as conference proceedings however, were not included in this assessment.

2.4.1.2 Quality assessment

The scoring system used to assess the quality of a paper is depicted in Table 2.2. This scoring system was a modified form of that of Su *et al*. (Su, et al., 2012). The standards included in this scoring system were divided into three major subheadings, i.e.

- population,
- exposure and
- outcome.

Under the *population subheading*, the probability for bias among participants, nonrespondent bias and confounding variables were taken into account, whereas under the *exposure subheading*, control of confounding variables and use of effective measurement tools to quantify exposure were recorded. Finally, in the *outcome subheading*, use of effective measurement tools to quantify outcome and appositeness of blinding were justified for the score. A paper in this review was categorized as either acceptable or of poor quality, based on the score gained. The acceptable quality of a paper would mean that a score of 2 was attained for each measurement of confounding variables, effective measurement to quantify exposure and outcome. If any score was below 2 for these standards, a score of at least 2 was necessary for probability of bias on selection of participants or subjects, and for avoidance of nonrespondent bias standards.

Table 2.2: Scoring system for ranking the quality of papers

Scope	Description
	Population
I) Probability of bias in selected subjects	
3	Survivor bias avoided
2	Volunteer bias avoided
1	Selection method not reported
II) Nonrespondent bias	
2	Response rate ≥ 75%
1	Response rate < 75% or not reported
III) Potential confounding variables between groups	
2	Potential confounders measured or both groups exposed to similar confounders
1	Potential confounders not measured
NA	No comparison group
	Exposure
IV) Confounding exposure controlled	
2	Exposure confounders measured or both groups exposed to similar confounders
1	Exposure confounders not measured nor reported
V) Effective measurement tool used to quantify exposure	
2	Exposure measured and reported
1	Exposure not measured nor reported
	Outcome
VI) Effective measurement tool used to quantify outcome	
2	Outcome measured and reported
1	Outcome not measured nor reported
VII) Blinding	
2	Relevant blinding
1	No blinding done or reported
	Judgment criteria
There were threats to the validity of a study if criteria III), V) and VI) were scored as 1. The quality of a study was acceptable if these criteria were scored as at least 2. The scores for criteria I) and II) should be at least 2 if criterion III) is scored as NA (not available) in order for the quality of a study to be considered as acceptable.	

2.4.1.3 Data extraction

Researchers approved and retrieved studies independently based on the inclusion criteria. We then extracted data from the included studies. This data was later gathered depending on the country in which the study was done, the setting, number of subjects, exposure information, noise level and the outcome.

After a thorough search by titles, there were a total of 47 pertinent articles through the PubMed database and 47 articles from the Lippincott Williams & Wilkins Journals@Ovid. The search of the Embase database identified 24 articles. A total of 14 duplicates found in the Lippincott Williams & Wilkins Journals@Ovid were then eliminated. There were a total of 36 relevant titles retrieved from the three databases. Of them, 20 relevant abstracts were obtained. Finally, a total of 13 relevant full texts were retrieved from these databases. After a thorough assessment, there were two similar papers from the Lippincott Williams & Wilkins@Ovid and three similar papers from the Embase which had also been retrieved from the PubMed. After removing the five similar papers from these databases, there were a total of eight papers that fulfilled the requirements of this systematic review. The process of identifying these eight articles is shown in Figure 2.1.

Search Terms	Effects 85 or 90 dBA AND Noise AND Threshold shift		
Databases searched	PubMed	Lippincott Williams & Wilkins@Ovid[a]	Embase
No. of searches	47	47	24
No. of searches after removal of duplicates	47	33	24
No. of relevant titles	17	10	9
No. of relevant abstract	11	4	5
No. of relevant full text retrieved based on inclusion criteria	6	3	4
Total relevant articles retrieved from three databases	8[b]		

Figure 2.1: Flow diagram of search strategy

[a]Resources included Journals@Ovid Full Text, UM Library Full Text Journals & LWW, EBM Reviews - ACP Journal Club (Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews 2005, Cochrane Methodology Register, Database of Abstracts of Reviews of Effects, Health Technology Assessment, NHS Economic Evaluation Database and ACP Journal Club), Biological Abstracts, CAB Abstracts, EconLit, GEOBASE, ICONDA and Ovid MEDLINE (In-Process & Other Non-Indexed Citations , without Revisions, Daily Update, Ovid OLDMEDLINE).
[b]Total number of papers searched for systematic review; 2 similar papers from the Lippincott Williams & Wilkins@Ovid were retrieved from the PubMed; 3 similar papers from the Embase were retrieved from the PubMed.

2.4.2 Epidemiology

All eight articles in the current review had effective measurement tools to quantify noise exposure and an instrument to measure outcome due to noise. Only three studies had not been controlled for confounding bias, i.e., McBride *et al*. (McBride, et al., 2003), Kvaerner *et al*. (Kvaerner, et al., 1995) and Chen and Tsai (Chen & Tsai, 2003). However, the three studies had avoided selection bias, and the response rate of participants in these studies was at least 75%. As a result, all eight articles showed acceptable quality based on the scoring system as outlined in Table 2.3. Most of the studies were carried out in the US. There was also a study conducted in the east, Taiwan by Chen and Tsai (Chen & Tsai, 2003). In Europe, there were two studies conducted in Denmark and Norway, while one study was conducted in the southwest Pacific, i.e., New Zealand. Hence, in this review most of the regions were ultimately covered with respect to the effects of different noise levels on hearing threshold, thereby eliminating effects of ethnic variability. A summary of the studies is shown in Table 2.4.

Table 2.3: Quality assessment of included papers in the systematic review

Paper	Avoid selection bias	Avoid nonrespondent bias	Comparable study and control groups	Control for confounding bias	Valid exposure measures	Valid outcome measures	Blinding	Overall quality and validity
Stephenson *et al*., 1980	1	2	2	2	2	2	2	A
Mc Bride *et al*., 2003	2	2	1	1	2	2	1	A
Mills *et al*., 1983	2	2	2	2	2	2	1	A
Yates *et al*., 1976	2	2	2	2	2	2	1	A
Kvaerner *et al*., 1995	3	2	1	1	2	2	1	A
Chen & Tsai, 2003	3	2	1	1	2	2	1	A
Rubak *et al*., 2006	2	1	2	2	2	2	1	A
Melnick, 1977	1	2	2	2	2	2	1	A

A, acceptable

Table 2.4: Summary of studies on different noise intensities

Country, authors, date	Setting	Study subjects	Exposure information		Outcomes
			Noise source (duration of exposure)	**Noise level**	
U.S., Stephenson *et al*., 1980	Experimental	n = 12	General Radio Model 1382 Random Noise Generator (24 hours)	≤ 85 dBA	Mean asymptotic threshold shift of various noise intensities from six frequencies (0.5-6kHz): 85 dBA - 4.4 dB 80 dBA - 1.9 dB 75 dBA - 0.73 dB 70 dBA - 0.7 dB 65 dBA - 0.06 dB
New Zealand, McBride *et al*., 2003	Industry	i. n_1 = 30 ii. n_2 = 34 iii. n_3 = 28	Railway workshop (7 hours 13 minutes)	≤ 85 dBA and > 85 dBA	Temporary threshold shifts were not statistically significant among the three groups (70.4-84.9; 85.1-89.8; 90.2-104.2), x^2 = 2.39, p = 0.24
U.S., Mills *et al*., 1983	Experimental	i. n_1 = 7-8 each at 84 dBA. ii. n_2 = 7-8 each at 90 dBA	Noise generating equipment with loudspeakers (24 hours for 84 dBA; 8 hours for 90 dBA)	≤ 85 dBA and > 85 dBA	Temporary threshold shifts: i. 84 dBA – 13, 9, 9 dB at 63, 125 and 250-Hz ii. 90 dBA – 17, 14 and 18 dB at 63, 125 and 250-Hz Recovery of threshold shifts: i. 48 hours for 84 dBA ii. 12 hours for 90 dBA
U.S., Yates *et al*., 1976	Experimental	i. n_1 = 6 at 85 dBA) ii. n_2 = 6 at 90 dBA)	Noise generating equipment (7 hours)	≤ 85 dBA and > 85 dBA	a) Mean temporary threshold shifts (combined frequencies): i. For 85 dBA- Mean (SD) = 6.26 (9.15) ii. For 90 dBA- Mean (SD) = 10.13 (7.45) b) No statistical significant difference in temporary threshold shifts for individual frequencies.

kHz, Kilohertz; SD, Standard deviation

Table 2.4, continued

Country, authors, date	Setting	Study subjects	Exposure information		Outcomes
			Noise source (duration of exposure)	**Noise level**	
Norway, Kvarner *et al*., 1995	Industry	n = 13 (excluded one ear)	Global iron works (7 hours each day for 3 days)	≥ 85 dBA	a) Temporary threshold shifts, exposure between 85-90 dBA: i. Median = 3.8 dB (range = -10.0 to 16.7 dB), p = 0.001 at 4 kHz ii. Median = 5.5 dB (range = -5.0 to 11.7 dB), p < 0.001 at 6 kHz b) Transient evoked otoacoustic emissions showing median = 0.65 (range = -0.8 to 3.3 dB), p = 0.001
Taiwan, Chen and Tsai, 2003	Industry	n = 384	Oil refinery (8 hours)	≤ 85 dBA	Hearing loss (average hearing threshold level more than 25 dBA), mean noise level was 81 dBA: i. 9.6% - Low frequencies (0.5 to 2 kHz) ii. 38.3% - High frequencies (3 to 6 kHz)
Denmark, Rubak *et al*., 2006	Industry	n = 649	All noisy trades (20 years and more)	≤ 85 dBA and > 85 dBA	i. Exposure between 80 and 84 dBA, no statistical significant change, OR 1.92 (95 % confidence interval (CI), 0.77- 4.80) ii. Exposure between 85 and 89 dBA, odds ratio (OR) 3.05 (95% CI, 1.33- 6.99)
U.S., Melnick, 1977	Experimental	n = 9	Noise generated through loudspeakers (24 hours)	≤ 85 dBA	Exposure at 80 dBA: i. 9.3 dB at 4 kHz 7.2 dB at 6 kHz Exposure at 85 dBA: i. 17.8 dB at 4 kHz ii. 14.6 dB at 6 kHz

2.4.2.1 Studies of the effectiveness of adopting 85 and 90 dBA as the permissible exposure limit

Stephenson *et al.* (Stephenson, et al., 1980) conducted an experimental study on college-age males. The aim of this study was to recognize the minimum noise intensity level that would result in asymptotic temporary threshold shift. Below this level, noise may be exposed for an unlimited period of time since continuous exposure would not result in permanent damage to hearing. The study was conducted in the US among 12 volunteers. The inclusion criteria, was that the volunteers should have a normal hearing threshold level of 15 dB or below at each frequency tested, and the change on hearing threshold level should be within 5 dB for the test frequency. Noise was generated using a General Radio Model 1382 Random Noise Generator, while the calibrated audiometer, Grason Stadler 1703 was used for recording the hearing threshold levels. These subjects were then exposed to noise levels of 65, 70, 75, 80 and 85 dBA in a room using a random noise generator. They had to be exposed to different noise levels for 24 hours with an interval of one week. The hearing threshold levels were measured on left ear only, without earplug, at various intervals upon exposure and post-exposure to noise. The right ear was fitted with earplug during this experiment. It was noted that the mean asymptotic of threshold shifts at two minutes of post-exposure to noise were higher among subjects exposed to 85 dBA, 10-13 dB at 4 kHz, compared to exposure to other noise intensities. These significant changes were also noted on other test frequencies among subjects exposed to 85 dBA, but not evident when exposed to below 80 dBA. It was also noted that upon exposure to 85 dBA, the subjects tended to have more threshold shifts, an average of six frequencies at 4.4 dB. The recovery period of these shifts were also prolonged. This was in contrast to the readings for subjects exposed to 80 dBA, where the mean threshold shift was only 1.9 dB; the recovery period was much faster. The investigators drew a general conclusion that the exposure to noise levels below 80 dBA for an indefinite period of time would not result in permanent changes in hearing. This study also showed that the action level should be at 80 dBA where the hearing conservation program may be instituted and the permissible exposure limit to be preferably at 85 dBA.

McBride *et al*. (McBride, et al., 2003) conducted a cross-sectional study in an engineering industry. The aim of the study was to determine the significant threshold shift, 15-dB hearing threshold level at any frequency using an audiometer. This significant shift is a precursor to noise-induced hearing loss. This study was carried out in New Zealand. Those who were exposed to noise above action level were included in this study. However, the author failed to state the action level for noise. Noise was generated in a railway workshop. There were 92 employees from this workshop took part in this study. These employees were exposed to levels either below 85, 85 to 90 or more than 90 dBA in the workplace. The noise exposure of these subjects was recorded using noise dosimeters. The baseline audiometry among these employees was initially taken, followed by the post-shift audiometry using manual pure-tone audiometer. The standard for the threshold shifts was based on the U.S. NIOSH's criteria for a recommended standard on noise exposure. The use of hearing protection devices during the study was not reported by the authors. A total of 50% of the subjects had temporary threshold shifts upon exposure to noise levels below 85 dBA, compared to 29% when exposed between 85 and 90 dBA and 39% when subjects were exposed beyond 90 dBA. There were no statistically significant differences on threshold shifts between these three groups, however. In this study, there were no changes observed in occurrence of temporary threshold shifts regardless of adoption of different permissible exposure limits. It was agreed that there was a need to retest the employees on the audiometric assessment on hearing threshold levels. Nonetheless, the duration of employment of these workers in this industry was not mentioned by the author. Moreover, the post-shift audiometry was done in a day, after the baseline audiometry was recorded. In any industry, noise is usually a fluctuating type and hence, a longer duration of exposure was required to observe any significant changes on threshold shifts upon adopting different permissible exposure limits.

Mills *et al*. (Mills, et al., 1983) conducted an experimental study among students. The aim of the study was to identify the temporary threshold shifts after they had been exposed to low-frequency noise. The study was conducted in the US. The inclusion criterion was that the participants should have hearing threshold levels within 10 dB. There were 52 students selected in this study from a 100 vetted; all males participated in this study. They were primarily divided into two groups: the first group of students was exposed to three octave bands centered at 63, 125 and 250 Hz at 84 dBA for a period of 24 hours, while the second was exposed at 90 dBA for a period of 8 hours. Another group of students was exposed to 90 dBA to only 63 Hz for 8 hours. Noise was generated in a room using noise generating equipment with loudspeakers. The threshold shifts were recorded on average of four minutes after exposure to noise by using the Békésy type of audiometer. Temporary threshold shifts were found to increase among students exposed to 90 dBA, more than 10 dB for all the three conditions. Among students exposed to 84 dBA, there were threshold shifts too, around 10 dB for all three conditions; increased throughout at 250-Hz, but decreased at 63 and 125-Hz settings after 12 hours of exposure. The crude estimate comparing threshold shifts among subjects exposed to two different noise levels showed that there was a more damaging effect noted among those exposed to noise levels of 90 dBA; which were 17, 14 and 18 dB at 63, 125 and 250 Hz compared to 13, 9 and 9 dB for 84 dBA. The recovery time from the threshold shifts took up to 48 hours for subjects exposed to 84 dBA since the duration of exposure was longer compared to 12 hours of exposure to 90 dBA. This study has shown that there were temporary threshold shifts upon exposure to 84 dBA, but they were comparatively worse when subjects were exposed to noise levels of 90 dBA. The author also discovered that median shift of 5 dB is produced if noise levels were between 78-80 dBA at 250 Hz. Hence, from this study, it is advisable to have action level at 80 dBA since there were threshold shifts at 84 dBA.

Yates *et al*. (Yates, et al., 1976) conducted an experimental study on college-aged subjects in the US. The aim of the study was to evaluate the damage risk of noise exposure of 85 and 90 dBA. All the candidates had hearing threshold levels, 25 dB or better which was the prerequisite of being selected for the study. There were six subjects in two groups, one group exposed to 85 and the other to 90 dBA. There were equal numbers of males and females in both groups. This experimental study was conducted in a room where noise was produced by using either one of the two noise generators; Grason Stadler Model 455C or M.B. Electronics Tandom Noise Generator Type 1390B Model N808 and four loudspeakers. Each half of the subjects in the group was exposed to noise for either half-day or a full-day. The Békésy type of audiometer was used to measure the threshold shifts ranging from 1 to 8 kHz for both ears. The result showed that the mean temporary threshold shifts for frequencies combined after two minutes post-exposure were higher among subjects exposed to 90 dBA, Mean (standard deviation, SD) = 10.13 (7.45) compared to 85 dBA, Mean (SD) = 6.26 (9.15) on a full-day exposure. This result was significantly different upon conducting Duncan multiple-range tests. This test however, showed no statistical significant difference of comparing individual frequencies for a full-day exposure. It also displayed that there were no statistically significant differences between exposure to 85 dBA full-day and 90 dBA half-day. The authors concluded that damage which occurred on exposure to 85 dBA full-day was similar to that of 90 dBA half-day. Yates *et al*. (Yates, et al., 1976) also noted that the mean threshold shifts measured at various time intervals by individual frequencies or frequencies together were similar to post-exposure noise after two minutes. This study has emphasized the effect on hearing upon exposure to 90 dBA was far more detrimental than that of 85 dBA. Based on this study, it is advisable to adopt the U.S. NIOSH recommended exposure limit.

In a paper published by Kvaerner *et al.* (Kvaerner, et al., 1995), the authors evaluated the temporary threshold shifts upon exposure to noise in an industry. The study was conducted in Norway. A total of 13 employees were involved in this intervention study. The employees were tested to have normal hearing threshold levels, within 20 dB hearing level and normal tympanogram prior to selection for the study. A Grason Stadler GSI 37 was used for assessing tympanometry findings. The subjects were exposed to noise levels between 85 and 90 dBA. Their hearing levels were examined for three days; hearing protection devices were used for the first two days. The hearing levels were measured over 1 to 6 kHz using air conduction pure-tone audiometry, tympanometry and transient evoked otoacoustic emissions. Both ears were examined since the correlation between them was low. Significant threshold shifts at post-work exposure and amplitude of otoacoustic emissions were measured. The differences were computed by *t*-test and Wilcoxon's test, while the linear regression and Spearman's correlation were for correlation study. The findings showed that there were significant threshold shifts at 4 kHz ($p = 0.001$) with median value of 3.8 dB (range = -10.0 to 16.7 dB), and at 6 kHz ($p < 0.001$) with 5.5 dB (range = -5.0 to 11.7 dB) comparing before and after-work exposure. Consequently, there was a reduction over amplitude on otoacoustic emissions, median = 0.65 dB (range = -0.8 to 3.3 dB), $p = 0.001$. The authors concluded that there were significant temporary threshold shifts when workers were exposed to noise levels beyond 85 dBA at 4 and 6 kHz with reduction of amplitude on otoacoustic emissions. This study again supports the notion that permissible exposure limit preferably should be at 85 dBA.

In Taiwan, Chen and Tsai (Chen & Tsai, 2003) performed a cross-sectional study on hearing loss among workers. The aim of the study was to evaluate physiognomies of hearing loss and its effects. The inclusion criterion was that the workers should be exposed to noise levels above 80 dBA. The exclusion criteria were insufficient data and past history of chronic otitis media. The authors adopted a universal sampling on recruiting the workers in the oil refinery industry. Only 384 of them were selected for the study; all were male. The average noise exposures among the subjects were 81 dBA. The left ears were analyzed using audiometry ranging from 0.5 to 8 kHz. The purpose of the study was to measure average hearing threshold levels above 25 dBA. The workers were categorized to have hearing loss if their average hearing threshold levels were more than 25 dBA between frequencies of 0.5 to 2 kHz (low frequencies) and 3 to 6 kHz (high frequencies). The use of hearing protection devices among these workers was not reported. The results showed that 9.6% of the workers had hearing loss over low frequencies compared to 38.3% on high frequencies. Most of the threshold shifts were noted at 6 kHz among the subjects. The authors concluded that chronic exposure to noise below 85 dBA might still lead to hearing loss. This study highlighted that action level should be at 80 dBA since slight hearing losses were observed among subjects on noise exposure below 85 dBA.

In Denmark, Rubak *et al*. (Rubak, et al., 2006) performed a cross-sectional study in all noisy trades. The aim of the study was to estimate the risk of hearing loss. The inclusion criteria were employees exposed to noise levels above 80 dB with at least 15 employees per industry. The exclusion criteria were ears with wax or perforated tympanic membranes. The authors included 91 companies in the study which comprised of 649 workers from noisy environments and 104 residents as reference population. Dosimeters were used to measure noise-prone areas and also to measure personal noise-exposure. The questionnaires were distributed to extract information such as duration of employment, ear diseases and exposure to noise during relaxation hours. The hearing threshold levels of the subjects were measured using a pure tone audiometer by a qualified technician. If the average hearing threshold levels were more than 20 dB at 2 to 4 kHz, then the subjects were having hearing impairment. The workers were wearing hearing protection devices. The results showed that the risk of hearing impairment was statistically significant among subjects exposed to noise levels between 85 and 89 dBA (OR, 3.05; 95% CI 1.33-6.99). These subjects worked for more than 20 years. The risk was mainly seen among subjects working in the construction and basic metals trades. The findings among subjects exposed to noise levels between 80 and 84 dBA and subjects who had worked less than 20 years, had showed no significant changes on hearing impairment. These findings indicated that if employees were exposed to noise levels above 85 dBA and continued to be exposed for many years, then the risk of hearing loss among them would be much higher. The U.S. NIOSH recommendation limit is far more appropriate based on the outcome of this study.

Melnick (Melnick, 1977) performed an experiment study on male subjects. The study was conducted in the US. The aim of the study was to determine the temporary threshold shifts upon 24 hours of noise exposure. This study was conducted among nine subjects who had normal hearing threshold levels, not surpassing 15 dB. Hearing threshold levels were taken among the participants at three timelines; before, during and after exposure to noise. The hearing threshold levels were measured as an average of 8th, 12th, 16th, 20th and 24th hours' of noise exposure. All nine subjects were exposed to 80 and then 85 dB through loudspeakers, where the octave band of noise was centered at 4 kHz. The workers were given hearing protection devices if they were exposed to high levels of noise at their workplace. The author failed to mention the cut-off noise intensity value when these protection devices were distributed. When the subjects were exposed to 80 dBA, they developed asymptotic threshold shifts measuring 9.3 dB at 4 kHz and 7.2 dB at 6 kHz, while at 85 dBA; the threshold shifts were 17.8 dB at 4 kHz and 14.6 dB at 6 kHz. The recovery of threshold when subjects were exposed to 85 dBA took more than a day compared to those exposed to noise levels of 80 dBA. This indicated that more damaging effects were seen on exposure to noise levels of 85 dBA. This indicated that action should have been taken earlier, preferably at 80 dBA (action level) as threshold shifts were also noted at this noise intensity.

2.4.2.2 Summary of studies of different noise intensities, 85 and 90 dBA

Half of the studies in this review were experimental in design, increasing the implications with regard to causality and outcome. According to DeVries and Berlet (DeVries & Berlet, 2010), the evidence from these experimental studies was of a high quality. The other studies in this review though were cross-sectional in design but they were appropriate for reporting on the occurrence of temporary threshold shifts, as they fulfil the aim of this systematic review, which was to compare the effects of 85 dBA and 90 dBA on temporary threshold shifts. There was only one study (Stephenson, et al., 1980) that used a blinding process. However, all the studies in this review had valid exposure and outcome measures. Probability of bias on selection may be noted in two studies (Melnick, 1977; Stephenson, et al., 1980); however, the exposure and control groups were comparable, and confounding bias was controlled in these studies. The search was not restricted to a specific study design, since there was only a limited number of published studies were available. Any discrepancies were resolved by consensus through discussion before the studies were included.

All four experimental studies, those of Stephenson *et al.* (Stephenson, et al., 1980), Mills *et al*. (Mills, et al., 1983), Yates *et al*. (Yates, et al., 1976) and Melnick (Melnick, 1977), were conducted on human subjects. The subjects were exposed to noise generated by equipment with loudspeakers. The noise introduced was of a continuous type. The other studies, those of McBride *et al*. (McBride, et al., 2003), Kvaerner *et al.*

(Kvaerner, et al., 1995), Chen and Tsai (Chen & Tsai, 2003) and Rubak *et al*. (Rubak, et al., 2006), were conducted in an industrial setting in which employees were exposed to a fluctuating type of noise. The precise machines involved in generating noise in these industries were not reported. Hearing protection devices were used by the workers during the studies of Kvaerner *et al.* (Kvaerner, et al., 1995) and Rubak *et al*. (Rubak, et al., 2006), but was not reported by McBride *et al*. (McBride, et al., 2003) and Chen and Tsai (Chen & Tsai, 2003). There were studies comparing 80 dBA and 85 dBA, as those of Stephenson *et al.* (Stephenson, et al., 1980) and Melnick (Melnick, 1977), and there was also a study on subjects exposed to 81 dBA, that of Chen and Tsai (Chen & Tsai, 2003). We included these studies to show the detrimental effects of exposure to 85 dBA and that the negative effects would be greater if employees were exposed to noise levels reaching 90 dBA.

Most of the studies recommend adoption of 85 dBA for conservation of the hearing threshold. They indicated that the temporary threshold shifts were much lower when subjects were exposed to noise levels of 85 dBA or lower. However, the study of McBride *et al*. (McBride, et al., 2003) showed that there were no statistically significant changes in temporary threshold shifts among subjects exposed to less than 85, between 85 and 90 dBA and more than 90 dBA. These findings of McBride *et al*. (McBride, et al., 2003) may not be applicable, since post-shift audiometry was done within a day and the employment duration of the workers exposed to these noise levels was not reported.

2.5 Risk factors of hearing loss

2.5.1 Smoking and hearing loss

Smoking is the inhalation of smoke of burning tobacco encased in cigarettes, pipes, and cigars. Many health experts now regard habitual smoking as a psychological addiction and one with serious health consequences (Olson & Kutner, 2000). Smoking is a modifiable risk factor of hearing loss. Chemicals released from smoking such as toluene, xylene, lead and carbon monoxide (Ferrite & Santana, 2005) are hazardous to hearing loss. Smoking may cause ischemia to the cochlear since carboxyhemoglobin concentration in blood is increased and constriction of vessels ensues. Moreover, blood viscosity is increased among the smokers (Sung, et al., 2013) and that there is only a single vessel supplying blood to the cochlear. According to a Health Interview Study, smoking at least two packs a day is likely to lead to hearing loss among smokers rather than non-smokers (National Center for Health Statistics, 1967).

Sung *et al*. (Sung, et al., 2013) conducted a cross-sectional study on workers in a shipyard in Korea. The aim of the study was to evaluate the effects of smoking on hearing threshold levels. It was conducted for a year; 8,543 workers participated in this study. These workers were classified into three categories, i.e., non-smokers, ex-smokers and current smokers. The last group was further divided based on pack-years; pack of cigarettes smoked over the years. The analysis was done on right ears only. The exclusion criteria were incomplete data on noise area measurement, failure to fill the questionnaire distributed, had chronic diseases such as hypertension, diabetes mellitus and dyslipidemia and also those who had ear diseases. Analysis of covariance (ANCOVA) and multiple logistic regressions were used in the statistical analysis. The use of hearing protection devices by the workers was not reported. The findings showed that the current smokers had more mean dBHL compared to ex-smokers and non-smokers at 2, 3 and 4 kHz; 19.6 (95% CI, 19.11-20.01), 28.0 (95% CI, 27.43-28.58) and 33.9 (95% CI, 33.34-34.55), respectively. The adjusted ORs for the current smokers were 1.291 (95% CI, 1.055-1.580), 1.180 (95% CI, 1.007-1.383), 1.295 (95% CI, 1.125-1.491) and 1.321 (95% CI, 1.157-1.507) at 1, 2, 3 and 4 kHz, respectively. The adjusted ORs for 10-19.9, 20-29.9 and $\geq$ 30 pack-years were 1.562 (95% CI, 1.013-2.408), 1.557 (95% CI, 0.990-2.450), 1.643 (95% CI, 1.023-2.640) at 1 kHz respectively, and 1.420

(95% CI, 1.014-1.988), 1.673 (95% CI, 1.179-2.374), 1.660 (95% CI, 1.143-2.411) at 2 kHz respectively. There were no significant changes among subjects smoking number of packs at 3 and 4 kHz. The authors concluded that smoking had a detrimental effect on hearing threshold levels; this effect was further damaging if the person is a heavy smoker.

Ferrite & Santana (Ferrite & Santana, 2005) conducted a cross-sectional study among workers in a metal plant in Brazil. The aim of the study was to evaluate the synergistic effect of smoking, age and noise on hearing loss. There were two groups among them, i.e., non-smokers and smokers; the age group was divided into 20-40 years and 41-55 years. The duration of noise exposure was also divided into two groups: the first group exposed to less than four years and the other exposed at least for four years. Hearing loss was defined as hearing thresholds above 25 dBHL at 3, 4, 6 or 8 kHz on both ears. The use of hearing protection devices by the workers was not reported. The response rate was 84%, but some were excluded as audiometric results were not available and those who had hearing loss were not due to noise. Finally, 560 workers were recruited into the study. The excess prevalence ratio is defined as a combined effect of two factors being larger than when the factor is functioning in isolation. The combined effects of factors were far more superior to the summation of the isolated factors. The relative differences, i.e., the differences between combined factors and separated exposures on hearing loss were largest when the worker was between 20-40 years old, smoking as well as being exposed to noise (133%) compared to 98% among smokers who were older but not exposed to noise. The relative difference was only 22% among the older group when exposed to noise. The authors concluded that smokers who were above 40 years of age were at a high risk of hearing loss regardless of whether they were exposed to noise.

An epidemiology study (Cruickshanks, et al., 1998) was done in the US. The aim of the study was to evaluate smoking and its effects on hearing loss. In this cross-sectional study, subjects were divided into non-smokers, ex-smokers and current smokers. The number of cigarettes smoked in a day was divided by 20 and then multiplied by the number of years of smoking or 'pack-years'. In this study, if the workers required raising their voices in the workplace, they would be included in the study. The age of participants were ranged from 48 to 92 years. The use of hearing protection devices by the workers was not reported. Hearing loss was defined as hearing thresholds more than 25 dBHL on "worse" hearing ear of the two. The results were analyzed using Chi-square, Mantel-Haenszel, independent *t*-tests and also logistic regression to determine the odds of having hearing loss when workers smoked. The current smokers showed a higher percentage of hearing loss among all age groups, but this was not statistically significant at age group between 80 and 92 years. The risks of current smokers to have hearing loss were higher than the non-smokers, (OR, 1.69; 95% CI, 1.31-2.17). Current smokers with or without noise exposure had significant hearing loss, (OR, 1.85; 95% CI, 1.33-2.57) and (OR, 1.53; 95% CI, 1.03-2.29), respectively. Smokers were 1.3 times more likely to have hearing loss if they recorded at least 40 pack-years compared to non-smokers. It was also noted that those exposed to environmental tobacco smoke were at higher risk than those who were not (OR, 1.94; 95% CI, 1.01-3.74, $p = 0.047$). The authors concluded that hearing loss was more prevalent among current smokers, 1.7 times more likely than the non-smokers. The risk of hearing loss increased among those who had more pack-years and also those exposed to passive-smoke.

Mizoue *et al*. (Mizoue, et al., 2003) conducted a cross-sectional study in a steel company in Japan. The aim of the study was to assess the association between smoking and hearing loss among workers exposed to noise. The exclusion criteria were females, aged more than 60, incomplete smoking history and audiometric results. The use of hearing protection devices by the workers was not reported. Hearing thresholds were measured by a nurse using an audiometer. The history of smoking was obtained through a questionnaire. A total of 4624 workers were recruited in this study. Around 40% of workers were exposed to noise levels between 85 and 90 dBA. Hearing loss was defined as hearing thresholds above 25 dB at 1000 Hz and above 40 dB at 4000 Hz. The group was divided into less than 40, 40-49 and 50-60 years old. The Cochran-Mantel-Haenszel method was used to assess the prevalence. The smokers, when exposed to noise had more hearing loss in all age groups compared to the non-smokers. The differences were huge at 4000 Hz than 1000 Hz. Among the smokers, those who smoked at least 25 cigarettes per day showed higher risk of hearing loss compared to those non-smokers, (OR, 2.6; 95% CI, 1.8-3.9, $p < 0.001$). The prevalence rate ratio of hearing loss was higher among smokers who were exposed to noise compared to non-smokers, (OR, 2.56; 95% CI, 2.12-3.07). The authors concluded that hearing loss was more among smokers but not increased when exposed to noise. Smoking was associated with high frequency hearing loss.

Camello *et al*. (Carmelo, et al., 2010) conducted a cross-sectional study in Italy. The aim of the study was to assess the association between smoking and hearing loss in a shipyard. All males participated in the study. The exclusion criteria were use of neurotoxic and ototoxic drugs, chronic ear, nose and throat diseases, metabolic and hematological diseases, ex-smokers and smoking less than 15 cigarettes per day and also those who were consuming alcohol. Other criteria excluded were those involved in hobbies such as listening to loud music, working less than 10 years and work experience with other companies. A total of 557 subjects recruited in the study were divided into three groups; non-smokers, those who were smoking 15-30 cigarettes per day for at least 10 years and those who had at least 30 cigarettes per day for at least 10 years. The subjects wore hearing protective devices. The ANCOVA model was used in the analysis. The hearing threshold levels were highest among those who smoked at least 30 cigarettes per day at 500, 1000, 2000, 3000 and 4000 Hz, followed by the other group that smoked and finally, the non-smokers group. The authors concluded that smoking had effect on hearing loss and associated with the number of cigarettes smoked per day. Smoking worked synergistically with noise on hearing loss.

Kumar *et al*. (Kumar, et al., 2013) conducted a hospital-based study on participants in an otorhinolaryngology department in India. The objective of the study was to assess the effect of smoking on hearing. This cross-sectional study divided the participants into smokers and non-smokers; 108 males participated in the study. This information was obtained from a questionnaire. The exclusion criteria were subjects with chronic diseases such as diabetes mellitus and hypertension, subjects on ototoxic drugs, those were having ear infections and ear diseases and also those exposed to noise. Hearing loss was identified if hearing threshold levels were above 25 dB at 500, 1000, 2000 and 4000 Hz. Statistical Package for the Social Sciences (SPSS) was used for statistical analysis. The findings showed that hearing loss was more common among smokers (65.7%) compared to non-smokers (15.0%). Among age group between 51 and 60 years, smokers had 100% hearing loss compared to non-smokers with only 50%. The more number of cigarettes smoked, the greater hearing loss was found among the subjects. The subjects smoking more than 36 cigarettes per day had 7.4% of hearing loss (more than 60 dB) compared to those who smoked only 25-36 cigarettes, who had 2.6%, $p < 0.05$. The authors concluded that smoking had an adverse effect on hearing loss and also number of cigarettes smoked was associated with the degree of hearing loss.

A meta-analysis was done on the effects of smoking on hearing loss without noise exposure from the workplace (Nomura, et al, 2005). The literature search was done from the Medline. The inclusion criteria were studies with mean hearing loss and that indicated risk of smoking on hearing loss. The exclusion criteria were studies with reviews, abstracts and editorials, environmental smoke, small sample size, children involved (less than 15 years of age), sudden deafness, middle ear diseases and occupational noise exposure. The quality assessments of studies were based on Downs and Black. There were a total of 15 studies identified. All the studies were observational. Among the current smokers, the risk ratios were 1.33 (95% CI, 1.24-1.44), 1.97 (95% CI, 1.44-2.70) and 2.89 (95% CI, 2.26-3.70) for cross-sectional, cohort and case-control studies, respectively. For past smokers, the risk ratios were 1.17 (95% CI, 1.03-1.33), 1.49 (95% CI, 0.93-2.39) and 1.83 (95% CI, 1.43- 2.35) for cross-sectional, cohort and case-control studies, respectively. The authors concluded that smoking had an adverse effect on hearing loss.

2.5.2 Alcohol and hearing loss

Consumption of alcohol may affect few organs including the auditory system. The effects may be due to direct toxic effect or indirect by the release of free radicals (Kumar & Patrick, 2011). The outer hair cells in the organ of Corti are damaged due to alcohol consumption (Bellé, et al., 2007).

Kumar and Patrick did a case-control study in India (Kumar & Patrick, 2011). The aim of the study was to evaluate hearing on subjects after discontinuing alcohol consumption. The exclusion criteria were subjects above 60 years old who had chronic diseases such as hypertension and diabetes mellitus, exposure to noise at workplace and consumption of ototoxic drugs. A total of 60 subjects participated in the study, 30 of them had consumed alcohol for at least two years whereas the other 30 acted as control. The independent *t*-test was used in the analysis. A total of 14 subjects who consumed alcohol had high frequency hearing loss, $p = 0.001$.

Also, 23 subjects who consumed alcohol had absent impulse on DPOAE, $p = 0.001$. These findings were the same after a month even when these subjects stopped consuming alcohol. The authors concluded that consumption of alcohol was associated with hearing loss. The hearing loss affected was sensorineural.

There was another study conducted on alcohol and its effects on hearing loss in the UK (Upile, et al., 2007). The inclusion criterion in this intervention study was that subjects should be at least 18 years of age with no hearing disorder. The exclusion criteria were breath alcohol threshold level below 30 u/l and those who failed psychometric and visuo-spatial skills tests. The Wilcoxon signed rank tests and Pearson Regression Coefficient Ratio were used in the analysis. In total, 26 subjects were involved in the study; 15 of them were females. The females were affected more than males with regard to hearing thresholds. The higher breath alcohol concentration, the worsening of hearing thresholds was observed. The hearing thresholds deteriorated mainly at lower frequencies, the mean losses were 12, 17, 10, 5, 7 and 8 dB at 250, 500, 1000, 2000, 4000 and 8000 Hz for females while 6, 5, 3, 2, 5, and 9 dB for males. The authors concluded that drinking alcohol may lead to threshold shifts and eventually be permanent when consumption of alcohol continued for a period of time.

A cross-sectional study was carried out in Brazil on effects of hearing due to consumption of alcohol (Bellé, et al., 2007). The exclusion criteria were diseases of the ear, nose and throat, and also subjects who taken drugs that may affect hearing. There were 37 subjects in the experimental arm; 20 of them were between 33 and 49 years and 17 of them between 50 and 70 years. The same number of subjects was in the control arm. There was worsening of hearing in the experimental arm, 67.6% compared to 27.0% in the control arm. In the experimental arm, 82.4% were between 50 and 70 years age group. The authors concluded that alcohol intake was associated with hearing loss.

2.5.3 Chemicals and hearing loss

In Europe, there were 10 million employees exposed to chemicals that damage hearing (Prasher, et al., 2002). Based on experimental studies done on animals, there are few chemicals affecting hearing synergistically with noise. They are styrene, toluene, trichloroethylene, ethyl benzene, hydrogen cyanide and carbon monoxide (Morata, 2003). These chemicals may act independently in mutilating hearing if concentration was sufficiently high. The damage to hearing occurs either through inhalation or absorption of chemicals via the skin. Other than these chemicals, lead is also said to be ototoxic (Nies, 2012). From human and animal data the chemicals; toluene, styrene, carbon monoxide, carbon disulfide, lead and mercury were involved in auditory system even with below or near normal occupational exposure limits, according to the Nordic Expert Group (Nies, 2012). The chemicals that damage the neurology or nephrology system may involve the auditory system too. The mechanism of chemicals damaging the auditory system is through the release of reactive oxygen species which damages the cell structures (Morata, 2003). Also, the exhaustion of glutathione (cellular antioxidant) may be harmful to hearing, since it reduces the occurrence of free radicals. According to Prasher et al. (Prasher, et al., 2002), the outer hair cells of the cochlear exposed to toluene are damaged and intracellular calcium levels were found to be elevated within these cells.

Kim *et al*. (Kim, et al., 2005) did a cross-sectional study in Korea. The study was conducted in an aviation industry. The aim of the study was to appraise the effect of noise with solvents on the auditory system. The exclusion criteria were non-accessibility of job exposure evidence, subjects who had hearing loss before joining the service or due to soldierly employment, and also those had hearing loss not due to occupational. Noise in this industry was generated from crushing, thrashing, riveting, trimming and engine operation. Noise levels in the industry ranged from 85 and 101 dBA. A total of 328 employees were involved in the study; all of them were males. The employees were exposed to solvents such as xylene, toluene, methyl ethyl ketone and methyl isobutyl ketone which were within the occupational exposure limits. The subjects were divided into no-exposure, noise-only, solvents-only and combined exposure to noise and solvents groups. Hearing threshold levels were measured using a pure tone audiometer. Hearing threshold levels were abnormal if they exceeded 25 dB at 500 to 2000 Hz and if the binaural average threshold levels were above 25 dB at 3000 to 8000 Hz. Data was analyzed using the Kruskal-Wallis and chi-square test, while the risks of hearing loss were analyzed by logistic regression and multiple logistic regression analysis. The use of hearing protection devices during the study was not reported by the authors. Most of the workers were not exposed to noise or solvents (46.0%), while 44.5% of them were exposed to noise-only. The mean age group was highest among combination noise and solvents exposure group, 39.6 ± 4.7. The combination group had the highest percentage of hearing loss, 54.9% followed by 27.8% among solvent-only group and 17.1% for noise-only group. The risks of hearing loss were 8.12 (95% CI, 2.03-32.53), 2.57 (95% CI, 0.64-10.31) and 4.28 (95% CI, 1.71-10.75) for combination group, solvents-only and noise-only groups, respectively. The results were adjusted for age, hypertension, diabetes mellitus, smoking and consumption of alcohol. The authors concluded that the combination effect of noise and solvents had a more damaging effect on hearing loss compared to exposure to noise-only or solvents-only.

A review was done to evaluate the effect of a mixture of organic solvents on hearing loss and also its dose-response relationship (Śliwinska-Kowalska, 2007). There were a total of 16 original papers searched. Most of the studies were cross-sectional, followed by five clinical and one cohort study. The solvents were xylene, toluene, methyl ethyl ketone, methyl isobutyl ketone, ethanol, ethyl acetate, butyl acetate, ethyl benzene, thinner, cyclohexane and benzene. There were 2400 workers in this review; 700 of them were solely exposed to the mixture of organic solvents and the rest of them exposed to these chemicals in combination with noise. The odds of having hearing loss among those exposed to solvents only were 5.0 (95% CI, 1.5-17.5) for those exposed to toluene 70 ppm and xylene 40 ppm, 4.4 (95% CI, 2.3-8.1) for toluene 24.7 ppm and xylene 25 ppm with noise less than 80 dB, 2.8 (95% CI, 1.8-4.3) for toluene 24.7 ppm and xylene 25 ppm with noise less than 85 dB, 1.4 (95% CI, 1.1-1.9) for those exposed to more than five years, 2.57 (95% CI, 0.64-10.31) for toluene 3.6 ppm and xylene 2.24 ppm, 1.8 (95% CI, 0.6-4.9) for toluene 18 ppm and 1.1 (95% CI, 0.6-1.9) for those up to four years of exposure. The odds of having hearing loss among those exposed to solvents and noise were 8.25 (95% CI, 1.67-55.6) for those exposed less than three years to jet fuel and noise, 2.41 (95% CI, 1.04-5.57) for 12 years to jet fuel and noise, 1.7 (95% CI, 1.14-2.41) for those up to 3 years exposure to jet fuel and noise exposure, 2.4 (95% CI, 1.6-3.7) for those exposed to Dockyard with paint and lacquer. The author concluded that the risks of hearing loss were found on those exposed to chemicals of at least a moderate concentration and with more than four years of exposure. The author also stressed that the effects of solvents on hearing were more prominent when combined with noise exposure. The author emphasized that the study conducted had not performed biological monitoring which would have been more accurate. Pure tone audiometry is not precise in evaluating the dose-response-relationship of the solvents.

2.5.4 Vibration and hearing loss

There is damage to vascular, neurological and musculoskeletal systems due to prolonged use of hand-transmitted vibration tools (Pettersson, 2013). The mechanism causing hearing loss among those having vibration-induced white finger is most plausible due to overstimulation of the sympathetic nervous system (Iki, 1994). Other possible mechanisms could be due to narrowing of the digital arteries by organic causes or increased sensitivity due to noradrenaline. The workers who are exposed to noise and vibration are at higher risk in developing hearing loss (Pettersson, 2013).

Iki (Iki, 1994) conducted a cross-sectional and follow-up study in Japan. The aim of the study was to evaluate association between vibration-induced white finger and hearing loss. The study was conducted among forest workers. In total, 289 subjects were involved in the study. The exclusion criteria were history of ear diseases and exposure to factors harmful to hearing excluding noise exposure. The use of hearing protection devices during the study was not reported by the author. Noise was generated from chain saws, bush cutters and winches. The findings showed that hearing loss was greater among subjects exposed to vibration-induced white finger. There were 4 kHz-dips in the audiometry findings. The author then matched two groups, one with vibration-induced white finger and the other as control, for age and duration of exposure to noise. There were 37 in each group. Median hearing loss was still greater among those had vibration-induced white finger at 4000 and 8000 Hz, $p < 0.05$. The author then conducted a follow-up with 86 workers for five years. Since the sample size was small, the author matched for each frequency. The results showed that more hearing loss noted among vibration-induced white finger group at 2000 and 4000 Hz, $p < 0.05$. The author concluded that more hearing loss was noted among those exposed to vibration-induced white finger.

Palmer *et al*. (Palmer, et al., 2002) did a cross-sectional study in the UK. The aim of the study was to assess the association of noise and hand-transmitted vibration with hearing loss. The inclusion criterion was the participants should be at least 35 years old. There were a total of 12,606 subjects recruited from the general practices. The information regarding hand-transmitted vibration, hearing loss and finger blanching were obtained from a validated questionnaire. Logistic regression was used to analyze the link between hand-transmitted vibration and hearing loss. The prevalence ratios were measured. The use of hearing protection devices during the study was not reported by the authors. The response rate was 65%; 57 of them were not included since full information on hearing loss and finger blanching was not gathered. The results showed the prevalence ratios for severe hearing difficulty among males were 2.2 (95% CI, 1.4-3.3) with 8.0% ever-blanched, while females were 1.4 (95% CI, 0.8-2.7) with 2.9% ever-blanched. Among those who never exposed to noise, the prevalence ratios for males were 2.2 (95% CI, 0.8-5.9) with 3.9% ever-blanched, while females were 1.9 (95% CI, 1.0-3.9) with 3.1% ever-blanched. Among those who were never exposed to hand-transmitted vibration, the prevalence ratios for hearing difficulty were 2.1 (95% CI, 0.9-4.7) with 5.1% ever-blanched, while females were 1.8 (95% CI, 0.9-3.6) with 3.1% ever-blanched. The authors concluded that blanching of fingers were associated with increased prevalence of hearing loss.

Szanto & Ligia (Szanto & Ligia, 1999) did a cross-sectional study on miners in Romania. The objective of the study was assessing association between vibration-induced white finger and hearing loss. The exclusion criteria were a history of ear disease, drugs that led to hearing loss and head injury. There were 348 subjects in the study. Pure tone audiometry was used to measure hearing threshold levels at 500 to 8000 Hz. The left ears of the participants were evaluated. The use of hearing protection devices during the study was not reported by the authors. The cold aggravation test would confirm the findings of vibration-induced white finger which lasted for 10 minutes at 9-9.5ºC. The third finger was considered for rate of retrieval after dipping in the cold water. Wilcoxon's and Mann-Whitney tests were used in the analysis for paired and unpaired samples, respectively. The measurements of acceleration vibration were between 120 and 150 m/sec^2 and the noise levels were 96 dBA. The miners with vibration-induced white finger showed significant deterioration in hearing threshold levels at 4000 ($p < 0.001$), 6000 ($p < 0.001$) and 8000 Hz ($p < 0.01$) compared to subjects without vibration-induced white finger. The temperature of skin over finger was much lower before (23-27ºC) and after dipping into water (11-15ºC) among subjects with vibration-induced white finger than those without (30-35ºC) and (17-23ºC), respectively. The rate of recovery was also slower among those with vibration-induced white finger. The authors then recruited and matched 65 subjects each in two arms to eliminate age and duration of exposure to vibration. There were statistically significant differences on deterioration of hearing threshold levels among those with vibration-induced white finger at 4000 ($p < 0.001$), 6000 ($p < 0.001$) and 8000 Hz ($p < 0.001$). Among subjects with vibration-induced white finger, the value for correlation coefficient showed there was an association between duration of vibration exposure and hearing threshold levels with the influence of age; 0.37 ($p < 0.01$), 0.40 ($p < 0.01$), 0.41 ($p < 0.01$), 0.40 ($p < 0.01$), 0.54 ($p < 0.001$), 0.45 ($p < 0.001$) and 0.55 ($p < 0.001$) at 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz, respectively. The authors concluded that longer exposure to vibration increased occurrence of hearing loss.

2.5.5 Activities and hearing loss

There are few activities such as scuba diving, shooting and listening to loud music may aggravate hearing loss.

2.5.5.1 Scuba diving associated with hearing loss

Nine million people participated in scuba diving in the US alone (Newton, 2001). Divers are at risk of barotrauma causing damage of tissues in gas-filled body space since there is no pressure equalization (Lynch & Bove, 2009). Barotrauma implicates the middle and inner ear, sinuses, teeth and lungs (Newton, 2001). Barotrauma over the middle ear occurs during descent as ambient pressure is increased. This is based on Boyle's law which states that as pressure is increased, the volume of gas is reduced and vice versa (McMullin, 2006; Newton, 2001; Taylor, 2004). Divers may experience pain, vertigo and conductive hearing loss. On examination, the tympanic membrane may be ruptured (Kumar, et al., 2013). During ascent at rapid pace, divers may end up with Bell’s palsy as pressure increases within the middle ear. There may be formation of fistula connecting the inner ear to middle ear as rupture of round or oval window may occur among divers, known as the inner ear barotrauma (Newton, 2001; Wang, et al., 2005). The divers may experience sensorineural hearing loss besides tinnitus, vertigo, nausea and vomiting.

Inert gases such as nitrogen convert to air bubbles within blood, interstitial fluids and the organs. This condition is termed as decompression sickness (Newton, 2001). During descent, the ambient pressure is high; the inert gas is dissolved in body tissues and blood according to Henry’s law (Taylor, 2004). The transformation of inert gas to gas bubbles is dependent on depth and duration of diving and also the rate of rising to the surface. There are two types of decompression sickness (Lynch & Bove, 2009); the type I (non-systemic or musculoskeletal) the divers may experience mild symptoms such as fatigue, weakness and poorly localized pain around joints. In type II (systemic or neurologic), the inner ear, cerebral cortex of the brain, spinal cord and also lung may be affected. If the inner ear is affected, the diver may experience vertigo, nausea, vomiting and sensorineural hearing loss besides tinnitus and nystagmus. Around 90% of divers may experience these symptoms within six hours of surfacing if they have inner ear decompression sickness. In studies done on animals, degeneration of the organ of Corti and perilymphatic hemorrhage were found (Azizi, 2011).

Parell and Becker (Parell & Becker, 1993) did a follow-up study among divers in Panama. The aim of the study was to evaluate inner ear barotrauma among divers. The inclusion criteria were divers who had a history of inner ear barotrauma and who continued diving. The divers were categorized to have hearing loss if their hearing threshold levels were at least 25 dBA. There were 20 divers who took part in this study.

The audiogram showed sensorineural hearing loss to all the divers ranging from mild to profound. All but one had unilateral hearing loss. The recovery occurred after a couple of weeks. The authors concluded that difficulty in equalizing the ears might aggravate the inner ear barotrauma among divers.

2.5.5.2 Shooting associated with hearing loss

Noise from shooting activities may result in acoustic trauma leading to middle or inner ear injury. This injury causes sudden loss of hearing with tinnitus or rupture of the tympanic membrane. Sound levels from gunshots produce impulsive noise with high peak levels in short duration (Celli, et al., 2008). High frequencies would be affected due to this noise impact, involving frequencies ranging from 3000 to 6000 Hz (Heupa, et al., 2011).

Heupa *et al.* (Heupa, et al., 2011) did a case-control study in Brazil. The aim of the study was to evaluate hearing loss from shooting activities. The inclusion criterion was that the subjects should be from the Special Operations Battalion. The controls were administrative staffs and those who had not involved in shooting activities for more than a year. The controls should not have had any hearing loss prior to the study. The exclusion criterion was subjects who had conductive or mixed type of hearing loss.

There were a total of 115 subjects recruited in the study; 65 of them from the battalion. Noise was generated from pistols, revolvers, carbine or rifles. Audiometry assessment was used to measure hearing threshold levels among the subjects. The subjects were experiencing hearing loss if the hearing threshold levels were above 25 dB. DPOAE were used to measure its amplitude to detect early changes in hearing loss. Noise generated ranged from 119 to 133 dBC. The majority of them (around 90%) were wearing hearing protection devices. There was 25.0% of the exposed group had noise-induced hearing loss compared to 0.0% from controls, $p < 0.001$. There was also lower amplitude among the exposed group at 3000 Hz on right ear and 4000 Hz on left ear using DPOAE. The authors concluded that those exposed to firearms were at higher risk of developing hearing loss.

Another study was conducted in Brazil to assess temporary threshold shifts and noise-induced hearing loss associated with impulsive noise (Celli, et al., 2008). The subjects recruited in this cross-sectional study were from the Brazilian Army. Noise generated by the gunshots was measured using a sound level meter. There were a total of four series of shots, with each series of five shots except in the third series. In the third series, only three shots were allowed. Noise generated from these shots was from 108 to 114 dBA. A total of 23 participants were involved in the study. The subjects wore hearing protection devices during the study. The findings showed that there were no significant differences between before and after the shooting activity. However, 53% of them showed they had hearing loss while 39% of the subjects had worsening of hearing thresholds at 6000 and 8000 Hz. The authors concluded that consistent exposure to gunfire could lead to hearing loss.

2.5.5.3 Listening to loud music associated with hearing loss

In classical music, sound levels produced ranged from 80 to 100 dBA, while in choirs were about 100 dBA (Peters, et al., 2005). In rock concerts, sound levels could peak to 150 dB; usually ranging between 90 and 105 dBA (Peters, et al., 2005). Incidence of hearing loss was estimated between 4 to 43% among the classical musicians, compared to 13% to 30% among the rock and pop musicians. In total, 25% of rock musicians had permanent threshold shifts and half of them had temporary threshold shifts (Sataloff, 1991).

Backus and Williamon did a cross-sectional study in the UK (Backus & Williamon, 2009). The objective of the study was to assess the hearing thresholds among young orchestral musicians. Students from the Royal College of Music were recruited in the study. The study was conducted for two years. The average age of 162 participants was about 24 years. The findings showed that there was significant threshold notch at 6000 Hz on left ear. The median threshold level at 6000 Hz was significant compared to 4000 and 8000 Hz, (Z = -6.37, $p < 0.001$) and (Z = -4.52, $p < 0.001$), respectively. The highest threshold levels were noted on left ear at 6000 Hz for all musicians, violin and trumpet players, 8.02 ± 0.74, 7.56 ± 1.81 and 8.63 ± 2.43, respectively, compared to those exposed at 4000 and 8000 Hz. The authors concluded that musicians were at risk of developing noise-induced hearing loss at 6000 Hz on left ear.

2.5.6 Chronic diseases and hearing loss

2.5.6.1 Hypertension associated with hearing loss

Hypertension is a chronic disease which may lead to hearing impairment. The pathologies on hearing impairment due to this vascular disorder are hemorrhage in the inner ear from the inner ear artery (supplied by the inferior cerebellar artery), increased blood viscosity and changes of ions in cell potentials (Marchiori, et al., 2006). Uncontrolled hypertension leads to sensorineural hearing loss besides causing hypertensive retinopathy, myocardial infarction and stroke (Tan, et al., 2009).

Marchiori *et al*. (Marchiori, et al., 2006) did a case-control study in Brazil. The aim of the study was to assess the link between arterial hypertension and hearing loss. The inclusion criterion was participants should be between 45 and 64 years old. The exclusion criteria were subjects who had hearing loss due to rubella and head injuries, subjects who had diabetes, stroke and exposure to noise at the workplace and also siblings or parents of subjects who had hypertension. There were 154 subjects in each arm; one with hypertension and the other served as the control. The participant was hypertensive if blood pressure was at least 140 for systolic and 90 for diastolic, consumed anti-hypertensive medicines or had blood pressure checked regularly. Those with hypertension showed a higher risk of hearing loss compared to those normotensive

(OR, 1.73; 95% CI, 1.05-2.85, $p = 0.032$); higher age group and males were at higher risks too with (OR, 2.25; 95% CI, 1.38-3.66, $p = 0.001$) and (OR, 2.54; 95% CI, 1.52-4.43, $p < 0.001$), respectively. The authors concluded that hypertension was an independent risk factor for hearing impairment.

A study was conducted to assess the hearing threshold levels among those with arterial hypertension (Mondelli & Lopes, 2009). This retrospective study was conducted in Brazil. Subjects between the age group of 45 and 60 were included in the study. The exclusion criteria were subjects with a past history of hearing disorders, exposure to noise and ototoxic agents such as chemicals and drugs, as well as metabolic and vascular disorders. There were two groups; in the first group subjects were without hypertension with hearing impairment, whereas the second was with hypertension and hearing impairment. A total of 160 participants fell in the first group compared to 232 in the second. In both groups, most of them (around 50%) had moderate hearing impairment. The sensorineural hearing loss (around 70%) was the commonest hearing loss in both groups. There was no difference between the degree of hearing loss and type of hearing loss between the two groups, $p = 0.721$ and $p = 0.618$, respectively. The authors concluded that hypertension could lead to hearing impairment.

There was another study conducted to evaluate the link between hypertension and hearing loss (Narlawar, et al., 2006). This cross-sectional study which was conducted in India also assessed hearing loss under continuous exposure and intermittent exposure to noise. The study was conducted among employees in a steel manufacturing industry. There were 770 workers who were involved in the study. Blood pressure was checked using a mercury sphygmomanometer, while the tuning fork and audiometry assessment were used for hearing threshold measurement. The Chi-square and correlation tests were used for the analysis. The use of hearing protection devices during the study was not reported by the authors. The findings showed that the longer duration of exposure to noise, higher the prevalence of hypertension (χ^2, 15.73; degree of freedom (*df*) = 2, $p <$ 0.001); hypertension was found more among the continuous exposure group (χ^2, 14.28; $df = 1$, $p < 0.001$). The hearing loss was linked with the duration of exposure to noise (χ^2, 20.27; $df = 2$, $p < 0.001$), among the continuous exposure group (χ^2, 11.69; $df = 1$, $p < 0.001$) and the subjects with hypertension (χ^2, 193.26; $df = 1$, $p < 0.0001$). The authors concluded that hypertension and hearing loss were linked (direct association), and they were associated with the duration and continuous exposure to noise.

A cross-sectional study was conducted in Taiwan (Chang, et al., 2011). The aim of the study was to assess the association between hypertension and occupational noise exposure, and also to determine high frequency hearing loss as a biological marker of noise exposure at the workplace. The study was conducted in an aircraft-manufacturing company. Noise was generated by grinding, hammering, riveting, trimming, forging and casting, element assembly and operating engines. A total of 790 workers were involved in the study. The blood pressure was measured by an automated sphygmomanometer. The subject was hypertensive if the resting value was at least 140 and 90 for systolic and diastolic blood pressure, respectively. Pure tone audiometry was used to measure hearing threshold levels among the subjects. They were divided into three groups; the 'high-hearing loss' group if the average hearing loss was at least 30 dB at 4000 and 6000 Hz, the 'median-hearing loss' group if the average hearing loss was 15 dB and above but below 30 dB and the 'low-hearing loss' group if below 15 dB at these frequencies. The subjects were older and exposed to higher noise levels among the 'high-hearing loss' group, but most of them were wearing hearing protection devices compared to other groups. Hearing loss at 4000 and 6000 Hz were most among the 'high-hearing loss' group, $p < 0.001$. The prevalence of hypertension among 'high-hearing loss' group and 'median-hearing loss' group were (OR, 1.50; 95% CI, 1.03-2.18, $p = 0.033$) and (OR, 1.45; 95% CI, 1.03-2.04, $p = 0.031$), respectively after being adjusted for age. The prevalence of 'median-hearing loss' group was higher compared to 'low-hearing loss' group, (OR, 1.46; 95% CI, 1.03-2.05, p = 0.031). The risk of hypertension was high among the group that was exposed to high levels of noise, (adjusted OR, 1.84; 95% CI, 1.29-2.63, p = 0.001). The authors concluded that the risk of hypertension was high when the mean hearing threshold levels exceeded 15 dB at 4000 and 6000 Hz and that high frequency hearing loss might be useful as the biological marker for noise-induced hearing loss.

Tan *et al*. conducted a cross-sectional study in Malaysia (Tan, et al., 2009). The study was conducted in a hypertensive clinic in a university. The aim of the study was to evaluate the link of hypertensive retinopathy with hearing loss and the severity of retinopathy on hearing threshold levels. The inclusion criteria were subjects who had no past history of hearing complications and availability of records on anti-hypertensive medications. The exclusion criteria were subjects who were exposed to noise at the workplace, infection or trauma over the ear, consuming drugs which were ototoxic, head trauma, diabetes mellitus and a family history of deafness. Hypertensive retinopathy were classified into retinal arteries which were minimally narrowed, narrowed with regions of focal narrowing and arteriovenous nicking, retinal hemorrhages with exudates and cotton-wool spots and also papilledema. There were 56 patients in each arm; hypertensive and control. Most of the hypertensive patients had no abnormalities in retina, while others belonged to the first two classifications. The average hearing threshold levels deteriorated to 2000, 4000 and 8000 Hz among hypertensive patients, $p < 0.05$. The group with retinal arteries of minimally narrowed had deteriorated average hearing threshold levels at 4000 and 8000 Hz bilaterally and at 1000 and 2000 Hz on right ear when Bonferroni applied, as compared to the control group. The difference was also significant among the subjects of the same group compared to hypertensive patients with normal retina on left ear at 8000 Hz and right ear at 4000 Hz. The subjects in retinal arteries with focal narrowing were very small in number and no significant results were obtained compared to the group with minimally narrowed arteries. The authors concluded that hypertensive retinopathy has increased the occurrence of sensorineural hearing loss affecting the high frequencies.

2.5.6.2 Diabetes mellitus associated with hearing loss

Diabetes mellitus is a metabolic disease due to chronic hyperglycemia. Prolonged affliction may affect the vascular and neurological system. Diabetes may also lead to sensorineural hearing loss (Harner, 1981). The pathology of hearing loss among diabetic patients may be due to neuropathy. In these patients, glucose is reduced to sorbitol leading to neuropathy. There is atrophy of ganglions in the cochlear leading to sensorineural hearing loss (Kakarlapudi, et al., 2003). The other possible pathology for hearing loss among the diabetic patients is due to microangiopathy. Genetic factors have also been postulated for hearing loss among diabetic patients. The mitochondrial DNA mutation was observed in these groups of patients (Kakarlapudi, et al., 2003). Diabetes mellitus may also be a part of genetic-inherited syndrome such as the Wolfram syndrome; Diabetes Insipidus, Diabetes Mellitus, Optic Atrophy and Deafness (Diniz & Guida, 2009). Among the diabetics, insulin-dependent diabetes mellitus (IDDM) showed more deteriorating changes over the cochlear compared to patients with non-insulin dependent diabetes mellitus (NIDDM) (Austin, et al., 2009).

A retrospective study was conducted in the US to evaluate the effect of diabetes on hearing loss (Kakarlapudi, et al., 2003). The data was extracted from the Veteran Affairs database. Among the subjects who were having sensorineural hearing loss, 13.1% had diabetes compared to 10.3% without the disease, $p < 0.05$. The mean hearing threshold levels for patients with creatinine level below 1.0mg/dL was 51.7 dB and speech discrimination scores were 82.0%. If the serum creatinine levels among patients was more than 2.5mg/dL, the mean hearing threshold levels and speech discrimination scores for patients were 58 dB and 72.5% respectively, $p < 0.05$. The authors concluded that there was a positive association between diabetes and sensorineural hearing loss; diabetes with high creatinine levels showed a decline in hearing levels most probably due to deteriorating microvascular disease.

Austin *et al*. did a cross-sectional study to assess the association of diabetes and hearing loss (Austin, et al., 2009). The study was conducted in the US and the patients were from the Portland Veteran Affairs Medical Center. The inclusion criterion was patients should be below 71 years old. The exclusion criteria were subjects wearing hearing aids, those had cancer, multiple sclerosis, neurological diseases, hearing loss of more than 40 dB at 2000 or 70 dB at 4000 Hz and also those who had 'air-bone gaps' of more than 10 dB. A total of 165 patients who had diabetes were recruited in the study with 137 in the comparison group; 77 of them had IDDM and 88 with NIDDM. Hearing threshold levels were measured using audiometry ranged from 250 to 14000 Hz on both ears and stimulus frequency otoacoustic emissions in the "better" hearing ear. The participants were divided into three age groups: 26-49, 50-56 and 57-71 years. The repeated measures analyses of variance were used to evaluate the consequence of diabetes on hearing threshold levels. The complication of diabetes such as retinopathy and neuropathy of feet were more common among the IDDM patients for all age-groups. The mean hearing threshold levels deteriorated significantly among patients aged 26-49 with NIDDM compared to the non-diabetics; 16.29 ($p \leq 0.001$), 16.14 ($p \leq 0.001$), 16.14 ($p \leq 0.05$), 17.29 ($p \leq 0.05$), 21.14 ($p \leq 0.01$), 24.43 ($p \leq 0.05$), 36.14 ($p \leq 0.05$) and 45.00 ($p \leq 0.05$) dB at 500, 1000, 1500, 2000, 3000, 4000, 10000 and 12500 Hz, respectively on right ear and 14.86 ($p \leq 0.001$), 17.43 ($p \leq 0.001$), 17.57 ($p \leq 0.001$), 17.57 ($p \leq 0.001$), 19.43 ($p \leq 0.01$), 24.00 ($p \leq 0.05$), 31.00 ($p \leq 0.05$) and 37.29 ($p \leq 0.05$) dB at 250, 500, 1000, 1500, 2000, 3000, 4000 and 10000 Hz, respectively on left ear. The mean hearing threshold levels also deteriorated significantly among patients aged 26-49 with IDDM compared to the non-diabetics; 13.71 ($p \leq 0.01$), 17.26 ($p \leq 0.001$), 14.52 ($p \leq 0.05$), 37.90 ($p \leq 0.05$), 45.81 ($p \leq 0.05$) and 56.13 ($p \leq 0.05$) dB at 250, 500, 1000, 10000, 12500 and 14000 Hz, respectively on right ear and 14.19 ($p \leq 0.01$) and 16.13 ($p \leq 0.01$) dB at 250 and 500 Hz, respectively on left ear. The severity of diabetes ($p < 0.001$), age group ($p < 0.001$) and test frequency ($p < 0.001$) independently had effects on hearing. The NIDDM among the age-group 26-49 showed deterioration in hearing threshold levels at all the tested frequencies compared to low frequencies and frequencies above 8000 Hz among the IDDM patients. Among the older subjects, IDDM had affected hearing at the lower frequencies. The authors concluded that diabetic patients were at higher risks of having hearing loss.

Mozaffari *et al*. (Mozaffari, et al., 2010) did a cross-sectional study to assess the association between diabetes mellitus and hearing loss. The study was conducted in Iran. There were 160 subjects recruited in the study; 80 of them were diabetic. The inclusion criteria were subjects should be less than 60 years old, non-smokers and used hypoglycemic agents. The exclusion criteria were subjects who consumed alcohol, ototoxic drugs, were exposed to noise at the workplace and had hearing disorders. Pure tone audiometry was used to measure hearing threshold levels of more than 25 dB over the “worse” hearing ear at 500 to 4000 Hz. Sensorineural hearing loss among diabetic patients were 45% compared to 20% among controls, (OR, 3.5; 95% CI, 1.6-6.6, $p = 0.001$). Sensorineural hearing loss was found to be more common among the subjects with a longer history of diabetes, [Mean (SD) = 11.7 (7.6), $p = 0.001$]. The subjects who were diagnosed with early diabetes and for a longer duration were at a higher risk of having severe hearing loss, $p = 0.042$ and $p = 0.007$, respectively. The type-I diabetic subjects had more severe hearing loss compared to type-II, $p = 0.032$. The authors concluded that there was a positive association between diabetes and hearing loss.

A cross-sectional study was conducted in India to evaluate hearing loss among diabetics (Pemmaiah & Srinivas, 2011). There were 110 participants were involved in the study. All of them had type-II diabetes mellitus. The exclusion criteria were subjects exposed to noise at the workplace, ototoxic and chemotherapy drugs, ear infection or had undergone ear surgery, suffered severe head injury, had a family history of deafness and also those who had respiratory tract infection over the upper tract for the past one month. Hearing threshold levels were measured using pure tone audiometry and were further divided into mild, moderate, moderately severe, severe, profound and total deafness. There were around 44% of diabetics with sensorineural hearing loss at 2000 and 4000 Hz. Around 23% had moderate hearing loss and around 15% with moderately severe loss. Most of the diabetics had hearing loss were above 50 years old and had long-standing diabetes of more than 10 years. The authors concluded that there was a positive link between diabetes and hearing loss.

Diniz and Guida (Diniz & Guida, 2009) conducted a study in Brazil to evaluate the link between diabetes mellitus and hearing loss. There were 50 subjects recruited in this cross-sectional study. Audiometry and logoaudiometry were used to measure the hearing threshold levels. Analysis of variance (ANOVA) was used in the analysis. Among diabetics, 38% had sensorineural hearing loss, while 24% had mixed hearing loss and more than 30% of them were normal. In the control group, only 26% had sensorineural hearing loss and 4% with mixed type. The mean hearing threshold levels according to the Bureau International d'Audio Phonologie were 38.25 ± 21.36 on right ear compared to the control group of 24.82 ± 12.28, $p < 0.001$, while 39.40 ± 20.96 on left ear among diabetics compared to the control group of 24.17 ± 12.67, $p < 0.001$. The mean hearing threshold levels according to Davis and Silvermann were 35.18 ± 20.55 on right ear compared to control group of 21.88 ± 11.68, $p < 0.001$, while 35.80 ± 19.53 on left ear among diabetics compared to the control group of 20.76 ± 12.44, $p < 0.001$.

The authors concluded that there was a positive association between diabetes mellitus and hearing loss.

A meta-analysis was done to evaluate the prevalence of hearing loss among diabetics (Horikawa, et al., 2013). The articles were sourced from the Embase and Medline databases. There were no language restrictions. The inclusion criteria were that the studies should be of cross-sectional design, adult participants and those that evaluated hearing loss among diabetics using pure tone audiometry (2000 Hz was included). The study quality was based on the type of diabetes, duration and complication of diabetes described, matched for age and gender among non-diabetics and exposure to noise at the workplace. A random effects model was used for determination of pooled OR and I^2 statistics were used for evaluation of between-study heterogeneity. Publication bias was evaluated by Begg's and Egger's tests. Hearing loss among the diabetics compared to non-diabetics was, (OR, 2.15; 95% CI, 1.72-2.68, $p < 0.001$) with I^2 of 76.2%. There was not much of a difference on I^2 after removal of a study with a negative link on hearing loss. There were no publication bias; Egger's and Begg's tests showed $p = 0.79$ and 0.54, respectively. The young diabetics were more prone to hearing loss, compared to the older subjects (more than 60 years), (OR, 2.61; 95% CI, 2.00-3.45) and (OR, 1.58; 95% CI, 1.38-1.81, $p = 0.008$), respectively. The authors concluded that diabetics were twice more likely to have hearing loss than non-diabetics.

2.5.7 Drugs and hearing loss

There are certain drugs that may lead to ototoxicity. The lethal effects of these drugs may involve either the cochlear or vestibular system or both. These effects may lead to deafness, vertigo and tinnitus (Cianfrone, et al., 2011). Most of these drugs are eliminated through the kidneys. Hearing loss from these ototoxic drugs occurs earlier than vertigo symptoms. Ototoxic drugs that cause sensorineural hearing loss are loop diuretics (furosemide), analgesics (aspirin), aminoglycosides (gentamicin), macrolides (erythromycin), anti-tuberculosis drugs (streptomycin), anti-fungal drugs (amphotericin B), tetracycline (minocycline), anti-protozoa agents (chloroquine), and also anti-neoplastic agents (cisplatin) (American Academy of Audiology, 2009; Cianfrone, et al., 2011). The drugs leading to specific disturbances on audiology are fluoroquinolones (ciprofloxacin), oseltamivir, quinine, tretinoin and iron-chelating agents. The ototoxic changes can be measured using a high-frequency audiometry and DPOAE; the former can detect changes of ototoxicity much earlier (American Academy of Audiology, 2009).

2.6 Hearing conservation program

In order to prevent this irremediable occupational malady, a program should be instituted within the industries. This program, a hearing conservation program, should be integrated in the management's policy of each industry. This program has many elements that are required to be adhered to by the employers as well as employees (Franks, et al., 1996; Kirchner, et al., 2012). It should be included in the key performance index of the workers and supervisors to encourage them to participate in this program. The cooperation is required at all levels including the top management, safety and health officers, supervisors and workers to make this program a success by achieving its objectives. The objectives that are stated should comply with the Factories and Machinery (Noise Exposure) Regulations 1989 (Laws of Malaysia, 2010). In order to achieve the targets, financial support from the top management is of paramount importance. Furthermore, safety and health officers and occupational physicians should be sufficiently trained to conduct the program. The elements that are instituted in the program should be sustainable for the continued success in curbing hearing loss due to noise. There should also be a sufficient number of workers appointed by the top management to carry out the program including monitoring and evaluation. Communication between employers and employees should be continued on a regular basis. The management should continue carrying out activities such as measuring prevalence of hearing loss and discuss with other stake-holders for all-round, sustained improvement.

There are number of benefits to the factories or companies by implementing this program. The prevalence of occupational noise-induced hearing loss can be reduced and subsequently, the compensation claims from employees would reduce the financial loss to the company. Besides complying with the Factories and Machinery Act 1967 (Laws of Malaysia, 2010), the productivity of the company is not reduced since the workers remain healthy and this may increase the prestige of the company. One of the barriers for the success of this program is poor obligation from the management plus poor knowledge and understanding of the employees. Continuous education should be imparted to both employees and employers.

There are few components that are needed to be enforced by both employers and employees in order to achieve success in implementing a hearing conservation program (Kirchner, et al., 2012). One of the components is noise measurement. Noise measurement is needed to be carried out not only from the source, but also the areas surrounding the source (Franks, et al., 1996). If the source was found to produce excessive noise, various methods should be employed to reduce the levels of noise. The measurement is also carried out on employees, over a period of time, depending on the type of noise produced by the machines or equipment. This is to measure noise exposure of the employees. The procedures above are observed to ensure noise emitted is not above the permissible exposure limit as per the regulation.

Another component in this program is regular audiometric testing (Kirchner, et al., 2012). This assessment is done among employees before starting the shift with 14 hour quiet; the employees are advised not to be exposed to noise exceeding 80 dBA. All the employees should undergo this surveillance if the factory or the company has areas exceeding 85 dBA (Laws of Malaysia, 2010). This medical surveillance has to be done within six months of employment. A pre-placement examination is important to detect any hearing loss among employees prior to joining the current workforce. This finding may be useful in calculating compensation claims through apportionment. Apportionment is done by assessing the workers' pre-placement hearing loss subtracted from the current audiometry findings (Cocchiarella & Andersson, 2000). Findings of the first audiogram are taken as the baseline for the employees. If the noise levels are found to be more than the permissible exposure limit, then the audiometry test needs to be repeated annually (Laws of Malaysia, 2010). The annual assessments are also performed on employees having standard threshold shifts and hearing impairment on subsequent audiograms. The audiometry test is given frequently in these conditions to assess the effectiveness of noise control after the initial findings. However, if the factory or the company produces noise levels at or above action level but below the permissible exposure limit, then the assessment needs to be repeated only once in two years (Laws of Malaysia, 2010).

The education and training (World Health Organization, 1997) of the employees are the other elements of the hearing conservation program. Through education, information on the effects and prevention of hearing loss are given to the employees. This continuous education can alter these employees' perception to being more positive in attitude and practice in prevention of hearing loss. The topics covered are:

- general aspects of noise,
- causes of hearing loss,
- risk factors,
- potential effects,
- signs and symptoms,
- treatment,

- prevention and
- proper practice to mitigate hearing loss.

The relevant regulations available in the country to protect workers from hearing loss are also conveyed to these workers. The education and training should be given at least once in two years (Laws of Malaysia, 2010). The training should include the proper use and care of hearing protection devices. Education and training may be given in many forms such as pamphlets or seminars. The language used during education and method of disseminating the information depends on the target audience; approach is different when giving information to management compared to informing manual workers or laborers.

Warning signs should be placed on the entrance to the areas where noise emission is at or above the permissible exposure limit (World Health Organization, 1997). These signs should caution the workers that entry is restricted to authorized personnel only.

The other element in this program is usage of hearing protection devices (American Academy of Audiology, 2003). Employees should wear these devices if they are exposed to levels above the permissible exposure limit (Laws of Malaysia, 2010).

The elements of the hearing conservation program that have been carried out should be documented (Franks, et al., 1996) and retained. These records should be kept intact until the worker stops working in the company and for the five years thereafter (Laws of Malaysia, 2010). The records are important for the management to review the effectiveness of reducing noise levels and noise exposure so that corrective and preventive action can commence.

2.6.1 Noise assessment

There are few objectives to be achieved by conducting a noise assessment (American Academy of Audiology, 2003-2004). The objectives should comply with the Factories and Machinery (Noise Exposure) Regulations 1989 (Laws of Malaysia, 2010). One of the objectives is to recognize areas which produce excessive noise including the noise source. The noise mapping of these areas and measurement of noise exposure among the employees are then assessed. The evaluation of noise with appropriate recommendation to reduce noise is specified such as engineering and administrative methods, training of employees, regular audiometric assessment and use of hearing protective devices.

The employees should not be exposed to levels above 90 dBA over eight working hours or levels above 115 dBA at any given time or 140 dB of impulsive noise (Laws of Malaysia, 2010).

The daily noise dose is 1.0, equivalent to noise exposure of 90 dBA for 8 hours (Franks, et al., 1996). This noise dose is the cumulative dose to which an employee is exposed in a day; the formula is as follows: ($D = 100 \times [C1/T1 + C2/T2 + \ldots Cn/Tn]$) (American Academy of Audiology, 2003), where D is the total noise, C is the total time of exposure at a specific noise level and T is the permissible duration of the measured sound. The total duration of exposure is added when the employees are exposed to different noise levels on performing different tasks. The exchange rate specified in the Factories and Machinery (Noise Exposure) Regulations 1989 is 5 dB (Laws of Malaysia, 2010). The exposure time is reduced by half for every 5 dB increment from 90 dBA. Likewise, exposure time doubles for every reduction of 5 dB. In contrast, the countries following the 3 dB exchange rate, the exposure time is reduced by half on every 3 dB increment from 90 dBA and vice versa.

2.6.2 Noise monitoring

There are few instruments used in noise monitoring. The instruments used must be calibrated at regular intervals and used by trained personnel only. The instruments required for noise measurement are a sound level meter, personal exposure noise dosimeter, calibrator and measuring tape.

The sound level meter is used for many applications. Besides the occupational noise measurements, it can be used in environmental noise monitoring. The DOSH uses it during enforcement activities in the industries in order to review the compliance on control measures by the employers. It can also be used in calibration of the audiometric booth as octave-band analyzers.

The microphone which is attached to the sound level meter receives external signals and converts them to decibel units. There are mainly two types of microphones (Malchaire, 1995) available, i.e., the piezoelectric and condenser. These microphones are stable within normal temperatures and humid conditions. The sound level meter has two responses, i.e., fast and slow. The latter is generally used to monitor noise in the occupational setting as it averages the readings in fluctuation of sound levels. There are three frequency-weighting available, i.e., A, B and C. Frequency-weighting A usually responds to lower dB compared to frequency-weighting C which corresponds to levels above 85 dB. Hence, frequency A and C can be used in occupational noise monitoring, though the former is preferred as per the legislation (Laws of Malaysia, 2010). The placement of the sound level meter is as important during noise measurement as the levels may be affected by the background noise.

The personal exposure noise dosimeter is used to measure noise among employees over a period of time. This equipment is placed close to the employees' ear for about 4 to 6 hours in continuous noise and 12 hours in fluctuating noise. The measurement method for fluctuating noise is according to practice guidelines of NIOSH Malaysia.

This dosimeter averages the noise level. It is fixed at the A-scale, with a 5-dB exchange rate (Malchaire, 1995). For countries following the U.S. NIOSH's recommended values; the 3-dB exchange rate is fixed in the dosimeter. It is fixed with a slow response as in the sound-level meter and at 80-dB threshold level. The signal then converts to dB value through root-mean-square. There are limitations with this device as it is not possible to be calibrated between noise measurements as workers are continuously exposed to noise. The calibration is required while monitoring noise as it will be placed for a long duration. Since it averages the noise level, impulse noise level may affect the general value.

A calibrator is used to standardize noise in both the sound level meter and personal exposure noise dosimeter. It is advisable to calibrate them (sound level meter and personal exposure noise dosimeter) just before and after the procedure to obtain accurate and valid results. A measuring tape is used to determine the distance from a noise source to recognize areas with high levels of noise.

The approaches involved in a noise measurement include a preliminary noise survey (Lester, et al., 1995). The assessment is conducted to identify the areas of high-intensity noise. In this assessment, a proposal is prepared by a competent noise assessor and the decision on the type of noise survey to be conducted is reached. The types of survey conducted are to determine the risk involved in damaging hearing or to control noise. The duration required for the survey to be conducted is also mentioned in the plan to alert the employers. The noise assessor identifies the type of noise in the factory and decides on the duration required to conduct a personal exposure noise dosimeter on employees. In this initial survey, high risk workers can also be identified and they should undergo a personal exposure of noise measurement.

Noise survey (Laws of Malaysia, 2010) is conducted after the preliminary review. The noise assessor identifies the levels of noise in each work area. In these work areas, the levels from the noise source such as noise generators are recorded. Similarly, noise levels from the workers in these high-intensity noise areas are recorded. These are done using a personal exposure noise dosimeter. The duration these workers are exposed to noise is also documented.

The type of noise can be identified by using a sound level meter while conducting a walk-through survey around the factory. In continuous noise, the changes of sound level do not exceed 3 dBA and in fluctuating noise, the levels can be more than 3 dBA (Koh, et al., 2001). The duration of noise measurement in the former may require only 4 to 6 hours, unlike in the latter, where 12 hours are required.

There are two techniques involved in noise measurement. Initially, the noise levels from noise sources are measured using a sound level meter. This device is held at about one meter from the noise source and at a height of about one meter. Noise level from machinery is obtained after deducting the background noise and the noise mapping is prepared. The purpose of noise mapping is to identify areas exceeding the permissible exposure limit. Hearing protection devices are distributed to the employees working in these areas after calculating the NRR (Occupational Safety & Health Administration, 2012). Besides distribution of hearing protection devices, the noise control measures are taken by the employers. Noise mapping is divided into a) noise contouring and b) noise zoning. Noise contouring is a detailed noise mapping where noise levels in the areas are specified, whereas noise zoning is classified into three zones, i.e.

i. Areas above permissible exposure limit…colored red,
ii. Areas above action level but below permissible exposure limit…colored orange,
iii. Areas below action level…left colorless.

The second technique is measurement of employees' noise using personal exposure noise dosimeters. The average level, maximum level and peak level of noise can be obtained. During this procedure, the noise dosimeter is switched off during breaks (Occupational Safety & Health Administration, 2014b).

2.6.3 Audiogram and its findings of hearing loss

An audiometer records the findings of hearing threshold levels. These findings are recorded in an audiogram. The frequencies recorded are 250, 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz (Kirchner, et al., 2012; Timmins, et al., 2010). The Y-axis records intensity of sound appreciated after the tone has been sent to the ear of the examinee. The level 0-dB is considered as a reference value (Stach, 2010). In other words, if the tone is appreciated with a high-intensity sound for the specific frequency, then the degree of hearing loss or hearing threshold is compared to the reference value. On occasion, the negative value is noted when measuring hearing level, indicating the hearing threshold is much better in the person compared to the reference level. An individual is said to be having a normal hearing level if the tone delivered is appreciated in each frequency at levels of or below 25 dB (National Health and Nutrition Examination Survey, 2003). A standard threshold shift is diagnosed among employees when there is a difference of an average of more than 10 dB at high frequencies, i.e., 2000, 3000 and 4000 Hz (Laws of Malaysia, 2010). In hearing impairment, there must be an average of permanent shift of at least 25 dB at 500, 1000, 2000 and 3000 Hz (Laws of Malaysia, 2010). The difference, either standard threshold shift or hearing impairment, should be compared with a baseline audiogram.

The audiogram has a range of frequencies on the horizontal plane; hearing threshold level is indicated on a vertical plane. Before conducting the procedure, the examiner needs to confirm the side of ear where hearing is impaired as the "better" hearing ear is tested first. By knowing the "better" hearing ear, the examinee is ensured of following the instructions given appropriately. If hearing on both ears are the same, then the tester examines the right ear first. The 1000 Hz is tested initially followed by 2000 up to 8000-Hz and finally to the lower frequencies, i.e., 500 and 250-Hz, as hearing is most sensitive to 1000-Hz. The hearing threshold of the right side is denoted as “O”, while the left side as “X” (Franks, 1995). The findings of the hearing threshold of the right side are written in red ink while the left in blue. In case bone conduction is tested, then “[” sign is used for the right side while “]” for left. If the instructions such as pressing the button upon hearing the tone are difficult to follow, the tester suggests raising the hand as the tone is delivered. Tones were presented by the Hughson-Westlake method; “up 5-down 10” method of threshold estimation, where the tone is raised by 5-dB if the subject fails to respond and the tone is reduced by 10-dB if the subject hears the increment until hearing threshold level is reached at which the subject fails to respond.

In testing for hearing threshold, only air conduction is used in the occupational setting. If there is any abnormal finding or features, then it is advisable to request for a more complete audiometry assessment. In conductive hearing loss, there is ‘air-bone gap’ as the levels of bone conduction and air conduction are not the same. In sensorineural hearing loss, there is no ‘air-bone gap’ (Gelfand, 2009) where the levels of air conduction and bone conduction are similar. Occupational noise-induced hearing loss is a sensorineural hearing loss and it affects the bone conduction pathway.

Noise is deliberately produced to the non-test ear to obtain a true hearing threshold level in the ear being tested; since there is a possibility that sound from the ear being tested may be heard by the other. This is common, when performing bone conduction, since sound waves travel through bone. The noise level introduced as masking should be more than the air conduction threshold. The level should be at least more than 25 dB from the threshold level. There are two types of masking, i.e., air conduction and bone conduction. Air conduction masking is performed when there are at least 40 dB differences of air conduction thresholds between the ears (British Society of Audiology, 2011; Warner, et al., 2009) to prevent cross-hearing. The “worse” hearing ear is tested, while the “better” hearing ear is masked. The other norm for air conduction masking is when there is a difference of at least 40 dB between air conduction and bone conduction of different ears. Bone conduction masking is executed when there are differences of 10 dB or more between air conduction and bone conduction threshold (British Society of Audiology, 2011; Warner, et al., 2009) of the ears. As above, masking is done on “better” hearing ear. Bone conduction may vary due to the thickness of the skin and density of the bone. The masking of noise is usually executed when performing bone conduction. There are exceptions where masking of noise is not performed in bone conduction, i.e., when there is no ‘air-bone gap’ as it indicates the involvement of a sensorineural pathway. Another condition is when only the high frequencies are involved, as bone conduction is only performed from a low frequency to 4000 Hz. It is customarily diagnosed as occupational noise-induced hearing loss if there is an isolated dip bilaterally at these high frequencies.

There are few characteristic features found in both conductive and sensorineural hearing loss in an audiogram. In conductive hearing loss, air conduction tends to be worse in lower frequencies as in otosclerosis. So the curve in the audiogram tends to be ascending in nature. There are instances where the findings of threshold in the audiogram tend to be flat as in otitis media and impacted cerumen. In rare occasions, the curve may be descending in nature when external auditory canal is fluid-filled. The findings may correspond to abnormal findings in the outer and middle ear. The maximum loss that can be recorded in the audiogram for conductive hearing loss is 70 dB. In otosclerosis, there is a dip in low frequencies, known as Carhart’s notch (Hussain, 2008). The audiogram from the Békésy audiometry may reveal Type I with continuous and interrupted tracings overlaying each other. The findings supplement history taking and a proper physical examination, including otoscopy evaluations. Other investigations such as using a tuning fork and tympanometry may supplement these findings for a more accurate diagnosis.

The features found in sensorineural hearing loss are different from the conductive hearing loss. In sensorineural hearing loss, the hearing thresholds in air conduction are reduced. The thresholds of bone conduction are reduced too, as similar or almost similar levels to that of air conduction leading to a non-detection of the ‘air-bone gap’. One of the main distinguishing features found in sensorineural hearing loss is that it affects high frequencies. The most common condition is presbycusis. There is a downward slope in high frequency and no recovery phase. These features can be well demonstrated in a high frequency audiometry. Noise-induced hearing loss also affects the high frequencies with dips usually from 3000 to 6000 Hz bilaterally with recovery at 8000 Hz (Kirchner, et al., 2012). They are usually noted among industrial workers exposed to noise levels above the permissible exposure limits for prolonged working hours. If this isolated dip is unilateral, a condition known as ‘acoustic neuroma’ should be ruled out by an imaging technique. There are instances as in Meniere’s disease (sensorineural hearing loss) where the speech frequencies are affected and the graph in the audiogram shows the ascending type. This is seen usually in the early stages of the disease. The audiogram from the Békésy audiometry may reveal Type III or Type IV if the auditory nerve is involved. In these types, there is a presence of abnormal tone decay. In Meniere’s disease, the features resemble that of sensory loss, as continuous tracing overlays the interrupted tracing initially at low frequencies and separates from the latter at about 500 Hz, simulating the findings of the Békésy Type II. The audiogram of sensorineural hearing loss should be supplemented by a detailed history and adequate physical examination including the tuning fork assessment. This is of utmost importance as in Meniere’s disease, the history of fullness of ear and poor discrimination affecting conversation would be the main problem while in occupational noise-induced hearing loss, the person may complain of gradual hearing loss with a history of working in noisy industries.

2.6.4 Hearing protection devices as a 'preventive factor' in hearing loss

The reduction of noise is possible through elimination of noise, substitution to quieter equipment, engineering controls at source and transmission, administrative controls by job rotation and also use of personal protective devices (American Academy of Audiology, 2003; Morris, 2006). A hearing protection device may be the last resort in the hearing conservation program, but its enforcement is the cornerstone of any industry in order to reduce noise exposure. Employees need to wear these devices if they are exposed to noise levels above the permissible exposure limits (Laws of Malaysia, 2010). These devices can be used to reduce noise exposure to levels below action level or permissible exposure limits depending on findings in the audiogram. Supervisors as well as the safety and health officers should monitor the workers are constantly wearing hearing protection devices when working in intense areas. There may be a few disadvantages for employees wearing these devices such as discomfort, but with persistent education and proper selection of the devices, the drawbacks eventually would diminish.

A study was conducted on industries in a state in Malaysia (Nor Saleha & Noor Hassim, 2006). The aim of this cross-sectional study was to evaluate the industries that are complying with the hearing conservation program and to assess the prevalence of standard threshold shifts and hearing impairment among their employees. This study was conducted for three months among industries in Negeri Sembilan, Malaysia. The inclusion criteria were presence of at least 40 employees in an industry who were exposed to noise and also that the industries should be registered under the DOSH, Negeri Sembilan. There were a total of 272 industries that fulfilled these criteria. Self-administered questionnaires were distributed to collect data on sociodemographics, i.e., job title of workers, subjects from factories exposed to noise levels above 85 dBA and also information regarding elements of the hearing conservation program. The information of employees with hearing impairment and standard threshold shifts were also obtained through the audiometric findings. The factories were fully compliant if they fulfilled all seven elements of the hearing conservation program. These elements were government policy and owner policy, personal exposure of noise monitoring, provision of hearing protection devices, training on wearing hearing protection devices at least once in two years, audiometric tests, noise control by engineering and administrative methods and also record keeping. The Chi-square test and logistic regression were used in the analysis.

Only 167 industries were studied from 272 since some of the industries did not respond and some had noise levels below 85 dBA. Most were Malaysian-owned industries (around 60%) with more than half of these industries had less than 150 workers. There were around a fifth of chemical industries, metal, machinery and equipment industries. Of these industries, more than 95% had safety and health committees. Less than half of the industries (41.3%) in Negeri Sembilan complied with all elements of the program. Around 93% of the industries studied had provided hearing protection devices. In the study (Nor Saleha & Noor Hassim, 2006), foreign companies were found to be more compliant (50.8%) with the program compared to Malaysian-owned industries (35.3%), p = 0.048. Compliance with the hearing conservation program increased two-fold when the companies had more than 150 employees (β, 0.717; OR, 2.048; 95% CI, 1.063-3.944). Among 1926 employees exposed to noise levels above the action level, around 24% had hearing impairment and 5% of them had standard threshold shifts. The industries which were fully compliant with the program had more prevalence of standard threshold shifts. This could be explained by regular noise monitoring and audiometry tests which were conducted in these industries and hence, the detection of abnormalities on hearing thresholds was much higher. However, there were no significant differences among these industries on hearing impairment.

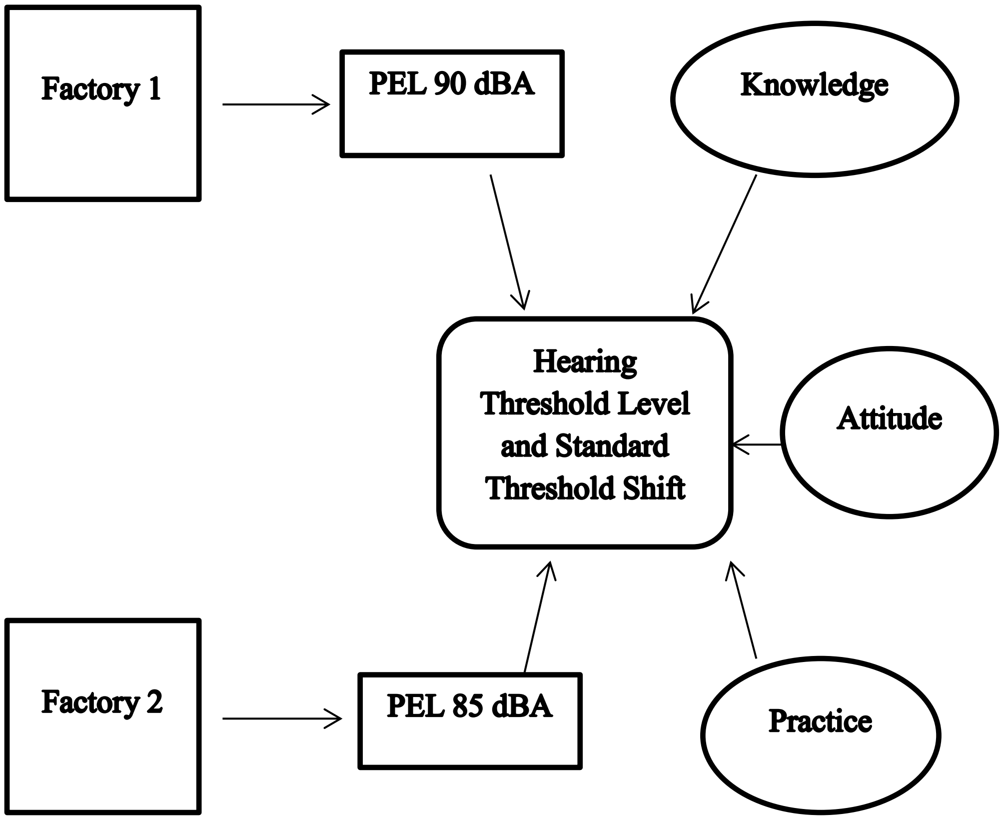
2.7 Knowledge, attitude and practice of noise-induced hearing loss

Educational programs are essential to be conducted to prevent noise-induced hearing loss among employees. Knowledge and awareness through health education provide information of effects and preventive measures to minimize this malady (World Health Organization, 1997).

Rus *et al.* (Rus, et al., 2008) conducted a cross-sectional study on sawmill workers. The aim of the study was to determine the knowledge, attitude and practice of workers towards noise. The study was conducted in Malaysia among 83 workers. Universal sampling was applied to recruit the workers. The exclusion criterion was those having psychotic disorder. A questionnaire was developed based on the literature searched, a focus group discussion which had involved six workers and also through a workshop. The questionnaire consisted of 42 items; the Cronbach's alpha coefficients were 0.67, 0.92 and 0.75 for knowledge, attitude and practice constructs, respectively. The Mean (SD) scores for knowledge, attitude and practice were 68.72 (8.69), 60.60 (8.79) and 19.36 (13.69), respectively. The weakest areas in knowledge domain were on risk factors, symptoms and signs and also treatment of noise-induced hearing loss. In attitude, the weakest areas were on general areas, prevention and risk-taking attitude of noise-induced hearing loss. Generally, the workers scored poor in all the items of practice domain. The authors concluded that more needed to be done on education to increase knowledge and improve attitude and practice among the workers to reduce noise exposure.

In a published by Ismail *et al.* (Ismail, et al., 2013), the prevalence and its associated factors of noise-induced hearing loss were evaluated. The study was conducted in Malaysia. A total of 97 quarry workers participated in this cross-sectional study. The inclusion criteria were employees working for more than six months (aged between 18 and 50 years) and with no family history of ear diseases. The distributed questionnaire was based on Rus *et al.* (Rus, et al., 2008). The hearing status of the participants was measured using pure tone audiometry. The Mean (SD) scores for knowledge, attitude and practice were 44 (11), 70 (10) and 28 (16), respectively. Generally, the workers scored poor in almost all the items of knowledge and practice constructs. The weakest areas in attitude domain were on general aspects, prevention, law and risk-taking attitude of noise-induced hearing loss. The mean hearing threshold levels among workers with noise-induced hearing loss were 16, 14, 17, 34 and 34 dBA compared to those without noise-induced hearing loss, 11, 12, 9, 13, and 13 dBA at 500, 1000, 2000, 4000 and 8000 Hz, respectively on right ear. The p-value of independent t-tests showed 0.007, 0.174, 0.001, < 0.001 and < 0.001, respectively. In left ear, the mean hearing threshold levels among workers with noise-induced hearing loss were 16, 17, 17, 41 and 35 dBA compared to those without noise-induced hearing loss, 11, 10, 11, 14, and 9 dBA at 500, 1000, 2000, 4000 and 8000 Hz, with p-value of 0.003, 0.005, 0.012, < 0.001 and < 0.001, respectively. The study showed age and practice variable of noise-induced hearing loss had adjusted OR of 1.1 (95% CI, 1.1-1.2; $p < 0.001$) and 0.9 (95% CI, 0.8-1.0; $p = 0.008$), respectively. The prevalence of noise-induced hearing loss was 57% in the quarry. Older workers and poor practice score are linked to the development of noise-induced hearing loss. The authors concluded that poor score of knowledge, attitude and practice were associated with noise-induced hearing loss.

2.8 Conceptual Framework



In this study, participants from the two different factories adopted two different permissible exposure limits. In Factory 1, participants were exposed to the current permissible exposure limit, i.e., 90 dBA according to the U.S. OSHA regulations and Factories and Machinery regulations for Noise Exposure 1989. In Factory 2 the participants followed 85 dBA according to the U.S. NIOSH's recommended criteria. The outcome of mean hearing threshold levels, hearing threshold levels above 25 dBA and standard threshold shifts were measured by an audiometer. The levels of knowledge, attitude and practice of noise-induced hearing loss were compared between participants of the two factories, as they may influence the outcome.

2.9 Summary

There is an increased prevalence of occupational noise-induced hearing loss globally. The mechanical damage of stereocilia and metabolic damage of the hair cells in the organ of Corti due to noise insult leads to noise-induced hearing loss.

Half of the studies in the systematic review were experimental in design, increasing the implications with regard to causality and outcome. The evidence from these experimental studies was of a high quality. The search was not restricted to a specific study design, since there was only a limited number of published studies were available. All four experimental studies were conducted on human subjects. The subjects were exposed to noise generated by equipment with loudspeakers. The noise introduced was of a continuous type. The other studies were conducted in an industrial setting in which employees were exposed to a fluctuating type of noise. The precise machines involved in generating noise in these industries were not reported. Hearing protection devices were used by the workers during the studies of Kvaerner *et al.* and Rubak *et al*., but were not reported by McBride *et al*. and Chen and Tsai.

Most of the studies from the systematic review recommend adoption of 85 dBA for conservation of hearing thresholds. They indicated that the temporary threshold shifts were much lower when subjects were exposed to noise levels of 85 dBA or lower. However, the study of McBride *et al*. showed that there were no statistically significant changes in the temporary threshold shifts among subjects exposed to less than 85, between 85 and 90 dBA and more than 90 dBA. These findings of McBride *et al*. may not be applicable, since post-shift audiometry was done within a day and the employment duration of the workers exposed to these noise levels was not reported.

There are few risk factors that may contribute to hearing loss. Smoking has an adverse effect to hearing loss by resulting ischemia to the cochlear. Alcohol consumption damages hair cells in the organ of Corti by release of free radicals. There are few chemicals such as solvents affect hearing synergistically with noise and may act independently if concentration is sufficiently high. This is possible by the release of reactive oxygen species which damages the cell structures and by exhaustion of cellular antioxidant. Overstimulation of the sympathetic nervous system causes hearing loss among those having vibration-induced white finger. There are few activities such as scuba diving, shooting and listening to loud music may aggravate hearing loss. Hypertension leads to hemorrhage in the inner ear, increases blood viscosity and changes of ions in cell potentials resulting in hearing loss. The pathology of hearing loss among diabetic patients may be due to neuropathy. There are certain drugs that may lead to sensorineural hearing loss.

There are few components in a hearing conservation program, for the continued success in curbing hearing loss due to noise, such as noise measurement, regular audiometric testing, education and training and also use of hearing protective devices. In occupational noise-induced hearing loss (sensorineural hearing loss), there is a non-detection of the ‘air-bone gap’ in the audiogram. They usually affect the high frequencies; dips at 3000 to 6000 Hz bilaterally with recovery at 8000 Hz.

CHAPTER 3

METHODOLOGY

This chapter begins with description of the study design, study area and also the target population. The sample size calculation, inclusion and exclusion criteria, study variables and study instrument are reviewed in detail. The reliability and exploratory factor analysis, data collection method and intervention are also discussed in depth. Statistical analysis, ethical considerations and flow chart are described at end of the chapter.

3.1 Study design

This is an intervention study, using hearing protection devices to reduce noise exposure among participants from two factories; participants from Factory 1 were exposed to a permissible exposure limit of 90-dBA, while those in Factory 2 were exposed to a level of 85-dBA. The study was conducted from February to August 2012.

3.2 Study area

Recruitment of the study area was initiated through online requests to the safety and health officers of the factories. The details of the study were explained to the safety and health officers, human resource managers and chief executive officers, i.e., the objectives, sample size, target population, data collection method, intervention by hearing protection device and hearing conservation education, flow chart, outcomes and duration of the study. The selected study areas were two factories from an automobile industry. These two factories were from the same parent company. The industry was selected, since it had two factories, as adoption of two different permissible exposure limits for comparison was probable. The factories were allocated randomly to adoption of different permissible exposure limits (toss of a coin).

Also, the enthusiasm of the management to take part in the study, as it would benefit them and the employees, was evident. Moreover, there was a sufficient number of employees in both factories. Upon approval to conduct the study in the factories, relevant information about this study was provided to the participants through the participant information sheet as shown in Appendices 5 and 6. It described the objectives, data collection method by audiometry assessment and questionnaire distribution, intervention by hearing protection device and distribution of pamphlets of noise-induced hearing loss, and also duration of the study.

3.3 Study population and Target population

3.3.1 Study population

The study population was made up of general workers from the two factories in the automobile industry. The general workers were from a homogeneous group of manual labor workers. The participation of employees was voluntary and upon obtaining their written, informed consent. Incentives were provided (food). A total of 260 staffs were employed from the two factories. Generally, the employees were operating on shift hours or office hours. The operation hours were as follows:

i. 8 am to 4 pm
ii. 7.00 am to 5.00 pm
iii. 8 pm to 6 am

3.3.2 Target population

The eligible participants in each factory were those exposed to a noise level above the action level. The action level was defined as a sound level of 85 dBA in Factory 1 and 80 dBA in Factory 2 (the daily noise doses were equal to 0.5 in both factories); the permissible exposure limits were 90 and 85 dBA in Factory 1 and Factory 2, respectively. The exchange rate of 5-dB was applied during noise measurement (Laws of Malaysia, 2010).

3.4 Sample size

Sample size for the primary objectives was calculated using the Power and Sample Size Calculations software (Dupont & Plummer, 1990; Pearson & Hartley, 1970). The sample size calculation was based on a literature of Yates *et al*. (Yates, et al., 1976).

Based on 1000 Hz, a study was planned on a continuous response variable from independent control and experimental subjects with 1 control per experimental subject. In a previous study, the response within each subject group was normally distributed with SD of 4.13. If the true difference in the experimental and control means is 2.62, a study of 40 experimental subjects and 40 control subjects are needed. Based on 2000 Hz, the response within each subject group was normally distributed with SD of 4.79. If the true difference in the experimental and control means is 5.49, a study of 13 experimental subjects and 13 control subjects are needed. Based on 3000 Hz, the response within each subject group was normally distributed with SD of 6.81. If the true difference in the experimental and control means is 7.39, a study of 14 experimental subjects and 14 control subjects are needed. Based on 4000 Hz, the response within each subject group was normally distributed with SD of 6.94. If the true difference in the experimental and control means is 6.42, a study of 19 experimental subjects and 19 control subjects are needed. Based on 6000 Hz, the response within each subject group was normally distributed with SD of 7.71. If the true difference in the experimental and control means is 4.73, a study of 43 experimental subjects and 43 control subjects are needed. Based on 8000 Hz, the response within each subject group was normally distributed with SD of 6.51. If the true difference in the experimental and control means is 5.39, a study of 24 experimental subjects and 24 control subjects are needed.

The number of experimental and control subjects are needed to be able to reject the null hypothesis that the population means of the experimental and control groups are equal with a probability (power) of 0.8. The Type I error probability associated with this test of this null hypothesis is 0.05.

Table 3.1: Estimated required sample size for the primary objectives

	kHz	1	2	3	4	6	8
Full day 90 dBA	Mean	5.54	7.88	12.56	15.73	13.57	5.57
	SD	4.13	6.27	6.81	6.94	7.71	6.51
Full day 85 dBA	Mean	2.92	2.39	5.17	7.31	8.84	10.96
	SD	4.37	4.79	9.7	12.18	12.1	9.51
Required sample size, *n*		40	13	14	19	43	24

The sample size required was 43 respondents for each factory, as displayed in Table 3.1. Taking into account a 20% drop-out rate (withdrawal from study or loss of follow-up), the required sample size was 52 for each factory.

Based on the literatures of Rus *et al*. (Rus, et al., 2008) and Ismail *et al.* (Ismail, et al., 2013), sample size required for the secondary objective was 13 respondents for each factory based on a two-sided significance level of 0.05 and power of 80%, as shown in Table 3.2. The calculation of sample size was based on a formula, $n = (Z * \sigma / \Delta)2$ where n = sample size; Z = 1.96; σ = SD; Δ = precision (Mathews, 2010). Taking into account a 20% drop-out rate, the required sample size was 16 for each factory.

Table 3.2: Estimated required sample size for the secondary objective

Literature		**Domain**		
		Knowledge	**Attitude**	**Practice**
Rus *et al.* (Rus, et al., 2008)	Mean	68.72	60.60	19.36
	SD	8.69	8.79	13.69
Ismail *et al.* (Ismail, et al., 2013)	Mean	44	70	28
	SD	11	10	16
Required sample size, *n*		1	4	13

The final sample size based on all the objectives was 52 for each factory. The sample size was maintained by communicating with the employees through phone calls and provision of incentives (food) to participate.

3.5 Sampling frame and sampling technique

3.5.1 Sampling frame

The employees of two factories from the automobile industry were the frame of the sample.

3.5.2 Sampling technique

The universal sampling technique was applied in this study as only 260 employees working from the two factories in the automobile industry. This technique can be realized by acquiring the name list of all workers from the human resource department of the automobile industry.

3.6 Inclusion Criteria and Exclusion Criteria

3.6.1 Inclusion Criteria

The inclusion criterion was subjects who were exposed to levels above the action level; 85 dBA and 80 dBA in Factory 1 and Factory 2, respectively.

3.6.2 Exclusion Criteria

a) Employees who refused to participate in the study.

b) Contract workers, since they were not continuously employed and exposed to noise.

c) Employees who were suffering from diseases of the ear such as chronic suppurative otitis media, impacted wax, perforated tympanic membrane and malignancy.

d) Employees who had experienced physical trauma to the ear due to a penetrating injury or a fall.

e) Lorry drivers, since they were not stationed in the factory.

f) Employees who had undergone ear surgery.

g) Employees who were diagnosed to have congenital hearing loss.

3.7 Study variables

3.7.1 Independent variables

a) Sociodemographic data – age, gender, ethnic group, marital status, religion, education level and income.

b) Risk factors - smoking, consumption of alcohol, duration of work, exposure to hand-arm vibration and also exposure to chemicals (solvents), hobbies (shooting, scuba diving, listening to loud music) and medication with an increased risk of hearing loss.

c) Knowledge, attitude (belief, feeling, judgment) and practice score between employees from Factory 1 and Factory 2.

3.7.2 Dependent variables

Primary outcome: *Audiogram reading*: The mean hearing threshold levels and hearing threshold levels above 25 dBA of participants from Factory 1 and Factory 2 were measured at the outset (baseline, pre-shift noise exposure), first month (post-shift noise exposure) and also at the sixth month (pre-shift noise exposure). The standard threshold shifts were measured at the first month (post-shift noise exposure) and sixth month (pre-shift noise exposure) between participants from the two factories.

Secondary outcome: *Audiogram reading*: Difference in scores on each domain, i.e., knowledge, attitude (belief, feeling, judgment) and practice of participants from the two factories, were measured at the outset, first month and sixth month.

3.8 Measurement scales

Table 3.3: Measurement scales

Variable	**Scale of measurement**
Age	Continuous (years)
Gender	Categorical (Male, Female)
Ethnic group	Categorical (Malay, Non-Malay)
Marital status	Categorical (Single, Ever married)
Religion	Categorical (Islam, Others)
Education level	Categorical (Primary/Secondary and Form Six/Certificate/College/University)
Income	Categorical (less than RM 3000, RM 3000 and more)
Exposure to chemicals with an increased risk of hearing loss	Categorical (No, Yes)
Exposure to hand-arm vibration	Categorical (No, Yes)
Duration of employment in current company	Continuous
Smoking status	Categorical (No smoking, ever smoked)
Alcohol consumption	Categorical (Not consumed, ever consumed)
Exposure to hobbies with an increased risk of hearing loss	Categorical (No, Yes)
Medication with an increased risk of hearing loss	Categorical (No, Yes)
Past surgical history	Categorical (No, Yes)
Knowledge score	Continuous
Attitude score (belief, feeling, judgment)	Continuous
Practice score	Continuous
Hearing threshold level	Continuous
Hearing threshold level above 25 dBA	Categorical (No, Yes)
Standard threshold shifts	Categorical (No, Yes)

3.9 Operational definition

Action level	85 dBA in Factory 1 and 80 dBA in Factory 2 measured using a sound level meter and personal exposure noise dosimeters.
Attitude	A state of readiness of employees relatively permanent to respond towards hearing loss, measured as a total score using a self-administered questionnaire, as shown in Appendix 13. The subdomains are belief, feeling and judgment.
Chemicals with an increased risk of hearing loss	Exposure to solvents such as xylene and toluene, as shown in Appendix 18. The information is obtained from the Chemical Health Risk Assessment of the automobile industry.
Exchange rate	The relationship between intensity and dose; also referred to as the doubling rate. A 5-dB exchange rate was used in both study locations.
Hobbies with an increased risk of hearing loss	Activities such as shooting, scuba diving or listening to loud music. The information is obtained from a self-administered questionnaire as shown in Appendix 13.
Hearing conservation education	Pamphlets are distributed when noise level was 85 dBA and above to participants in Factory 1 and 80 dBA and above to participants in Factory 2. They are distributed in English and Bahasa Malaysia as displayed in Appendices 14 and 15.
Hearing protection devices	The devices (synthetic and corded types of reusable earplugs) were given to participants to attenuate noise level to levels between 85 and 90 dBA in Factory 1, and between 80 and 85 dBA in Factory 2, as shown in Appendix 26.
Hearing threshold level	Threshold of audibility in dB from the standard audiometric reference level, measured using a manual audiometer.

Hearing threshold level above 25 dBA	More than 25 A-weighted decibels above the threshold of hearing from the standard audiometric reference level, measured using a manual audiometer.
Knowledge	Awareness and information regarding hearing loss by employees through training and education, measured as a total score using a self-administered questionnaire as shown in Appendix 13.
Medications with an increased risk of hearing loss	Drugs such as loop diuretics (furosemide), analgesics (aspirin), antibiotics (aminoglycosides), macrolides (erythromycin), anti-tuberculosis drugs (streptomycin), anti-fungal drugs (amphotericin B), tetracycline (minocycline), anti-protozoa agents (chloroquine), and also anti-neoplastic agents (cisplatin). The information is obtained from a self-administered questionnaire as shown in Appendix 13.
Permissible exposure limit	90 dBA among participants in Factory 1 and 85 dBA in Factory 2. Noise levels were measured using a sound level meter and personal exposure noise dosimeter.
Practice	It is a continuous exercise by the employees to prevent hearing loss, measured as a total score using a self-administered questionnaire as displayed in Appendix 13.
Standard threshold shift	According to the Factories and Machinery (Noise exposure) regulations 1989, it is an average shift of more than 10 dB at 2000, 3000 and 4000 Hz. According to the U.S. OSHA regulations, it is an average shift of 10 dB and more at 2000, 3000 and 4000 Hz. According to the U.S. NIOSH recommended standard, it is an average shift of 15 dB and more at 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz. The shifts were relative to the baseline audiogram in either ear. They were measured using a manual audiometer.

3.10 Study instrument

3.10.1 Sound level meter and personal exposure noise dosimeter

Noise area measurement was conducted using a sound level meter (noise dosimeter that able to detect sound levels less than 70 dBA with piezoelectric microphone) (Laws of Malaysia, 2010), calibrated and approved by the DOSH (Larson Davis, model Spark 706 RC). It was fixed at the A-scale with a slow response. Noise exposure among employees were measured using personal exposure noise dosimeters (as shown in Appendix 27) (Laws of Malaysia, 2010), calibrated and approved by the DOSH (Larson Davis, model Spark 706 RC and Spark 703+). They were fixed at the A-scale with a 5-dB exchange rate; at 80-dB threshold level with a slow response. The date of calibration, the manufacturers, the model numbers and serial numbers were taken for both sound level meter and noise dosimeters, and recorded as displayed in Appendix 2. The sound level meter and noise dosimeters were supplied by a noise assessor, who is a competent person in noise measurements.

3.10.2 Audiometer

Manual audiometers (as shown in Appendix 28) were used to collect data on hearing threshold levels and standard threshold shifts of the participants from Factory 1 and Factory 2, calibrated and approved by the DOSH, as displayed in Appendix 3. The make was of model asi 17 equipped with TDH-39 headphones as shown in Appendix 29. The audiometers were placed in the sound-proof booths (as shown in Appendix 30), calibrated according to the Factories and Machinery (Noise Exposure) Regulations 1989 (Laws of Malaysia, 2010). The specifications of the audiometric booth (sound pressure level) were 27, 30, 35, 42 and 41 dB at 500, 1000, 2000, 4000 and 8000 Hz, respectively as shown in Appendix 4 (Laws of Malaysia, 2010). Initial audiometry assessments were taken as baseline audiograms and subsequent tests were given at the first and sixth month to all participants from the two factories. The test frequencies measured on both ears were 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz (American Academy of Otolaryngology, 2011; Laws of Malaysia, 2010). To increase the reliability of measurements, two similar readings were taken before entering them in the audiogram. The audiometers and audiometric booths were manned by competent persons in noise (audiometric technicians).

3.10.3 Self-administered questionnaire

A questionnaire, as shown in Appendices 11 and 12, was created based and modified from a study of Rus *et al*. (Rus, et al., 2008) and reviewed by a panel of occupational physicians to ensure a dependable content validity. They have involved in regular teaching of noise-induced hearing loss among workers. They have reviewed the relevance and coverage of the items in each construct of the questionnaire. A pragmatic consensus was reached after in-depth discussion of every single item. The scope covered in the questionnaire was maintained from the study of Rus *et al*. (Rus, et al., 2008). The items of the questionnaire were screened by a few healthcare professionals to assess face validity. They were also involved in consistent training of noise-induced hearing loss among employees.

The questionnaire initially was created in English, then later translated to Bahasa Malaysia and then back to English (forward and backward translation). This translation was done by the Department of Malaysian Languages and Applied Linguistics of University Malaya. The self-administered questionnaires consisted of 4 main parts, i.e., demographic, knowledge, attitude (belief, feeling and judgment) and practice.

3.10.3.1 Reliability and exploratory factor analysis of the questionnaire

The questionnaires were distributed to determine reliability and exploratory factor analysis in English and Bahasa Malaysia, since participants in the main study locations might know either language well. Consistency of the questionnaire was determined by conducting test-retest reliability. This reliability method was realized by distributing the questionnaire among 39 participants. The similar sets of questionnaires were re-distributed among the same employees after two weeks. Among them, 19 participants were given the questionnaire in English and 20 of them were handed out in Bahasa Malaysia. The English language questionnaires (Appendix 11) were distributed in a cement factory, while the Bahasa Malaysia ones (Appendix 12) in a sawmill factory. The first and second set of all the items showed a strong correlation (Cohen, 1988), where all of them were more than 0.700. The details are described in 4.5.1.

The other method to test reliability of the questionnaire was to evaluate internal consistency using Cronbach's alpha coefficients. The internal consistency of the knowledge, belief, feeling, judgment and practice constructs were 0.879, 0.723, 0.747, 0.737 and 0.849, respectively. The specifics are narrated in 4.5.2.1.

The exploratory factor analysis was done to identify the contents of the questions that could be grouped under the same factor. The Kaiser-Meyer-Olkin measures of the knowledge, belief, feeling, judgment and practice constructs were 0.879, 0.500, 0.525, 0.601 and 0.791, respectively. The particulars are reported in 4.5.2.2. The internal consistency reliability and factor analyses were obtained by distributing the questionnaire among 116 participants; 60 participants were distributed in English and 56 of them in Bahasa Malaysia. The English language questionnaires (Appendix 11) were distributed in an oil and gas company, whereas the Bahasa Malaysia ones (Appendix 12) in a concrete manufacturing factory.

3.10.3.2 Scoring of each construct in the questionnaire

The self-administered questionnaire that was distributed in the main study locations of the automobile industry, after the reliability and exploratory factor analysis, has 24 items, as shown in Appendix 13. Categorical responses of “true”, “false” and “don’t know” were used for the knowledge construct comprising nine items; the correct and wrong response were given scores of 1 and -1, respectively and the “don’t know” response was given a score of 0. The maximum score of the knowledge construct was 9. As for the attitude items, there were three subdomains, i.e., belief, feeling and judgment. There were 2, 4 and 4 items in belief, feeling and judgment constructs, respectively. The subjects were asked to reply according to a five-point Likert scales ranging from ‘‘strongly disagree’’ to ‘‘strongly agree”. For a positive attitude item, scores of 5, 4, 3, 2 and 1 were given to ‘strongly agree’, ‘agree’, ‘neither agree nor disagree’, ‘disagree’ and ‘strongly disagree’, respectively; maximum scores were 10, 20 and 20 for belief, feeling and judgment subdomains, respectively. The above scoring was reversed for a negative attitude. As for the practice construct of five items, the responses were “never”, “seldom” or “sometimes” and “always”. For a positive practice item, scores of 3, 2 and 1 were given to “always”, “seldom” or “sometimes” and “never”, respectively, with a maximum score of 15. The above scoring was reversed for a negative practice. The overall maximum score of the questionnaire was 74. The total scores of each construct were compared between the participants from the two factories adopting different permissible exposure limits over a period of six months.

3.11 Data collection method

3.11.1 Noise exposure

Noise area measurement was performed using sound level meters (Laws of Malaysia, 2010). They were calibrated just before and after noise measurement. The noise areas were categorized separately as different permissible exposure limits were adopted among participants in both factories. They were categorized as follows:

In Factory 1, the areas of noise exposure were divided into 3 categories, as displayed in Appendix 21:

i. Area with more than 90 dBA
ii. Area between 85 and 90 dBA
iii. Area below 85 dBA

In Factory 2, the areas of noise exposure were divided into 3 categories, as displayed in Appendix 22:

i. Area with more than 85 dBA
ii. Area between 80 and 85 dBA
iii. Area below 80 dBA

These areas were categorized to alert the employees to wear appropriate hearing protection devices in areas with noise levels at or above the permissible exposure limit, where they would be supervised for continuous usage of these devices.

Noise exposure among employees was measured using personal exposure noise dosimeters (Laws of Malaysia, 2010). The measurement was done in each job area, exceeding the action level at each factory. One employee represented a group of employees from the same job area (Laws of Malaysia, 2010). The noise dosimeters were worn by the participants for the entire shift and were switched off during breaks (Occupational Safety & Health Administration, 2014b).

The average noise exposure was taken and recorded. The exchange rate of 5 dB and threshold of 80 dBA was applied during noise measurement (Occupational Safety & Health Administration, 2014a). The dosimeters were calibrated just before and after noise measurement. Groups of workers were categorized based on calculation of the area (noise measurement) and not for the individual, since sound levels between individuals fluctuate from day to day (Rubak, et al., 2006).

The noise level was measured using a sound level meter and noise dosimeter. The former measures noise at one point of time and the assessment was not repeated, whereas the latter measures average exposure of an employee to noise over the job area (Levey, et al., 2012). The instrument which showed a higher measured level of noise, thus causing more damage to hearing, was used for calculating NRR.

3.11.2 Hearing threshold level

A manual audiometer was used to collect data on mean hearing threshold levels of the participants from Factory 1 and Factory 2. The audiometer was placed in a sound-proof booth. The two portable audiometers and sound-proof booths were placed in a van, where data on hearing threshold levels were collected among the participants. The test frequencies measured were 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz for both ears of participants. Initial audiometry assessments were taken as baseline audiograms and subsequent tests were given at the first and sixth month to all participants in both factories. The hearing threshold levels were measured before participants began to work at baseline and at the sixth month; they were not expose to noise levels above 80 dBA for a period of 14 hours (Laws of Malaysia, 2010), as instructed by the safety and health officers. They were instructed not to involve in activities such as listening to loud music or shooting prior to the audiometry assessment.

At the first month, hearing threshold levels were measured within one hour before end of the shift. The participants were communicated to do their normal activities without any limit on their non-working noise exposure during the study period. In an experimental study (Stephenson, et al., 1980), there was a significant change noted on mean asymptotic temporary threshold shifts when subjects were made to expose to noise levels of 65, 70, 75, 80 and 85 dBA for 24 hours with a gap of one week interval, to the different noise levels. Hence, data was collected post-shift after one month in this study. According to the Factories and Machinery (Noise exposure) regulations 1989 (Laws of Malaysia, 2010), baseline audiometry assessment should be conducted within six months of commencement of work (pre-shift) as changes on hearing threshold levels is possible after a period of six months. Hence, data was re-collected at the six month.

Hearing threshold level above 25 dBA is measured as hearing loss, and can be divided into mid-frequency (500 to below 3000 Hz) and high frequency hearing loss (3000 to 8000 Hz) (Jafari, et al., 2010). McNemar's test was conducted to detect any changes on hearing threshold levels above 25 dBA among the participants at the first and six month. If there were any significant changes, a Chi-square test for association was conducted between participants from Factory 1 and Factory 2 to determine preservation of hearing threshold levels among these participants. Hearing threshold levels are 'preserved' if the levels were at or below 25 dBA after the intervention; before the intervention, the subjects had hearing threshold levels above 25 dBA. If the hearing threshold levels among the subjects before and after the intervention were at or below 25 dBA, the intervention have 'maintained preservation' of hearing thresholds. On the other hand, hearing threshold levels have 'deteriorated' if the levels were above 25 dBA after the intervention; before intervention, these subjects had hearing threshold levels at or below 25 dBA. If the hearing threshold levels before and after intervention remained unchanged, above 25 dBA, adoption of the permissible exposure limit have resulted in 'continued deterioration' of hearing thresholds.

Temporary threshold shifts may progress to permanent threshold shifts over time (Lawton, 2001). Standard threshold shifts were calculated according to the Factories and Machinery (Noise exposure) regulations 1989, U.S. OSHA regulations and U.S. NIOSH recommended standard. According to the Factories and Machinery (Noise exposure) regulations 1989, it is an average shift of more than 10 dB at 2000, 3000 and 4000 Hz relative to the baseline audiogram in either ear (Laws of Malaysia, 2010). According to the U.S. OSHA regulations, it is an average shift of 10 dB and more at 2000, 3000 and 4000 Hz relative to the baseline audiogram in either ear (Occupational Safety and Health Administration, 2013). According to the U.S. NIOSH recommended standard, it is an average shift of 15 dB and more at 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz relative to the baseline audiogram in either ear (National Institute for Occupational Safety and Health, 1998). The findings from the first and sixth month of audiogram were used to detect the development of standard threshold shifts of between participants from the two factories.

To increase the reliability of measurements, two similar readings were taken before entering them in the audiogram. There were two trained audiometric technicians (single observer for each worker) at a time carrying out measurement, of hearing thresholds on the participants, randomly from the two factories. They were blinded from the allocation arm, as they did not know which factory was adopting 85 or 90 dBA as the permissible exposure limit during the measurement of hearing thresholds. The same technicians carried out the assessment at the outset and also at the first and sixth month. These technicians were competent person in noise; trained in NIOSH, Malaysia.

3.11.3 Data on sociodemographic, risk factors and also scores of knowledge, attitude and practice domains of the questionnaire

Self-administered questionnaires (Appendix 13) were distributed by the safety and health officers to participants to extract data on sociodemographic and risk factors of hearing loss. The scores of knowledge, attitude (belief, feeling, judgment) and practice between participants from Factory 1 and Factory 2 were also obtained. The questionnaires were collected on same day they were distributed by the safety and health officers. These questionnaires were distributed at the outset, first month and sixth month.

3.12 Intervention

3.12.1 Hearing protection devices

Hearing protection devices, i.e. earplugs as shown in Appendix 26 (Laws of Malaysia, 2010) were used to reduce noise exposure levels among participants to levels ranging between the permissible exposure limit and action level. Some of the workers were wearing hearing protection devices based on 90 dBA as the permissible exposure limit before the study. The appropriate hearing protection devices (based on the permissible exposure limit and noise levels in the study location) were distributed at the outset by the safety and health officers to participants from Factory 1 and Factory 2 after the initial audiometry assessments. They were taught regarding the proper insertion techniques by the safety and health officers. To ensure continuous usage of these devices, the participants were supervised at all times by these officers during work. Hearing protection devices were given to participants who were exposed at and above the permissible exposure limit. The noise levels were obtained after conducting noise area and personal exposure noise monitoring.

Noise levels that showed higher results from these measurements were included in the calculation of NRR. The hearing protection devices were made-up of synthetic and corded types of earplugs, which are reusable.

The noise levels at each job area were achieved by determining the appropriate NRR. There was an addition of 7 dB to the calculated NRR in order to convert dBA to dBC. The correction was applied, since the attenuation levels are frequency specific and hearing protective devices were reported in the 'linear' dBC metric. The figures obtained were then multiplied by 50% (50% derating) (Holthouser, 2000). The formula to calculate NRR is as follows:

$Exposure\ of\ noise\ level\ in\ a\ specific\ job\ area\ =$

$\{Measured\ noise\ level - [(NRR - 7) \times 50\%]\}$ (Berger, et al., 2003) (Factory 1 or Factory 2).

In Factory 1, the perceived noise level was reduced to levels between 85 and 90 dBA. In Factory 2, the perceived noise level was reduced to levels between 80 and 85 dBA.

3.12.2 Hearing conservation education

Hearing conservation education was given to participants from the two factories, Factory 1 and Factory 2. The education was disseminated in the form of pamphlets by the safety and health officers. The pamphlets were distributed among the participants when the noise level was above action level in the job area, 85 dBA or above in Factory 1 and 80 dBA or above in Factory 2. Hearing conservation education was given at the outset, first month and sixth month; a week after the distribution of the questionnaires. The pamphlets used were in English and Bahasa Malaysia as shown in Appendices 14 and 15, respectively.

3.13 Compliance

The continuous usage of hearing protection devices by the participants was ensured by providing checklists to the safety and health officers for monitoring purposes as shown in Appendix 20. Usage of these hearing protection devices was also monitored by regular spot checks (once a month) by researcher.

3.14 Blinding

The participants as well as the safety and health officers were blinded to the levels of permissible exposure limits adopted in the factories. The outcome assessors (audiometric technicians) were blinded from the allocation arm, as they did not know which factory was adopting 85 or 90 dBA as the permissible exposure limit during the measurement of hearing thresholds. The statistician who analyzed the data was blinded to the permissible exposure limit (85dBA or 90dBA) applied at each factory. The researchers were not blinded as the NRR needed to be considered in each job area for the two factories.

3.15 Statistical analysis

The data analysis was carried out using SPSS version 20.0 for Windows. Data of the participants were imputed as per-protocol analysis, and those who were lost to follow-up by baseline values capitalizing the intention-to-treat principle. In the former principle, only the subjects that participated in the study and the follow-up were included in the analysis, whereas in the latter principle, all the participants who had signed the written consent forms were included regardless of their participation in the intervention.

3.15.1 Descriptive analysis

The sociodemographic characteristics of participants identified from the questionnaire survey were age, gender, ethnic, marital status, religion, education level and income. The risk factor variables were exposure to chemicals and hobbies with an increased risk of hearing loss, exposure to hand-arm vibration, duration of employment in the current factory, smoking and consumption of alcohol status, medication with an increased risk of hearing loss and past surgical history specific to ears were also extracted from the questionnaire. All expression levels are described as frequency (%) for categorical variables or mean (SD) for continuous variables.

3.15.2 Comparative analysis

A Chi-square test was used to detect differences between Factory 1 and 2 participants in the frequencies of categorical characteristics such as cigarette smoking, alcohol consumption, exposure to hand-arm vibration, exposure to chemicals and hobbies with an increased risk of hearing loss. The Chi-square tests were also used to compare association between the participants from the two factories and hearing threshold levels above 25 dBA, and also to assess link on standard threshold shifts. Fisher's exact test was used if the assumptions of the Chi-square test were not met. An independent *t*-test was used to analyze the difference in mean for continuous characteristics such as age, the duration of employment and mean hearing threshold levels and also the mean score of various domains between participants exposed to permissible exposure limits of 85 and 90 dBA. The paired *t*- test was used to conduct test-retest reliability.

3.15.3 Further statistical analysis

Repeated measures ANOVA were conducted to determine whether there were statistically significant differences in mean hearing threshold levels at 500 to 8000 Hz on right and left ears between participants from Factory 1 and Factory 2 over six months. The repeated measures ANOVA were also conducted to determine the mean scores of various domains, i.e., knowledge, attitude (belief, feeling, judgment) and practice between participants from both study locations. This analysis was done after taking into account possible confounders. The reliability analysis was used to detect internal consistency of the questionnaire and exploratory factor analysis, using the principal axis method with Promax rotation, to identify items of the questionnaire to be grouped in the same factor. A *p*-value of less than 0.05 was considered statistically significant. The 95% CI or the effect sizes were calculated and reported for categorical and continuous variables in all statistical tests between participants from the two factories for comparison.

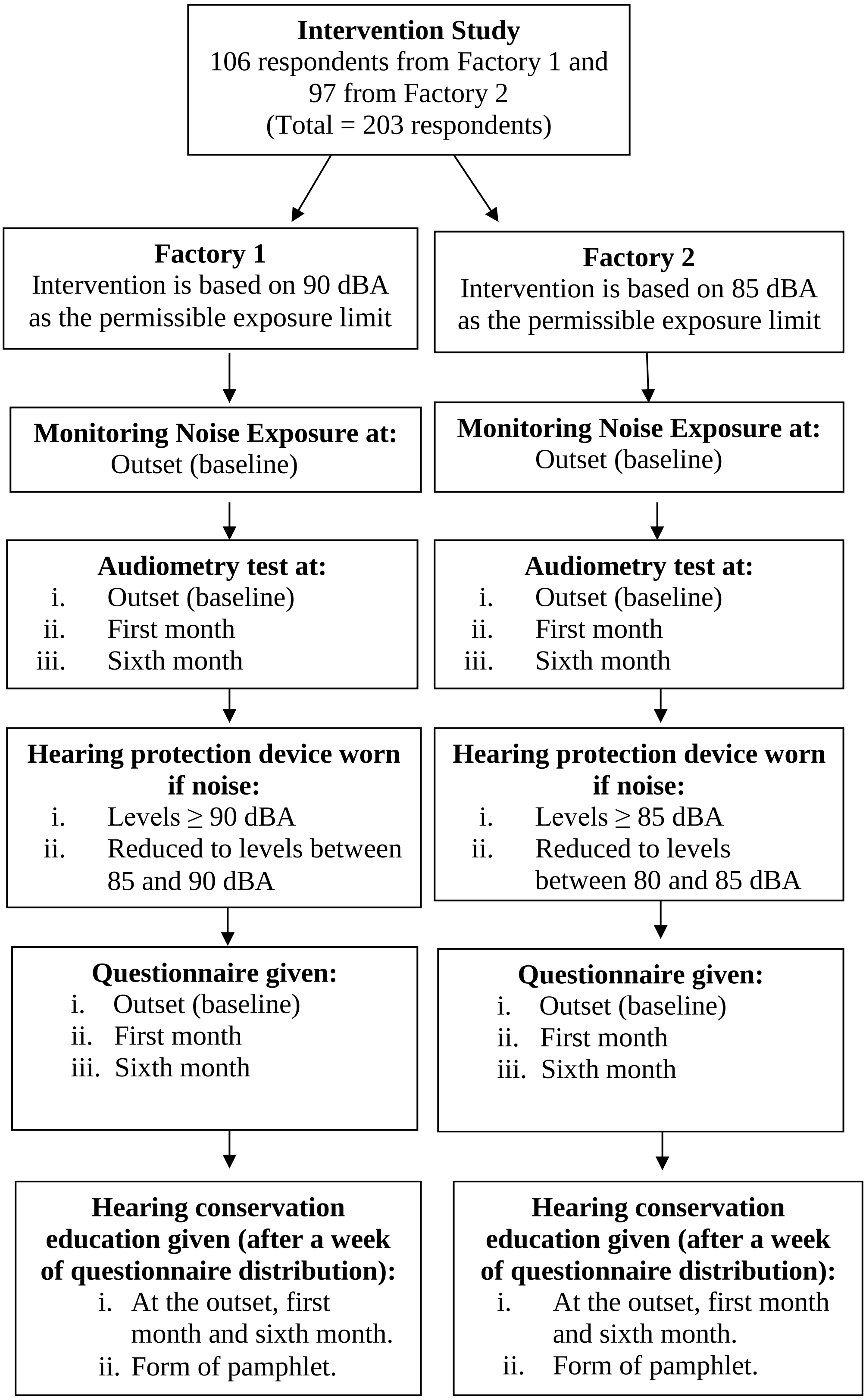
3.16 Ethical considerations

This trial is registered with Iranian Registry of Clinical Trials (registration ID: IRCT2013121515783N1). Ethical approval was obtained from the Research and Ethics Committee, University of Malaya (MEC Ref. No: 848.37), as shown in Appendix 24. Written authorization was then obtained from the relevant personnel to conduct the study in the automobile industry, as shown in Appendix 25. Participant information sheets were distributed to the employees specifying the study objectives and assuring confidentiality as well as the freedom to opt out at any time during the study are shown in Appendices 5 and 6. Contact details were given in the event participants required any clarification pertaining to the study. The written informed consent forms were collected before participants were allowed to take part in this study, as shown in Appendices 7 to 10.

3.17 Work plan and budget

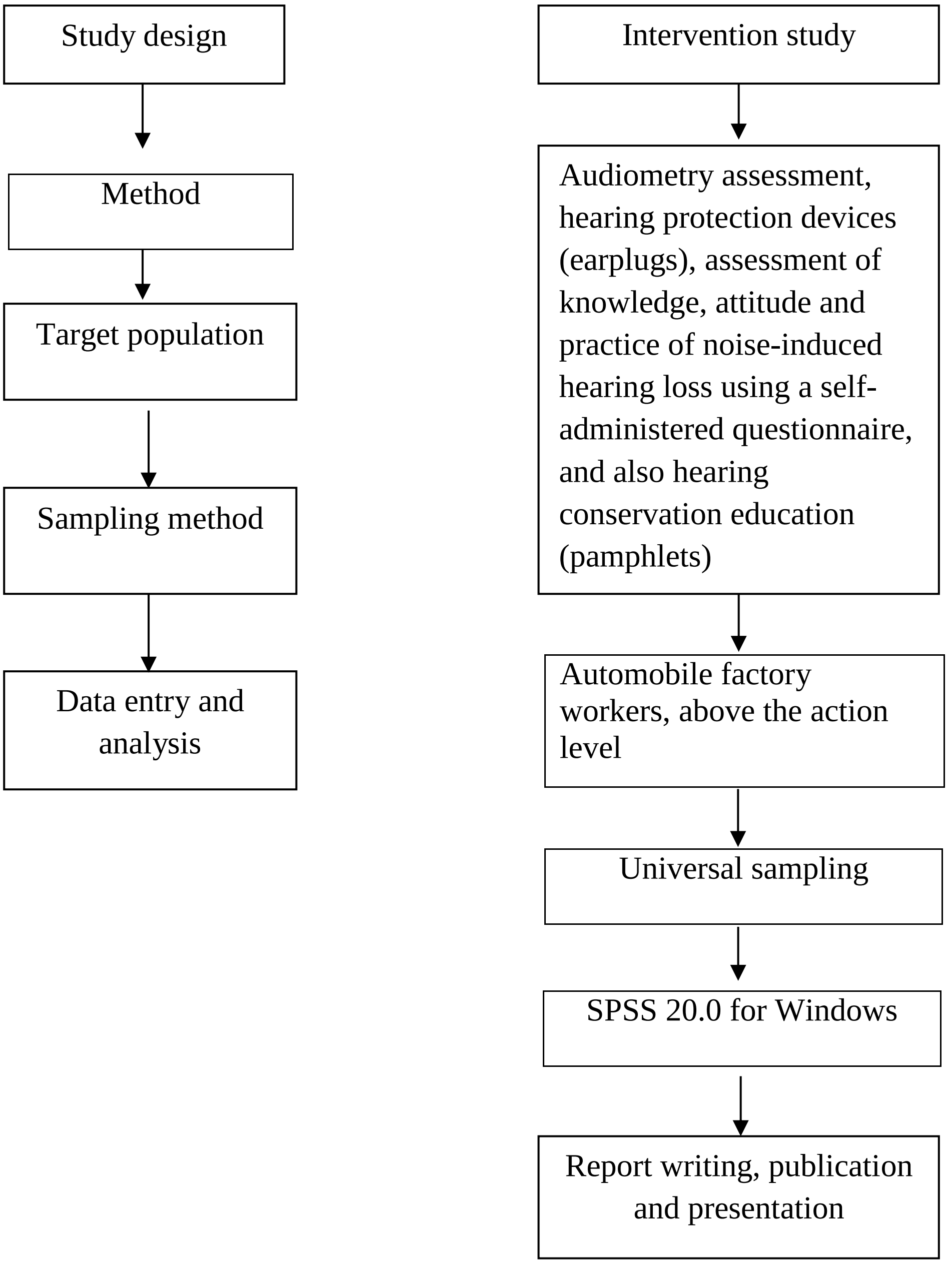
The work plan of the study was illustrated in Gantt chart, as shown in Appendix 23. This study is supported by the Post Graduate Research Grant (Grant number PV106/2011A) from the University of Malaya, Malaysia.

3.18 Flow chart



Outcomes	**Outcomes**
i. To compare mean hearing threshold levels at various frequencies between participants from the two factories. ii. To compare association of hearing threshold levels more than 25 dBA at various frequencies between participants from the two factories. iii. To compare association of standard threshold shifts between participants from the two factories. iv. To compare levels of knowledge, attitude and practice between participants from the two factories.	i. To compare mean hearing threshold levels at various frequencies between participants from the two factories. ii. To compare association of hearing threshold levels more than 25 dBA at various frequencies between participants from the two factories. iii. To compare association of standard threshold shifts between participants from the two factories. iv. To compare levels of knowledge, attitude and practice between participants from the two factories.

3.19 Research working framework



3.20 Summary

This intervention study evaluates the effectiveness of applying different permissible exposure limits on hearing thresholds; 90 and 85 dBA in Factory 1 and Factory 2, respectively. The study population was the general workers from the two factories in an automobile industry. The minimum sample size required was 52 workers in each factory. Universal sampling was applied in both study locations. The inclusion criterion was subjects who were exposed to levels above the action level, 85 and 80 dBA with the permissible exposure limit of 90 and 85 dBA in Factory 1 and Factory 2, respectively. The exchange rate of 5-dB was applied in both study locations. The exclusion criteria were those who refused to participate, contract workers, workers suffering from diseases of ear, physical trauma to ear, lorry drivers, workers who had undergone ear surgery and those who were diagnosed to have congenital hearing loss.

Noise level was measured using a personal exposure noise dosimeter and a sound level meter. They were fixed at the A-scale and a slow response, with a 5-dB exchange rate. The personal exposure noise dosimeter was set at 80-dB threshold level. Two portable audiometers and sound-proof booths were placed in a van, where data on hearing threshold levels were collected among the participants. Hearing threshold levels were measured at baseline (pre-shift) and then followed up at the first month (post-shift exposure) and again, at the sixth month (pre-shift). Data was collected at the first month based on a study of Stephenson *et al.* and sixth month according to the Factories and Machinery (Noise exposure) regulations 1989. Data on the hearing threshold levels were measured using a manual audiometer.

The face validity and content validity of the self-administered questionnaire were assessed appropriately. The reliability and exploratory factor analysis of the questionnaire were determined before dissemination to the main study locations. The distributed questionnaires extract data on sociodemographic and risk factors of hearing loss. The scores of knowledge, attitude (belief, feeling and judgment) and practice of workers towards noise-induced hearing loss were also mined through the questionnaire; the total scores were 9, 10, 20, 20 and 15 for knowledge, belief, feeling, judgment and practice constructs, respectively.

The primary outcomes of the study were to measure the mean hearing threshold levels, hearing threshold levels beyond 25 dBA and standard threshold shifts among participants between the two factories over six months. Hearing threshold level above 25 dBA is considered as hearing loss, and can be divided into mid-frequency (500 to below 3000 Hz) and high frequency hearing loss (3000 to 8000 Hz). Temporary threshold shifts may progress to permanent threshold shifts over time. Standard threshold shifts were calculated according to the Factories and Machinery (Noise exposure) regulations 1989, U.S. OSHA regulations and U.S. NIOSH recommended standard. The secondary outcome was to assess the scores obtained from each domain, i.e., knowledge, attitude (belief, feeling and judgment) and practice between participants from the two factories over a period of six months.

Hearing protection devices (earplugs) with appropriate NRR were used to reduce noise exposure among participants; the aim targeted was between 85 and 90 dBA in Factory 1, and between 80 and 85 dBA in Factory 2. Hearing conservation education (pamphlets) was distributed among participants exposed to noise levels above the action level at the outset, first month and sixth month a week after the distribution of the questionnaires.

Repeated measures ANOVA were conducted to determine a difference in mean hearing threshold levels and mean scores of various domains between the participants from the two factories. The Chi-square tests were used to compare association between the participants from the two factories and hearing threshold levels above 25 dBA, and also to assess link on standard threshold shifts. Fisher's exact test was used if the assumptions of the Chi-square test were not met.

CHAPTER 4

RESULTS

This chapter examines the results of mean hearing threshold levels, hearing threshold levels above 25 dBA and standard threshold shifts between participants from the two factories, adopting different permissible exposure limits (90 and 85 dBA in Factory 1 and Factory 2, respectively) over a period of six months. Similarly, the mean scores of knowledge, attitude and practice of participants from the two factories are also reported, besides the reliability and factor analysis of the questionnaire.

4.1 Participants' sociodemographic characteristics

The sampling frame consisted of 260 employees of an automobile industry from February till August 2012. A total of 203 employees participated in the study. The nonrespondents were busy with their work procedure and also those with a personal predilection not to participate in the study.

All the participants were Malaysians of mean age of 27.1 ± 6.56 years as depicted in Table 4.1. More than 95% of them were Malay males. Most of these workers were single and more than two third ever smoked. About 97% had never consumed alcohol. More than two third of these employees had primary or secondary school education and hence, most of them were earning less than RM 3000 a month; low income payees earn below RM 3000 a month in Malaysia (Mohd, 2009). The mean duration of employment in the automobile industry was 2.4 ± 2.05 years. More than a third were exposed to hobbies with an increased risk of hearing loss, i.e., listening to loud music, scuba diving or shooting. More than 90% were exposed to chemicals with an increased risk of hearing loss and more than two third were exposed to hand-arm vibration. The workers exposed to chemicals with an increased risk of hearing loss and hand-arm vibration of various departments in each factory are shown in Appendices 18 and 19. Almost all never took medication with an increased risk of hearing loss and none of them had surgeries on the ears. Of the 203 employees, there were 106 participants from Factory 1 and the remaining 97 from Factory 2. The participants from the two factories were exposed to a fluctuating type of noise

Table 4.1: Participants' sociodemographic characteristics

Sociodemographic variables	**Frequency (%)** ***n* = 203**
Gender	
Male	193 (95.1)
Female	10 (4.9)
Age	
Mean (SD) years	27.12 (6.56)
Median	25.78
Range	17.59 – 54.46
Race	
Malay	198 (97.5)
Non-Malay	5 (2.5)
Religion	
Islam	200 (98.5)
Non-Islam	3 (1.5)
Marital status	
Single	125 (61.6)
Ever married	78 (38.4)
Education level	
Primary and Secondary school	137 (67.5)
Form Six, Certificate, College and University	66 (32.5)
Income	
<3000	184 (90.6)
3000 and above	19 (9.4)
Smoking	
No smoking	65 (32.0)
Ever smoked	138 (68.0)
Alcohol consumption	
Not consuming alcohol	196 (96.6)
Ever consumed alcohol	7 (3.4)
Duration of work	
Mean (SD) years	2.41 ± 2.05
Median	2.00
Range	0.08 - 11

Table 4.1, continued

Sociodemographic variables	Frequency (%) *n* = 203
Factory	
Factory 1	106 (52.2)
Factory 2	97 (47.8)
Exposure to chemicals with an increased risk of hearing loss (Appendix 18)	
Exposed	189 (93.1)
Not exposed	14 (6.9)
Exposure to hand-arm vibration (Appendix 19)	
Exposed	149 (73.4)
Not exposed	54 (26.6)
Surgery to ear	
Yes	0 (0.0)
No	203 (100.0)
Exposure to hobbies with an increased risk of hearing loss	
Exposed	73 (36.0)
Not exposed	130 (64.0)
Medication with an increased risk of hearing loss	
Yes	2 (1.0)
No	201 (99.0)

The basic sociodemographic characteristics and risk factors of hearing loss were compared between participants from Factory 1 and Factory 2 as shown in Table 4.2. All the independent variables between the factories were not statistically significant different, except the variable of exposure to chemicals with an increased risk of hearing loss. All the subjects in Factory 2 were exposed to the chemicals, whereas almost 87% of them exposed in Factory 1.

Table 4.2: Comparison of independent variables between participants from Factory 1 and Factory 2

Characteristics/ Risk factors	**Factory 1 (*n* = 106) Freq (%)**	**Factory 2 (*n* = 97) Freq (%)**	***p* value**
Gender			
Male	103 (97.2)	90 (92.8)	0.199[a]
Female	3 (2.8)	7 (7.2)	
Age			
Mean (SD)	27.94 (7.25)[b]	26.22 (5.60)[b]	0.060[c]
Education level			
Primary and Secondary School	69 (65.1)	68 (70.1)	0.447[d]
Form Six, Certificate, College and University	37 (34.9)	29 (29.9)	
Smoking			
Ever smoked	74 (69.8)	64 (66.0)	0.559[d]
No smoking	32 (30.2)	33 (34.0)	
Alcohol consumption			
Ever consumed alcohol	3 (2.8)	4 (4.1)	0.712[a]
Not consumed alcohol	103 (97.2)	93 (95.9)	
Duration of work			
Mean (SD)	2.45 (2.11)	2.37 (2.00)	0.798[c]
Exposure to chemicals with an increased risk of hearing loss			
Exposed	92 (86.8)	97 (100.0)	<0.001[d]
Not exposed	14 (13.2)	0 (0.0)	
Exposure to hand-arm vibration			
Exposed	83 (78.3)	66 (68.0)	0.098[d]
Not Exposed	23 (21.7)	31 (32.0)	
Exposure to hobbies with an increased risk of hearing			
loss	40 (37.7)	33 (34.0)	0.582[d]
Exposed	66 (62.3)	64 (66.0)	
Not exposed			
Medication with an increased risk of hearing loss			
Yes	1 (0.9)	1 (1.0)	1.000[a]
No	105 (99.1)	96 (99.0)	

[a]Statistical significance is based on Fisher's exact test
[b]Data represents mean (SD)
[c]Statistical significance is based on Independent *t* test
[d]Statistical significance is based on Chi-square test for independence
Freq, Frequency

In Factory 1, the employees were working in the Production Control (PC), Quality Control (QC) Press, welding and maintenance departments, while in Factory 2, the workers were in the PC, QC Resin, Kaizen and also painting departments. There were more than a fifth of subjects in each department. Noise levels of source and area of the two factories is depicted in Appendices 16, 21 and 22, while that of personal exposure noise monitoring results of the participants of each department is shown in Appendix 17. Noise level within the van, where data on hearing threshold levels were collected among the participants through portable audiometers, was 25 dBA. Generally, noise measurement using sound level meter showed a higher level of noise exposure than average exposure levels of personal exposure noise dosimeter. Hence, noise levels that of sound level meter were used as noise exposure of the participants for calculating NRR. The mean noise exposure of participants from each department is shown in Table 4.3. The mean noise exposures of the participants from the two factories were compared. There was no difference of noise exposure between participants from the two factories, [0.275 (95% CI, -0.42 to 0.97) dBA, t (164) = 0.78, p = 0.436].

Table 4.3: Comparison of noise exposure between participants from Factory 1 and Factory 2

Factory	**Departments**	**Leq (hours)**	**Frequency (%)** ***n* = 203**	**Mean (SD) dBA**
Factory 1 (*n* = 106)	PC and QC Press	8	41 (20.2)	90.8 (0.75)
	Welding and Maintenance	8	65 (32.0)	87.2 (1.60)
Factory 2 (*n* = 97)	PC Resin and QC Resin	8	44 (21.7)	88.6 (1.62)
	Kaizen and Painting	8	53 (26.1)	90.1 (2.50)

4.2 Comparing mean hearing threshold levels between participants from Factory 1 and Factory 2

4.2.1 Comparing mean hearing threshold levels between participants from the two factories at baseline

An independent sample *t*-test was used to compare the mean (Chinna, et al., 2012; Stephens, 2009) hearing threshold levels between participants from Factory 1 and Factory 2. This *t*-test was run to determine if there were differences in mean hearing threshold levels from 500 to 8000 Hz on right and left ears at baseline. There was homogeneity of variances, as assessed by Levene's test for equality of variances at all the tested frequencies on both ears. As depicted in Table 4.4, there were no statistically significant differences in the mean hearing threshold levels at all the frequencies between participants from the two factories at the outset.

Table 4.4: Comparison of mean hearing threshold levels between participants from Factory 1 and Factory 2 at baseline

Frequency (Ear)	Factory 1 (*n*=106) Mean (SD) dBA	Factory 2 (*n*=97) Mean (SD) dBA	Mean difference (95% CI) dBA	*t* statistic (*df*)	*p* value*
500 (Right)	22.59 (9.14)	22.78 (7.60)	0.19 (-2.15 to 2.53)	0.16 (201)	0.873
500 (Left)	18.44 (5.95)	19.54 (5.45)	1.09 (-0.49 to 2.68)	-1.36 (201)	0.175
1000 (Right)	20.42 (10.05)	19.64 (6.82)	0.79 (-1.61 to 3.18)	0.65 (201)	0.519
1000 (Left)	18.25 (6.40)	18.61 (5.81)	0.35 (-1.34 to 2.05)	-0.41 (201)	0.682
2000 (Right)	19.34 (10.07)	18.51 (6.97)	0.83 (-1.58 to 3.25)	0.68 (201)	0.497
2000 (Left)	17.45 (6.91)	17.73 (5.68)	0.28 (-1.48 to 2.04)	-0.31 (201)	0.755
3000 (Right)	19.53 (11.25)	18.14 (8.40)	1.38 (-1.38 to 4.15)	0.99 (201)	0.325
3000 (Left)	17.74 (7.34)	18.14 (7.34)	0.41 (-1.63 to 2.44)	-0.40 (201)	0.692
4000 (Right)	20.66 (11.71)	19.18 (10.20)	1.49 (-1.57 to 4.54)	0.96 (201)	0.338
4000 (Left)	18.54 (8.11)	18.76 (8.75)	0.23 (-2.11 to 2.56)	-0.19 (201)	0.849
6000 (Right)	27.78 (14.74)	26.96 (15.64)	0.82 (-3.38 to 5.03)	0.39 (201)	0.699
6000 (Left)	25.09 (12.76)	23.20 (11.14)	1.90 (-1.43 to 5.23)	1.13 (201)	0.262
8000 (Right)	16.65 (14.26)	15.88 (15.05)	0.78 (-3.28 to 4.83)	0.38 (201)	0.707
8000 (Left)	15.99 (12.79)	15.21 (11.39)	0.78 (-2.58 to 4.15)	0.46 (201)	0.646

* Statistical significance is based on Independent *t*-test

4.2.2 Comparing mean hearing threshold levels between participants from the two factories of post-shift exposure at the first month based on intention-to-treat analysis

Repeated measures ANOVA (Cohen, et al., 2011; Jennings, 1988; Krueger & Tian, 2004) were conducted to determine whether there were statistically significant differences in the mean hearing threshold levels at 500 to 8000 Hz on right and left ears between the participants from Factory 1 and Factory 2 upon adopting different permissible exposure limits at the first month, based on intention-to-treat analysis. The intervention of applying different permissible exposure limits elicited statistically significant changes in the mean hearing threshold levels over time, i.e., the mean hearing threshold levels increased from pre-intervention to post-intervention among participants from Factory 1 and Factory 2 at 1000 Hz on right ear (0.73; 95% CI, 0.09-1.37 dBA, p = 0.026, partial η^2 = 0.025), 2000 Hz on right ear (0.74; 95% CI, 0.14-1.35 dBA, p = 0.015, partial η^2 = 0.029), 2000 Hz on left ear (0.99; 95% CI, 0.35-1.63 dBA, p = 0.003, partial η^2 = 0.044), 3000 Hz on right ear (1.10; 95% CI, 0.42-1.77 dBA, p = 0.002, partial η^2 = 0.049), 3000 Hz on left ear (1.33; 95% CI, 0.69-1.96 dBA, p < 0.001, partial η^2 = 0.078), 4000 Hz on right ear (1.52; 95% CI, 0.72-2.32 dBA, p < 0.001, partial η^2 = 0.065), 4000 Hz on left ear (1.33; 95% CI, 0.59-2.07 dBA, p < 0.001, partial η^2 = 0.059), 6000 Hz on left ear (1.03; 95% CI, 0.05-2.01 dBA, p = 0.039, partial η^2 = 0.021), 8000 Hz on right ear (1.24; 95% CI, 0.13-2.35 dBA, p = 0.029, partial η^2 = 0.023) and 8000 Hz on left ear (1.09; 95% CI, 0.10-2.09 dBA, p = 0.032, partial η^2 = 0.023). However, as shown in Table 4.5, there were no differences in the mean hearing threshold levels at these frequencies between participants from the two factories. Hence, there was no effect in the mean hearing threshold levels at all the tested frequencies on both ears upon adopting different permissible exposure limits.

Table 4.5: Comparison of mean hearing threshold levels between participants from Factory1 and Factory 2 at the first month based on intention-to-treat analysis

Frequency	Ear	Time Period	Factory 1 (*n* = 106) Mean (SD) dBA	Factory 2 (*n* = 97) Mean (SD) dBA	Repeated measures ANOVA Mean (95% CI) dBA	*p* value*
500	Right	Baseline	22.59 (9.14)	22.78 (7.60)	0.28 (-1.91 to 2.46)	0.803
		First month	21.70 (8.86)	22.06 (7.90)		
500	Left	Baseline	18.44 (5.95)	19.54 (5.45)	0.73 (-0.78 to 2.24)	0.344
		First month	18.92 (6.25)	19.28 (5.59)		
1000	Right	Baseline	20.42 (10.05)	19.64 (6.82)	1.00 (-1.26 to 3.26)	0.384
		First month	21.37 (9.72)	20.15 (6.31)		
1000	Left	Baseline	18.25 (6.40)	18.61 (5.81)	0.23 (-1.40 to 1.86)	0.783
		First month	18.87 (6.30)	18.97 (6.16)		
2000	Right	Baseline	19.34 (10.07)	18.51 (6.97)	0.70 (-1.68 to 3.09)	0.561
		First month	19.95 (10.18)	19.38 (7.51)		
2000	Left	Baseline	17.45 (6.91)	17.73 (5.68)	0.94 (-0.80 to 2.68)	0.288
		First month	17.78 (6.73)	19.38 (7.30)		
3000	Right	Baseline	19.53 (11.25)	18.14 (8.40)	1.14 (-1.64 to 3.92)	0.420
		First month	20.38 (11.83)	19.48 (9.20)		
3000	Left	Baseline	17.74 (7.34)	18.14 (7.34)	0.89 (-1.12 to 2.89)	0.384
		First month	18.58 (7.36)	19.95 (8.28)		
4000	Right	Baseline	20.66 (11.71)	19.18 (10.20)	1.15 (-1.86 to 4.15)	0.452
		First month	21.84 (12.16)	21.03 (10.56)		
4000	Left	Baseline	18.54 (8.11)	18.76 (8.75)	0.24 (-1.96 to 2.43)	0.833
		First month	19.86 (8.06)	20.10 (8.60)		
6000	Right	Baseline	27.78 (14.74)	26.96 (15.64)	1.05 (-2.97 to 5.08)	0.606
		First month	28.96 (14.60)	27.68 (15.88)		
6000	Left	Baseline	25.09 (12.76)	23.20 (11.14)	1.95 (-1.19 to 5.09)	0.221
		First month	26.18 (12.39)	24.18 (10.91)		
8000	Right	Baseline	16.65 (14.26)	15.88 (15.05)	0.10 (-3.77 to 3.98)	0.958
		First month	17.22 (13.99)	17.78 (14.98)		
8000	Left	Baseline	15.99 (12.79)	15.21 (11.39)	0.02 (-3.21 to 3.26)	0.989
		First month	16.32 (12.77)	17.06 (11.77)		

* Statistical significance is based on repeated measures ANOVA

4.2.3 Comparing mean hearing threshold levels between participants from the two factories of post-shift exposure at the first month as per-protocol analysis

Repeated measures ANOVA were conducted to determine whether there were statistically significant differences in the mean hearing threshold levels at 500 to 8000 Hz on right and left ears between the participants from Factory 1 and Factory 2 upon adopting different permissible exposure limits at the first month as per-protocol analysis. The intervention on applying different permissible exposure limits elicited statistically significant changes in the mean hearing threshold levels over time, i.e., the mean hearing threshold levels increased from pre-intervention to post-intervention among participants from Factory 1 and Factory 2 at 1000 Hz on right ear (1.19; 95% CI, 0.17-2.21 dBA, $p = 0.022$, partial $\eta^2 = 0.041$), 2000 Hz on right ear (1.18; 95% CI, 0.22-2.14 dBA, $p = 0.016$, partial $\eta^2 = 0.045$), 2000 Hz on left ear (1.51; 95% CI, 0.49-2.53 dBA, $p = 0.004$, partial $\eta^2 = 0.065$), 3000 Hz on right ear (1.73; 95% CI, 0.66-2.79 dBA, $p = 0.002$, partial $\eta^2 = 0.076$), 3000 Hz on left ear (2.07; 95% CI, 1.08-3.07 dBA, $p < 0.001$, partial $\eta^2 = 0.119$), 4000 Hz on right ear (2.39; 95% CI, 1.13-3.66 dBA, $p < 0.001$, partial $\eta^2 = 0.101$), 4000 Hz on left ear (2.13; 95% CI, 0.97-3.29 dBA, $p < 0.001$, partial $\eta^2 = 0.095$), 6000 Hz on left ear (1.66; 95% CI, 0.09-3.23 dBA, $p = 0.038$, partial $\eta^2 = 0.034$), 8000 Hz on right ear (1.91; 95% CI, 0.14-3.68 dBA, $p = 0.035$, partial $\eta^2 = 0.035$) and 8000 Hz on left ear (1.67; 95% CI, 0.08-3.25 dBA, $p = 0.040$, partial $\eta^2 = 0.033$). However, as shown in Table 4.6, there were no differences in the mean hearing threshold levels at these frequencies between participants from the two factories. Hence, there was no effect in the mean hearing threshold levels at all the tested frequencies on both ears upon adopting different permissible exposure limits.

Table 4.6: Comparison of mean hearing threshold levels between participants from Factory 1 and Factory 2 at the first month as per-protocol analysis

Frequency	**Ear**	**Time Period**	**Factory1 (*n* = 62) Mean (SD) dBA**	**Factory 2 (*n* = 65) Mean (SD) dBA**	**Repeated measures ANOVA Mean (95% CI) dBA**	***p* value***
500	Right	Baseline	22.02 (7.33)	23.15 (8.41)	1.37 (-1.06 to 3.79)	0.267
		First month	20.48 (6.51)	22.08 (8.83)		
500	Left	Baseline	18.47 (5.77)	19.54 (5.78)	0.48 (-1.40 to 2.35)	0.618
		First month	19.27 (6.26)	19.15 (5.97)		
1000	Right	Baseline	19.84 (7.24)	20.15 (7.50)	0.11 (-2.13 to 2.35)	0.925
		First month	21.45 (6.49)	20.92 (6.73)		
1000	Left	Baseline	18.95 (6.96)	18.62 (5.90)	0.59 (-1.52 to 2.71)	0.581
		First month	20.00 (6.65)	19.15 (6.41)		
2000	Right	Baseline	19.60 (8.88)	18.77 (7.29)	0.70 (-2.06 to 3.46)	0.617
		First month	20.65 (9.03)	20.08 (7.98)		
2000	Left	Baseline	18.23 (7.58)	17.69 (5.31)	0.42 (-1.82 to 2.65)	0.713
		First month	18.79 (7.23)	20.15 (7.60)		
3000	Right	Baseline	19.60 (8.11)	18.46 (8.47)	0.86 (-2.07 to 3.80)	0.563
		First month	21.05 (8.29)	20.46 (9.51)		
3000	Left	Baseline	18.15 (7.70)	18.15 (7.68)	0.63 (-1.99 to 3.25)	0.636
		First month	19.60 (7.59)	20.85 (8.86)		
4000	Right	Baseline	21.53 (11.00)	18.54 (10.22)	2.62 (-1.00 to 6.23)	0.154
		First month	23.55 (11.57)	21.31 (10.80)		
4000	Left	Baseline	19.44 (8.00)	18.46 (9.10)	1.10 (-1.61 to 3.82)	0.423
		First month	21.69 (7.52)	20.46 (8.87)		
6000	Right	Baseline	27.58 (14.11)	26.08 (13.65)	1.97 (-2.49 to 6.44)	0.384
		First month	29.60 (13.83)	27.15 (14.11)		
6000	Left	Baseline	24.52 (11.19)	22.62 (10.12)	2.10 (-1.20 to 5.40)	0.211
		First month	26.37 (10.49)	24.08 (9.80)		
8000	Right	Baseline	16.37 (12.32)	14.00 (12.88)	1.43 (-2.60 to 5.46)	0.484
		First month	17.34 (11.80)	16.85 (13.07)		
8000	Left	Baseline	15.48 (10.59)	14.46 (9.89)	0.08 (-3.22 to 3.38)	0.962
		First month	16.05 (10.56)	17.23 (10.61)		

* Statistical significance is based on repeated measures ANOVA

4.2.4 Comparing mean hearing threshold levels between participants from the two factories of pre-shift exposure at the sixth month based on intention-to-treat analysis

Repeated measures ANOVA were conducted to determine whether there were statistically significant differences in the mean hearing threshold levels at 500 to 8000 Hz on right and left ears between the participants from Factory 1 and Factory 2 upon adopting different permissible exposure limits at the sixth month based on intention-to-treat analysis. The intervention on applying different permissible exposure limits elicited statistically significant changes in the mean hearing threshold levels over time, i.e., the mean hearing threshold levels increased from pre-intervention to post-intervention among participants from Factory 1 and Factory 2 at 500 Hz on right ear (2.43; 95% CI, 1.41-3.44 dBA, $p < 0.001$, partial $\eta^2 = 0.100$), 500 Hz on left ear (4.04; 95% CI, 3.06-5.03 dBA, $p < 0.001$, partial $\eta^2 = 0.247$), 1000 Hz on right ear (5.47; 95% CI, 4.34-6.59 dBA, $p < 0.001$, partial $\eta^2 = 0.313$), 1000 Hz on left ear (4.62; 95% CI, 3.71-5.52 dBA, $p < 0.001$, partial $\eta^2 = 0.335$), 2000 Hz on right ear (4.73; 95% CI, 3.71-5.74 dBA, $p < 0.001$, partial $\eta^2 = 0.296$), 2000 Hz on left ear (4.70; 95% CI, 3.72-5.68 dBA, $p < 0.001$, partial $\eta^2 = 0.308$), 3000 Hz on right ear (4.84; 95% CI, 3.83-5.85 dBA, $p < 0.001$, partial $\eta^2 = 0.308$), 3000 Hz on left ear (5.26; 95% CI, 4.24-6.28 dBA, $p < 0.001$, partial $\eta^2 = 0.338$), 4000 Hz on right ear (6.02; 95% CI, 4.82-7.22 dBA, $p < 0.001$, partial $\eta^2 = 0.330$), 4000 Hz on left ear (5.96; 95% CI, 4.82-7.10 dBA, $p < 0.001$, partial $\eta^2 = 0.346$), 6000 Hz on right ear (4.17; 95% CI, 2.66-5.68 dBA, $p < 0.001$, partial $\eta^2 = 0.128$), 6000 Hz on left ear (4.47; 95% CI, 3.14-5.81 dBA, $p < 0.001$, partial $\eta^2 = 0.178$), 8000 Hz on right ear (3.87; 95% CI, 2.59-5.14 dBA, $p < 0.001$, partial $\eta^2 = 0.151$) and 8000 Hz on left ear (3.10; 95% CI, 2.00-4.21 dBA, $p < 0.001$, partial $\eta^2 = 0.132$). However, as shown in Table 4.7, there were no differences in the mean hearing threshold levels at these frequencies between participants from the two factories. Hence, there was no effect in the mean hearing threshold levels at all the tested frequencies on both ears upon adopting different permissible exposure limits.

Table 4.7: Comparison of mean hearing threshold levels between participants from Factory 1 and Factory 2 at the sixth month based on intention-to-treat analysis

Frequency	**Ear**	**Time Period**	**Factory 1 (*n* = 106) Mean (SD) dBA**	**Factory 2 (*n* = 97) Mean (SD) dBA**	**Repeated measures ANOVA Mean (95% CI) dBA**	***p* value***
500	Right	Baseline	22.59 (9.14)	22.78 (7.60)	0.59 (-1.62 to 2.80)	0.600
		Sixth month	25.80 (9.71)	24.43 (8.44)		
500	Left	Baseline	18.44 (5.95)	19.54 (5.45)	0.09 (-1.57 to 1.75)	0.915
		Sixth month	23.49 (8.87)	22.58 (6.96)		
1000	Right	Baseline	20.42 (10.05)	19.64 (6.82)	1.41 (-0.99 to 3.80)	0.249
		Sixth month	26.51 (11.80)	24.48 (8.55)		
1000	Left	Baseline	18.25 (6.40)	18.61 (5.81)	0.50 (-1.30 to 2.30)	0.584
		Sixth month	23.73 (8.62)	22.37 (7.84)		
2000	Right	Baseline	19.34 (10.07)	18.51 (6.97)	1.49 (-1.01 to 3.98)	0.241
		Sixth month	24.72 (11.85)	22.58 (9.08)		
2000	Left	Baseline	17.45 (6.91)	17.73 (5.68)	0.17 (-1.74 to 2.07)	0.863
		Sixth month	22.26 (8.95)	22.32 (8.81)		
3000	Right	Baseline	19.53 (11.25)	18.14 (8.40)	1.59 (-1.21 to 4.39)	0.264
		Sixth month	24.58 (13.08)	22.78 (9.33)		
3000	Left	Baseline	17.74 (7.34)	18.14 (7.34)	0.15 (-2.02 to 2.32)	0.892
		Sixth month	23.25 (10.14)	23.14 (9.45)		
4000	Right	Baseline	20.66 (11.71)	19.18 (10.20)	1.79 (-1.34 to 4.90)	0.261
		Sixth month	26.98 (14.40)	24.90 (11.30)		
4000	Left	Baseline	18.54 (8.11)	18.76 (8.75)	0.42 (-1.96 to 2.80)	0.727
		Sixth month	25.14 (10.43)	24.07 (10.57)		
6000	Right	Baseline	27.78 (14.74)	26.96 (15.64)	1.33 (-2.76 to 5.42)	0.522
		Sixth month	32.45 (16.59)	30.62 (15.95)		
6000	Left	Baseline	25.09 (12.76)	23.20 (11.14)	1.58 (-1.70 to 4.85)	0.343
		Sixth month	29.25 (13.50)	27.99 (13.42)		
8000	Right	Baseline	16.65 (14.26)	15.88 (15.05)	0.26 (-3.63 to 4.14)	0.896
		Sixth month	20.00 (14.72)	20.26 (15.06)		
8000	Left	Baseline	15.99 (12.79)	15.21 (11.39)	0.84 (-2.45 to 4.14)	0.614
		Sixth month	19.15 (13.30)	18.25 (12.48)		

* Statistical significance is based on repeated measures ANOVA

4.2.5 Comparing mean hearing thresholds levels between participants from the two factories of pre-shift exposure at the sixth month as per-protocol analysis

Repeated measures ANOVA were conducted to determine whether there were statistically significant differences in the mean hearing threshold levels at 500 to 8000 Hz on right and left ears between participants from Factory 1 and Factory 2 upon adopting different permissible exposure limits at the sixth month as per-protocol analysis. The intervention on applying different permissible exposure limits elicited statistically significant changes in the mean hearing threshold levels over time, i.e., the mean hearing threshold levels increased from pre-intervention to post-intervention among participants from Factory 1 and Factory 2 at 500 Hz on right ear (7.45; 95% CI, 6.05-8.84 dBA, $p < 0.001$, partial $\eta^2 = 0.567$), 500 Hz on left ear (9.05; 95% CI, 7.57-10.53 dBA, $p < 0.001$, partial $\eta^2 = 0.632$), 1000 Hz on right ear (12.46; 95% CI, 11.08-13.84 dBA, $p < 0.001$, partial $\eta^2 = 0.789$), 1000 Hz on left ear (9.95; 95% CI, 8.73-11.16 dBA, $p < 0.001$, partial $\eta^2 = 0.755$), 2000 Hz on right ear (10.34; 95% CI, 8.96-11.77 dBA, $p < 0.001$, partial $\eta^2 = 0.714$), 2000 Hz on left ear (9.54; 95% CI, 8.16-10.92 dBA, $p < 0.001$, partial $\eta^2 = 0.687$), 3000 Hz on right ear (9.90; 95% CI, 8.34-11.45) dBA, $p < 0.001$, partial $\eta^2 = 0.650$), 3000 Hz on left ear (10.08; 95% CI, 8.43-11.74 dBA, $p < 0.001$, partial $\eta^2 = 0.631$), 4000 Hz on right ear (12.47; 95% CI, 10.80-14.14 dBA, $p < 0.001$, partial $\eta^2 = 0.718$), 4000 Hz on left ear (12.52; 95% CI, 11.00-14.04 dBA, $p < 0.001$, partial $\eta^2 = 0.756$), 6000 Hz on right ear (9.67; 95% CI, 7.14-12.20 dBA, $p < 0.001$, partial $\eta^2 = 0.401$), 6000 Hz on left ear (9.55; 95% CI, 7.34-11.77 dBA, $p < 0.001$, partial $\eta^2 = 0.461$), 8000 Hz on right ear (9.04; 95% CI, 6.99-11.09 dBA, $p < 0.001$, partial $\eta^2 = 0.472$) and 8000 Hz on left ear (7.35; 95% CI, 5.55-9.16 dBA, $p < 0.001$, partial $\eta^2 = 0.433$).

The mean hearing threshold levels at 3000 Hz on right ear was statistically significantly lower among participants in Factory 2 adopting 85 dBA compared to those from Factory 1 on 90 dBA, (3.17; 95% CI, 0.04-6.30 dBA, p = 0.048, partial η^2 = 0.045). According to Portney and Watkins (2009), the effect size was "small" (Portney & Watkins, 2009). There were no significant differences in the mean hearing threshold levels elicited by the other variables, i.e., age, education level, income, smoking, alcohol consumption, duration of work exposure, chemicals and hobbies with an increased risk of hearing loss and also exposure to hand-arm vibration between participants from the two factories over a period of six months.

The mean hearing threshold levels at 4000 Hz on right ear was statistically significantly lower among participants in Factory 2 adopting 85 dBA compared to those from Factory 1 on 90 dBA, (4.45; 95% CI, 0.05-8.84 dBA, p = 0.047, partial η^2 = 0.045). According to Portney and Watkins (2009), the effect size was "small" (Portney & Watkins, 2009). The participants who were exposed to the chemicals with an increased risk of hearing loss showed that the mean hearing threshold levels at 4000 Hz on right ear was statistically significantly lower compared to those who were not exposed, (11.81; 95% CI, 4.88-18.74 dBA, p = 0.001, partial η^2 = 0.089). According to Portney and Watkins (2009), the effect size was "moderate" (Portney & Watkins, 2009). There were no significant differences in the mean hearing threshold levels elicited by the other variables, i.e., age, education level, income, smoking, alcohol consumption, duration of work exposure, exposure to hand-arm vibration and also exposure to hobbies with an increased risk of hearing loss between both study groups over six months period.

Hence, the participants from the Factory 2 (embraced 85 dBA) maintained lower hearing threshold levels at 3000 and 4000 Hz on right ear compared to those from the Factory 1 (embraced 90 dBA). However, at other tested frequencies, there were no differences between participants from the two factories in either ear as shown in Table 4.8.

Table 4.8: Comparison of mean hearing threshold levels between participants from Factory 1 and Factory 2 at the sixth month as per-protocol analysis

Frequency	**Ear**	**Time Period**	**Factory1 (*n* = 48) Mean (SD) dBA**	**Factory 2 (*n* = 40) Mean (SD) dBA**	**Repeated measures ANOVA Mean (95% CI) dBA**	***p* value***
500	Right	Baseline	22.08 (5.73)	20.63 (5.21)	1.41 (-0.73 to 3.55)	0.195
		Sixth month	29.48 (7.01)	28.12 (5.74)		
500	Left	Baseline	18.02 (4.70)	18.87 (8.54)	0.20 (-1.94 to 2.34)	0.854
		Sixth month	28.12 (8.54)	26.87 (5.51)		
1000	Right	Baseline	18.96 (6.44)	19.00 (4.56)	0.42 (-2.07 to 2.91)	0.740
		Sixth month	31.88 (8.79)	31.00 (5.80)		
1000	Left	Baseline	18.13 (5.42)	19.12 (5.30)	0.20 (-2.00 to 2.39)	0.858
		Sixth month	29.27 (6.84)	27.88 (5.76)		
2000	Right	Baseline	18.96 (8.63)	18.00 (6.58)	1.95 (-1.39 to 5.29)	0.249
		Sixth month	30.31 (10.08)	27.38 (8.01)		
2000	Left	Baseline	17.71 (6.01)	18.12 (4.49)	0.25 (-2.05 to 2.55)	0.829
		Sixth month	27.92 (6.83)	27.00 (7.41)		
3000	Right	Baseline	19.90 (7.68)	17.25 (7.84)	3.17 (0.04 to 6.30) partial η^2 = 0.045	0.048
		Sixth month	30.31 (9.70)	26.63 (7.20)		
3000	Left	Baseline	18.33 (6.95)	17.37 (6.89)	1.92 (-1.18 to 5.01)	0.222
		Sixth month	29.38 (9.54)	26.50 (9.21)		
4000	Right	Baseline	21.35 (11.57)	17.88 (8.69)	4.45 (0.05 to 8.84) partial η^2 = 0.045	0.047
		Sixth month	34.79 (13.21)	29.38 (9.55)		
4000	Left	Baseline	17.92 (7.35)	17.88 (8.23)	1.06 (-2.32 to 4.44)	0.534
		Sixth month	31.46 (9.39)	29.38 (9.75)		
6000	Right	Baseline	29.17 (13.93)	26.38 (14.37)	3.96 (-1.65 to 9.57)	0.164
		Sixth month	40.00 (16.18)	34.88 (12.88)		
6000	Left	Baseline	26.15 (10.73)	23.63 (10.50)	1.20 (-3.25 to 5.65)	0.594
		Sixth month	34.38 (11.23)	34.50 (14.18)		
8000	Right	Baseline	16.88 (11.47)	13.00 (13.77)	2.54 (-2.43 to 7.51)	0.312
		Sixth month	24.58 (12.50)	23.38 (12.93)		
8000	Left	Baseline	15.94 (10.30)	14.12 (10.49)	1.54 (-2.91 to 5.99)	0.493
		Sixth month	23.02 (11.29)	21.75 (13.04)		

* Statistical significance is based on repeated measures ANOVA

4.3 Comparing association between hearing threshold levels above 25 dBA and participants from Factory 1 and Factory 2

4.3.1 Comparing association between hearing threshold levels above 25 dBA and participants from the two factories at baseline

Chi-square tests for association (Connolly, 2007; Hinders, 2008) were conducted between participants from the two factories and hearing threshold levels above 25 dBA at 500 to 8000 Hz (both ears) at baseline. All expected cell frequencies were greater than five. There were no statistically significant associations between the participants from the two factories and hearing threshold levels above 25 dBA at all the tested frequencies at baseline as shown in Table 4.9.

Table 4.9: Comparison of hearing threshold levels of 25 dBA between participants from Factory 1 and Factory 2 at baseline

Factory 1 (*n* = 106) **Factory 2 (*n* = 97)**	**Frequency** **(Ear)**	**> 25 dBA** ***n* (%)**	**≤ 25 dBA** ***n* (%)**	**χ^2 statistic** **(*df*)**	***p* value***
Factory 1	500 (Right)	18 (17.0)	88 (83.0)	0.09 (1)	0.769
Factory 2		18 (18.6)	79 (81.4)		
Factory 1	1000 (Right)	10 (9.4)	96 (90.6)	0.33 (1)	0.569
Factory 2		7 (7.2)	90 (92.8)		
Factory 1	2000 (Right)	6 (5.7)	100 (94.3)	0.53 (1)	0.467
Factory 2		8 (8.2)	89 (91.8)		
Factory 1	3000 (Right)	7 (6.6)	99 (93.4)	0.91 (1)	0.341
Factory 2		10 (10.3)	87 (89.7)		
Factory 1	4000 (Right)	25 (23.6)	81 (76.4)	2.73 (1)	0.098
Factory 2		14 (14.4)	83 (85.6)		
Factory 1	6000 (Right)	43 (40.6)	63 (59.4)	0.12 (1)	0.724
Factory 2		37 (38.1)	60 (61.9)		
Factory 1	8000 (Right)	17 (16.0)	89 (84.0)	0.56 (1)	0.456
Factory 2		12 (12.4)	85 (87.6)		
Factory 1	500 (Left)	6 (5.7)	100 (94.3)	0.03 (1)	0.874
Factory 2		5 (5.2)	92 (94.8)		
Factory 1	1000 (Left)	7 (6.6)	99 (93.4)	0.02 (1)	0.903
Factory 2		6 (6.2)	91 (93.8)		
Factory 1	2000 (Left)	7 (6.6)	99 (93.4)	0.19 (1)	0.662
Factory 2		5 (5.2)	92 (94.8)		
Factory 1	3000 (Left)	11 (10.4)	95 (89.6)	< 0.001 (1)	0.987
Factory 2		10 (10.3)	87 (89.7)		

* Statistical significance is based on Chi-square test for independence

Table 4.9, continued

Factory 1 (*n* = 106) **Factory 2 (*n* = 97)**	**Frequency** **(Ear)**	**> 25 dBA** ***n* (%)**	**≤ 25 dBA** ***n* (%)**	**χ^2 statistic** **(*df*)**	***p* value***
Factory 1	4000 (Left)	13 (12.3)	93 (87.7)	0.44 (1)	0.509
Factory 2		15 (15.5)	82 (84.5)		
Factory 1	6000 (Left)	36 (34.0)	70 (66.0)	1.22 (1)	0.269
Factory 2		26 (26.8)	71 (73.2)		
Factory 1	8000 (Left)	14 (13.2)	92 (86.8)	0.41 (1)	0.523
Factory 2		10 (10.3)	87 (89.7)		

* Statistical significance is based on Chi-square test for independence

4.3.2 Comparing association between hearing threshold levels above 25 dBA and participants from the two factories of post-shift exposure at the first month based on intention-to-treat analysis

McNemar's tests were conducted between participants from the two factories upon adopting different permissible exposure limits and hearing threshold levels above 25 dBA at the first month based on intention-to-treat analysis. The associations were tested on both ears of the participants at 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz. The hearing threshold levels of more than 25 dBA had changed significantly from pre-intervention to post-intervention among participants from Factory 1 and Factory 2 at 3000 Hz of the right ear and 2000 Hz of the left ear, respectively as depicted in Table 4.10 and Table 4.11. There were noticeable differences in the hearing threshold levels above 25 dBA at these frequencies after one month upon adopting different permissible exposure limits.

Table 4.10: Comparison of change in hearing threshold levels above 25 dBA at the first month among participants from Factory 1 based on intention-to-treat analysis

Frequency	**Ear**	**Pre-intervention** ***n*** **= 106** ***n*** **(%) (dBA)**	**Post-intervention** ***n*** **= 106**		***p*** **value***
			≤ 25 dBA ***n*** **(%)**	**> 25 dBA** ***n*** **(%)**	
500	Right	88 (83.0) (≤ 25)	84 (95.5)	4 (4.5)	0.267
		18 (17.0) (> 25)	9 (50.0)	9 (50.0)	
1000	Right	96 (90.6) (≤ 25)	91 (94.8)	5 (5.2)	1.000
		10 (9.4) (> 25)	4 (40.0)	6 (60.0)	
2000	Right	100 (94.3) (≤ 25)	95 (95.0)	5 (5.0)	0.219
		6 (5.7) (> 25)	1 (16.7)	5 (83.3)	
3000	Right	99 (93.4) (≤ 25)	90 (90.9)	9 (9.1)	0.021
		7 (6.6) (> 25)	1 (14.3)	6 (85.7)	
4000	Right	81 (76.4) (≤ 25)	76 (93.8)	5 (6.2)	1.000
		25 (23.6) (> 25)	4 (16.0)	21 (84.0)	
6000	Right	63 (59.4) (≤ 25)	50 (79.4)	13 (20.6)	0.167
		43 (40.6) (> 25)	6 (14.0)	37 (86.0)	
8000	Right	89 (84.0) (≤ 25)	86 (96.6)	3 (3.4)	1.000
		17 (16.0) (> 25)	4 (23.5)	13 (76.5)	
500	Left	100 (94.3) (≤ 25)	100 (100.0)	0 (0.0)	0.500
		6 (5.7) (> 25)	2 (33.3)	4 (66.7)	
1000	Left	99 (93.4) (≤ 25)	96 (97.0)	3 (3.0)	1.000
		7 (6.6) (> 25)	3 (42.9)	4 (57.1)	
2000	Left	99 (93.4) (≤ 25)	97 (98.0)	2 (2.0)	0.687
		7 (6.6) (> 25)	4 (57.1)	3 (42.9)	
3000	Left	95 (89.6) (≤ 25)	90 (94.7)	5 (5.3)	1.000
		11 (10.4) (> 25)	5 (45.5)	6 (54.5)	
4000	Left	93 (87.7) (≤ 25)	90 (96.8)	3 (3.2)	1.000
		13 (12.3) (> 25)	2 (15.4)	11 (84.6)	
6000	Left	70 (66.0) (≤ 25)	61 (87.1)	9 (12.9)	0.424
		36 (34.0) (> 25)	5 (13.9)	31(86.1)	
8000	Left	92 (86.8) (≤ 25)	89 (96.7)	3 (3.3)	0.625
		14 (13.2) (> 25)	1 (7.1)	13 (92.9)	

*Statistical significance is based on McNemar's test

Table 4.11: Comparison of change in hearing threshold levels above 25 dBA at the first month among participants from Factory 2 based on intention-to-treat analysis

Frequency	**Ear**	**Pre-intervention** ***n* = 97** ***n* (%) (dBA)**	**Post-intervention** ***n* = 97**		***p* value***
			≤ 25dBA ***n* (%)**	**> 25dBA** ***n* (%)**	
500	Right	79 (81.4) (≤ 25)	73 (92.4)	6 (7.6)	0.454
		18 (18.6) (> 25)	10 (55.6)	8 (44.4)	
1000	Right	90 (92.8) (≤ 25)	88 (97.8)	2 (2.2)	1.000
		7 (7.2) (> 25)	3 (42.9)	4 (57.1)	
2000	Right	89 (91.8) (≤ 25)	84 (94.4)	5 (5.6)	0.727
		8 (8.2) (> 25)	3 (37.5)	5 (62.5)	
3000	Right	87 (89.7) (≤ 25)	85 (97.7)	2 (2.3)	0.500
		10 (10.3) (> 25)	0 (0.0)	10 (100.0)	
4000	Right	83 (85.6) (≤ 25)	77 (92.8)	6 (7.2)	0.289
		14 (14.4) (> 25)	2 (14.3)	12 (85.7)	
6000	Right	60 (61.9) (≤ 25)	51 (85.0)	9 (15.0)	1.000
		37 (38.1) (> 25)	10 (27.0)	27 (73.0)	
8000	Right	85 (87.6) (≤ 25)	81 (95.3)	4 (4.7)	0.687
		12 (12.4) (> 25)	2 (16.7)	10 (83.3)	
500	Left	92 (94.8) (≤ 25)	89 (96.7)	3 (3.3)	1.000
		5 (5.2) (> 25)	4 (80.0)	1 (20.0)	
1000	Left	91 (93.8) (≤ 25)	91 (100.0)	0 (0.0)	1.000
		6 (6.2) (> 25)	1 (16.7)	5 (83.3)	
2000	Left	92 (94.8) (≤ 25)	86 (93.5)	6 (6.5)	0.031
		5 (5.2) (> 25)	0 (0.0)	5 (100.0)	
3000	Left	87 (89.7) (≤ 25)	80 (92.0)	7 (8.0)	0.070
		10 (10.3) (> 25)	1 (10.0)	9 (90.0)	
4000	Left	82 (84.5) (≤ 25)	78 (95.1)	4 (4.9)	1.000
		15 (15.5) (> 25)	4 (26.7)	11 (73.3)	
6000	Left	71 (73.2) (≤ 25)	64 (90.1)	7 (9.9)	1.000
		26 (26.8) (> 25)	7 (26.9)	19 (73.1)	
8000	Left	87 (89.7) (≤ 25)	80 (92.0)	7 (8.0)	0.774
		10 (10.3) (> 25)	5 (50.0)	5 (50.0)	

*Statistical significance is based on McNemar's test

A Chi-square test for association was performed to compare the association between participants from the two factories and change in the hearing threshold levels above 25 dBA at the first month based on intention-to-treat analysis. The comparison was done between participants from both study locations at frequencies that showed a statistically significant difference on the McNemar's test. The Fisher's exact test was performed if the assumptions of the Chi-square were not met. There was a statistically significant association between participants from the two factories and change in the hearing threshold level above 25 dBA at 3000 Hz on right ear at the ‘deteriorated’ level (Table 4.12), χ^2 (1) = 4.08, φ = 0.145, p = 0.043. According to Cohen (1988), the effect size was “small” (Cohen, 1988). The finding indicated that there was a weak association (Rea & Parker, 1992) between adoption of different permissible exposure limits and worsening of the hearing threshold levels. There were more participants that showed deteriorated hearing threshold levels above 25 dBA in Factory 1 where 90 dBA was adopted as the permissible exposure limit compared to Factory 2 adopting 85 dBA at 3000 Hz. There were no statistically significant associations between participants from the two factories and change in the hearing threshold levels above 25 dBA at 2000 Hz on left ear as shown in Table 4.12.

Table 4.12: Comparison of hearing threshold levels above 25 dBA between participants from Factory 1 and Factory 2 at the first month based on intention-to-treat analysis

Frequency	**Ear**	**Hearing Threshold Level**	**Factory 1 (*n* = 106)**		**Factory 2 (*n* = 97)**		**χ^2 statistic* (*df*)**	***p* value***
			Yes Frequency (%)	**No Frequency (%)**	**Yes Frequency (%)**	**No Frequency (%)**		
3000	Right	Preserved	1 (0.9)	105 (99.1)	0 (0.0)	97 (100.0)	-	1.000**
		Maintained preservation	90 (84.9)	16 (15.1)	85 (87.6)	12 (12.4)	0.32 (1)	0.574
		Deteriorated	9 (8.5)	97 (91.5)	2 (2.1)	95 (97.9)	4.08 (1)	0.043
		Continued deterioration	6 (5.7)	100 (94.3)	10 (10.3)	87 (89.7)	1.51 (1)	0.219
2000	Left	Preserved	4 (3.8)	102 (96.2)	0 (0.0)	97 (100.0)	-	0.123**
		Maintained preservation	97 (91.5)	9 (8.5)	86 (88.7)	11 (11.3)	0.46 (1)	0.496
		Deteriorated	2 (1.9)	104 (98.1)	6 (6.2)	91 (93.8)	-	0.155**
		Continued deterioration	3 (2.8)	103 (97.2)	5 (5.2)	92 (94.8)	-	0.483**

* Statistical significance is based on Chi-square test for independence; ** Statistical significance is based on Fisher's exact test

4.3.3 Comparing association between hearing threshold levels above 25 dBA and participants from the two factories of post-shift exposure at the first month as per-protocol analysis

A McNemar's test was conducted between participants from the two factories upon adopting different permissible exposure limits and hearing threshold levels above 25 dBA at the first month as per-protocol analysis. The associations were tested on both ears of the participants at 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz. The hearing threshold levels of more than 25 dBA had changed significantly from pre-intervention to post-intervention between participants from Factory 1 and Factory 2 at 3000 Hz of the right ear and 2000 Hz of the left ear, respectively as depicted in Table 4.13 and Table 4.14. Hence, there were differences in the hearing threshold levels above 25 dBA at these frequencies after one month upon adopting different permissible exposure limits.

Table 4.13: Comparison of change in hearing threshold levels above 25 dBA at the first month among participants from Factory 1 as per-protocol analysis

Frequency	Ear	Pre-intervention *n* = 106 *n* (%) (dBA)	Post-intervention *n* = 62		*p* value*
			≤ 25 dBA *n* (%)	**> 25 dBA** *n* (%)	
500	Right	88 (83.0) (≤ 25)	47 (92.2)	4 (7.8)	0.267
		18 (17.0) (> 25)	9 (81.8)	2 (18.2)	
1000	Right	96 (90.6) (≤ 25)	49 (90.7)	5 (9.3)	1.000
		10 (9.4) (> 25)	4 (50.0)	4 (50.0)	
2000	Right	100 (94.3) (≤ 25)	53 (91.4)	5 (8.6)	0.219
		6 (5.7) (> 25)	1 (25.0)	3 (75.0)	
3000	Right	99 (93.4) (≤ 25)	49 (84.5)	9 (15.5)	0.021
		7 (6.6) (> 25)	1 (25.0)	3 (75.0)	
4000	Right	81 (76.4) (≤ 25)	41 (89.1)	5 (10.9)	1.000
		25 (23.6) (> 25)	4 (25.0)	12 (75.0)	
6000	Right	63 (59.4) (≤ 25)	25 (65.8)	13 (34.2)	0.167
		43 (40.6) (> 25)	6 (25.0)	18 (75.0)	
8000	Right	89 (84.0) (≤ 25)	48 (94.1)	3 (5.9)	1.000
		17 (16.0) (> 25)	4 (36.4)	7 (63.6)	
500	Left	100 (94.3) (≤ 25)	59 (100.0)	0 (0.0)	0.500
		6 (5.7) (> 25)	2 (66.7)	1 (33.3)	
1000	Left	99 (93.4) (≤ 25)	54 (94.7)	3 (5.3)	1.000
		7 (6.6) (> 25)	3 (60.0)	2 (40.0)	
2000	Left	99 (93.4) (≤ 25)	54 (96.4)	2 (3.6)	0.687
		7 (6.6) (> 25)	4 (66.7)	2 (33.3)	
3000	Left	95 (89.6) (≤ 25)	50 (90.9)	5 (9.1)	1.000
		11 (10.4) (> 25)	5 (71.4)	2 (28.6)	
4000	Left	93 (87.7) (≤ 25)	50 (94.3)	3 (5.7)	1.000
		13 (12.3) (> 25)	2 (22.2)	7 (77.8)	
6000	Left	70 (66.0) (≤ 25)	34 79.1)	9 (20.9)	0.424
		36 (34.0) (> 25)	5 (26.3)	14 (73.7)	
8000	Left	92 (86.8) (≤ 25)	51 (94.4)	3 (5.6)	0.625
		14 (13.2) (> 25)	1 (12.5)	7 (87.5)	

*Statistical significance is based on McNemar's test

Table 4.14: Comparison of change in hearing threshold levels above 25 dBA at the first month among participants from Factory 2 as per-protocol analysis

Frequency	Ear	Pre-intervention ***n* = 97** ***n* (%) (dBA)**	Post-intervention ***n* = 65**		***p* value***
			≤ 25 dBA ***n* (%)**	**> 25 dBA** ***n* (%)**	
500	Right	79 (81.4) (≤ 25)	46 (88.5)	6 (11.5)	0.454
		18 (18.6) (> 25)	10 (76.9)	3 (23.1)	
1000	Right	90 (92.8) (≤ 25)	57 (96.6)	2 (3.4)	1.000
		7 (7.2) (> 25)	3 (50.0)	3 (50.0)	
2000	Right	89 (91.8) (≤ 25)	54 (91.5)	5 (8.5)	0.727
		8 (8.2) (> 25)	3 (50.0)	3 (50.0)	
3000	Right	87 (89.7) (≤ 25)	49 (84.5)	9 (15.5)	0.500
		10 (10.3) (> 25)	1 (25.0)	3 (75.0)	
4000	Right	83 (85.6) (≤ 25)	51 (89.5)	6 (10.5)	0.289
		14 (14.4) (> 25)	2 (25.0)	6 (75.0)	
6000	Right	60 (61.9) (≤ 25)	32 (78.0)	9 (22.0)	1.000
		37 (38.1) (> 25)	10 (41.7)	14 (58.3)	
8000	Right	85 (87.6) (≤ 25)	55 (93.2)	4 (6.8)	0.687
		12 (12.4) (> 25)	2 (33.3)	4 (66.7)	
500	Left	92 (94.8) (≤ 25)	58 (95.1)	3 (4.9)	1.000
		5 (5.2) (> 25)	4 (100.0)	0 (0.0)	
1000	Left	91 (93.8) (≤ 25)	62 (100.0)	0 (0.0)	1.000
		6 (6.2) (> 25)	1 (33.3)	2 (66.7)	
2000	Left	92 (94.8) (≤ 25)	57 (90.5)	6 (9.5)	0.031
		5 (5.2) (> 25)	0 (0.0)	2 (100.0)	
3000	Left	87 (89.7) (≤ 25)	52 (88.1)	7 (11.9)	0.070
		10 (10.3) (> 25)	1 (16.7)	5 (83.3)	
4000	Left	82 (84.5) (≤ 25)	52 (92.9)	4 (7.1)	1.000
		15 (15.5) (> 25)	4 (44.4)	5 (55.6)	
6000	Left	71 (73.2) (≤ 25)	41 (85.4)	7 (14.6)	1.000
		26 (26.8) (> 25)	7 (41.2)	10 (58.8)	
8000	Left	87 (89.7) (≤ 25)	51 (87.9)	7 (12.1)	0.774
		10 (10.3) (> 25)	5 (71.4)	2 (28.6)	

* Statistical significance is based on McNemar's test

A Chi-square test for association was carried out to compare association between participants from the two factories and change in the hearing threshold levels above 25 dBA at the first month as per-protocol analysis. The comparison was done between participants from the two factories at frequencies that showed a statistically significant difference on the McNemar's test. The Fisher's exact test was performed if the assumptions of the Chi-square were not met. There was statistically significant association between the participants from both factories and change in the hearing threshold level above 25 dBA at 3000 Hz on right ear at the ‘deteriorated’ level (Table 4.15), χ^2 (1) = 5.25, φ = 0.203, p = 0.022. According to Cohen (1988), the effect size was “small” (Cohen, 1988). The finding indicated that there was a moderate association (Rea & Parker, 1992) between adoption of different permissible exposure limits and worsening of the hearing threshold levels. There were more participants that showed deteriorated hearing threshold levels above 25 dBA in Factory 1 where 90 dBA was adopted as the permissible exposure limit compared to Factory 2 adopting 85 dBA at 3000 Hz. There were no statistically significant associations between participants from the two factories and change in the hearing threshold levels above 25 dBA at 2000 Hz on left ear as shown in Table 4.15.

Table 4.15: Comparison of hearing threshold levels above 25 dBA between participants from Factory 1 and Factory 2 at the first month as per-protocol analysis

Frequency	**Ear**	**Hearing threshold level**	**Factory 1 (*n* = 62)**		**Factory 2 (*n* = 65)**		**χ^2 statistic* (*df*)**	***p* value***
			Yes Frequency (%)	**No Frequency (%)**	**Yes Frequency (%)**	**No Frequency (%)**		
3000	Right	Preserved	1 (1.6)	61 (98.4)	0 (0.0)	65 (100.0)	-	0.488**
		Maintained preservation	49 (79.0)	13 (21.0)	56 (86.2)	9 (13.8)	1.12 (1)	0.289
		Deteriorated	9 (14.5)	53 (85.5)	2 (3.1)	63 (96.9)	5.25 (1)	0.022
		Continued deterioration	3 (4.8)	59 (95.2)	7 (10.8)	58 (89.2)	-	0.325**
2000	Left	Preserved	4 (6.5)	58 (93.5)	0 (0.0)	65 (100.0)	-	0.054**
		Maintained preservation	54 (87.1)	8 (12.9)	57 (87.7)	8 (12.3)	0.01 (1)	0.919
		Deteriorated	2 (3.2)	60 (96.8)	6 (9.2)	59 (90.8)	-	0.274**
		Continued deterioration	2 (3.2)	60 (96.8)	2 (3.1)	63 (96.9)	-	1.000**

* Statistical significance is based on Chi-square test for independence; ** Statistical significance is based on Fisher's exact test

4.3.4 Comparing association between hearing threshold levels above 25 dBA and participants from the two factories of pre-shift exposure at the sixth month based on intention-to-treat analysis

A McNemar's test was conducted between participants from the two factories upon adopting different permissible exposure limits and hearing threshold levels above 25 dBA at the sixth month based on intention-to-treat analysis. The associations were tested for both ears of the participants at 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz. The hearing threshold levels of more than 25 dBA has changed significantly from pre-intervention to post-intervention between participants from Factory 1 and Factory 2 at all the tested frequencies except at 8000 Hz on left ear as depicted in Table 4.16 and Table 4.17. Hence, there were differences in the hearing threshold levels above 25 dBA at these frequencies at the sixth month upon adopting different permissible exposure limits.

Table 4.16: Comparison of change in hearing threshold levels above 25 dBA at the sixth month among participants from Factory 1 based on intention-to-treat analysis

Frequency	Ear	Pre-intervention *n* = 106 *n* (%) (dBA)	Post-intervention *n* = 106		*p* value*
			≤ 25dBA *n* (%)	> 25dBA *n* (%)	
500	Right	88 (83.0) (≤ 25)	65 (73.9)	23 (26.1)	<0.001
		18 (17.0) (> 25)	4 (22.2)	14 (77.8)	
1000	Right	96 (90.6) (≤ 25)	63 (65.6)	33 (34.4)	<0.001
		10 (9.4) (> 25)	2 (20.0)	8 (80.0)	
2000	Right	100 (94.3) (≤ 25)	74 (74.0)	26 (26.0)	<0.001
		6 (5.7) (> 25)	0 (0.0)	6 (100.0)	
3000	Right	99 (93.4) (≤ 25)	73 (73.7)	26 (26.3)	<0.001
		7 (6.6) (> 25)	1 (14.3)	6 (85.7)	
4000	Right	81 (76.4) (≤ 25)	57 (70.4)	24 (29.6)	<0.001
		25 (23.6) (> 25)	0 (0.0)	25 (100.0)	
6000	Right	63 (59.4) (≤ 25)	42 (66.7)	21 (33.3)	<0.001
		43 (40.6) (> 25)	1 (2.3)	42 (97.7)	
8000	Right	89 (84.0) (≤ 25)	79 (88.8)	10 (11.2)	0.012
		17 (16.0) (> 25)	1 (5.9)	16 (94.1)	
500	Left	100 (94.3) (≤ 25)	78 (78.0)	22 (22.0)	<0.001
		6 (5.7) (> 25)	1 (16.7)	5 (83.3)	
1000	Left	99 (93.4) (≤ 25)	76 (76.8)	23 (23.2)	<0.001
		7 (6.6) (> 25)	0 (0.0)	7 (100.0)	
2000	Left	99 (93.4) (≤ 25)	77 (77.8)	22 (22.2)	<0.001
		7 (6.6) (> 25)	2 (28.6)	5 (71.4)	
3000	Left	95 (89.6) (≤ 25)	70 (73.7)	25 (26.3)	<0.001
		11 (10.4) (> 25)	3 (27.3)	8 (72.7)	
4000	Left	93 (87.7) (≤ 25)	65 (69.9)	28 (30.1)	<0.001
		13 (12.3) (> 25)	0 (0.0)	13 (100.0)	
6000	Left	70 (66.0) (≤ 25)	47 (67.1)	23 (32.9)	0.001
		36 (34.0) (> 25)	5 (13.9)	31(86.1)	
8000	Left	92 (86.8) (≤ 25)	84 (91.3)	8 (8.7)	0.109
		14 (13.2) (> 25)	2 (14.3)	12 (85.7)	

* Statistical significance is based on McNemar’s test

Table 4.17: Comparison of change in hearing threshold levels above 25 dBA at the sixth month among participants from Factory 2 based on intention-to-treat analysis

Frequency	**Ear**	**Pre-intervention** ***n* = 97** ***n* (%) (dBA)**	**Post-intervention** ***n* = 97**		***p* value***
			≤ 25dBA ***n* (%)**	**> 25dBA** ***n* (%)**	
500	Right	79 (81.4) (≤ 25)	57 (72.2)	22 (27.8)	0.016
		18 (18.6) (> 25)	8 (44.4)	10 (55.6)	
1000	Right	90 (92.8) (≤ 25)	61 (67.8)	29 (32.2)	<0.001
		7 (7.2) (> 25)	3 (42.9)	4 (57.1)	
2000	Right	89 (91.8) (≤ 25)	67 (75.3)	22 (24.7)	<0.001
		8 (8.2) (> 25)	2 (25.0)	6 (75.0)	
3000	Right	87 (89.7) (≤ 25)	69 (79.3)	18 (20.7)	<0.001
		10 (10.3) (> 25)	0 (0.0)	10 (100.0)	
4000	Right	83 (85.6) (≤ 25)	62 (74.7)	21 (25.3)	<0.001
		14 (14.4) (> 25)	2 (14.3)	12 (85.7)	
6000	Right	60 (61.9) (≤ 25)	41 (68.3)	19 (31.7)	0.200
		37 (38.1) (> 25)	11 (29.7)	26 (70.3)	
8000	Right	85 (87.6) (≤ 25)	74 (87.1)	11 (12.9)	0.022
		12 (12.4) (> 25)	2 (16.7)	10 (83.3)	
500	Left	92 (94.8) (≤ 25)	73 (79.3)	19 (20.7)	0.001
		5 (5.2) (> 25)	3 (60.0)	2 (40.0)	
1000	Left	91 (93.8) (≤ 25)	72 (79.1)	19 (20.9)	<0.001
		6 (6.2) (> 25)	1 (16.7)	5 (83.3)	
2000	Left	92 (94.8) (≤ 25)	72 (78.3)	20 (21.7)	<0.001
		5 (5.2) (> 25)	0 (0.0)	5 (100.0)	
3000	Left	87 (89.7) (≤ 25)	67 (77.0)	20 (23.0)	<0.001
		10 (10.3) (> 25)	1 (10.0)	9 (90.0)	
4000	Left	82 (84.5) (≤ 25)	63 (76.8)	19 (23.2)	<0.001
		15 (15.5) (> 25)	1 (6.7)	14 (93.3)	
6000	Left	71 (73.2) (≤ 25)	52 (73.2)	19 (26.8)	0.001
		26 (26.8) (> 25)	3 (11.5)	23 (88.5)	
8000	Left	87 (89.7) (≤ 25)	77 (88.5)	10 (11.5)	0.180
		10 (10.3) (> 25)	4 (40.0)	6 (60.0)	

* Statistical significance is based on McNemar's test

A Chi-square test for association was done to compare association between participants from the two factories and the change in the hearing threshold levels above 25 dBA at the six month based on intention-to-treat analysis. The comparison was done between participants from both study locations at frequencies that showed a statistically significant difference on the McNemar's test. This test was therefore conducted at all studied frequencies except at 8000Hz on left ear. The Fisher's exact test was performed if the assumptions of the Chi-square were not met. There were statistically significant associations between the participants from the two factories and change in the hearing threshold levels above 25 dBA at 4000 Hz on right ear at the 'continued deterioration' level (Table 4.18), χ^2 (1) = 4.27, φ = 0.145, p = 0.039 and 6000 Hz on right ear at the 'preserved' level (Table 4.18), χ^2 (1) = 9.84, φ = 0.220, p = 0.002. According to Cohen (1988), the effect sizes of change in the hearing threshold levels were "small" (Cohen, 1988). The outcomes indicated that there was a weak association at 4000 Hz but a moderate association at 6000 Hz (Rea & Parker, 1992) between adoption of different permissible exposure limits and worsening of the hearing threshold levels. There were more participants that showed 'continued deterioration' of hearing threshold levels above 25 dBA from Factory 1 adopting a 90 dBA level; compared to those in Factory 2 adopting 85 dBA at 4000 Hz. An adoption of 85 dBA as the permissible exposure limit had preserved hearing threshold levels among participants from Factory 2 at 6000 Hz compared to those from Factory 1. At other frequencies, there were no statistically significant associations between participants from the two factories and change in the hearing threshold levels above 25 dBA as shown in Table 4.18.

Table 4.18: Comparison of hearing threshold levels above 25 dBA between participants from Factory 1 and Factory 2 at the sixth month based on intention-to-treat analysis

Frequency	**Ear**	**Hearing threshold level**	**Factory 1 (*n* = 106)**		**Factory 2 (*n* = 97)**		**χ^2 statistic* (*df*)**	***p* value***
			Yes ***n* (%)**	**No** ***n* (%)**	**Yes** ***n* (%)**	**No** ***n* (%)**		
500	Right	Preserved	4 (3.8)	102 (96.2)	8 (8.2)	89 (91.8)	1.82 (1)	0.177
		Preservation maintained	65 (61.3)	41 (38.7)	57 (58.8)	40 (41.2)	0.14 (1)	0.710
		Deteriorated	23 (21.7)	83 (78.3)	22 (22.7)	75 (77.3)	0.03 (1)	0.866
		Continued deterioration	14 (13.2)	92 (86.8)	10 (10.3)	87 (89.7)	0.41 (1)	0.523
1000	Right	Preserved	2 (1.9)	104 (98.1)	3 (3.1)	94 (96.9)	-	0.671**
		Preservation maintained	63 (59.4)	43 (40.6)	61 (62.9)	36 (37.1)	0.25 (1)	0.614
		Deteriorated	33 (31.1)	73 (68.9)	29 (29.9)	68 (70.1)	0.04 (1)	0.849
		Continued deterioration	8 (7.5)	98 (92.5)	4 (4.1)	93 (95.9)	1.07 (1)	0.302
2000	Right	Preserved	0 (0.0)	106 (100.0)	2 (2.1)	95 (97.9)	-	0.227**
		Preservation maintained	74 (69.8)	32 (30.2)	67 (69.1)	30 (30.9)	0.01(1)	0.909
		Deteriorated	26 (24.5)	80 (75.5)	22 (22.7)	75 (77.3)	0.10 (1)	0.757
		Continued deterioration	6 (5.7)	100 (94.3)	6 (6.2)	91 (93.8)	0.03 (1)	0.874
3000	Right	Preserved	1 (0.9)	105 (99.1)	0 (0.0)	97 (100.0)	-	1.000**
		Preservation maintained	73 (68.9)	33 (31.1)	69 (71.1)	28 (28.9)	0.12 (1)	0.725
		Deteriorated	26 (24.5)	80 (75.5)	18 (18.6)	79 (81.4)	1.06 (1)	0.302
		Continued deterioration	6 (5.7)	100 (94.3)	10 (10.3)	87 (89.7)	1.51 (1)	0.219

* Statistical significance is based on Chi-square test for independence; ** Statistical significance is based on Fisher's exact test.
† indicates constant value.

Table 4.18, continued

Frequency	Ear	Hearing threshold level	Factory 1 (n = 106)		Factory 2 (n = 97)		χ^2 statistic* (*df*)	*p* value*
			Yes *n* (%)	No *n* (%)	Yes *n* (%)	No *n* (%)		
4000	Right	Preserved	0 (0.0)	106 (100.0)	2 (2.1)	95 (97.9)	-	0.227**
		Preservation maintained	57 (53.8)	49 (46.2)	62 (63.9)	35 (36.1)	2.15 (1)	0.143
		Deteriorated	24 (22.6)	82 (77.4)	21 (21.6)	76 (78.4)	0.03 (1)	0.865
		Continued deterioration	25 (23.6)	81 (76.4)	12 (12.4)	85 (87.6)	4.27 (1)	0.039
6000	Right	Preserved	1 (0.9)	105 (99.1)	11 (11.3)	86 (88.7)	9.84 (1)	0.002
		Preservation maintained	42 (39.6)	64 (60.4)	41 (42.3)	56 (57.7)	0.15 (1)	0.702
		Deteriorated	21 (19.8)	85 (80.2)	19 (19.6)	78 (80.4)	0.00 (1)	0.968
		Continued deterioration	42 (39.6)	64 (60.4)	26 (26.8)	71 (73.2)	3.74 (1)	0.053
8000	Right	Preserved	1 (0.9)	105 (99.1)	2 (2.1)	95 (97.9)	-	0.607**
		Preservation maintained	79 (74.5)	27 (25.5)	74 (76.3)	23 (23.7)	0.09 (1)	0.771
		Deteriorated	10 (9.4)	96 (90.6)	11 (11.3)	86 (88.7)	0.20 (1)	0.656
		Continued deterioration	16 (15.1)	90 (84.9)	10 (10.3)	87 (89.7)	1.04 (1)	0.308
500	Left	Preserved	1 (0.9)	105 (99.1)	3 (3.1)	94 (96.9)	-	0.350**
		Preservation maintained	78 (73.6)	28 (26.4)	73 (75.3)	24 (24.7)	0.07 (1)	0.785
		Deteriorated	22 (20.8)	84 (79.2)	19 (19.6)	78 (80.4)	0.04 (1)	0.836
		Continued deterioration	5 (4.7)	101 (95.3)	2 (2.1)	95 (97.9)	-	0.448**

* Statistical significance is based on Chi-square test for independence; ** Statistical significance is based on Fisher's exact test.
† indicates constant value.

Table 4.18, continued

Frequency	Ear	Hearing threshold level	Factory 1 (n = 106)		Factory 2 (n = 97)		χ^2 statistic* (df)	p value*
			Yes n (%)	No n (%)	Yes n (%)	No n (%)		
1000	Left	Preserved	0 (0.0)	106 (100.0)	1 (1.0)	96 (99.0)	-	0.478**
		Preservation maintained	76 (71.7)	30 (28.3)	72 (74.2)	25 (25.8)	0.16 (1)	0.686
		Deteriorated	23 (21.7)	83 (78.3)	19 (19.6)	78 (80.4)	0.14 (1)	0.711
		Continued deterioration	7 (6.6)	99 (93.4)	5 (5.2)	92 (94.8)	0.19 (1)	0.662
2000	Left	Preserved	0 (0.0)	106 (100.0)	0 (0.0)	97 (100.0)	-	†
		Preservation maintained	0 (0.0)	106 (100.0)	0 (0.0)	97 (100.0)	-	†
		Deteriorated	0 (0.0)	106 (100.0)	0 (0.0)	97 (100.0)	-	†
		Continued deterioration	0 (0.0)	106 (100.0)	0 (0.0)	97 (100.0)	-	†
3000	Left	Preserved	0 (0.0)	106 (100.0)	0 (0.0)	97 (100.0)	-	†
		Preservation maintained	0 (0.0)	106 (100.0)	0 (0.0)	97 (100.0)	-	†
		Deteriorated	0 (0.0)	106 (100.0)	0 (0.0)	97 (100.0)	-	†
		Continued deterioration	0 (0.0)	106 (100.0)	0 (0.0)	97 (100.0)	-	†
4000	Left	Preserved	0 (0.0)	106 (100.0)	1 (1.0)	96 (99.0)	-	0.478**
		Preservation maintained	65 (61.3)	41 (38.7)	63 (64.9)	34 (35.1)	0.29 (1)	0.593
		Deteriorated	28 (26.4)	78 (73.6)	19 (19.6)	78 (80.4)	1.33 (1)	0.249
		Continued deterioration	13 (12.3)	93 (87.7)	14 (14.4)	83 (85.6)	0.21 (1)	0.649
6000	Left	Preserved	5 (4.7)	101 (95.3)	3 (3.1)	94 (96.9)	-	0.723**
		Preservation maintained	47 (44.3)	59 (55.7)	52 (53.6)	45 (46.4)	1.74 (1)	0.187
		Deteriorated	23 (21.7)	83 (78.3)	19 (19.6)	78 (80.4)	0.14 (1)	0.711
		Continued deterioration	31 (29.2)	75 (70.8)	23 (23.7)	74 (76.3)	0.79 (1)	0.373

* Statistical significance is based on Chi-square test for independence; ** Statistical significance is based on Fisher's exact test.
† indicates constant value.

4.3.5 Comparing association between hearing threshold levels above 25 dBA and participants from the two factories of pre-shift exposure at the sixth month as per-protocol analysis

A McNemar’s test was conducted between participants from the two factories upon adopting different permissible exposure limits and hearing threshold levels above 25 dBA at the sixth month as per-protocol analysis. The associations were tested on both ears of the participants at 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz. The hearing threshold levels of more than 25 dBA has changed significantly from pre-intervention to post-intervention among participants from Factory 1 and Factory 2 at all the tested frequencies, except at 8000 Hz on left ear (those from Factory 1), as depicted in Table 4.19 and Table 4.20. Hence, there were differences in the hearing threshold levels above 25 dBA at these frequencies at the sixth month upon adopting different permissible exposure limits.

Table 4.19: Comparison of change in hearing threshold levels above 25 dBA at the sixth month among participants from Factory 1 as per-protocol analysis

Frequency	Ear	Pre-intervention *n* = 106 *n* (%) (dBA)	Post-intervention *n* = 48		*p* value*
			≤ 25dBA *n* (%)	> 25dBA *n* (%)	
500	Right	88 (83.0) (≤ 25)	16 (42.1)	22 (57.9)	< 0.001
		18 (17.0) (> 25)	2 (20.0)	8 (80.0)	
1000	Right	96 (90.6) (≤ 25)	11 (25.6)	32 (74.4)	< 0.001
		10 (9.4) (> 25)	1 (20.0)	4 (80.0)	
2000	Right	100 (94.3) (≤ 25)	21 (46.7)	24 (53.3)	< 0.001
		6 (5.7) (> 25)	0 (0.0)	3 (100.0)	
3000	Right	99 (93.4) (≤ 25)	22 (47.8)	24 (52.2)	< 0.001
		7 (6.6) (> 25)	0 (0.0)	2 (100.0)	
4000	Right	81 (76.4) (≤ 25)	13 (36.1)	23 (63.9)	< 0.001
		25 (23.6) (> 25)	0 (0.0)	12 (100.0)	
6000	Right	63 (59.4) (≤ 25)	8 (29.6)	19 (70.4)	< 0.001
		43 (40.6) (> 25)	0 (0.0)	21 (100.0)	
8000	Right	89 (84.0) (≤ 25)	29 (74.4)	10 (25.6)	0.002
		17 (16.0) (> 25)	0 (0.0)	9 (100.0)	
500	Left	100 (94.3) (≤ 25)	25 (53.2)	22 (46.8)	< 0.001
		6 (5.7) (> 25)	0 (0.0)	1 (100.0)	
1000	Left	99 (93.4) (≤ 25)	23 (51.1)	22 (48.9)	< 0.001
		7 (6.6) (> 25)	0 (0.0)	3 (100.0)	
2000	Left	99 (93.4) (≤ 25)	25 (54.3)	21 (45.7)	< 0.001
		7 (6.6) (> 25)	0 (0.0)	2 (100.0)	
3000	Left	95 (89.6) (≤ 25)	21 (47.7)	23 (52.3)	< 0.001
		11 (10.4) (> 25)	0 (0.0)	4 (100.0)	
4000	Left	93 (87.7) (≤ 25)	16 (37.2)	27 (62.8)	< 0.001
		13 (12.3) (> 25)	0 (0.0)	5 (100.0)	
6000	Left	70 (66.0) (≤ 25)	8 (27.6)	21 (72.4)	0.001
		36 (34.0) (> 25)	4 (21.1)	15 (78.9)	
8000	Left	92 (86.8) (≤ 25)	34 (82.9)	7 (17.1)	0.180
		14 (13.2) (> 25)	2 (28.6)	5 (71.4)	

* Statistical significance is based on McNemar's test

Table 4.20: Comparison of change in hearing threshold levels above 25 dBA at the sixth month among participants from Factory 2 as per-protocol analysis

Frequency	Ear	Pre-intervention *n* = 97 *n* (%) (dBA)	Post-intervention *n* = 40		*p* value*
			≤ 25dBA *n* (%)	> 25dBA *n* (%)	
500	Right	79 (81.4) (≤ 25)	16 (43.2)	21 (56.8)	< 0.001
		18 (18.6) (> 25)	0 (0.0)	3 (100.0)	
1000	Right	90 (92.8) (≤ 25)	11 (28.2)	28 (71.8)	< 0.001
		7 (7.2) (> 25)	0 (0.0)	1 (100.0)	
2000	Right	89 (91.8) (≤ 25)	20 (52.6)	18 (47.4)	< 0.001
		8 (8.2) (> 25)	0 (0.0)	2 (100.0)	
3000	Right	87 (89.7) (≤ 25)	21(55.3)	17 (44.7)	< 0.001
		10 (10.3) (> 25)	0 (0.0)	2 (100.0)	
4000	Right	83 (85.6) (≤ 25)	18 (50.0)	18 (50.0)	< 0.001
		14 (14.4) (> 25)	1 (25.0)	3 (75.0)	
6000	Right	60 (61.9) (≤ 25)	11 (44.0)	14 (56.0)	0.013
		37 (38.1) (> 25)	3 (20.0)	12 (80.0)	
8000	Right	85 (87.6) (≤ 25)	28 (75.7)	9 (24.3)	0.004
		12 (12.4) (> 25)	0 (0.0)	3 (100.0)	
500	Left	92 (94.8) (≤ 25)	23 (59.0)	16 (41.0)	< 0.001
		5 (5.2) (> 25)	0 (0.0)	1 (100.0)	
1000	Left	91 (93.8) (≤ 25)	19 (50.0)	19 (50.0)	< 0.001
		6 (6.2) (> 25)	0 (0.0)	2 (100.0)	
2000	Left	92 (94.8) (≤ 25)	22 (56.4)	17 (43.6)	< 0.001
		5 (5.2) (> 25)	0 (0.0)	1 (100.0)	
3000	Left	87 (89.7) (≤ 25)	22 (57.9)	16 (42.1)	< 0.001
		10 (10.3) (> 25)	0 (0.0)	2 (100.0)	
4000	Left	82 (84.5) (≤ 25)	19 (54.3)	16 (45.7)	< 0.001
		15 (15.5) (> 25)	0 (0.0)	5 (100.0)	
6000	Left	71 (73.2) (≤ 25)	11 (40.7)	16 (59.3)	< 0.001
		26 (26.8) (> 25)	1 (7.7)	12 (92.3)	
8000	Left	87 (89.7) (≤ 25)	27 (77.1)	8 (22.9)	0.039
		10 (10.3) (> 25)	1 (20.0)	4 (80.0)	

* Statistical significance is based on McNemar's test

A Chi-square test for association was done to compare association between participants from the two factories and the change in the hearing threshold level above 25 dBA at the six month as per-protocol analysis. The comparison was done between participants from the two factories at frequencies that showed a statistically significant difference on the McNemar's test. This test was therefore conducted at all studied tested frequencies including at 8000Hz on left ear since there was a significant change among participants in Factory 2. The Fisher's exact test was performed if the assumptions of the Chi-square were not met. There was statistically significant association between participants from the two factories and change in the hearing threshold levels above 25 dBA at 4000 Hz on right ear at the 'continued deterioration' level (Table 4.20), χ^2 (1) = 4.73, φ = 0.232, p = 0.030. According to Cohen (1988), the effect size was "small" (Cohen, 1988). The finding indicated that there was a moderate association (Rea & Parker, 1992) between adoption of different permissible exposure limits and worsening of the hearing threshold levels. There were more participants that showed 'continued deterioration' of hearing threshold levels above 25 dBA in Factory 1 adopting a 90 dBA level; compared to those in Factory 2 adopting 85 dBA at 4000 Hz. At other frequencies, there were no statistically significant associations between participants from the two factories and change in the hearing threshold levels above 25 dBA as shown in Table 4.21.

Table 4.21: Comparison of hearing threshold levels above 25 dBA between participants from Factory 1 and Factory 2 at the sixth month as per-protocol analysis

Frequency	**Ear**	**Hearing threshold level**	**Factory 1 (*n* = 48)**		**Factory 2 (*n* = 40)**		**χ^2 statistic* (*df*)**	***p* value***
			Yes *n* (%)	**No *n* (%)**	**Yes *n* (%)**	**No *n* (%)**		
500	Right	Preserved	2 (4.2)	46 (95.8)	0 (0.0)	40 (100.0)	-	0.498**
		Maintained preservation	16 (33.3)	32 (66.7)	16 (40.0)	24 (60.0)	0.42 (1)	0.517
		Deteriorated	22 (45.8)	26 (54.2)	21 (52.5)	19 (47.5)	0.39 (1)	0.533
		Continued deterioration	8 (16.7)	40 (83.3)	3 (7.5)	37 (92.5)	1.68 (1)	0.195
1000	Right	Preserved	1 (2.1)	47 (97.9)	0 (0.0)	40 (100.0)	-	1.000**
		Maintained preservation	11 (22.9)	37 (77.1)	11 (27.5)	29 (72.5)	0.24 (1)	0.621
		Deteriorated	32 (66.7)	16 (33.3)	28 (70.0)	12 (30.0)	0.11 (1)	0.738
		Continued deterioration	4 (8.3)	44 (91.7)	1 (2.5)	39 (97.5)	-	0.371
2000	Right	Preserved	0 (0.0)	48 (100.0)	0 (0.0)	40 (100.0)	-	†
		Maintained preservation	21 (43.8)	27 (56.2)	20 (50.0)	20 (50.0)	0.34 (1)	0.558
		Deteriorated	24 (50.0)	24 (50.0)	18 (45.0)	22 (55.0)	0.22 (1)	0.640
		Continued deterioration	3 (6.2)	45 (93.8)	2 (5.0)	38 (95.0)	-	1.000**
3000	Right	Preserved	0 (0.0)	48 (100.0)	0 (0.0)	40 (100.0)	-	†
		Maintained preservation	22 (45.8)	26 (54.2)	21 (52.5)	19 (47.5)	0.39 (1)	0.533
		Deteriorated	24 (50.0)	24 (50.0)	17 (42.5)	23 (57.5)	0.49 (1)	0.483
		Continued deterioration	2 (4.2)	46 (95.8)	2 (5.0)	38 (95.0)	-	1.000**

* Statistical significance is based on Chi-square test for independence; ** Statistical significance is based on Fisher's exact test.
† indicates constant value.

Table 4.21, continued

Frequency	**Ear**	**Hearing threshold level**	**Factory 1 (*n* = 48)**		**Factory 2 (*n* = 40)**		**χ^2 statistic* (*df*)**	***p* value***
			Yes *n* (%)	**No *n* (%)**	**Yes *n* (%)**	**No *n* (%)**		
4000	Right	Preserved	0 (0.0)	48 (100.0)	1 (2.5)	39 (97.5)	-	0.455**
		Maintained preservation	13 (27.1)	35 (72.9)	18 (45.0)	22 (55.0)	3.07 (1)	0.080
		Deteriorated	23 (47.9)	25 (52.1)	18 (45.0)	22 (55.0)	0.08 (1)	0.785
		Continued deterioration	12 (25.0)	36 (75.0)	3 (7.5)	37 (92.5)	4.73 (1)	0.030
6000	Right	Preserved	0 (0.0)	48 (100.0)	3 (7.5)	37 (92.5)	-	0.090**
		Maintained preservation	8 (16.7)	40 (83.3)	11 (27.5)	29 (72.5)	1.51 (1)	0.219
		Deteriorated	19 (39.6)	29 (60.4)	14 (35.0)	26 (65.0)	0.20 (1)	0.658
		Continued deterioration	21 (43.8)	27 (56.2)	12 (30.0)	28 (70.0)	1.76 (1)	0.185
8000	Right	Preserved	0 (0.0)	48 (100.0)	0 (0.0)	40 (100.0)	-	†
		Maintained preservation	29 (60.4)	19 (39.6)	28 (70.0)	12 (30.0)	0.88 (1)	0.349
		Deteriorated	10 (20.8)	38 (79.2)	9 (22.5)	31 (77.5)	0.04 (1)	0.850
		Continued deterioration	9 (18.8)	39 (81.2)	3 (7.5)	37 (92.5)	2.35 (1)	0.126
500	Left	Preserved	0 (0.0)	48 (100.0)	0 (0.0)	40 (100.0)	-	†
		Maintained preservation	25 (52.1)	23 (47.9)	23 (57.5)	17 (42.5)	0.26 (1)	0.611
		Deteriorated	22 (45.8)	26 (54.2)	16 (40.0)	24 (60.0)	0.30 (1)	0.582
		Continued deterioration	1 (2.1)	47 (97.9)	1 (2.5)	39 (97.5)	-	1.000**

* Statistical significance is based on Chi-square test for independence; ** Statistical significance is based on Fisher's exact test.
† indicates constant value.

Table 4.21, continued

Frequency	**Ear**	**Hearing threshold level**	**Factory 1 (*n* = 48)**		**Factory 2 (*n* = 40)**		**χ^2 statistic* (*df*)**	***p* value***
			Yes ***n* (%)**	**No** ***n* (%)**	**Yes** ***n* (%)**	**No** ***n* (%)**		
1000	Left	Preserved	0 (0.0)	48 (100.0)	0 (0.0)	40 (100.0)	-	†
		Maintained preservation	23 (47.9)	25 (52.1)	19 (47.5)	21 (52.5)	0.00 (1)	0.969
		Deteriorated	22 (45.8)	26 (54.2)	19 (47.5)	21 (52.5)	0.02 (1)	0.876
		Continued deterioration	3 (6.2)	45 (93.8)	2 (5.0)	38 (95.0)	-	1.000**
2000	Left	Preserved	0 (0.0)	48 (100.0)	0 (0.0)	40 (100.0)	-	†
		Maintained preservation	25 (52.1)	23 (47.9)	22 (55.0)	18 (45.0)	0.08 (1)	0.785
		Deteriorated	21 (43.8)	27 (56.2)	17 (42.5)	23 (57.5)	0.01 (1)	0.906
		Continued deterioration	2 (4.2)	46 (95.8)	1 (2.5)	39 (97.5)	-	1.000**
3000	Left	Preserved	0 (0.0)	48 (100.0)	0 (0.0)	40 (100.0)	-	†
		Maintained preservation	21 (43.8)	27 (56.2)	22 (55.0)	18 (45.0)	1.11 (1)	0.293
		Deteriorated	23 (47.9)	25 (52.1)	16 (40.0)	24 (60.0)	0.55 (1)	0.457
		Continued deterioration	4 (8.3)	44 (91.7)	2 (5.0)	38 (95.0)	-	0.685**
4000	Left	Preserved	0 (0.0)	48 (100.0)	0 (0.0)	40 (100.0)	-	†
		Maintained preservation	16 (33.3)	32 (66.7)	19 (47.5)	21 (52.5)	1.83 (1)	0.176
		Deteriorated	27 (56.2)	21 (43.8)	16 (40.0)	24 (60.0)	2.31 (1)	0.129
		Continued deterioration	5 (10.4)	43 (89.6)	5 (12.5)	35 (87.5)	-	1.000**

* Statistical significance is based on Chi-square test for independence; ** Statistical significance is based on Fisher's exact test.
† indicates constant value.

Table 4.21, continued

Frequency	**Ear**	**Hearing threshold level**	**Factory 1 (*n* = 48)**		**Factory 2 (*n* = 40)**		**χ^2 statistic* (*df*)**	***p* value***
			Yes *n* (%)	**No *n* (%)**	**Yes *n* (%)**	**No *n* (%)**		
6000	Left	Preserved	4 (8.3)	44 (91.7)	1 (2.5)	39 (97.5)	-	0.371**
		Maintained preservation	8 (16.7)	40 (83.3)	11 (27.5)	29 (72.5)	1.51 (1)	0.219
		Deteriorated	21 (43.8)	27 (56.2)	16 (40.0)	24 (60.0)	0.13 (1)	0.723
		Continued deterioration	15 (31.2)	33 (68.8)	12 (30.0)	28 (70.0)	0.02 (1)	0.899
8000	Left	Preserved	2 (4.2)	46 (95.8)	1 (2.5)	39 (97.5)	-	1.000**
		Maintained preservation	34 (70.8)	14 (29.2)	27 (67.5)	13 (32.5)	0.11 (1)	0.736
		Deteriorated	7 (14.6)	41 (85.4)	8 (20.0)	32 (80.0)	0.45 (1)	0.501
		Continued deterioration	5 (10.4)	43 (89.6)	4 (10.0)	36 (90.0)	-	1.000**

* Statistical significance is based on Chi-square test for independence; ** Statistical significance is based on Fisher’s exact test.

† indicates constant value

4.4 Comparing association between standard threshold shifts and participants from Factory 1 and Factory 2

4.4.1 Comparing association between standard threshold shifts and participants from the two factories of post-shift exposure at the first month according to the Factories and Machinery (Noise Exposure) Regulations 1989

A Fisher's exact test for association was conducted to compare association between participants from the two factories and standard threshold shifts. These associations were conducted to both ears at 2000, 3000 and 4000 Hz. All expected cell frequencies were not greater than five in either ear. Based on intention-to-treat analysis and as per-protocol analysis, there were no statistically significant associations between participants from the two factories and standard threshold shifts at these frequencies as depicted in Table 4.22. Hence, there were no differences in the standard threshold shifts upon adopting different permissible exposure limits at these frequencies according to the Factories and Machinery (Noise Exposure) Regulations 1989.

4.4.2 Comparing association between standard threshold shifts and participants from the two factories of post-shift exposure at the first month according to the U.S. OSHA regulations

A Chi-square test for association was conducted to compare association (Connolly, 2007; Hinders, 2008) between the participants from the two factories and standard threshold shifts. These associations were conducted on both ears at 2000, 3000 and 4000 Hz. All expected cell frequencies were greater than five for both ears. Based on intention-to-treat analysis and as per-protocol analysis, there were no statistically significant associations between participants from the two factories and standard threshold shifts at these frequencies as depicted in Table 4.23. Hence, there were no differences in the standard threshold shifts upon adopting different permissible exposure limits at these frequencies according to the U.S. OSHA regulations.

4.4.3 Comparing association between standard threshold shifts and participants from the two factories of post-shift exposure at the first month according to the U.S. NIOSH recommended standard

A Chi-square test for association was conducted to compare association between participants from the two factories and standard threshold shifts when all the expected cell frequencies were greater than five for both ears. If the criteria were not met, a Fisher’s exact test for association was conducted. These associations were conducted to both right and left ears at 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz. Based on intention-to-treat analysis and as per-protocol analysis, there were no statistically significant associations between participants from the two factories and standard threshold shifts for these frequencies as depicted in Table 4.24. Hence, there were no differences in the standard threshold shifts upon adopting different permissible exposure limits at these frequencies according to the U.S. NIOSH recommended standard.

Table 4.22: Comparison of association between standard threshold shifts and participants from Factory 1 and Factory 2 at the first month according to the Factories and Machinery (Noise Exposure) Regulations 1989

Variable (Factory)	**Frequency (Ear)**	**Based on intention-to-treat analysis Factory 1 (*n* = 106) Factory 2 (*n* = 97)**				**As per-protocol analysis Factory 1 (*n* = 62) Factory 2 (*n* = 65)**			
		STS *n* (%)	**No STS *n* (%)**	**χ^2 statistic (*df*)**	***p* value***	**STS *n* (%)**	**No STS *n* (%)**	**χ^2 statistic (*df*)**	***p* value***
Factory 1	2000	0 (0.0)	106 (100.0)	-	0.050	0 (0.0)	62 (100.0)	-	0.119
Factory 2	(Right)	4 (4.1)	93 (95.9)			4 (6.2)	61 (93.8)		
Factory 1	2000	1 (0.9)	105 (99.1)	-	0.607	1 (1.6)	61 (98.4)	-	1.000
Factory 2	(Left)	2 (2.1)	95 (97.9)			2 (3.1)	63 (96.9)		
Factory 1	3000	1 (0.9)	105 (99.1)	-	0.350	1 (1.6)	61 (98.4)	-	0.619
Factory 2	(Right)	3 (3.1)	94 (96.9)			3 (4.6)	62 (95.4)		
Factory 1	3000	3 (2.8)	103 (97.2)	-	0.623	3 (4.8)	59 (95.2)	-	0.357
Factory 2	(Left)	1 (1.0)	96 (99.0)			1 (1.5)	64 (98.5)		
Factory 1	4000	5 (4.7)	101 (95.3)	-	0.723	5 (8.1)	57 (91.9)	-	0.485
Factory 2	(Right)	3 (3.1)	94 (96.9)			3 (4.6)	62 (95.4)		
Factory 1	4000	5 (4.7)	101 (95.3)	-	0.448	5 (8.1)	57 (91.9)	-	0.266
Factory 2	(Left)	2 (2.1)	95 (97.9)			2 (3.1)	63 (96.9)		

* Statistical significance is based on Fisher's exact test
STS, Standard threshold shift

Table 4.23: Comparison of association between standard threshold shifts and participants from Factory 1 and Factory 2 at the first month according to the U.S. OSHA regulations

Variable (Factory)	**Frequency (Ear)**	**Based on intention-to-treat analysis Factory 1 (*n* = 106) Factory 2 (*n* = 97)**				**As per-protocol analysis Factory 1 (*n* = 62) Factory 2 (*n* = 65)**			
		STS *n* (%)	**No STS *n* (%)**	**χ^2 statistic* (*df*)**	***p* value***	**STS *n* (%)**	**No STS *n* (%)**	**χ^2 statistic* (*df*)**	***p* value***
Factory 1	2000	4 (3.8)	102 (96.2)	1.17 (1)	0.279	4 (6.5)	58 (93.5)	0.75 (1)	0.387
Factory 2	(Right)	7 (7.2)	90 (92.8)			7 (10.8)	58 (89.2)		
Factory 1	2000	5 (4.7)	101 (95.3)	0.57 (1)	0.451	5 (8.1)	57 (91.9)	0.27 (1)	0.602
Factory 2	(Left)	7 (7.2)	90 (92.8)			7 (10.8)	58 (89.2)		
Factory 1	3000	10 (9.4)	96 (90.6)	0.20 (1)	0.656	10 (16.1)	52 (83.9)	0.01 (1)	0.904
Factory 2	(Right)	11 (11.3)	86 (88.7)			11 (16.9)	54 (83.1)		
Factory 1	3000	8 (7.5)	98 (92.5)	0.48 (1)	0.489	8 (12.9)	54 (87.1)	0.16 (1)	0.689
Factory 2	(Left)	10 (10.3)	87 (89.7)			10 (15.4)	55 (84.6)		
Factory 1	4000	13 (12.3)	93 (87.7)	0.00 (1)	0.982	13 (21.0)	49 (79.0)	0.13 (1)	0.723
Factory 2	(Right)	12 (12.4)	85 (87.6)			12 (18.5)	53 (81.5)		
Factory 1	4000	11 (10.4)	95 (89.6)	0.20 (1)	0.654	11 (17.7)	51 (82.3)	0.01 (1)	0.916
Factory 2	(Left)	12 (12.4)	85 (87.6)			12 (18.5)	53 (81.5)		

* Statistical significance is based on Chi-square test for independence
STS, Standard threshold shift

Table 4.24: Comparison of association between standard threshold shifts and participants from Factory 1 and Factory 2 at the first month according to the U.S. NIOSH recommended standard

Variable (Factory)	Frequency (Ear)	Based on intention-to-treat analysis Factory 1 (*n* = 106) Factory 2 (*n* = 97)				As per-protocol analysis Factory 1 (*n* = 62) Factory 2 (*n* = 65)			
		STS *n* (%)	**No STS *n* (%)**	**χ^2 statistic (*df*)**	***p* value***	**STS *n* (%)**	**No STS *n* (%)**	**χ^2 statistic (*df*)**	***p* value***
Factory 1	500	0 (0.0)	106 (100.0)	-	0.107	0 (0.0)	62 (100.0)	-	0.244
Factory 2	(Right)	3 (3.1)	94 (96.9)			3 (4.6)	62 (95.4)		
Factory 1	500	0 (0.0)	106 (100.0)	-	0.478	0 (0.0)	62 (100.0)	-	1.000
Factory 2	(Left)	1 (1.0)	96 (99.0)			1 (1.5)	64 (98.5)		
Factory 1	1000	-	106 (100.0)	-	1.000	-	62 (100.0)	-	1.000
Factory 2	(Right)		97 (100.0)				65 (100.0)		
Factory 1	1000	0 (0.0)	106 (100.0)	-	0.478	0 (0.0)	62 (100.0)	-	1.000
Factory 2	(Left)	1 (1.0)	96 (99.0)			1 (1.5)	64 (98.5)		
Factory 1	2000	0 (0.0)	106 (100.0)	-	0.050	0 (0.0)	62 (100.0)	-	0.119
Factory 2	(Right)	4 (4.1)	93 (95.9)			4 (6.2)	61 (93.8)		
Factory 1	2000	1 (0.9)	105 (99.1)	-	0.607	1 (1.6)	61 (98.4)	-	1.000
Factory 2	(Left)	2 (2.1)	95 (97.9)			2 (3.1)	63 (96.9)		
Factory 1	3000	1 (0.9)	105 (99.1)	-	0.350	1 (1.6)	61 (98.4)	-	0.619
Factory 2	(Right)	3 (3.1)	94 (96.9)			3 (4.6)	62 (95.4)		
Factory 1	3000	3 (2.8)	103 (97.2)	-	0.623	3 (4.8)	59 (95.2)	-	0.357
Factory 2	(Left)	1 (1.0)	96 (99.0)			1 (1.5)	64 (98.5)		
Factory 1	4000	5 (4.7)	101 (95.3)	-	0.723	5 (8.1)	57 (91.9)	-	0.485
Factory 2	(Right)	3 (3.1)	94 (96.9)			3 (4.6)	62 (95.4)		

* Statistical significance is based on Fisher's exact test, ** Statistical significance is based on Chi-square test for independence
STS, Standard threshold shift

Table 4.24, continued

Variable (Factory)	Frequency (Ear)	**Based on intention-to-treat analysis** **Factory 1 (*n* = 106)** **Factory 2 (*n* = 97)**				**As per-protocol analysis** **Factory 1 (*n* = 62)** **Factory 2 (*n* = 65)**			
		STS *n* (%)	**No STS *n* (%)**	**χ^2 statistic (*df*)**	***p* value***	**STS *n* (%)**	**No STS *n* (%)**	**χ^2 statistic (*df*)**	***p* value***
Factory 1	4000	5 (4.7)	101 (95.3)	-	0.448	5 (8.1)	57 (91.9)	-	0.266
Factory 2	(Left)	2 (2.1)	95 (97.9)			2 (3.1)	63 (96.9)		
‘Factory 1	6000	10 (9.4)	96 (90.6)	0.74 (1)	0.391**	10 (16.1)	52 (83.9)	1.37 (1)	0.242**
Factory 2	(Right)	6 (6.2)	91 (93.8)			6 (9.2)	59 (90.8)		
Factory 1	6000	3 (2.8)	103 (97.2)	-	0.483	3 (4.8)	59 (95.2)	-	0.718
Factory 2	(Left)	5 (5.2)	92 (94.8)			5 (7.7)	60 (92.3)		
Factory 1	8000	4 (3.8)	102 (96.2)	-	0.739	4 (6.5)	58 (93.5)	-	1.000
Factory 2	(Right)	5 (5.2)	92 (94.8)			5 (7.7)	60 (92.3)		
Factory 1	8000	3 (2.8)	103 (97.2)	3.79 (1)	0.052**	3 (4.8)	59 (95.2)	3.01 (1)	0.083**
Factory 2	(Left)	9 (9.3)	88 (90.7)			9 (13.8)	56 (86.2)		

* Statistical significance is based on Fisher’s exact test, ** Statistical significance is based on Chi-square test for independence
STS, Standard threshold shift

4.4.4 Comparing association between standard threshold shifts and participants from the two factories of pre-shift exposure at the sixth month according to the Factories and Machinery (Noise Exposure) Regulations 1989

A Chi-square test for association was conducted to compare association between participants from the two factories and standard threshold shifts. These associations were conducted to both ears at 2000, 3000 and 4000 Hz. All expected cell frequencies were greater than five for both ears. Based on intention-to-treat analysis and as per-protocol analysis, there were no statistically significant associations between participants from the two factories and standard threshold shifts at these frequencies as depicted in Table 4.25. Hence, there were no differences in the standard threshold shifts upon adopting different permissible exposure limits at these frequencies.

4.4.5 Comparing association between standard threshold shifts and participants from the two factories of pre-shift exposure at the sixth month according to the U.S. OSHA regulations

A Chi-square test for association was conducted to compare association between participants from the two factories and standard threshold shifts. These associations were conducted to both ears at 2000, 3000 and 4000 Hz. All expected cell frequencies were greater than five for both ears. Based on intention-to-treat analysis and as per-protocol analysis, there were no statistically significant associations between participants from the two factories and standard threshold shifts at these frequencies as depicted in Table 4.26. Hence, there were no differences in the standard threshold shifts upon adopting different permissible exposure limits at these frequencies.

4.4.6 Comparing association between standard threshold shifts and participants from the two factories of pre-shift exposure at the sixth month according to the U.S. NIOSH recommended standard

A Chi-square test for association was conducted to compare association between participants from the two factories and standard threshold shifts. These associations were conducted to both ears at 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz. All expected cell frequencies were greater than five for both ears. Based on intention-to-treat analysis, there were no statistically significant associations between participants from the two factories and standard threshold shifts at these frequencies as depicted in Table 4.27. However, as per-protocol analysis, there was statistically significant association between participants from the two factories and standard threshold shifts at 1000 Hz on left ear at the sixth month, χ^2 (1) = 3.93, φ = 0.211, p = 0.047. According to Cohen (1988), the effect size was “small” (Cohen, 1988). The finding indicated that there was a moderate association (Rea & Parker, 1992) between adoption of different permissible exposure limits and worsening of the temporary standard threshold shifts among participants from Factory 1. There were no statistically significant associations between participants from the two factories and standard threshold shifts at other tested frequencies. Hence, there were no differences in the standard thresholds shifts upon adopting different permissible exposure limits at frequencies other than 1000 Hz of left ear.

Table 4.25: Comparison of association between standard threshold shifts and participants from Factory 1 and Factory 2 at the sixth month according to the Factories and Machinery (Noise Exposure) Regulations 1989

Variable (Factory)	**Frequency (Ear)**	**Based on intention-to-treat analysis Factory 1 (*n* = 106) Factory 2 (*n* = 97)**				**As per-protocol analysis Factory 1 (*n* = 48) Factory 2 (*n* = 40)**			
		STS *n* (%)	**No STS *n* (%)**	**χ^2 statistic* (*df*)**	***p* value***	**STS *n* (%)**	**No STS *n* (%)**	**χ^2 statistic* (*df*)**	***p* value***
Factory 1	2000	17 (16.0)	89 (84.0)	1.44 (1)	0.230	17 (35.4)	31 (64.6)	2.55 (1)	0.110
Factory 2	(Right)	10 (10.3)	87 (89.7)			8 (20.0)	32 (80.0)		
Factory 1	2000	16 (15.1)	90 (84.9)	0.62 (1)	0.431	16 (33.3)	32 (66.7)	0.73 (1)	0.394
Factory 2	(Left)	11 (11.3)	86 (88.7)			10 (25.0)	30 (75.0)		
Factory 1	3000	16 (15.1)	90 (84.9)	0.02 (1)	0.894	16 (33.3)	32 (66.7)	0.11 (1)	0.738
Factory 2	(Right)	14 (14.4)	83 (85.6)			12 (30.0)	28 (70.0)		
Factory 1	3000	22 (20.8)	84 (79.2)	1.39 (1)	0.239	20 (41.7)	28 (58.3)	0.78 (1)	0.376
Factory 2	(Left)	14 (14.4)	83 (85.6)			13 (32.5)	27 (67.5)		
Factory 1	4000	25 (23.6)	81 (76.4)	0.77 (1)	0.381	25 (52.1)	23 (47.9)	1.28 (1)	0.258
Factory 2	(Right)	18 (18.6)	79 (81.4)			16 (40.0)	24 (60.0)		
Factory 1	4000	28 (26.4)	78 (73.6)	1.33 (1)	0.249	26 (54.2)	22 (45.8)	0.73 (1)	0.392
Factory 2	(Left)	19 (19.6)	78 (80.4)			18 (45.0)	22 (55.0)		

* Statistical significance is based on Chi-square test for independence
STS, Standard threshold shift

Table 4.26: Comparison of association between standard threshold shifts and participants from Factory 1 and Factory 2 at the sixth month according to the U.S. OSHA regulations

Variable (Factory)	**Frequency (Ear)**	**Based on intention-to-treat analysis Factory 1 (*n* = 106) Factory 2 (*n* = 97)**				**As per-protocol analysis Factory 1 (*n* = 48) Factory 2 (*n* = 40)**			
		STS *n* (%)	**No STS *n* (%)**	**χ^2 statistic* (*df*)**	***p* value***	**STS *n* (%)**	**No ST S *n* (%)**	**χ^2 statistic* (*df*)**	***p* value***
Factory 1	2000	41 (38.7)	65 (61.3)	1.73 (1)	0.189	39 (81.2)	9 (18.8)	2.98 (1)	0.084
Factory 2	(Right)	29 (29.9)	68 (70.1)			26 (65.0)	14 (35.0)		
Factory 1	2000	34 (32.1)	72 (67.9)	0.98 (1)	0.323	32 (66.7)	16 (33.3)	1.83 (1)	0.176
Factory 2	(Left)	25 (25.8)	72 (74.2)			21 (52.5)	19 (47.5)		
Factory 1	3000	36 (34.0)	70 (66.0)	0.02 (1)	0.883	32 (66.7)	16 (33.3)	0.01 (1)	0.934
Factory 2	(Right)	32 (33.0)	65 (67.0)			27 (67.5)	13 (32.5)		
Factory 1	3000	34 (32.1)	72 (67.9)	0.25 (1)	0.620	32 (66.7)	16 (33.3)	1.25 (1)	0.263
Factory 2	(Left)	28 (28.9)	69 (71.1)			22 (55.0)	18 (45.0)		
Factory 1	4000	43 (40.6)	63 (59.4)	0.04 (1)	0.840	40 (83.3)	8 (16.7)	0.48 (1)	0.490
Factory 2	(Right)	38 (39.2)	59 (60.8)			31 (77.5)	9 (22.5)		
Factory 1	4000	44 (41.5)	62 (58.5)	0.41 (1)	0.522	39 (81.2)	9 (18.8)	0.50 (1)	0.478
Factory 2	(Left)	36 (37.1)	61 (62.9)			30 (75.0)	10 (25.0)		

* Statistical significance is based on Chi-square test for independence
STS, Standard threshold shift

Table 4.27: Comparison of association between standard threshold shifts and participants from Factory 1 and Factory 2 at the sixth month according to the U.S. NIOSH recommended standard

Variable (Factory)	**Frequency (Ear)**	**Based on intention-to-treat analysis Factory 1 (*n* = 106) Factory 2 (*n* = 97)**				**As per-protocol analysis Factory 1 (*n* = 48) Factory 2 (*n* = 40)**			
		STS *n* (%)	**No STS *n* (%)**	**χ^2 statistic* (*df*)**	***p* value***	**STS *n* (%)**	**No STS *n* (%)**	**χ^2 statistic* (*df*)**	***p* value***
Factory 1	500	11 (10.4)	95 (89.6)	0.00 (1)	0.987	11 (22.9)	37 (77.1)	0.00 (1)	0.963
Factory 2	(Right)	10 (10.3)	87 (89.7)			9 (22.5)	31 (77.5)		
Factory 1	500	5 (4.7)	101 (95.3)	1.05 (1)	0.305	10 (20.8)	38 (79.2)	0.50 (1)	0.480
Factory 2	(Left)	8 (8.2)	89 (91.8)			6 (15.0)	34 (85.0)		
Factory 1	1000	22 (20.8)	84 (79.2)	0.60 (1)	0.437	22(45.8)	26 (54.2)	0.30 (1)	0.582
Factory 2	(Right)	16 (16.5)	81 (83.5)			16 (40.0)	24 (60.0)		
Factory 1	1000	19 (17.9)	87 (82.1)	3.18 (1)	0.074	19 (39.6)	29 (60.4)	3.93 (1)	0.047
Factory 2	(Left)	9 (9.3)	88 (90.7)			8 (20.0)	32 (80.0)		
Factory 1	2000	17 (16.0)	89 (84.0)	1.44 (1)	0.230	17 (35.4)	31 (64.6)	2.55 (1)	0.110
Factory 2	(Right)	10 (10.3)	87 (89.7)			8 (20.0)	32 (80.0)		
Factory 1	2000	16 (15.1)	90 (84.9)	0.62 (1)	0.431	16 (33.3)	32 (66.7)	0.73 (1)	0.394
Factory 2	(Left)	11 (11.3)	86 (88.7)			10 (25.0)	30 (75.0)		
Factory 1	3000	16 (15.1)	90 (84.9)	0.02 (1)	0.894	16 (33.3)	32 (66.7)	0.11 (1)	0.738
Factory 2	(Right)	14 (14.4)	83 (85.6)			12 (30.0)	28 (70.0)		
Factory 1	3000	22 (20.8)	84 (79.2)	1.39 (1)	0.239	20 (41.7)	28 (58.3)	0.78 (1)	0.376
Factory 2	(Left)	14 (14.4)	83 (85.6)			13 (32.5)	27 (67.5)		
Factory 1	4000	25 (23.6)	81 (76.4)	0.77 (1)	0.381	25 (52.1)	23 (47.9)	1.28 (1)	0.258
Factory 2	(Right)	18 (18.6)	79 (81.4)			16 (40.0)	24 (60.0)		

* Statistical significance is based on Chi-square test for independence
STS, Standard threshold shift

Table 4.27, continued

Variable (Factory)	Frequency (Ear)	Based on intention-to-treat analysis Factory 1 (n = 106) Factory 2 (n = 97)				As per-protocol analysis Factory 1 (n = 48) Factory 2 (n = 40)			
		STS ***n* (%)**	**No STS** ***n* (%)**	**χ^2 statistic*** **(*df*)**	***p* value***	**STS** ***n* (%)**	**No STS** ***n* (%)**	**χ^2 statistic*** **(*df*)**	***p* value***
Factory 1	4000	28 (26.4)	78 (73.6)	1.33 (1)	0.249	26 (54.2)	22 (45.8)	0.73 (1)	0.392
Factory 2	(Left)	19 (19.6)	78 (80.4)			18 (45.0)	22 (55.0)		
Factory 1	6000	21 (19.8)	85 (80.2)	0.00 (1)	0.968	20 (41.7)	28 (58.3)	0.03 (1)	0.874
Factory 2	(Right)	19 (19.6)	78 (80.4)			16 (40.0)	24 (60.0)		
Factory 1	6000	18 (17.0)	88 (83.0)	0.44 (1)	0.507	17 (35.4)	31 (64.6)	0.46 (1)	0.497
Factory 2	(Left)	20 (20.6)	77 (79.4)			17 (42.5)	23 (57.5)		
Factory 1	8000	13 (12.3)	93 (87.7)	0.74 (1)	0.390	12 (25.0)	36 (75.0)	1.05 (1)	0.306
Factory 2	(Right)	16 (16.5)	81 (83.5)			14 (35.0)	26 (65.0)		
Factory 1	8000	11 (10.4)	95 (89.6)	1.64 (1)	0.200	10(20.8)	38 (79.2)	1.54 (1)	0.215
Factory 2	(Left)	16 (16.5)	81 (83.5)			13 (32.5)	27 (67.5)		

* Statistical significance is based on Chi-square test for independence
STS, Standard threshold shift

4.5 Reliability and factor analysis of knowledge, attitude and practice of noise-induced hearing loss questionnaire

The questionnaires, as shown in Appendices 11 and 12, were used for the test-retest and internal consistency reliability, and also to identify the contents of the questions that could be grouped under the same factor by the exploratory factor analysis.

4.5.1 Test-retest reliability of the questionnaire

There were a total of 39 participants who took part in this procedure in the cement and sawmill factories. The mean age of the participants was 39.5 (± 10.37) years. Around 40% of them were Malays and around 40% were manual laborers. The mean duration of employment among the participants was 7.6 ± 8.50 years. More than 90% were earning less than RM 3000 a month with more than 70% had attained either primary or secondary school education only. Around three quarter of them never smoked and majority of them had never consumed alcohol and never took up hobbies with an increased risk of hearing loss. The first and second set of all the items showed a strong correlation (Cohen, 1988) where all of them were more than 0.700. All the items of the questionnaires were not statistically significant different when they were re-distributed, except for the item AJ5 (p = 0.033) as depicted in Table 4.28.

Table 4.28: Test-retest reliability of the questionnaire

Paired *t*-test	**Correlation**	**Mean difference (SD)**	***p* value***
First K1 and Second K1	0.812	0.000 (± 0.459)	1.000
First K2 and Second K2	0.721	0.000 (± 0.229)	1.000
First K3 and Second K3	0.930	0.000 (± 0.229)	1.000
First K4 and Second K4	0.910	0.000 (± 0.229)	1.000
First K5 and Second K5	0.921	- 0.051 (± 0.320)	0.324
First K6 and Second K6	0.845	- 0.051 (± 0.320)	0.324
First K7 and Second K7	0.753	- 0.077 (± 0.580)	0.412
First K8 and Second K8	0.940	- 0.026 (± 0.160)	0.324
First K9 and Second K9	0.948	- 0.051 (± 0.320)	0.324
First K10 and Second K10	0.834	- 0.051 (± 0.320)	0.324
First K11 and Second K11	1.000	0	1.000
First K12 and Second K12	0.886	0.026 (± 0.280)	0.570
First AB1 and Second AB1	0.964	0.077 (± 0.270)	0.083
First AB2 and Second AB2	0.975	0.026 (± 0.160)	0.324
First AB3 and Second AB3	0.758	0.000 (± 0.324)	1.000
First AB4 and Second AB4	0.931	0.026 (± 0.280)	0.570
First AB5 and Second AB5	0.879	0.103 (± 0.384)	0.103
First AB6 and Second AB6	0.888	0.000 (± 0.562)	1.000
First AB7 and Second AB7	0.968	- 0.026 (± 0.160)	0.324
First AB8 and Second AB8	1.000	0	1.000
First AF1 and Second AF1	1.000	0	1.000
First AF2 and Second AF2	0.970	0.000 (± 0.229)	1.000
First AF3 and Second AF3	0.874	0.026 (± 0.280)	0.570
First AF4 and Second AF4	0.811	0.026 (± 0.362)	0.661
First AF5 and Second AF5	0.984	0.051 (± 0.223)	0.160
First AF6 and Second AF6	0.986	0.000 (± 0.229)	1.000
First AJ1 and Second AJ1	0.978	- 0.026 (± 0.160)	0.324
First AJ2 and Second AJ2	0.953	0.026 (± 0.362)	0.661`
First AJ3 and Second AJ3	0.976	- 0.026 (± 0.280)	0.570
First AJ4 and Second AJ4	0.935	- 0.026 (± 0.280)	0.570
First AJ5 and Second AJ5	0.866	0.179 (± 0.506)	0.033

* Statistical significance is based on Paired *t*-test

Table 4.28, continued

Paired *t*-test	**Correlation**	**Mean difference (SD)**	***p* value***
First AJ6 and Second AJ6	0.782	0.051 (± 0.647)	0.623
First P1 and Second P1	0.921	- 0.051 (± 0.320)	0.324
First P2 and Second P2	0.986	- 0.026 (± 0.160)	0.324
First P3 and Second P3	0.985	0.026 (± 0.160)	0.324
First P4 and Second P4	0.986	- 0.026 (± 0.160)	0.324
First P5 and Second P5	1.000	0	1.000
First P6 and Second P6	0.979	0.026 (± 0.160)	0.324
First P7 and Second P7	1.000	0	1.000
First P8 and Second P8	0.984	- 0.026 (± 0.160)	0.324
First P9 and Second P9	0.964	0.051 (± 0.223)	0.160
First P10 and Second P10	0.986	- 0.026 (± 0.160)	0.324

* Statistical significance is based on Paired *t*-test

4.5.2 Internal consistency reliability and exploratory factor analysis of the questionnaire

There were a total of 116 participants in a pilot study to assess internal consistency and factor analysis of the questionnaire. This study was conducted in an oil and gas company and concrete manufacturing factory. The mean age of these participants was 36.7 (± 10.12). Around 65% of them were Malays. The mean duration of employment among the participants was 7.2 ± 7.18 years. More than half were earning less than RM 3000 a month. More than 40% had attained secondary or primary school education, and the rest continued education at Form Six, college or university equal. More than 70% of them never smoked and the majority of them never consumed alcohol, while around 15% of them took up hobbies with an increased risk of hearing loss.

4.5.2.1 Internal consistency reliability of the questionnaire

There were five domains analyzed separately, i.e., knowledge, attitude (belief, feeling, judgment) and practice for internal consistency. The results are shown in Table 4.29 and Table 4.30. The Cronbach's Alpha for the knowledge domain was 0.879. The correlation value of each item with at least one other item in the construct was acceptable (the level was at least 0.3) (Field, 2005), except for the item K12.

The initial Cronbach's Alpha for the belief subdomain was 0.367. In order to increase the internal consistency of this domain, the items AB5, AB3, AB6, AB2 and AB1 were deleted, respectively. The Cronbach's Alpha for this domain was then increased to 0.604. However, the correlation value of the item AB4, with at least one other item in this construct, was below 0.3; the item AB4 in the corrected item-total correlation was also below 0.3. Therefore, the item AB4 was deleted too. The Cronbach's Alpha for the belief subdomain was then increased to 0.723.

The initial Cronbach's Alpha for the feeling subdomain was 0.629. However, the correlation value of the items AF2 and AF1 with at least one other item in this construct were below 0.3; the items AF2 and AF1 in the corrected item-total correlation were very low (below 0.3). After deleting items AF2 and AF1, respectively, the Cronbach's Alpha for the feeling subdomain was then increased to 0.747.

The initial Cronbach's Alpha for the judgment subdomain was 0.515. In order to increase the internal consistency in this domain, the item AJ2 was deleted. The Cronbach's Alpha was then increased to 0.623. However, the correlation value of the item AJ3 with at least one other item in this construct was below 0.3; the AJ3 item in the corrected item-total correlation was very low, 0.073 (below 0.3). Hence, the item AJ3 was deleted, and the Cronbach's Alpha for the judgment subdomain was increased to 0.737.

The initial Cronbach's Alpha for practice domain was 0.405. In order to increase the internal consistency in this domain, the items P4 and P7 were deleted, respectively. The Cronbach's Alpha was then increased to 0.635. However, the correlation value of the item P6 with at least one other item in this construct was below 0.3; the item P6 in the corrected item-total correlation was very low (below 0.3). Hence, the item P6 was deleted. The Cronbach's Alpha for the practice domain had then increased to 0.720. The correlation value for the item P9 with at least one other item in this construct was below 0.3 and the item P9 also showed that the corrected item-total correlation was very low and hence, the item P9 was deleted. The Cronbach's Alpha for the practice domain was later increased to 0.784. The correlation value of the item P1 with at least one other item in this construct was below 0.3; the item P1 in the corrected item-total correlation was very low and hence, the item P1 was also deleted. The Cronbach's Alpha for the practice domain had improved to 0.849.

Table 4.29: Internal consistency reliability of various domains

Domain	**Cronbach's Alpha**
Knowledge	0.879
Belief	0.723
Feeling	0.747
Judgment	0.737
Practice	0.849

Table 4.30: Corrected item-total correlation on different items of various domains after internal consistency reliability

Item	Corrected Item-Total Correlation
K1	0.498
K2	0.519
K3	0.511
K4	0.504
K5	0.578
K6	0.595
K7	0.700
K8	0.659
K9	0.568
K10	0.707
K11	0.666
K12	0.445
AB7	0.568
AB8	0.568
AF3	0.630
AF4	0.396
AF5	0.540
AF6	0.611
AJ1	0.448
AJ4	0.462
AJ5	0.641
AJ6	0.575
P2	0.684
P3	0.727
P5	0.631
P8	0.611
P10	0.654

4.5.2.2 Exploratory factor analysis of the questionnaire

The items K4, K12 and K2 were removed, respectively from the Pattern Matrix of knowledge domain, since either the factor score coefficient matrix or the correlation value of the item with at least one other item in the construct was not at acceptable levels, i.e., less than 0.5 for the factor score coefficient matrix (Field, 2000) and less than 0.3 for the correlation value (Field, 2005). The Kaiser-Meyer-Olkin measure was 0.879 and Bartlett's Test of Sphericity was statistically significant ($p < 0.001$).

The items AB6, AB5, AB3, AB1, AB4 and AB2 were removed, respectively from the Pattern Matrix of belief subdomain, since either the factor score coefficient matrix or the correlation value of the item with at least one other item in the construct was not acceptable (Field, 2000, 2005). The Kaiser-Meyer-Olkin measure was 0.500 and Bartlett's Test of Sphericity was of statistically significant ($p < 0.001$). All the six items in feeling subdomain initially failed to converge in the Pattern Matrix. The items AF2 and AF1 were removed, respectively, since the correlation value of each item with at least one other item in the construct was not acceptable (less than 0.3) (Field, 2005). The Kaiser-Meyer-Olkin measure was 0.525 and Bartlett's Test of Sphericity was statistically significant value ($p < 0.001$). The items AJ3 and AJ2 were removed, respectively from the Pattern Matrix of judgment subdomain, since either the factor score coefficient matrix or the correlation value of the item with at least one other item in the construct was not acceptable (Field, 2000, 2005). The Kaiser-Meyer-Olkin measure was 0.601 and Bartlett's Test of Sphericity was statistically significant ($p < 0.001$).

The items P7, P6, P9, P4 and P1 were removed, respectively from the Pattern Matrix of the practice domain, since either the factor score coefficient matrix or the correlation value of the item with at least one other item in the construct was not acceptable (Field, 2000, 2005). The Kaiser-Meyer-Olkin measure was 0.791 and Bartlett's Test of Sphericity was statistically significant (p < 0.001). The results are shown in Table 4.31 and 4.32.

Table 4.31: Kaiser-Meyer-Olkin and Bartlett's Test of various domains

Domain	**Kaiser-Meyer-Olkin Measure of Sampling Adequacy**	**Bartlett's Test of Sphericity - Approximate Chi-Square**	***p* value**
Knowledge	0.879	401.160	<0.001
Belief	0.500	44.190	<0.001
Feeling	0.525	242.541	<0.001
Judgment	0.601	151.544	<0.001
Practice	0.791	243.656	<0.001

Table 4.32: Pattern Matrix of various domains

Item	**Factor 1**	**Factor 2**
	Knowledge domain	
	Risk factors and prevention of hearing loss	Causes of hearing loss and policy protecting workers
K8	0.913	
K7	0.722	
K10	0.711	
K11	0.661	
K6	0.613	
K9	0.587	
K3		0.933
K5		0.532
K1		0.507

Table 4.32, continued

Item	Factor 1	Factor 2
	Attitude domain	
	Belief subdomain	
	Hearing protection devices and law on preventing hearing loss	
AB7	0.753	
AB8	0.753	
	Feeling subdomain	
	Outcome of hearing loss	Prevention of hearing loss
AF6	0.966	
AF5	0.847	
AF4		0.888
AF3		0.867
	Judgment subdomain	
	Prevention of hearing loss	Risk factors of hearing loss
AJ1		0.637
AJ4		0.752
AJ5	0.864	
AJ6	0.903	
	Practice domain	
	Prevention of hearing loss	
P3	0.830	
P2	0.773	
P10	0.727	
P5	0.678	
P8	0.648	

4.6 Comparing mean scores of various domains of the questionnaire between participants from Factory 1 and Factory 2

4.6.1 Comparing mean scores of various domains between participants from the two factories at baseline

As depicted in Table 4.33, an independent sample *t*-test was run to determine if there were differences in the mean scores of knowledge, belief, feeling, judgment and practice domains between participants from Factory 1 and Factory 2 at baseline (the questionnaire is shown in Appendix 13 after reliability and exploratory factor analysis). There were no statistically significant associations between participants from the two factories and mean scores of all the domains at the outset.

Table 4.33: Comparison of mean scores of various domains between participants from Factory 1 and Factory 2 at baseline

Domain	**Factory 1 (*n*=106) Mean (SD)**	**Factory 2 (*n*=97) Mean (SD)**	**Mean difference (95% CI)**	***t* statistic**	***p* value***
Knowledge	0.10 (4.01)	0.08 (3.94)	0.02 (-1.08, 1.12)	0.04 (201)	0.970
Belief	7.46 (1.59)	7.36 (1.79)	0.10 (-0.37, 0.57)	0.43 (201)	0.669
Feeling	14.84 (3.33)	14.70 (3.19)	0.14 (-0.77, 1.04)	0.30 (201)	0.763
Judgment	15.05 (3.26)	15.80 (2.86)	-0.76 (-1.60, 0.09)	-1.76 (200.65)	0.080
Practice	9.62 (2.92)	9.82 (2.61)	-0.20 (-0.97, 0.57)	-0.52 (201)	0.605

* Statistical significance is based on Independent *t* test

4.6.2 Comparing mean scores of various domains between participants from the two factories over six months based on intention-to-treat analysis

As shown in Table 4.34, repeated measures ANOVA were conducted to determine whether there were statistically significant differences in the mean scores of knowledge, attitude (belief, feeling, judgment) and practice domains between participants from Factory 1 and Factory 2 over a period of six months. Health education intervention on participants from the two factories elicited statistically significant changes in the mean scores of knowledge, belief and practice domains over time. The mean scores of the knowledge construct increased from pre-intervention to the first month (0.70; 95% CI, 0.31-1.10, $p < 0.001$), and from pre-intervention to the sixth month (0.56; 95% CI, 0.17-0.96, $p = 0.002$), but there was no statistically significant different in the mean scores of this construct from the first month to sixth month (0.14; 95% CI, -0.07-0.35, $p = 0.320$). The mean scores of the belief subdomain increased from pre-intervention to the first month (0.20; 95% CI, 0.02-0.38, $p = 0.027$), and from pre-intervention to the sixth month (0.25; 95% CI, 0.08-0.41, $p = 0.002$), but there was no change in the mean scores of the belief subdomain from the first month to sixth month (0.05; 95% CI, -0.08-0.17, $p = 1.000$). The mean scores of the feeling subdomain was not statistical significant from pre-intervention to the first month (0.34; 95% CI, -0.08-0.75, $p = 0.152$) and from pre-intervention to the sixth month (0.30; 95% CI, -0.11-0.71, $p = 0.224$), and also there was no change in the mean scores of this subdomain from the first month to the sixth month (0.04; 95% CI, -0.17-0.24, $p = 1.000$). The mean scores of the judgment subdomain was not statistical significant from pre-intervention to the first month (0.32; 95% CI, -0.03-0.67, $p = 0.080$) and from pre-intervention to the sixth month (0.26; 95% CI, -0.08-0.60, $p = 0.200$). There was also no change in the mean scores of the judgment subdomain from the first month to sixth month (0.06; 95% CI, -0.11-0.24, $p = 1.000$). The mean scores of the practice construct increased from pre-intervention to the first month (0.55; 95% CI, 0.19-0.92, p = 0.001), and from pre-intervention to the sixth month (0.37; 95% CI, 0.03-0.71, p = 0.031), but there was no change in the mean scores of the practice domain from the first month to sixth month (0.19; 95% CI, -0.02-0.39, p = 0.082). Health education intervention did not lead to any statistically significant changes in mean scores of the feeling and judgment constructs over a period of six months. There were also no differences in the mean scores of the knowledge, belief, feeling, judgment and practice domains between participants from the two factories as shown in Table 4.34.

Table 4.34: Comparison of mean scores of various domains between participants from Factory 1 and Factory 2 based on intention-to-treat analysis

Domain	**Time Period**	**Factory 1 (*n* = 106) Mean (SD)**	**Factory 2 (*n* = 97) Mean (SD)**	**Mean (95% CI)**	***p* value***
Knowledge	Baseline	0.10 (±4.01)	0.08 (±3.94)	0.05 (-0.98 to 1.09)	0.920
	First month	0.84 (±3.90)	0.75 (±3.98)		
	Sixth month	0.68 (±3.82)	0.63 (±3.89)		
Belief	Baseline	7.46 (±1.59)	7.36 (±1.79)	0.32 (-0.14 to 0.77)	0.172
	First month	7.86 (±1.61)	7.36 (±1.91)		
	Sixth month	7.83 (±1.62)	7.48 (±1.84)		
Feeling	Baseline	14.84 (±3.33)	14.70 (±3.19)	0.13 (-0.73 to 0.99)	0.761
	First month	15.22 (±3.38)	15.00 (±3.35)		
	Sixth month	15.09 (±3.39)	15.05 (±3.37)		
Judgment	Baseline	15.05 (±3.26)	15.35 (±2.86)	0.60 (-0.20 to 1.41)	0.140
	First month	15.56 (±3.08)	7.36 (±3.02)		
	Sixth month	15.35 (±3.14)	16.02 (±3.02)		
Practice	Baseline	9.62 (±2.92)	9.82 (±2.61)	0.09 (-0.61 to 0.79)	0.798
	First month	10.25 (±2.82)	10.31 (±2.75)		
	Sixth month	10.08 (±2.68)	10.09 (±2.66)		

* Statistical significance is based on repeated measures ANOVA

4.6.3 Comparing mean scores of various domains between participants from the two factories over six months as per-protocol analysis

As shown in Table 4.35, repeated measures ANOVA were conducted to determine whether there were statistically significant differences in the mean scores of knowledge, attitude (belief, feeling, judgment) and practice domains between participants from Fcatory 1 and Factory 2 as per-protocol analysis. Health education intervention on participants from the two factories elicited statistically significant changes in the mean scores of knowledge, belief and practice domains over time. The mean scores of the knowledge domain increased from pre-intervention to the first month (2.73; 95% CI, 1.66-3.80, $p < 0.001$) and from pre-intervention to the sixth month (1.99; 95% CI, 0.90-3.09, $p < 0.001$). There was also a statistically significant change in the mean scores of the knowledge construct from the first month to sixth month (0.74; 95% CI, 0.20-1.28, $p = 0.004$). The mean scores of the belief subdomain was not statistical significant from pre-intervention to the first month (0.48; 95% CI, -0.12-1.08, $p = 0.162$) and the first month to sixth month (0.17; 95% CI, -0.26-0.60, $p = 1.000$), but increased from pre-intervention to the sixth month (0.65; 95% CI, 0.10-1.19, $p = 0.014$). The mean scores of the feeling subdomain was not statistical significant from pre-intervention to the first month (1.16; 95% CI, -0.180-2.50, $p = 0.110$) and from pre-intervention to the sixth month (0.96; 95% CI, -0.31-2.23), $p = 0.205$), and there was also no change in the mean scores of feeling subdomain from the first month to sixth month (0.20; 95% CI, -0.46-0.86, $p = 1.000$). The mean scores of the judgment subdomain was not statistical significant from pre-intervention to the first month (1.01; 95% CI, -0.08-2.10, $p = 0.076$) and from pre-intervention to the sixth month (0.92; 95% CI, -0.14-1.97, $p = 0.111$). There was also no change in the mean scores of the judgment subdomain from the first month to sixth month (0.10; 95% CI, -0.52-0.72, $p = 1.000$]. The mean scores of the practice level increased from pre-intervention to the first month (1.65; 95% CI, 0.50-2.81, p = 0.003], and from the first month to sixth month (0.84; 95% CI, 0.18-1.50, p = 0.008), but there was no significant change in the mean scores of the practice construct from pre-intervention to the sixth month (0.81; 95% CI, -0.27-1.89, p = 0.206). Health education intervention did not lead to any statistically significant changes in the mean scores of feeling and judgment subdomains over a period of six months. There were also no differences in the mean scores of knowledge, belief, feeling, judgment and practice domains between participants from the two factories, as depicted in Table 4.35.

Table 4.35: Comparison of mean scores of various domains between participants from Factory 1 and Factory 2 as per-protocol analysis

Domain	**Time Period**	**Factory 1 (*n* = 37) Mean (SD)**	**Factory 2 (*n* = 22) Mean (SD)**	**Mean (95% CI)**	***p* value***
Knowledge	Baseline	- 0.42 (±3.58)	- 0.41 (±3.63)	0.25 (-1.28 to 1.79)	0.744
	First month	2.14 (±2.87)	2.50 (±3.17)		
	Sixth month	1.39 (±3.10)	1.77 (±3.27)		
Belief	Baseline	7.51 (±1.85)	7.50 (±1.37)	0.49 (-0.28 to 1.26)	0.206
	First month	8.51 (±1.61)	7.45 (±1.97)		
	Sixth month	8.35 (±1.70)	7.95 (±1.53)		
Feeling	Baseline	15.39 (±3.38)	15.09 (±3.05)	0.35 (-1.07 to 1.76)	0.625
	First month	16.67 (±3.14)	16.14 (±3.43)		
	Sixth month	16.31 (±3.24)	16.09 (±3.37)		
Judgment	Baseline	15.27 (±3.53)	15.86 (±2.40)	0.49 (-0.78 to 1.77)	0.444
	First month	16.57 (±2.74)	16.59 (±2.50)		
	Sixth month	16.05 (±3.06)	16.91 (±2.31)		
Practice	Baseline	9.70 (±3.09)	10.05 (±2.80)	0.22 (-0.91 to 1.34)	0.700
	First month	11.32 (±2.57)	11.73 (±2.60)		
	Sixth month	10.73 (±2.45)	10.64 (±2.63)		

* Statistical significance is based on repeated measures ANOVA

4.7 Summary

All the independent variables between Factory 1 and Factory 2 were not different, except for the variable of exposure to chemicals with an increased risk of hearing loss. Noise levels that of sound level meter were used as noise exposure of the participants for calculating NRR as noise measurement using it showed a higher level of noise exposure than average noise level of personal exposure noise dosimeter. Noise level within the van, where data on hearing threshold levels were collected among the participants through portable audiometers, was 25 dBA. There were no differences in the mean hearing threshold levels at all the frequencies on both ears between participants from the two factories upon adopting different permissible exposure limits at the outset, and also at the first month (post-shift exposure) based on intention-to-treat analysis and as per-protocol analysis. Similarly, there was no effect in the mean hearing threshold levels at all the frequencies on both ears upon adopting different permissible exposure limits at the sixth month (pre-shift) based on intention-to-treat analysis. However, as per-protocol analysis, the participants from the Factory 2 (embraced 85 dBA) maintained lower hearing threshold levels at 3000 and 4000 Hz on right ear compared to those from the Factory 1 (embraced 90 dBA); (3.17; 95% CI, 0.04-6.30 dBA, p = 0.048, partial η^2 = 0.045) and (4.45; 95% CI, 0.05-8.84 dBA, p = 0.047, partial η^2 = 0.045), respectively at the sixth month (pre-shift). The effect sizes at 3000 and 4000 Hz were “small”. The participants, however, who were exposed to the chemicals with an increased risk of hearing loss showed that the mean hearing threshold levels at 4000 Hz on right ear was lower compared to those who were not exposed at the sixth month, (11.81; 95% CI, 4.88-18.74 dBA, p = 0.001, partial η^2 = 0.089); the effect size was “moderate”.

There were no differences between participants from the two factories and hearing threshold levels above 25 dBA at all the tested frequencies at baseline. There were more participants that showed 'deteriorated' hearing threshold levels above 25 dBA in Factory 1 where 90 dBA was adopted as the permissible exposure limit, compared to those from Factory 2 adopting 85 dBA at 3000 Hz on right ear based on intention-to-treat analysis and as per-protocol analysis at the first month, χ^2 (1) = 4.08, φ = 0.145, p = 0.043 (weak association) and χ^2 (1) = 5.25, φ = 0.203, p = 0.022 (moderate association), respectively. At the sixth month, there were more participants that showed 'continued deterioration' of hearing thresholds above 25 dBA in Factory 1 compared to those from Factory 2 at 4000 Hz on right ear based on intention-to-treat analysis and as per-protocol analysis, χ^2 (1) = 4.27, φ = 0.145, p = 0.039 (weak association) and $\boldsymbol{\chi^2}$ (1) = 4.73, φ = 0.232, p = 0.030 (moderate association), respectively. Moreover, an adoption of 85-dBA as the permissible exposure limit had 'preserved' the hearing threshold levels among participants from Factory 2 at 6000 Hz compared to those from Factory 1 on right ear based on intention-to-treat analysis, χ^2 (1) = 9.84, φ = 0.220, p = 0.002 (moderate association) at the sixth month.

There were no differences in the standard threshold shifts upon adopting different permissible exposure limits according to the Factories and Machinery (Noise Exposure) Regulations 1989, U.S. OSHA regulations and U.S. NIOSH recommended standard at the first month based on intention-to-treat analysis and as per-protocol analysis. At the six month, there were also no differences in the standard threshold shifts upon adopting different permissible exposure limits according to the standards mentioned, based on intention-to-treat analysis. However, as per-protocol analysis, there was a worsening of temporary standard threshold shifts on left ear among participants from Factory 1 compared to those from Factory 2 at 1000 Hz, χ^2 (1) = 3.93, φ = 0.211, p = 0.047, according to the U.S. NIOSH recommended standard (moderate association).

In test-retest reliability of the questionnaire (knowledge, attitude and practice of noise-induced hearing loss), the first and second set of all the items showed a strong correlation where all of them were more than 0.700. There were no differences in the items of the questionnaires when they were re-distributed, except for the item AJ5 (p = 0.033). The Cronbach's Alpha of knowledge, belief, feeling, judgment and practice constructs were 0.879, 0.723, 0.747, 0.737 and 0.849, respectively. The Kaiser-Meyer-Olkin measures of the knowledge, belief, feeling, judgment and practice were 0.879, 0.500, 0.525, 0.601 and 0.791, respectively. The Bartlett's Test of Sphericity was statistically significant ($p < 0.001$) for all the domains. Finally, there were a total of nine items from the knowledge domain (K1, K3, K5, K6, K7, K8, K9, K10, and K11), two items from the belief subdomain (AB7 and AB8), four items from the feeling subdomain (AF3, AF4, AF5 and AF6), four items from the judgment subdomain (AJ1, AJ4, AJ5 and AJ6) and five items from the practice domain (P2, P3, P5, P8 and P10) included in the study to determine the mean scores of participants from the two factories in the automobile industry.

There were no differences between participants from the two factories and mean scores of all the domains at the outset. The mean scores of knowledge, belief and practice domains have increased within participants from each factory over a period of six months, however, there were no differences in the mean scores of all the constructs between participants from the two factories, based on intention-to-treat analysis and as per-protocol analysis. .

CHAPTER 5

DISCUSSION

There were a total of eight papers from the three databases that fulfilled the requirements of systematic review of the effectiveness of adopting 85 and 90 dBA as the permissible exposure limit. Most of the studies recommend adoption of 85 dBA for conservation of the hearing thresholds. They indicated that the temporary threshold shifts were much lower when subjects were exposed to noise levels of 85 dBA or lower. Accordingly, the focus of this chapter is on discussion of the effectiveness of adopting different permissible exposure limits in preserving hearing threshold levels and prevention of standard threshold shifts. Also, levels of knowledge, attitude and practice between participants from the two factories are compared.

In an experimental study (Stephenson, et al., 1980), there was a significant change noted on mean asymptotic temporary threshold shifts when subjects were made to expose to noise levels of 65, 70, 75, 80 and 85 dBA for 24 hours with a gap of one week interval, to the different noise levels. Hence, data was collected after one month in this study. According to the Factories and Machinery (Noise Exposure) Regulations 1989 (Laws of Malaysia, 2010), baseline audiometry assessment should be conducted within six months of commencement of work (pre-shift) as changes in hearing threshold levels is possible after a period of six months. Therefore, data was re-collected at the six month. The significance and limitations of the study are also included in this chapter.

Hearing threshold level above 25 dBA is measured as hearing loss, and can be divided into mid-frequency and high frequency hearing loss (Jafari, et al., 2010). Temporary threshold shifts may progress to permanent threshold shifts over a period of time with continuous exposure to high levels of noise (Lawton, 2001).

5.1 The effectiveness of adopting different permissible exposure limits in preserving hearing threshold levels between participants from Factory 1 and Factory 2

5.1.1 The preservation of hearing thresholds between participants from the two factories of post-shift exposure at the first month

There were no differences in terms of the mean hearing thresholds at all the tested frequencies between participants from Factory 1 and Factory 2 at baseline. Only 62.6% of the subjects turned-up for a follow-up on audiometry assessment at the first month due to their busy schedule and also those with a personal predilection not to participate in the study. There was no difference in hearing threshold levels between participants in relation to the adoption of different permissible exposure limits at the first month based on intention-to-treat and as per-protocol analysis. These findings were consistent with a cross-sectional study conducted by McBride *et al*. (McBride, 2004), where there were no significant differences in threshold shifts for groups of participants adopting different exposure limits to noise, i.e. below 85, 85 to 90 and more than 90 dBA.

The participants in both factories were only exposed to noise for a short period of time. Noise in any industry usually fluctuates; since it is so, a longer duration of exposure is required to observe any significant changes in threshold shifts upon adopting different permissible exposure limits.

5.1.2 The preservation of hearing thresholds between participants from the two factories of pre-shift exposure at the sixth month

There were no differences in the mean hearing threshold levels observed between participants from Factory 1 and Factory 2 when different permissible exposure limits were adopted over a period of six months, based on intention-to-treat analysis. However, as per-protocol analysis, there were differences in the mean hearing threshold levels between the two comparison groups. This may be explained by the fact that only 43.3% of participants turned-up for the six-month audiometry assessment. As per-protocol analysis, participants from Factory 2, who adopted 85 dBA as the permissible exposure limit, had preserved hearing thresholds about 4 dBA at 3000 Hz and more than 5 dBA at 4000 Hz on right ear. These findings were consistent with Yates *et al*. (Yates, et al., 1976) and Kvaerner *et al.* (Kvaerner, et al., 1995), as more temporary threshold shifts developed among subjects exposed to noise intensity of 90 dBA compared to those exposed to 85 dBA. These temporary threshold shifts may progress to permanent threshold shifts over time (Lawton, 2001), with continuous exposure to high levels of noise and also a longer duration of exposure to noise.

Noise-induced hearing loss shows a few characteristic features in an audiogram. There is a permanent shift compared to baseline findings (Rutka, 2011) - known as ‘permanent threshold shift’. This shift usually occurs in both ears and involves frequencies ranging from 3000 to 6000 Hz (Haboosheh & Brown, 2012; Kirchner, et al., 2012). There is a dip in these frequencies in early phase of the disease with recovery at 8000 Hz. In this study, participants from Factory 2 developed lower mean hearing thresholds at 3000 and 4000 Hz compared to those from Factory 1, who adopted 90 dBA as the permissible exposure limit.

On exposure to continuous high levels of noise, stereocilia is damaged causing distortion of the normal structure (Moussavi-Najarkola, et al., 2012). Another possible mechanism to explain noise-induced hearing loss is the generation of reactive oxygen species with augmented levels of lethal free radicals. This will lead to damage to hair cells of the organ of Corti, and also degeneration of lipid and protein leading to disintegration of cells. It has also been postulated that the narrowing of vessels in the inner ear may result in noise-induced hearing loss. These constricting vessels lead to reduced blood flow and damage the hair cells in the organ of Corti. The narrowing of vessels is due to activation of the sympathetic nervous system.

High frequency notch may not necessary be diagnostic of noise-induced hearing loss, unless there is a history of noise exposure (Osei-Lah & Yeoh, 2010). The changes noted in the study were most probably due to noise as the participants were exposed to noise levels above action level.

5.1.3 Prevention of hearing threshold levels above 25 dBA between participants from the two factories of post-shift exposure at the first month

In Factory 1, around 9% of participants had developed hearing thresholds above 25 dBA at 'deteriorated' level compared to 2% from Factory 2 at the first month, based on intention-to-treat analysis. As per-protocol analysis, around 15% of them developed hearing thresholds above 25 dBA compared to 3% from Factory 2. The changes noted at 3000 Hz on right ear is that of frequencies involved in noise-induced hearing loss, i.e., 3000 to 6000 Hz (Haboosheh & Brown, 2012; Kirchner, et al., 2012). The significant changes noted were temporary threshold shifts. This finding elucidated that the hearing threshold levels were more preserved when participants embraced 85 dBA as the permissible exposure limit instead of 90 dBA.

The subjects or employees exposed to noise level adoption of 90 dBA as the permissible exposure limit may end up having more damaging effects on hearing compared to those embracing 85 dBA. Temporary threshold shifts may result in permanent shifts of hearing thresholds over time, if continuous exposure to noise ensues (Lawton, 2001; Moussavi-Najarkola, et al., 2012). According to Kryter (Kryter, 1965), temporary threshold shifts that developed reflected one day's exposure to noise. These temporary threshold shifts mentioned occurred two minutes (TTS_2) after exposure to noise. The author had also stressed that TTS_2 may result to permanent threshold shifts if one is exposed to noise continuously for a longer duration. It is hypothesized that permanent threshold shifts would occur in about 10 years due to this continuous noise insult. Kryter (Kryter, 1965) also revealed that the recovery period of threshold shifts would be prolonged if TTS_2 was above 40 dB.

5.1.4 Prevention of hearing threshold levels above 25 dBA between participants from the two factories of pre-shift exposure at the sixth month

The participants from Factory 1 and Factory 2 had shown changes of hearing threshold levels above 25 dBA over a period of six months, after intervention, at all tested frequencies except at 8000 Hz. In this population, around 24% of them who were exposed to 90 dBA as the permissible noise limit showed 'continued deterioration' of hearing threshold level above 25 dBA; compared to around 12% among those exposed to noise of up to 85 dBA at 4000 Hz on right ear based on intention-to-treat analysis. As per-protocol analysis, 25% of subjects from Factory 1 showed 'continued deterioration' compared to around 8% from Factory 2. This showed that despite the usage of appropriate hearing protection devices, exposure to noise levels between 85 and 90 dBA had shown worsening of hearing threshold levels. This was also found at a lower percentage in those exposed to permitted levels between 80 and 85 dBA. These findings were consistent with a study conducted in Iran (Jafari, et al., 2010), where there is no significant hearing loss when exposed to noise levels below 80 dBA, but seen when exposed to levels at and above 90 dBA. Most of the workers from the two factories were smoking and exposed to hand-arm vibration as shown in Table 4.2, and a third of them were exposed to hobbies such as listening to loud music; these activities increase the risk of hearing loss. This could be the justification for the participants exposed to 85 dBA having hearing threshold level more than 25 dBA, though less compared to those exposed to 90 dBA.

At the same time, around 11% of the subjects from Factory 2 were shown to have 'preserved' hearing thresholds to levels at or below 25 dBA at 6000 Hz on right ear, based on intention-to-treat analysis. This is in contrast to participants from Factory 1, where only less than 1% of them had shown their hearing thresholds were 'preserved' upon usage of the appropriate hearing protection devices. Hence, hearing loss above 25 dBA occurs more when one is exposed to noise levels where the permissible exposure limit is fixed at 90 dBA as compared to 85 dBA.

Hearing loss was more significant at 4000 and 6000 Hz. These findings were consistent with a study conducted in England and Wales (McBride & Williams, 2001), where there were significant associations of exposure to noise and presence of notch at 4000 Hz but the findings were variable at 6000 Hz. According to Lawton (Lawton, 2001), noise levels above 80 dBA produced temporary threshold shifts that recover quickly upon cessation of noise insult. Noise levels at or below 80 dBA may not produce hearing loss at 4000 Hz; a frequency that is most susceptible to noise. Lawton also mentioned that employees exposed to noise levels above 85 dBA over a period of eight hours would acquire some degree of hearing loss. It would be more appropriate then, to institute a hearing conservation program (Kirchner, et al., 2012) at 80 dBA where action can be taken to reduce noise exposure among employees, also known as action level, and to adopt 85 dBA as the permissible exposure limit. The Japan Society for Occupational Health (The Japan Society for Occupational Health, 2012) has also recommended a permissible exposure limit of U.S. NIOSH, 85 dBA for a period of eight hours.

5.2 The effectiveness in preventing standard threshold shifts between participants from Factory 1 and Factory 2 upon adopting different permissible exposure limits

5.2.1 Prevention of standard threshold shifts between participants from the two factories of post-shift exposure at the first month

There were no differences on occurrence of temporary standard threshold shifts between participants from Factory 1 and Factory 2, based on intention-to-treat and as per-protocol analysis. The dissimilarities on standard threshold shifts were not noted according to the Factories and Machinery (Noise Exposure) Regulations 1989, U.S. OSHA regulations and U.S. NIOSH recommended standard. These findings were consistent with a cross-sectional study conducted in New Zealand, McBride *et al*. (McBride, 2004), where there were no statistically significant changes in the temporary threshold shifts between subjects exposed to less than 85 dBA, between 85 and 90 dBA and more than 90 dBA. Due to a shorter duration of exposure to noise, changes in threshold shifts between participants were not observed, as occupational noise-induced hearing loss is a long-latency disease (Meyer, et al., 2002).

5.2.2 Prevention of standard threshold shifts between participants from the two factories of pre-shift exposure at the sixth month

In this population, as per-protocol analysis, 39.6% of subjects showed temporary standard threshold shifts on adoption of 90 dBA as the permissible exposure limit at 1000 Hz on left ear from Factory 1, compared to 20% of subjects in Factory 2. These findings were consistent with that of Lawton (Lawton, 2001), where the noise levels above 80 dBA produced temporary threshold shifts that recover quickly upon cessation of noise insult, but those produced at levels above 85 dBA may result in some degree of permanent hearing loss. These significant changes on threshold shifts were according to the U.S. NIOSH recommended standard (National Institute for Occupational Safety and Health, 1998) as the frequencies ranging from 500 to 8000 Hz were tested; the alteration is more than 15 dB at all the frequencies. The finding indicated that mid-frequency was involved in the threshold shifts, which is consistent with a study conducted by Idota *et al.* (Idota, et al., 2010) where the temporary threshold shifts were greater at 1500 and 2000 Hz. The significant changes on threshold shifts noted among participants from the two factories as per-protocol analysis only, and not based on intention-to-treat analysis. This could be explained as only 43.3% of the subjects had turned-up for the follow-up on audiometry assessment at the sixth month.

There were no statistically significant changes, however, among participants who adopted 90 or 85 dBA as the permissible exposure limits when the Factories and Machinery (Noise Exposure) Regulations 1989 (Laws of Malaysia, 2010) and U.S. OSHA regulations (Berger, et al., 2003; Kirchner, et al., 2012; Occupational Safety & Health Administration, 2013) were anticipated. According to the Factories and Machinery (Noise Exposure) Regulations 1989 and U.S. OSHA regulations, standard threshold shift is considered only when the shifts occurred at 2000 to 4000 Hz. Hence, all frequencies should be tested to recognize temporary threshold shifts early as recommended by the U.S. NIOSH (National Institute for Occupational Safety and Health, 1998), in order to avert noise-induced hearing loss.

The findings in the study are consistent with a survey done earlier in the US. According to the U.S. NIOSH (National Institute for Occupational Safety and Health, 1998), the survey was conducted to estimate material hearing impairment in industries over a 40-year working lifetime. Employees from the 13 noise and hearing surveys were gauged from 1968 to 1971. Material hearing impairment is said to occur if the hearing threshold level is above 25 dBA at 1000, 2000, 3000 and 4000 Hz. Only 1172 audiograms were taken for data analysis from more than 4000 audiograms collected, since the others did not fulfill the inclusion criteria (noise exposures could not be categorized and medical history caused the hearing loss). The abnormal hearing levels of the employees and levels of noise exposure were obtained through questionnaires and audiometry assessments. Excess risk estimates were then calculated; the difference between employees exposed to noise resulting in levels beyond the maximum acceptable hearing loss and the unexposed population exceeded these levels in percentage. The excess risk estimates increased as duration of exposure to noise increased among the population exposed to noise levels of 85 and 90 dBA. Employees exposed to noise levels of 85 dBA had excess risk estimates of 1.4 (95% CI, 0.3-3.2), 2.6 (95% CI, 0.6-6.0), 4.0 (95% CI, 0.9-9.3) and 4.9 (95% CI, 1.0-11.5) at 30, 40, 50 and 60 years old, respectively, for a duration of exposure to noise of between 5 to 10 years, compared to those exposed to 90 dBA, who had excess risks of 5.4 (95% CI, 2.1-9.5), 9.7 (95% CI, 3.7-16.5), 14.3 (95% CI, 5.5-24.4), and 15.9 (95% CI, 6.2-26.2). For employees who were exposed to noise for more than 10 years, the excess risk estimates for 85 dBA were 2.3 (95% CI, 0.7-5.3), 4.3 (95% CI, 1.3-9.4), 6.7 (95% CI, 2.0-13.9) and 7.9 (95% CI, 2.3-16.6) at ages 30, 40, 50 and 60 years, respectively, compared to those exposed to 90 dBA, who had excess risks of 10.3 (95% CI, 5.8-16.2), 17.5 (95%

CI, 10.7-25.3), 24.1 (95% CI, 14.6-33.5), and 24.7 (95% CI, 14.9-34.3). In summary, at 60 years old, the excess risk estimates were 8% for employees exposed to 85 dBA and 25% for employees exposed to 90 dBA.

There was an experimental study (Takagi, et al., 1988) conducted on noise-induced temporary threshold shifts in Japan. The exposure group, three to five subjects were exposed to noise levels between 65 and 86 dB for 24 hours. The control group was not exposed to noise. The hearing thresholds were measured on right ear for both these groups. There were no statistically significant changes on threshold levels among the control group. Among the exposure group, however, the temporary threshold shifts increased as noise levels increased. The study accentuated by Yates *et al*. (Yates, et al., 1976) showing that the damaging effects on threshold shift of subjects exposed to full-day noise of 85 dBA was equivalent with 90 dBA half-day. Moreover, most of the detrimental effects were seen at 4 kHz (Melnick, 1977; Yates, et al., 1976). It would be more appropriate, then, to institute a hearing conservation program (Kirchner, et al., 2012) at 80 dBA where action can be taken to reduce noise exposure among employees (action level), and to adopt 85 dBA as the permissible exposure limit.

In a paper published by Dolan & Mills (Dolan & Mills, 1989), the authors evaluated thresholds of action potential, its amplitude and tuning curves on exposure to noise. This experiment was conducted on five gerbils. Noise intensity of 85 dBA was introduced through loudspeakers to the gerbils in a room. They were exposed to noise for 2 weeks. The measurement of thresholds of action potential, its amplitude and tuning curves were taken after one hour, on 8th and 16th day of post-exposure to noise. The thresholds were recorded via electrodes which were surgically implanted on one of the ears. The results showed the thresholds increased in all the frequencies except at very high frequencies, i.e., 15 and 20 kHz. The threshold shifts mostly occurred at 4 kHz and 6 kHz with shifts from 26 to 52 dB and 18 to 38 dB, respectively. These thresholds remain at the increased level for more than a month, especially if the initial increment in the threshold was high. The amplitude of action potential was reduced at 4 kHz, and the threshold shifts were 28 dB and 16 dB at post-exposure of one hour and 8^{th} day, respectively. The recovery was not complete even after 16^{th} day. On tuning curve findings at 4 kHz, the tip was broader at post-exposure of one hour and after 8^{th} day with the lower frequency part of curve was lesser than the pre-exposure noise reading. The amplitude of action potential was also reduced at 8 kHz, and the threshold shift was 18 dB at post-exposure of 1 hour; it recovered fully by 16^{th} day. On tuning curve findings at 8 kHz, the ratio from tip-to-tail was broader and reduced from 33 dB (before exposure to noise 85 dBA) to 13 dB (on the 8^{th} day). This study showed continuous exposure of 85 dBA, the recovery of amplitude of action potential and tuning curve may not be possible and may result in permanent hearing loss. Action level should, accordingly, be at 80 dBA with 85 dBA as permissible exposure limit to reduce noise exposure among employees.

5.3 Knowledge, attitude and practice of noise-induced hearing loss between participants from Factory 1 and Factory 2

5.3.1 Knowledge, attitude and practice of noise-induced hearing loss questionnaire between participants from the two factories

The test-retest procedure was performed to gauge reliability of knowledge, attitude and practice of the noise-induced hearing loss questionnaire. The statistical test used to analyze was the Paired *t*-test. All items of the questionnaire were consistent, except for the item AJ5 (p = 0.033). However, the first and second set of the item (AJ5) had showed strong correlation (Cohen, 1988) which was 0.866; subsequently, the item (AJ5) was not dropped and all the items of the questionnaire were retained.

The other test carried out to analyze reliability of the questionnaire was to detect internal consistency of scale as a whole. The relationship between the individual items in the scale could be determined. The Alpha (Cronbach's) model used is based on an average inter-item correlation. The questionnaire was distributed to measure different, underlying constructs, i.e. knowledge, attitude (belief, feeling and judgment) and practice. One construct, 'knowledge', consisted of twelve questions. The scale had a high level of internal consistency (DeVellis, 2003; McMillan & Schumacher, 2001), as determined by a Cronbach's alpha of 0.879. All the items correlated adequately in the knowledge domain and the values of corrected item-total correlation were within the acceptable range, i.e., at least 0.3 (Field, 2005). One construct, 'belief', consisted of eight questions. The scale had an accepted level of internal consistency, as determined by a Cronbach's alpha of 0.723 (DeVellis, 2003; McMillan & Schumacher, 2001). The correlation value of items AB7 and AB8 and the corrected item-total correlation values were within the acceptable range (at least 0.3). One construct, 'feeling', consisted of six questions. The scale had an accepted level of internal consistency (DeVellis, 2003; McMillan & Schumacher, 2001), as determined by a Cronbach's alpha of 0.747. The correlation value of the items AF3, AF4, AF5 and AF6 with one another and the corrected item-total correlation were within the acceptable range (at least 0.3). One construct, 'judgment', consisted of six questions. The scale had an accepted level of internal consistency, as determined by a Cronbach's alpha of 0.737 (DeVellis, 2003; McMillan & Schumacher, 2001). The correlation value of the items AJ1, AJ4, AJ5 and AJ6 with one another and the corrected item-total correlation were within the acceptable range (at least 0.3). One construct, 'practice', consisted of ten questions. The scale had a high level of internal consistency (DeVellis, 2003; McMillan & Schumacher, 2001), as determined by a Cronbach's alpha of 0.849. The correlation value of the items P2, P3, P5, P8 and P10 with one another and the corrected item-total correlation were within the acceptable range (at least 0.3) (Field, 2005). Based on this reliability, all items of the knowledge domain, AB7 and AB8 of the belief domain, AF3, AF4, AF5 and AF6 of the feeling domain, AJ1, AJ4, AJ5 and AJ6 of the judgment domain, and P2, P3, P5, P8 and P10 of the practice domain were retained.

Later, an exploratory factor analysis was conducted to identify the contents of questions that can be grouped in the same factor where these items would share the same subjects or groups. This method of data reduction was conducted and explored using the principal axis method. After the initial extraction of factors, the Promax rotation was performed.

A principal axis factoring was run on a 12-question questionnaire that measured knowledge domain of noise-induced hearing loss among the 116 employees. The suitability of the principal axis method was assessed prior to the analysis. Inspection of the correlation matrix showed that all the variables had a correlation coefficient greater than 0.3, which is considered as a positive correlation (Kubinger, et al., 2007; Mukaka, 2012), after removing items K2, K4 and K12. The overall Kaiser-Meyer-Olkin measure was classified as meritorious (Kaiser, 1974) and Bartlett's Test of Sphericity was significant indicating that the data was likely to be factorable. The principal axis factoring revealed two components that had eigenvalues greater than one and explained 49.6% and 13.0% of the total variance, respectively. In addition, a two-component solution met the interpretability criterion. As such, the two components were retained. The two-component solution explained 62.6% of the total variance. The interpretation of the data was consistent with the knowledge construct of noise-induced hearing loss to measure risk factors and prevention of hearing loss with items K6 (*Hobbies such as shooting and scuba diving may cause hearing loss*), K7 (*Smoking increases the risk of hearing loss when working in a noisy environment*), K8 (*Ear discharge is the earliest sign of hearing loss due to noise*), K9 (*There is medication available to treat hearing* *loss due to noise*), K10 (*Hearing loss can't be prevented by wearing ear plugs or ear muffs*) and K11 (*There is law in existence protecting employees from exposure to loud noise*) as Factor 1, while causes of hearing loss, and policy protecting workers with items K1 (*Hearing loss due to noise is not permanent*), K3 (*Hearing loss may not occur if the worker is exposed to loud noise*), and K5 (*Hearing loss may not occur if the worker is repeatedly exposed to a noisy environment*) as Factor 2.

A principal axis factoring was run on an 8-question questionnaire that measured belief subdomain of noise-induced hearing loss. Inspection of the correlation matrix showed the two variables had a correlation coefficient greater than 0.3, which is considered as a positive correlation (Kubinger, et al., 2007; Mukaka, 2012), after removing items AB1, AB2, AB3, AB4, AB5 and AB6. The overall Kaiser-Meyer-Olkin measure was acceptable (Kaiser, 1974) and Bartlett's Test of Sphericity was significant showing that the data was likely to be factorable. The principal axis factoring had revealed only one component that had eigenvalues greater than one and explained 78.4% of the total variance. In addition, only this component solution met the interpretability criterion. As such, only one component was retained. A Promax rotation was employed to aid interpretability but failed to rotate since only one factor was extracted. The interpretation of the data was consistent with the belief subdomain of noise-induced hearing loss to measure hearing protection devices and law on prevention of hearing loss with items AB7 (*I believe it is right to wear one ear plug only during communication in a noisy environment*) and AB8 (*As an employee, I think I do not need to know the law on noise control*) as Factor 1.

A principal axis factoring was run on a 6-question questionnaire that measured feeling subdomain of noise-induced hearing loss. Inspection of the correlation matrix showed all variables had a correlation coefficient greater than 0.3, which is considered as a positive correlation (Kubinger, et al., 2007; Mukaka, 2012), after removing items AF1 and AF2. The overall Kaiser-Meyer-Olkin measure was acceptable (Kaiser, 1974) and Bartlett's Test of Sphericity was significant showing that the data was likely to be factorable. The principal axis factoring revealed two components that had eigenvalues greater than one and which explained 57.2% and 33.0% of the total variance, respectively. In addition, a two-component solution met the interpretability criterion. As such, the two components were retained. The two-component solution explained 90.1% of the total variance. The interpretation of the data was consistent with the feeling subdomain of noise-induced hearing loss to measure outcomes of hearing loss with items AF5 [*I feel nothing is wrong if we are not informed about the results of audiogram (stating the hearing loss level)*] and AF6 (*I feel nothing is wrong if we are not informed on the results of initial noise exposure monitoring*) as Factor 1, and prevention of hearing loss with items AF3 (*I feel my employer should be informed if I have hearing loss*) and AF4 (*I feel it is my responsibility as well as the employers' to reduce noise exposure*) as Factor 2.

A principal axis factoring was run on a 6-question questionnaire that measured judgment subdomain of noise-induced hearing loss. Inspection of the correlation matrix showed all the variables had a correlation coefficient greater than 0.3, which is considered as a positive correlation (Kubinger, et al., 2007; Mukaka, 2012), after removing items AJ2 and AJ3. The overall Kaiser-Meyer-Olkin measure was acceptable (Kaiser, 1974) and Bartlett's Test of Sphericity was significant showing that the data was likely to be factorable. The principal axis factoring revealed two components that had eigenvalues greater than one and which explained 56.5% and 25.3% of the total variance, respectively. In addition, a two-component solution met the interpretability criterion. As such, the two components were retained. The two-component solution explained 81.7% of the total variance. The interpretation of the data was consistent with the judgment subdomain of noise-induced hearing loss to measure prevention of hearing loss with items AJ5 (*I will wear ear plugs or ear muffs in a noisy industry*) and AJ6 (*I will undergo regular hearing assessment to detect any hearing loss*) as Factor 1, and risk factors of hearing loss with items AJ1 (*I can ignore hearing loss since it does not lead to death*) and AJ4 (*I will ignore hearing loss since it is not painful*) as Factor 2.

A principal axis factoring was run on a 10-question questionnaire that measured practice construct of noise-induced hearing loss. Inspection of the correlation matrix showed all the variables had a correlation coefficient greater than 0.3, which is considered as a positive correlation (Kubinger, et al., 2007; Mukaka, 2012), after removing items P1, P4, P6, P7 and P9. The overall Kaiser-Meyer-Olkin measure was classified as middling (Kaiser, 1974) and Bartlett's Test of Sphericity was significant showing that the data was likely to be factorable. The principal axis factoring revealed one component that had eigenvalues greater than one and which explained 62.8% of the total variance. In addition, only one component solution met the interpretability criterion. As such, only one component was retained. A Promax rotation was employed to aid interpretability but failed to rotate since only one factor was extracted. The interpretation of the data was consistent with the practice construct of noise-induced hearing loss to measure prevention of hearing loss with items P2 (*I undergo hearing assessment to discover if I have hearing loss*), P3 (*I attend health education to know the effects of noise*), P5 (*I wear earplugs or ear muffs to protect from hearing loss*), P8 (*I only wear approved ear plugs or ear muffs*) and P10 (*I will get information from the safety and health committee regarding noise*) as Factor 1.

5.3.2 Comparing levels of knowledge, attitude and practice of noise-induced hearing loss between participants of the two factories upon adopting different permissible exposure limits

Most of the participants who took part in the test-retest reliability and also in the internal consistency reliability and factor analysis of the questionnaire were Malay males. The mean age of former participants (test-retest reliability) was 39.5 ± 10.37 years, while that of latter (internal consistency reliability and factor analysis) was 36.7 ± 10.12 years. The majority of them had completed either primary or secondary school education. The participants were exposed to noise levels above the action level. This questionnaire was used in the main study locations (factories from the automobile industry) since most of the participants from the two factories were also Malay males who had attended either primary or secondary school only. Their mean age was 27.1 ± 6.56; they were also exposed to noise levels above the action level.

There were no differences observed in the mean scores between participants from the two factories of various constructs at baseline. Over a period of six months, there were also no differences observed in the mean scores of knowledge, attitude (belief, feeling and judgment) and practice constructs between participants from the two factories based on intention-to-treat and as per-protocol analysis. This shows that there were no differences in the levels of knowledge, attitude and practice between participants from the two factories applying different permissible exposure limits. However, based on intention-to-treat analysis, there were dissimilarities in the mean scores of knowledge, belief and practice constructs from baseline results within the participants from Factory 1 and Factory 2 over time. The health education intervention elicited statistically significant changes in the mean scores of the knowledge domain, F (1.44, 289.45) = 13.54, $p < 0.001$, partial $\eta^2 = 0.063$, belief subdomain, F (1.71, 344.17) = 7.78, p = 0.001, partial $\eta^2 = 0.037$ and also the practice domain, F (1.49, 300.16) = 9.46, p <

0.001, partial $\eta^2 = 0.045$, among participants within Factory 1 and Factory 2. According to Portney and Watkins (2009), the effect sizes were “moderate” for the knowledge domain and “small” for belief and practice constructs (Portney & Watkins, 2009). The mean scores of knowledge, belief and practice constructs have increased over a period of six months from pre-intervention. This shows that the levels of knowledge, belief and practice have increased similarly among participants from the two factories over six months.

As per-protocol analysis, there were also significant changes in the mean scores of knowledge, belief and practice constructs from baseline results within the participants over time. The health education intervention elicited statistically significant changes in the mean scores of the knowledge domain, F (1.38, 77.43) = 27.68, $p < 0.001$, partial $\eta^2 = 0.331$; the mean scores have increased over a period of six months from pre-intervention among participants within Factory 1 and Factory 2. According to Portney and Watkins (2009), the effect size of the knowledge domain was “large” (Portney & Watkins, 2009). The belief subdomain, F (1.77, 144.65) = 4.89, $p = 0.012$, partial $\eta^2 = 0.079$, showed the mean scores have increased among participants within Factory 1 and Factory 2 at the sixth month, but not at the first month from pre-intervention. According to Portney and Watkins (2009), the effect size of the belief domain was “moderate” (Portney & Watkins, 2009). The health education intervention of the practice domain, F (1.52, 86.42) = 8.50, $p < 0.001$, partial $\eta^2 = 0.130$, showed that the mean scores have increased among participants within Factory 1 and Factory 2 at the first month but not at the sixth month from pre-intervention. According to Portney and Watkins (2009), the effect size of the practice domain was “moderate” (Portney & Watkins, 2009). This shows that the levels of knowledge, belief and practice have increased similarly among participants from the two factories at different period. *It follows that health education should be imparted more regularly among employees, and not once in two years as per* *the Factories and Machinery (Noise Exposure) Regulations 1989* (Laws of Malaysia, 2010). It should be conveyed as regularly bi-annually as the score levels of knowledge and practice declined over six months compared to the first month as depicted in Table 4.34 and 4.35.

5.4 Analysis of risk factors

There were no differences on possible confounding factors such as smoking (Carmelo, et al., 2010), consumption of alcohol (Upile, et al., 2007) and exposure to hand-arm vibration (Pettersson, 2013) between participants from the two factories, as displayed in Table 4.2. There were also no significant differences in exposure to risks of hearing loss from hobbies such as listening to loud music (Levey, et al., 2012), shooting (Pawlaczyk-Luszczynska, et al., 2004) and scuba diving (Newton, 2001). Age, education level and employment duration were also not significantly different between the study groups. There was a difference, however, between participants of exposure to chemicals with an increased risk of hearing loss (Śliwinska-Kowalska, 2007) variable. All participants from the Factory 2, adopting 85 dBA were exposed to the chemicals compared to almost 87% from Factory 1.

These variables were adjusted for during the analysis; there was more preservation of hearing thresholds among participants from the Factory 2 compared to those from Factory 1. The participants, however, who were exposed to the chemicals with an increased risk of hearing loss showed that the mean hearing threshold levels was lower at 4000 Hz on right ear compared to those who were not exposed, (11.81; 95% CI, 4.88-18.74 dBA, p = 0.001, partial η^2 = 0.089); the effect size was “moderate” (Portney & Watkins, 2009). Biological monitoring may be normal even if the participants were exposed to the chemical substances above the mean concentration of occupational exposure limit (The Japan Society for Occupational Health, 2012). However, biological monitoring was not performed among participants from the two factories due to cost factor. Hence, the lower mean hearing threshold levels among participants from the Factory 2 is most likely due to the adoption of lower permissible exposure limit compared to those from Factory 1. Moreover, combined exposures of noise and solvents had greater damage to hearing than exposure to noise alone (Kim, et al., 2005). Also, pure tone audiometry is not precise in evaluating the dose-response-relationship of the solvents (Śliwinska-Kowalska, 2007). The wide CI is most probably due to inadequate sample size as the sample size for the primary objectives was calculated based on a literature from Yates *et al*. (Yates, et al., 1976). This experimental study (Yates, et al., 1976) compared temporary threshold shifts using the main variables, i.e., exposure to noise intensities of 85 and 90 dBA, and confounding factors such as exposure to chemicals with an increased risk of hearing loss were not taken into consideration in the study.

Researcher has disseminated the similar pamphlets of noise-induced hearing loss to the participants from the two factories. The main aim was to increase awareness and institute change to a more positive attitude and practice among them, regardless of the adoption of different permissible exposure limits. These leaflets were distributed as knowledge, attitude and practice towards noise-induced hearing loss may also contribute to hearing loss. The participants from the two factories showed improvement of knowledge, belief (subdomain of attitude) and practice over time, but there were no differences between them in these constructs.

5.5 Compliance on usage of hearing protection devices

The supervisors were provided checklists to make certain of the continuous usage of hearing protection devices by the participants as shown in Appendix 20. Usage of these hearing protection devices was also observed by regular spot checks (once a month) by the researchers.

5.6 Significance and limitations of the study

5.6.1 Significance of the study

This intervention study was designed to preserve hearing thresholds by adopting different permissible exposure limits, i.e., 85 and 90 dBA. Temporary threshold shifts may be recognized early and subsequent development to permanent threshold shifts could be prevented. The outcome of the study is of utmost importance, to determine adoption of permissible exposure limits scientifically as the legal limit, since it will impose cost and enforcement issues besides the mandatory issuance of hearing protection among workers. The findings recommend countries to adopt 85 dBA as the permissible exposure limit in order to preserve hearing thresholds and prevent standard threshold shifts. Consequently, the prevalence of noise-induced hearing loss is reduced.

5.6.2 Limitations and biases of the study

There was a possibility of a cross-over effect of employees from the two factories where the participants could be placed in the other factory during the study. This was avoided by informing the management that the duration of this study was six months, and that the participants were stationed in the same department and factory during the study period. Real exposure measurement of each worker was not done due to impracticability (transporting the equipment to the factories) and also owing to financial grounds. There was a possibility that some workers may take extra measures to reduce noise exposure, but this is random, and the effect is negligible.

The previous occupational exposure to noise was not taken into account, since it was irrelevant, as baseline comparison of participants from the two study location was analyzed. Moreover, the workers may not be telling the truth or recall bias was expected.

The measurement of personal noise exposure level was done only for one subject in each work area. The measurement was done accordingly, since all workers in a job area were exposed to similar levels of noise intensities. This is also in accordance to the regulations for noise in Malaysia (Laws of Malaysia, 2010), where not all workers in a job area are required to undergo personal exposure noise measurement.

A universal sampling was used in both study locations. A total of 78.1% of employees from the two factories agreed to participate. The nonrespondents were busy with their work procedure and also those with a personal predilection not to participate in the study. There were no differences between respondents and nonrespondents in age (mean age was 27.1 ± 6.56 and 27.7 ± 7.03 among the respondents and nonrespondents, respectively), gender (most of them were males in both groups), ethnicity (most of them were Malays in both groups) and duration of work (mean duration of employment was 2.4 ± 2.04 and 2.3 ± 1.57 among the respondents and nonrespondents, respectively) variables.

A total of 62.6% and 43.3% followed-up till the first and six month, respectively based on the primary objectives (determining the effectiveness of adopting 85 dBA as a permissible exposure limit compared to 90 dBA in preserving hearing threshold levels and preventing standard threshold shifts). However, the total number of subjects who participated from the two factories throughout the study was more than the minimum sample size required based on a literature of Yates *et al.* (Yates, et al., 1976) and hence, the power of study was not affected. There were no differences between participants who followed-up at the first month of the study and those who had loss to follow-up in age (mean age was 26.8 ± 6.42 and 27.6 ± 6.81 among those responded and loss to follow-up, respectively), gender (most of them were males in both groups), ethnicity (most of them were Malays in both groups), education level (most of them had primary or secondary school education only in both groups) and duration of work (mean duration of employment was 2.3 ± 1.85 and 2.7 ± 2.34 among those responded and loss to follow-up, respectively) variables. There were differences in smoking and alcohol consumption variables, where those who loss to follow-up were more non-smokers and consume alcohol compared to those who followed-up at the first month. However, most of them ever smoked and never consume alcohol in the loss to follow-up group.

There were also no differences between participants who followed-up till end of the study (sixth month) and those who had loss to follow-up in age (mean age was 28.0 ± 6.54 and 26.5 ± 6.53 among those responded and loss to follow-up, respectively), gender (most of them were males in both groups), ethnicity (most of them were Malays in both groups), education level (most of them had primary or secondary school education only in both groups), smoking (most of them ever smoked in both groups) and alcohol consumption (most of them never consume alcohol in both groups) variables. There were differences in duration of work variables (mean duration of employment was 2.8 ± 2.26 and 2.1 ± 1.84 among those responded and loss to follow-up, respectively) where those who followed-up till end of the study worked almost three years compared to two years among those who loss to follow-up. The difference was not clinically significant as permanent threshold shifts would occur in about 10 years due to continuous noise insult (Kryter, 1965).

Around 30% of subjects followed-up till end of the study, based on the secondary objective (comparing levels of knowledge, attitude and practice of noise-induced hearing loss between participants from the two factories). However, the total number of subjects who participated from the two factories throughout the study was more than the minimum sample size required for this objective, based on the literatures of Rus *et al*. (Rus, et al., 2008) and Ismail *et al.* (Ismail, et al., 2013). There were no differences between participants who followed-up till end of the study and those who had loss to follow-up in age (mean age was 28.2 ± 5.96 and 26.6 ± 6.78 among those responded and loss to follow-up, respectively), gender (most of them were males in both groups), ethnicity (most of them were Malays in both groups), education level (most of them had primary or secondary school education only in both groups) and smoking (most of them ever smoked in both groups), and alcohol consumption (most of them never consumed alcohol in both groups) variables. There was a difference in duration of work variable (mean duration of employment was 3.0 ± 2.40 and 2.2 ± 1.83 among those responded and loss to follow-up, respectively) where those who followed-up till end of the study worked on average of three years compared to two years among those who loss to follow-up. The difference was not clinically significant as permanent threshold shifts would occur in about 10 years due to continuous noise insult (Kryter, 1965).

Two similar readings were taken before entering them in the audiogram to prevent measurement bias. The participants and the safety and health officers were blinded to the levels of permissible exposure limits adopted in the factories. The outcome assessors (audiometric technicians) were blinded from the allocation arm, as they did not know which factory was adopting 85 or 90 dBA as the permissible exposure limit during the measurement of hearing thresholds. The statistician who analyzed the data was blinded to the permissible exposure limit (85dBA or 90dBA) applied at each factory. Hence, the risk of bias was low. The researchers were not blinded as the NRR needed to be considered in each job area for the two factories. The findings were limited to the automobile industry. Future research is definitely required to confirm these findings; these include studies on different types of industries and ensure a higher response rate among participants, for results to be conclusive.

In the present study, only air conduction was used to measure hearing threshold levels. To ensure that there was no prior damage in the outer or middle ear, an ear assessment was performed to all the participants. The assessment was done using an otoscopy examination at baseline, and also at the first and sixth month. Only participants who had no damage to their ears (impacted wax and perforated tympanic membrane) were allowed to undergo audiometry assessment. The tuning fork assessment was not used in the study to determine the type of hearing loss, since there were a few limitations to using this test (Thiagarajan & Arjunan, 2012). This test is unable to quantify hearing loss unlike the gold standard test of audiometry assessment. Another limitation is the response of the opposite ear in bone conduction testing.

In the study, practice scores were measured using self-administered questionnaire. However, no attempt was made to validate statement of respondents and real practice as it does not affect the main objectives of the study.

5.7 Future research direction

DPOAE, two pure tone frequencies presented simultaneously, measures the functional status of the outer hair cells where identification of cochlear dysfunction can be detected much earlier compared to the gold standard audiometry assessment. Besides being an objective evaluation, the drawback of DPOAE, if used alone, is that the degree of hearing loss cannot be determined. In this study, although the participants from the two factories showed no differences in mean hearing threshold levels based on intention-to-treat analysis, the absence of activity of DPOAE between participants from the two factories may differ (Guida, et al., 2012).

5.8 Summary

Data was collected at the first and sixth month based on an experimental study, Stephenson *et al.* and the Factories and Machinery (Noise Exposure) Regulations 1989, respectively. There were no differences between participants from Factory 1 and Factory 2 in the mean hearing thresholds for all the tested frequencies at baseline and at the first month based on intention-to-treat and as per-protocol analysis. A longer duration of exposure is required to observe any significant changes in threshold shifts upon adopting different permissible exposure limits. At the sixth month, as per-protocol analysis, participants from Factory 2, who adopted 85 dBA as the permissible exposure limit, had preserved hearing thresholds about 4 dBA at 3000 Hz and more than 5 dBA at 4000 Hz on right ear. And so, the participants from Factory 1, who adopted 90 dBA as the permissible exposure limit, developed more temporary threshold shifts that may progress to permanent threshold shifts over time by damaging hair cells of the organ of Corti. This is possible through distorted stereocilia, the generation of reactive oxygen species with release of free radicals and also narrowing of the inner ear vessels. These findings support the notion that the permissible exposure limit preferably should be at 85 dBA.

Hearing threshold level above 25 dBA is reflected as hearing loss. The participants from Factory 1 developed more temporary threshold shifts above 25 dBA (9.0%) compared to those from Factory 2 (2.0%) based on intention-to-treat analysis, while as per-protocol analysis; the subjects developed 15.0% and 3.0% from Factory 1 and Factory 2, respectively at 3000 Hz on right ear at the first month. Around 24% of participants who were embracing 90 dBA as the permissible noise limit showed ‘continued deterioration’ of hearing threshold level above 25 dBA compared to 12% who embraced 85 dBA, at 4000 Hz on right ear at the sixth month, based on intention-to-treat analysis. As per-protocol analysis, 25% of subjects from Factory 1 showed ‘continued deterioration’ compared to around 8% from Factory 2. Moreover, more subjects from Factory 2 (11.0%) shown to have preserved more hearing thresholds to levels at or below 25 dBA compared to those from Factory 1 (< 1.0%) at 6000 Hz on right ear at the sixth month, based on intention-to-treat analysis. The frequencies affected in the study are that of noise-induced hearing loss, i.e., 3000 to 6000 Hz. The TTS_2 may result to permanent threshold shifts in about 10 years of exposure to noise continuously. It would be more appropriate to institute a hearing conservation program at 80 dBA where action can be taken to reduce noise exposure among employees, and to adopt 85 dBA as the permissible exposure limit. Most of the workers from the two factories were smoking, exposed to hand-arm vibration and a third of them were exposed to hobbies such as listening to loud music which increase the risk of hearing loss. This could be the justification for those who were exposed to 85 dBA for having hearing threshold level more than 25 dBA, though less compared to those exposed to 90 dBA.

Temporary threshold shifts may progress to permanent threshold shifts over time with continuous exposure to high levels of noise. Due to a shorter duration of exposure to noise, changes of standard threshold shifts among participants at the first month were not observed. Around twice of the subjects developed temporary standard threshold shifts upon adoption of 90 dBA (39.6%) as the permissible exposure limit compared to those who were adopting 85 dBA (20.0%) at 1000 Hz on left ear at the sixth month, as per-protocol analysis. The findings indicated that mid-frequency was involved in the threshold shifts; hence, all frequencies should be tested to recognize temporary standard threshold shifts as recommended by the U.S. NIOSH. The excess risk estimates for material hearing impairment was increased as exposure to noise intensity and duration of exposure to noise is increased. The temporary threshold shifts increased as noise levels increased. The noise levels above 85 dBA may result in some degree of permanent hearing loss. This is probably due to swelling in the hair cells or auditory nerve synapse secondary to excessive release of glutamate. This explains the role of N-acetyl cysteine in preventing noise-induced temporary threshold shift among those exposed to noise (Lin, et al., 2010). The finding highlighted the action level should be at 80 dBA and the permissible exposure limit at 85 dBA, since fewer standard threshold shifts noted in this group.

The supervisors were provided checklists to make certain of the continuous usage of hearing protection devices by the participants. Usage of these hearing protection devices was also observed by regular spot checks (once a month). Two similar readings were taken before entering them in the audiogram to prevent measurement bias. The risk of bias was low as the outcome assessor (audiometric technicians) was blinded from the allocation arm, as they did not know which factory was adopting 85 or 90 dBA as the permissible exposure limit during the measurement of hearing thresholds. The participants and the safety and health officers were blinded to the levels of permissible exposure limits adopted in the factories. The statistician who analyzed the data was also blinded to the permissible exposure limit applied at each factory. The researchers, however, were not blinded.

Reliability of the questionnaire was determined by test-retest procedure and also by evaluating internal consistency using Cronbach's alpha coefficients. The exploratory factor analysis was performed to identify items of the questionnaire that can be grouped in the same factor. The items of knowledge construct retained were items K1 (*Hearing loss due to noise is not permanent*), K3 (*Hearing loss may not occur if the worker is exposed to loud noise*) and K5 (*Hearing loss may not occur if the worker is repeatedly exposed to a noisy environment*) measuring causes of hearing loss and policy protecting workers, while items K6 (*Hobbies such as shooting and scuba diving may cause hearing loss*), K7 (*Smoking increases the risk of hearing loss when working in a noisy environment*), K8 (*Ear discharge is the earliest sign of hearing loss due to noise*), K9 (*There is medication available to treat hearing loss due to noise*), K10 (*Hearing loss can't be prevented by wearing ear plugs or ear muffs*) and K11 (*There is law in existence protecting employees from exposure to loud noise*) measure risk factors and prevention of hearing loss. The items of belief subdomain retained were items AB7 (*I believe it is right to wear one ear plug only during communication in a noisy* *environment*) and AB8 (*As an employee, I think I do not need to know the law on noise control*) measuring hearing protection devices and law on prevention of hearing loss. The items of feeling subdomain retained were items AF3 (*I feel my employer should be informed if I have hearing loss*) and AF4 (*I feel it is my responsibility as well as the employers' to reduce noise exposure*) measuring prevention of hearing loss, while items AF5 [*I feel nothing is wrong if we are not informed about the results of audiogram (stating the hearing loss level)*] and AF6 (*I feel nothing is wrong if we are not informed on the results of initial noise exposure monitoring*) measures outcomes of hearing loss. The items of judgment subdomain retained were items AJ1 (*I can ignore hearing loss since it does not lead to death*) and AJ4 (*I will ignore hearing loss since it is not painful*) measuring risk factors of hearing loss, while items AJ5 (*I will wear ear plugs or ear muffs in a noisy industry*) and AJ6 (*I will undergo regular hearing assessment to detect any hearing loss*) measures prevention of hearing loss. The items of practice construct retained were items P2 (*I undergo hearing assessment to discover if I have hearing loss*), P3 (*I attend health education to know the effects of noise*), P5 (*I wear earplugs or ear muffs to protect from hearing loss*), P8 (*I only wear approved ear plugs or ear muffs*) and P10 (*I will get information from the safety and health committee regarding noise*) measuring prevention of hearing loss.

There were no differences in the levels of knowledge, attitude (belief, feeling and judgment) and practice between participants from the two factories applying different permissible exposure limits over a period of six months based on intention-to-treat and as per-protocol analysis. However, the levels of knowledge, belief and practice have increased similarly among them.

There were no differences between the two study groups in possible confounding factors such as smoking, consumption of alcohol, exposure to hand-arm vibration, hobbies with an increased risk of hearing loss (listening to loud music, shooting and scuba diving), age, education level and employment duration between the study groups. Those who were exposed to the chemicals with an increased risk of hearing loss showed the mean hearing threshold levels was lower at 4000 Hz on right ear compared to those not exposed, (11.81; 95% CI, 4.88-18.74 dBA, $p = 0.001$, partial $\eta^2 = 0.089$); the effect size was "moderate". However, biological monitoring values may be normal even if these participants were exposed to the chemical substances above the mean concentration of occupational exposure limit and hence, biological monitoring should be done for more accurate results. This monitoring was not carried out in the study. Also, pure tone audiometry is not precise in evaluating the dose-response-relationship of the solvents. Moreover, combined exposures of noise and solvents had no greater damage to hearing than exposure to noise alone.

The findings recommend countries to adopt 85 dBA as the permissible exposure limit in order to preserve hearing thresholds and prevent standard threshold shifts. The findings of the study were also supported by a systematic review conducted which was narrated in detail in 2.4.2, where most of the studies recommend adoption of 85 dBA for conservation of the hearing thresholds. They indicated that the temporary threshold shifts were much lower when subjects were exposed to noise levels of 85 dBA or lower.

There were no differences between the respondents and nonrespondents at the outset. The nonrespondents were busy with their work procedure and also those with a personal predilection not to participate in the study. Generally, there were no differences between the participants who followed-up till end of the study and those who had loss to follow-up. The power of study was not affected as the total number of subjects who participated from the two factories throughout the study was more than the minimum sample size. Cross-over effect of employees from the two factories was avoided. Only air conduction was used to measure hearing threshold levels and hence, those who had no damage to their ears (impacted wax and perforated tympanic membrane) were allowed to undergo audiometry assessment.

CHAPTER 6

CONCLUSION and RECOMMENDATION

6.1 Summary

In summary, the participants from Factory 2, adopting 85 dBA as the permissible exposure limit, preserved a greater hearing thresholds compared to those adopting the 90 dBA. As per-protocol analysis, the participants from Factory 2 preserved hearing thresholds compared to those from the Factory 1 at 3000 Hz and 4000 Hz on right ear, [3.17 (95% CI, 0.04-6.30) dBA, p = 0.048, partial η^2 = 0.045] and [4.45 (95% CI, 0.05-8.84) dBA, p = 0.047, partial η^2 = 0.045], respectively over a period of six months. The effect sizes at 3000 and 4000 Hz were “small”. At the first month, the hearing threshold levels above 25 dBA occurred more on participants adopting 90 dBA compared to those adopting 85 dBA at 3000 Hz on right ear based on intention-to-treat analysis and as per-protocol analysis, χ^2 (1) = 4.08, φ = 0.145, p = 0.043 (weak association) and [χ^2 (1) = 5.25, φ = 0.203, p = 0.022] (moderate association), respectively. Similarly, participants from Factory 1 were having more hearing thresholds above 25 dBA compared to those from Factory 2 at 4000 Hz on right ear at the sixth month based on intention-to-treat analysis and as per-protocol analysis, χ^2 (1) = 4.27, φ = 0.145, p = 0.039 (weak association) and χ^2 (1) = 4.73, φ = 0.232, p = 0.030 (moderate association), respectively. Moreover, an adoption of 85 dBA as the permissible exposure limit had preserved the hearing threshold levels among participants from Factory 2 at 6000 Hz compared to those in Factory 1 on right ear based on intention-to-treat analysis, χ^2 (1) = 9.84, φ = 0.220, p = 0.002 (moderate association) at the sixth month. The damaging effect, adopting the permissible exposure limit of 90 dBA, would eventually lead to hearing impairment as speech frequencies would be affected. As per-protocol analysis, there were more standard threshold shifts occurring among participants adopting 90 dBA compared to those adopting 85 dBA, according to the U.S. NIOSH recommended standard, at 1000 Hz on left ear, χ^2 (1) = 3.93, φ = 0.211, p = 0.047 (moderate association) over a period of 6 months. Standard threshold shift is a precursor to permanent threshold shift, leading to noise-induced hearing loss. The knowledge, belief and practice towards noise-induced hearing loss had improved overtime, after affording health education in the form of pamphlets, but there were no differences in the outcomes between participants from the two factories.

6.2 Conclusion and Recommendation

By adopting 90 dBA as the permissible exposure limit, employees were at higher risk of developing noise-induced hearing loss. It is indeed advisable to adopt 85 dBA as the permissible exposure limit to reduce prevalence of this irreversible occupational malady. All frequencies, 500 to 8000 Hz, should be tested to recognize temporary standard threshold shifts early as recommended by the U.S. NIOSH in order to avert noise-induced hearing loss. This study focused on an automobile industry only; however, it provides some estimation on the damaging effect of adopting 90 dBA as the permissible exposure limit. Further research with a larger sample and wider coverage are required. The use of hearing protection device is a solution to workplace noise exposure. The placement of hearing protection device is important besides the attenuation rate of these devices. Though the usage of hearing protectors is cost effective and simple, it is far from being an effective solution to control noise exposure. Other means such as engineering and administrative methods, which are higher in hierarchy for noise control, should be adopted prior to the usage of these devices. All efforts to increase knowledge and improve attitude and practice towards mitigating noise-induced hearing loss should be implemented through continuous education and training. This education and training should be given at regular intervals. Regular inspection by employers and other related personnel will increase responsibility of employees towards averting noise-induced hearing loss. Health promotion programs should be integrated into the Occupational Safety and Health policy in order to increase awareness and adopt preventive measures pertaining to hearing loss. There is sufficient legislation in Malaysia, such as the Occupational and Safety Health Act 1994 (Act 514) and Factories and Machinery (Noise Exposure) Regulations 1989, to reduce prevalence of noise-induced hearing loss, but the implementation and enforcement of these legislations should be more appropriate. Trained personnel to conduct inspections in the factories should be sufficient. The reporting systems and recordkeeping should be improved, as inadequate data and reporting systems may not describe the risks of workplace. There are limited industrial hygienists and occupational health physicians especially among small and medium enterprises due to high cost. Workshops can be given frequently to these enterprises by these experts. The workers should also control the non-occupational exposures (environmental hazards) such as cigarette smoking as they may act synergistically with noise in hastening the process of hearing loss. This can be realized by regular health education on noise-induced hearing loss and its risk factors.

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LIST of PUBLICATIONS in ACADAEMIC JOURNALS

1. Sayapathi BS, Su AT, Koh D. The effectiveness of applying different permissible exposure limits in preserving the hearing threshold level: A systematic review. J Occup Health. (*Epub*) (*PMID: 24270928*) (*ISI-Cited Publication*) (Appendix 39).
2. Sayapathi BS, Su AT, Koh D. Comparing the effect of different permissible exposure limits on hearing threshold levels above 25 dBA over six months. J Int Adv Otol. (*Accepted*) (*ISI-Cited Publication*) (Appendix 40).
3. Sayapathi BS, Su AT, Koh D. Mean hearing threshold levels upon adopting 85 and 90 dBA as permissible exposure limits over six months. WASJ. (*Accepted via conference*) (*ISI-Cited Publication*).
4. Sayapathi BS, Su AT, Koh D. Comparing standard threshold shift among employees adopting 85 and 90 dBA as permissible exposure limits over six months. UMK Procedia (*Accepted via conference*) (*SCOPUS-Cited Publication*).
5. Sayapathi BS, Su AT, Su TT. The effectiveness of applying different permissible exposure limits in preserving hearing threshold level among automobile industry workers: An intervention study. Journal of Practical Medicine. 2012; 12:146-8. (*Study protocol*) (*Non-ISI/Non-SCOPUS Cited Publication*) (Appendix 41).

The following papers have been submitted for publication from this thesis:

1. Sayapathi BS, Su AT, Koh D. The Impact of different permissible exposure limits on hearing threshold levels beyond 25 dBA of post-shift exposure to noise over one month. Iran Red Crescent Med J (*ISI-Cited Journal - Revision*). (*Manuscript ID: 15520).*

2. Sayapathi BS, Su AT, Koh D. Reliability and factor analysis of knowledge, attitude and practice of noise-induced hearing loss. J Occup Health. (*ISI-Cited Journal*) (*Manuscript ID: JOH-2013-0129-OA*).

3. Sayapathi BS, Su AT, Koh D. Post-shift measurement of mean hearing threshold levels upon adopting 85 and 90 dBA in the first month among employees in an automobile industry. J Nepal Med Assoc. (*ISI-Cited Journal*). (*Manuscript ID: 2268-OA*).

LIST of PUBLICATIONS as CONFERENCE PROCEEDINGS

1. Sayapathi BS, Su AT, Su TT. The effectiveness of applying different permissible exposure limits in preserving hearing threshold level among automobile industry workers: an intervention study (*The 4th International Conference of Occupational and Environmental Health, Hanoi, Vietnam, 2012*) *(Abstract).*
2. Sayapathi BS, Su AT, Koh D. Comparing standard threshold shifts among employees adopting different permissible exposure limits (*First World Congress for Advanced Medical Research WORMED 2013, Kuala Lumpur, Malaysia*) *(Abstract)*.
3. Sayapathi BS, Su AT, Koh D. The mean hearing threshold levels among employees adopting different permissible exposure limits (*International Conference on Innovation Challenges in Multidisciplinary Research & Practice, ICMRP 2013, Kuala Lumpur, Malaysia*) *(Abstract).*

LIST of ORAL PRESENTATIONS

1. Sayapathi BS, Su AT, Su TT. The effectiveness of applying different permissible exposure limits in preserving hearing threshold level among automobile industry workers: An intervention study (*The 4th International Conference of Occupational and Environmental Health, Hanoi, Vietnam; presented on 26th-27th November 2012*).
2. Sayapathi BS, Su AT, Koh D. Comparing hearing threshold levels beyond 25 dBA adopting different permissible exposure limits, post-work exposure (*Asia Pacific Safety Symposium 2013, Singapore; presented on 17th-18th October 2013*).
3. Sayapathi BS, Su AT, Koh D. Comparing standard threshold shifts among employees adopting different permissible exposure limits (*First World Congress for Advanced Medical Research WORMED 2013, Kuala Lumpur, Malaysia; presented on 21st -23rd October 2013*).
4. Sayapathi BS, Su AT, Koh D. The mean hearing threshold levels among employees adopting different permissible exposure limits (*International Conference on Innovation Challenges in Multidisciplinary Research & Practice, ICMRP 2013, Kuala Lumpur, Malaysia; presented on 13th-14th December 2013*).
5. Sayapathi BS, Su AT, Koh D. Noise-induced Standard Threshold Shifts of 85 and 90 dBA as Permissible Exposure Limits, post-shift exposure of one month duration (*International Conference on Trends in Multidisciplinary, Business and Economics Research, Bangkok, Thailand; accepted for presentation on 27th - 28th March 2014*) (*ID:TMBER-14-196*).

6. Sayapathi BS, Su AT. Knowledge, Attitude and Practice of noise-induced hearing loss among automobile industry workers (*WONCA Asia Pacific Regional Conference 2014, Kuching, Malaysia; accepted for presentation on 21st – 24th May 2014*) (*ID: MO337*).
7. Sayapathi BS, Su AT. Effect of smoking on hearing thresholds among automobile industry workers (*International Conference on Global Trends in Academic Research, Bali, Indonesia; accepted for presentation on 2nd – 3rd June 2014*) (*ID:GTAR-14-140*)

LIST of POSTER PRESENTATIONS

1. Sayapathi BS, Su AT, Su TT. The effectiveness of applying different permissible exposure limits in preserving hearing threshold level among automobile industry workers: An intervention study (*The 4th International Conference of Occupational and Environmental Health, Hanoi, Vietnam; presented on 26th-27th November 2012*).
2. Sayapathi BS, Su AT. Comparing Hearing Threshold Level beyond 25 dBA between two Factories adopting different Permissible Exposure Limits over 6 months (*23rd Annual Art and Science of Health Promotion Conference Producing the Best Health and Financial Outcomes; by using the most effective health promotion strategies, South Carolina, United States of America; presented on 20th -22nd March 2013*).
3. Sayapathi BS, Su AT. Hearing threshold levels on different permissible exposure limits, post-noise exposure (*21st IUHPE World Conference on Health Promotion, Pattaya, Thailand; presented on 25th-29th August 2013).*
4. Sayapathi BS, Su AT. Standard threshold shifts on different permissible exposure limits, post-shift exposure (*International Research Symposium on Population Health 2013, presented on 19th-20th November 2013*).

LIST of AWARDS

1. Best Session Presentation Award given from the International Conference on Innovation Challenges in Multidisciplinary Research & Practice, ICMRP 2013, Kuala Lumpur for the paper titled "The mean hearing threshold levels among employees adopting different permissible exposure limits", *presented on 13th-14th December 2013*.
2. Appreciation Award for organizing the International Conference on Innovation Challenges in Multidisciplinary Research & Practice, ICMRP 2013

LIST of APPENDICES

Appendix 1: Glossary

Age	Age in years was calculated from the date of birth as stated in Mykad or International Passport during the initial data collection (information obtained from a self-administered questionnaire).
Alcohol consumption	History of current or past alcohol intake (information obtained from a self-administered questionnaire).
Audiogram	A chart showing the hearing threshold levels at frequencies ranging from 500 to 8000 Hz; measured by an audiometer.
Audiometer	An equipment that generates signals of varying frequency (500 to 8000 Hz) and intensity measuring employees hearing sensitivity.
Decibels, A-weighted (dBA)	A unit of measurement of sound level corrected to a A-weighted scale; measured using personal exposure noise dosimeter and sound level meter.
Decibels, C-weighted (dBC)	A unit of measurement of sound level corrected to a C-weighted scale; measured using sound level meter.
Duration of current employment	Number of months or years working in the current company, calculated from the date of commencement until the initial data collection (information obtained from a self-administered questionnaire).
Education level	Highest education level ever achieved by participants are as follows (information obtained from a self-administered questionnaire): i. Primary school - Education until standard six or equivalent ii. Secondary School - Education from Form 1 to Form 5 or equivalent iii. Tertiary Education- Education from Form Six and above or equivalent iv. No Formal Education - Never attended any form of school.

Ethnic group	Ethnic group classification was given by the participants (information obtained from a self-administered questionnaire).
Excessive noise	Level of noise that may lead to standard threshold shifts when the employees are continuously exposed for 8 hours; measured using personal exposure noise dosimeter and sound level meter. The noise level is at or above the permissible exposure limit for noise.
Hearing conservation program	A program consisting of strategies to be taken by the employers to limit hearing loss among employees.
Hz	Unit of measurement of frequency in an audiogram.
Income	Gross salary earned by the participants per month (information obtained from a self-administered questionnaire).
Noise reduction rate	An estimation of adequacy of hearing protector attenuation, displayed on the hearing protection devices.
Smoking status	History of current or past tobacco usage (information obtained from a self-administered questionnaire).

Appendix 2: Calibration of sound level meter and personal exposure noise dosimeter

Instrument	Manufacturer	Model	Serial number	Calibration date	Re-calibration date	Reference standard (calibrator)
1	Larson Davis	Spark 706RC	0719018	28/7/2011	28/7/14	STD 030/3
2	Larson Davis	Spark 706RC	0719035	28/7/2011	28/7/14	STD 030/3
3	Larson Davis	Spark 703+	0624019	02/8/2011	02/8/14	STD 030/3
4	Larson Davis	Spark 703+	0624021	02/8/2011	02/8/14	STD 030/3
5	Larson Davis	Spark 703+	0624020	02/8/2011	02/8/14	STD 030/3

Appendix 3: Calibration of earphones and audiometers

Model and serial number:

Model	Make	Serial number	Earphones	Right serial number	Left serial number
asi 17 (1st set)	asi	20032591	TDH 39	C118573	C118608
asi 17 (2nd set)	asi	20032919	TDH 39	C75247	C75248

Calibration:

Set	Hz	500	1000	2000	3000	4000	6000	8000
1st	dB SPL	81.5 ± 3	77.0 ± 3	79.0 ± 3	81.5 ± 3	80.0 ± 4	85.5 ± 5	83.0 ± 5
	Left (dB)	81.8	77.1	79.2	81.7	80.1	85.4	83.3
	Right (dB)	81.7	77.0	79.3	81.8	80.1	85.7	83.1
2nd	dB SPL	81.5 ± 3	77.0 ± 3	79.0 ± 3	81.5 ± 3	80.0 ± 4	85.5 ± 5	83.0 ± 5
	Left (dB)	81.7	77.1	79.1	81.4	79.9	85.7	83.2
	Right (dB)	81.5	77.3	79.2	81.7	80.3	85.4	83.1

SPL, Sound pressure level

Calibration date: 17/7 2012

Next calibration date: 17/7 2013

Appendix 4: Calibration of silent cabin or audiometric booth

Y-octave band (Hz)	500	1000	2000	4000	8000
Maximum SPL allowable	27	30	35	25	41
Measured level (1st set)	22.4	21.9	23.8	22.6	23.9
Measured level (2nd set)	20.2	27.9	25.8	24.8	23.7

SPL, Sound pressure level

Calibration date: 17/7 2012

Next calibration date: 17/7 2013

Workplace noise level (within the van): 25 dBA

Appendix 5: Participant information sheet

Please read the following information carefully, do not hesitate to discuss any questions you may have with your doctor.

Study Title

The effectiveness of applying different permissible exposure limits in preserving hearing threshold level among automobile industry workers: An intervention study.

Introduction

A corollary to industrialization is a significant increase in noise levels where these noise levels become potential health hazards. Lately, occupational diseases are emerging more in developing countries compared to developed countries due to rapid industrialization. Occupational noise-induced hearing loss is defined as development of hearing loss due to exposure to excessive noise where the progression is reliant on three factors: frequency, intensity and duration. This is preventable but once hearing loss has occurred, it is permanent and irreversible. There are various adverse outcomes due to exposure to excessive noise namely auditory and non- auditory effects. Besides hearing loss, other conditions such as tinnitus and vertigo may occur. The non-auditory effects may have increased incidence of blood pressure, heart rate, blood glucose, lipid levels and peptic ulcers.

What is the purpose of this study?

To determine the effectiveness of applying different permissible exposure limits in preserving hearing threshold level among automobile industry workers. This study is a comparison between two factories: one factory following the current Malaysian level, i.e., 90 dBA as the permissible exposure limit and another factory with 85 dBA. The specific objectives are:

1. To determine the effectiveness of adopting 85 dBA as the permissible exposure limit compared to that of 90 dBA in preserving hearing thresholds.
2. To decide on the effectiveness of adopting 85 dBA as the permissible exposure limit compared to 90 dBA in preventing standard threshold shifts.
3. To gauge levels of knowledge, attitude and practice of noise- induced hearing loss between participants from the two factories upon adopting different permissible exposure limits.

What are the procedures to be followed?

The procedures are as follows:

i. The audiogram is carried out on all employees. The initial audiogram is taken as baseline, followed by subsequent audiograms at the first and sixth month.

ii. A pair of hearing protection device is given to reduce noise exposure to levels between the permissible exposure limit and action level.

iii. Hearing conservation education is given in the form of pamphlets. It is given at the outset, first month and sixth month after the initial data collection**.**

iv. The self-administered questionnaires of knowledge, attitude and practice of noise-induced hearing loss with consent forms and information sheets are distributed among employees from the two factories at the outset, and also at the first and sixth month.

Who should not enroll in the study?

a) Employees who refuse to participate in the study.
b) Employees who excused themselves from the study before completing six months.
c) Employees suffering from diseases of the ear such as chronic suppurative otitis media and malignancy.
d) Employees who have experienced physical trauma to the ear due to a penetrating injury or fall.
e) Employees who had undergone ear surgery.
f) Employees who are having congenital hearing loss.

What are the benefits of the study?

(a) To you as the subject:

During data collection, if employees are found to have hearing loss, they are given hearing protection devices to attenuate sound levels to levels below the action level. Researcher recommends the employer to reduce noise levels to levels below the permissible exposure level by applying the engineering and administrative methods. Health education is also given, increasing knowledge and awareness of this malady and the necessary action to be taken to prevent them.

(b) To the investigator:

With early introduction of a hearing protection device, regular audiograms and health education, temporary threshold shifts may be recognized earlier and subsequently, permanent threshold shifts can be prevented through various methods. The outcome of the study may be beneficial to policy-makers to encourage review of the current permissible exposure limit in the country and also to other countries adopting levels that of the OSHA's regulations. This study contributes to the limited evidence of adopting different permissible exposure limits on hearing threshold levels.

What are the possible drawbacks?

None, since the levels of noise exposure studied are below than the current limit followed in the country.

Can I refuse to take part in the study?

Participation is on a voluntary basis. The researcher sincerely hopes that all employees participate till the completion of the study (6 months). However, they may withdraw from the study at any time and may also choose not to answer any questions that are deemed sensitive.

Who should I contact if I have additional questions during the course of the study?

Doctor's Name: Dr Balachandar S. Sayapathi Tel: 013-5670809

Appendix 6: Participant information sheet in Bahasa Malaysia (*Maklumat kajian peserta*)

Tajuk Kajian:

Keberkesanan melindungi tahap pendengaran pekerja-pekerja di industri kereta dengan tahap bunyi yang berlainan: Suatu kajian intervensi.

Pengenalan:

Tahap bunyi semakin bertambah terutamanya di kalangan industri-industri. Penyakit di kalangan pekerja semakin bertambah di antara negara yang sedang membangun. Penyakit pekak disebabkan bunyi muncul sebab pendedahan kepada bunyi yang kuat. Bunyi yang kuat ini bergantung kepada frekuensi, tahap bunyi dan lamanya pendedahan kepada bunyi. Penyakit ini adalah tetap dan tidak boleh bertambah baik sebab tidak ada ubat untuk mengubatinya. Selain dari pekak, penyakit pekak sebab bunyi ini dapat menaikkan tekanan darah, denyutan jantung, tahap gula dalam badan, meninggikan tahap kolesterol dan meninggikan tahap ulser di dalam perut.

Tujuan kajian:

Keberkesanan melindungi tahap pendengaran pekerja-pekerja di industri kereta dengan tahap bunyi yang berlainan. Dalam kajian ini, dua tahap pendengaran akan digunakan di dua industri yang berlainan. Tahap pendengaran yang akan digunakan adalah 90 dBA sebagai *permissible exposure limit* dan 85 dBA sebagai *permissible exposure limit*.

Tujuan utama kajian adalah seperti berikut:

i. Untuk mengetahui keberkesanan melindungi tahap pendengaran pekerja-pekerja di industri kereta dengan tahap bunyi yang berlainan iaitu antara 85 dBA sebagai *permissible exposure limit* dengan 90 dBA *permissible exposure limit*.

ii. Untuk mengetahui keberkesanan dalam pencegahan *standard threshold shifts* dengan menggunakan tahap bunyi berlainan iaitu antara 85 dBA sebagai *permissible exposure limit* dengan 90 dBA *permissible exposure limit*.
iii. Untuk mengetahui tahap pengetahuan, sikap dan praktis dalam penyakit pekak disebabkan bunyi dikalangan pekerja-pekerja yang terdeadah dengan tahap pndengaran bunyi yang berlainan.

Apakah prosedur perlu diikuti?

i. *Audiogram* akan dilakukan pada setiap pekerja tiga kali, pada permulaan kajian, satu bulan kemudian dan enam bulan kemudian.
ii. Pemberian alat pelindung telinga untuk mengurangkan tahap bunyi ke tahap antara *permissible exposure limit* dan *action level*.
iii. Pendidikan kesihatan akan disampaikan pada pada permulaan kajian, satu bulan kemudian dan enam bulan kemudian dalam bentuk *pamphlets*.
iv. Kajian dalam bentuk soal selidik akan disampaikan pada pada permulaan kajian, satu bulan kemudian dan enam bulan kemudian kepada semua pekerja.

Siapa yang tidak perlu mengambil bahagian dalam kajian ini?

i. Pekerja yang tidak mahu mengambil bahagian dalam kajian ini.
ii. Pekerja yang mahu berhenti dari mengambil bahagian dalam kajian ini sebelum enam bulan.
iii. Pekerja yang ada penyakit kuman telinga menyebabkan telinga bernanah dan telinga yang berkanser.
iv. Pekerja yang jatuh mencederakan telinga.
v. Pekerja yang telah mengalami pembedahan telinga.
vi. Pekerja yang mengalami pekak telinga sejak kecil.

Kelebihan yang diperolehi ketika menyertai kajian ini:

A) **Kepada pekerja:**

Alat pelindung telinga yang sesuai akan diberikan pada pekerja. Pihak majikan akan dinasihatkan supaya tahap bunyi dikurangkan melalui cara kejuruteraan dan pentadbiran sekiranya pekerja ada kehilangan pendengaran. Pendidikan kesihatan akan juga disampaikan pada pekerja mengenai sakit pekak disebabkan bunyi kuat.

B) **Kepada penyelidik:**

Penyakit pekak disebabkan bunyi dapat dikesan awal, supaya tahap bunyi dapat dikurangkan. Lagipun, tidak banyak kajian dilakukan dalam bidang ini.

Risiko ketika menyertai kajian ini:

Tidak ada risiko, disebabkan tahap bunyi akan dikurangkan dari tahap yang biasa dipraktikkan.

Kesukarelaan menyertai kajian:

Dijelaskan bahawa penyertaan tuan/ puan di dalam kajian ini adalah secara sukarela. Tidak ada sebarang pihak boleh memaksa tuan/ puan untuk menyertai kajian ini. Jika tuan/ puan membuat keputusan untuk tidak meneruskan penyertaan dalam kajian ini, tuan/ puan tidak akan menghadapi sebarang hukuman atau kehilangan sebarang keuntungan yang tuan/ puan berhak dapat diluar kajian ini. Tuan/ puan dapat menarik diri pada bila-bila masa semasa kajian ini dijalankan. Diharapkan tuan/ puan dapat mengambil bahagian dalam kajian selama enam bulan.

Soalan dapat ditujukan pada pengkaji seperti dibawah:

Nama Penyelidik: **<u>Dr Balachandar S. Sayapathi</u>** **Tel**: **<u>0135670809</u>**

Appendix 7: Consent form

I, …………………………………………………………………….

Identity Card No……….……………………………….

(Participant)

Of
……

(Address)

hereby agree to take part in the clinical research (clinical study and questionnaire) as specified below:

<u>Title of Study:</u> The effectiveness of applying different permissible exposure limits in preserving hearing threshold level among automobile industry workers: An intervention study.
.

The nature and purpose of which has been explained to me by **Dr. Balachandar S. Sayapathi, MBBS, MPH**

and interpreted by **……………………..……………………………….…..…………**

(Name & Designation of Interpreter)

……………………………………….. to the best of his/her ability in
………………………….language/dialect.

I have been told about the nature of the clinical research in terms of methodology, possible adverse effects and complications (as per the participant information sheet). After knowing and understanding all the possible advantages and disadvantages of this clinical research, I voluntarily consent to participate in the clinical research, as specified above.

I understand that I can withdraw from this clinical research at any time without assigning any reason whatsoever and in such a situation shall not be denied the benefits offered by the company.

Date: ……………...………..

Signature or

Thumb print

…………………………

(Participant)

IN THE PRESENCE OF

Name ………………………………………..….……..…

Identity Card No. ………………………..……..…… **Signature**

………………………………….

(*Witness for Signature of Patient)*

Designation ……………………………..……………

I confirm that I have explained to the participant the nature and purpose of the above-mentioned clinical research.

Date ……………………………. **Signature**

……………………

(Researcher)

Appendix 8: Consent form in Bahasa Malaysia *(Borang keizinan)*

Saya,……………………………………………….……………….

No. Kad Pengenalan …………………..…………………

(Peserta)

beralamat…………………………………………………………………………….……..…………

dengan ini bersetuju menyertai dalam penyelidikan klinikal (pengajian klinikal dan pengajian soal-selidik) seperti berikut:

<u>TajukPenyelidikan</u>: Keberkesanan melindungi tahap pendengaran pekerja-pekerja di industri kereta dengan tahap bunyi yang berlainan: Suatu kajian intervensi.

yang mana sifat dan tujuannya telah diterangkan kepada saya oleh **Dr. Balachandar S. Sayapathi, MBBS, MPH**

mengikut terjemahan …………………..………………………………………………

(Nama & Jawatan Penterjemah)

………………………………………. yang telah menterjemahkan kepada saya dengan sepenuh kemampuan dan kebolehannya di dalam Bahasa / loghat …………………………………………….

Saya telah diberitahu bahawa dasar penyelidikan klinikal dalam keadaan methodologi, risiko dan komplikasi (mengikut kertas maklumat peserta). Selepas mengetahui dan memahami semua kemungkinan kebaikan dan keburukan penyelidikan klinikal ini, saya merelakan/mengizinkan sendiri menyertai penyelidikan klinikal tersebut di atas.

Saya faham bahawa saya boleh menarik diri dari penyelidikan klinikal ini pada bila-bila masa tanpa memberi sebarang alasan dalam situasi ini dan tidak akan dikecualikan dari kemudahan di industri.

Tarikh: …………………….. **Tandatangan/Cap Jari**

……………………………………………….

(Peserta)

DI HADAPAN

Nama …………………………………………………)

No. K/P……………………………………………….) **Tandatangan**

………………………………………

(Saksi untuk Tandatangan Peserta)

Jawatan …………..…………………………………..)

Saya sahkan bahawa saya telah menerangkan kepada peserta sifat dan tujuan penyelidikan klinikal tersebut di atas.

Tarikh: ….………………………. **Tandatangan**

……………..

(Penyelidik)

Appendix 9: Consent form by responsible relative

I, ……………………………………………………………………….

Identity Card No…………...……………………………

(Name)

of ……

(Address)

hereby agree that my relative ……………………………………………………….. (Name)

I.C. No………..………………………

participates in the clinical research (clinical study and questionnaire) as specified below:-

<u>**Title of Study**</u>: The effectiveness of applying different permissible exposure limits in preserving hearing threshold level among automobile industry workers: An intervention study.

The nature and purpose of which has been explained to me by **Dr. Balachandar S. Sayapathi, MBBS, MPH**

and interpreted by **……………………..………………………………..…..…………**

(Name & Designation of Interpreter)

…………………………………… to the best of his/her ability in …………………….…………… language/dialect.

I have been informed of the nature of this clinical research in terms of procedure, possible adverse effects and complications (as per the participant information sheet). I understand the possible advantages and disadvantages of participating in this research. I voluntarily give my consent for my relative to participate in this research, as specified above.

I understand that I can withdraw my relative from this clinical research at any time without assigning any reason whatsoever and in such situation; my relative shall not be denied the benefits offered by the company. Should my relative regain his/her ability to consent; he/she will have the right to remain in this research or may choose to withdraw.

Relationship to participant	**Date:**	**Signature or Thumbprint**
……………………..	**……………………….**	**………………………….**

IN THE PRESENCE OF

Name ………………………………………………..…..)

Identity Card No. ………………………………….) **Signature**

Designation …………………………………………) **……………….**

(*Witness)*

I confirm that I have explained to the participant's relative the nature and purpose of the above-mentioned clinical research.

Date …………………………….

………………

(Researcher)

Appendix 10: Consent form by responsible relative in Bahasa Malaysia *(Borang keizinan oleh waris yang bertanggungjawab)*

Saya,………………………………………..……………………………..…………………………………..

…………..….………………………………………………………………………………………………..

(Nama Waris dan kad pengenalan yang bertanggungjawab)

beralamat…………………………………………………………………………………………………..

dengan ini telah bersetuju supaya saudara atau saudari saya

………………………………………..……………………………………… menyertai

(Nama Peserta)

dalam penyelidikan klinikal (pengajian klinikal dan pengajian soal-selidik) disebut berikut:

TajukPenyelidikan: Keberkesanan melindungi tahap pendengaran pekerja-pekerja di industri kereta dengan tahap bunyi yang berlainan: Suatu kajian intervensi.

Di mana sifat dan tujuannya telah diterangkan kepada saya oleh **Dr. Balachandar S. Sayapathi, MBBS, MPH**

……………………………………………………………………………………………mengikut terjemahan

(Nama & Jawatan Penterjemah)

……………………………………..... yang telah menterjemahkan kepada saya dengan sepenuh kemampuan dan kebolehannya di dalam Bahasa / loghat……………………………………….

Saya telah diberitahu bahawa dasar penyelidikan klinikal dalam keadaan metodologi, risiko dan komplikasi (mengikut kertas maklumat peserta). Saya mengetahui dan memahami semua kemungkinan kebaikan dan keburukan penyelidikan klinikal ini. Saya merelakan/mengizinkan saudara saya menyertai penyelidikan klinikal tersebut di atas.

Saya faham bahawa saya boleh menarik balik penyertaan saudara saya dalam penyelidikan klinikal ini pada bila-bila masa tanpa memberi sebarang alasan dalam situasi ini dan tidak akan dikecualikan dari kemudahan di industri. Sekiranya saudara saya kembali berupaya untuk memberi keizinan, beliau mempunyai hak untuk terus menyertai kajian ini atau memilih untuk menarik diri.

Tarikh:	**Pertalian dengan pesakit**	**Tandatangan/Cap Jari Waris yang bertanggungjawab**
……………	…..…………………………	……………………………….

DI HADAPAN

Nama ………………………………………..….)

No. K/P…………………………………………) **Tandatangan**

…………………………………

Jawatan………..………………………………) ***(Saksi untuk Tandatangan***

Waris yang bertanggungjawab)

Saya sahkan bahawa saya telah menerangkan kepada waris yang bertanggungjawab sifat dan tujuan penyelidikan klinikal tersebut di atas.

Tarikh: ……..……………………… **Tandatangan**

……………………….

(Penyelidik)

Appendix 11:

QUESTIONNAIRE OF

NOISE-INDUCED HEARING LOSS AMONG WORKERS

INSTRUCTIONS

1. This questionnaire is divided into 4 sections:

    a. Sociodemographic characteristics

    b. Knowledge

    c. Attitude

    d. Practice

2. Please attempt all the questions.

3. Please do not spend too much time in attempting to answer a question.

4. Please answer according to instructions given in each section.

5. All the information given in this form is confidential.

DEMOGRAPHIC INFORMATION

<table>
<tr><td>Name:</td><td></td><td>Identification Number (IC):</td><td></td></tr>
<tr><td>Gender:</td><td>☐ Male ☐ Female</td><td colspan="2">Date of Birth:
_____/_____/________</td></tr>
<tr><td>Address:
(Current)</td><td colspan="3"></td></tr>
<tr><td>Hand-phone:</td><td></td><td>Office:</td><td></td></tr>
<tr><td>Ethnic Group:</td><td colspan="3">☐ Malay ☐ Chinese ☐ Indian
☐ Others, please state: ____</td></tr>
<tr><td>Marital Status:</td><td colspan="3">☐ Married ☐ Single ☐ Divorced ☐ Widow ☐ Separated
____________(specify duration)</td></tr>
<tr><td>Religion:</td><td colspan="3">☐ Islam ☐ Buddhism ☐ Hinduism ☐ Christianity
☐ Other, please state: ___________________________</td></tr>
<tr><td rowspan="3">Work Information:</td><td colspan="3">Name of company:</td></tr>
<tr><td colspan="3">Position:</td></tr>
<tr><td colspan="3">Date of joining this company:
______(Day)/______(Month)/ ________(Year)
If you can’t remember, please state the year only: _________________</td></tr>
<tr><td>Family Income:</td><td colspan="3">☐ Estimation: RM __________ (entire household income including other family members if you are living with them)
☐ Your salary: RM _________ per month (gross salary)</td></tr>
</table>

Educational Level:	☐ No formal Schooling (For the following, please mark "x". You may indicate the highest completed educational level. ☐ Primary School (Year 1-6). Completed till primary_______________ ☐ Secondary School (Form 1-5) Completed till form _______________ ☐ Form 6 or certificate Completed till form _______________ ☐ College or university Completed ___________________ degree.

Do you smoke cigarettes? No ☐ Yes ☐ Previous smoker ☐
If "yes", please state how many cigarettes you smoke every day:
I smoke ____________ a day.
If "previous smoker", please state when you stopped and state how many cigarettes you smoked a day and for how long:
I did not smoke for_________, I previously did smoke ____________ cigarettes a day and for_________months/years.

Do you consume alcohol regularly? No ☐ Yes ☐ Occasionally ☐
If "yes", please state how many cans or bottles or glasses you drink per week.
I drink approximately ________ cans or bottles or glasses of alcohol in a week.
If "occasionally", please state how many cans or bottles or glasses you drink per month or per year.
I drink approximately ________ cans or bottles or glasses of alcohol per ______.

Have you been diagnosed with any chronic medical illness?
No ☐ Yes ☐
If "yes", please state the name of your health problems as mentioned by your doctor.
____

Have you had any surgery before?
No ☐ Yes ☐
If "yes", please state the name of the surgery.
____

Have you had any trauma or accident in the past resulting in permanent injury to the ears or brain?
No ☐ Yes ☐
If "yes", please briefly state the traumatic event below:
____

Have you been working in a different company other than this company which produced loud noise?
No ☐ Yes ☐
If "yes", please fill the table below:

No.	Date (year)		Name of the Company	Nature of Business/ Production	Job Description
	From	To			
1.					
2.					
3.					
4.					

Are you on any long term medication: No ☐ Yes ☐
If "yes", please state the name of the medicine or what it is used for if you do not know the name of the medicine.
____

Do you listen to loud music or are you involved in activities such as scuba diving or shooting? No ☐ Yes ☐
If "yes", please tick what activities are you involved with below (you can tick more than 1 option):
☐ Listening to loud music
☐ Scuba diving
☐ Shooting
☐ Others: Please specify ______________________________________

Do you have another job outside this company or do you do any part-time job? No ☐ Yes ☐
If "yes", please specify below:

No.	Company	Business or Nature of Production	Job Description	How frequently you perform this job
1.				
2.				

B. Knowledge on Hearing Loss

- Please read the following statements from K1 to K12, and tick **True** if you think the statement is correct and **False** if you think the statement is incorrect. If you do not know the answer, tick **Don't Know**.
- Please tick only **one box** for each question.

No.	**Items**	**True**	**False**	**Don't know**	**Coding (Office use only)**
	General aspects of hearing loss				
K1.	Hearing loss due to noise is not permanent.				
K2.	Industry workers are more prone to hearing loss compared to office workers.				
	Causes of hearing loss				
K3.	Hearing loss may not occur if the worker is exposed to loud noise.				
K4.	Hearing loss may occur if the worker is exposed to a noisy environment for many years.				
K5.	Hearing loss may not occur if the worker is repeatedly exposed to a noisy environment.				
K6.	Hobbies such as shooting and scuba diving may cause hearing loss.				
	Risk factors of hearing loss				
K7.	Smoking increases the risk of hearing loss when working in a noisy environment.				
	Signs & Symptoms of hearing loss				
K8.	Ear discharge is the earliest sign of hearing loss due to noise.				
	Treatment of hearing loss				
K9.	There is medication available to treat hearing loss due to noise.				
	Prevention (worker's responsibility)				
K10.	Hearing loss can't be prevented by wearing ear plugs or ear muffs.				

No.	Items	True	False	Don't know	Coding (Office use only)
Policy protecting workers from occupational hazardous noise					
K11.	There is law in existence protecting employees from exposure to loud noise.				
K12.	It is the responsibility of the employers to make ear plugs or ear muffs available to employees at no cost.				

C. Attitude

- Please read the following statements from AB1 to AB8, AF1 to AF6 and AJ1 to AJ6 and then tick either **Strongly Disagree** or **Disagree** if you think the statement is incorrect and **Agree** or **Strongly Agree** if you think the statement is correct. If you think the statement is neither correct nor incorrect, then tick **Neither Agree nor Disagree.**
- Please tick only **one box** for each question.

No.	Items	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Coding (Office use only)
				Belief			
AB1.	I believe hearing loss is due to age rather than noise exposure.						
AB2.	I believe traditional medicine can treat hearing loss.						
AB3.	I think I should replace ear plugs once they are damaged.						
AB4.	In my opinion, I should wear any form of ear plugs or ear muffs that are provided by the management.						
AB5.	I believe health education and training is required to reduce hearing loss.						
AB6.	In my opinion, it is more comfortable to use cotton buds to reduce noise exposure.						

No.	Items	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Coding (Office use only)
AB7.	I believe it is right to wear one ear plug only during communication in a noisy environment.						
AB8.	As an employee, I think I do not need to know the law on noise control.						
				Feeling			
AF1.	When there is a case of hearing loss, I feel that only employers are affected (rather than employees) since they have to compensate employees financially.						
AF2.	I am not worried about exposure to loud noise if the exposure is of short duration.						
AF3.	I feel my employer should be informed if I have hearing loss.						
AF4.	I feel it is my responsibility as well as the employers' to reduce noise exposure.						
AF5.	I feel nothing is wrong if we are not informed about the results of audiogram (stating the hearing loss level).						

No.	Items	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Coding (Office use only)
AF6.	I feel nothing is wrong if we are not informed on the results of initial noise exposure monitoring.						
			Judgment				
AJ1.	I can ignore hearing loss since it does not lead to death.						
AJ2.	I will still have an increased risk of hearing loss despite wearing ear plugs or ear muffs.						
AJ3.	I will continue to work despite having hearing loss since it is reversible.						
AJ4.	I will ignore hearing loss since it is not painful.						
AJ5.	I will wear ear plugs or ear muffs in a noisy industry.						
AJ6.	I will undergo regular hearing assessment to detect any hearing loss.						

D. Practice

- Please read the following statements from P1 to P10, and then tick either **Never** if you don't practice and **Always** if you constantly practice. If you occasionally practice, i.e., neither Never nor Always, and then tick **Seldom or Sometimes.**
- Please tick only **one box** for each question.

No.	**Items**	**Never**	**Seldom/ Sometimes**	**Always**	**Coding (Office use only)**
P1.	I will not inform my employer if I'm having hearing loss.				
P2.	I undergo hearing assessment to discover if I have hearing loss.				
P3.	I attend health education to know the effects of noise.				
P4.	I don't attend training to know usage and care of ear plugs or ear muffs.				
P5.	I wear earplugs or ear muffs to protect from hearing loss.				
P6.	I will not inform my employer if my earplug is damaged.				
P7.	I will continue to wear the ear plug despite having an ear discharge.				
P8.	I only wear approved ear plugs or ear muffs.				
P9.	I will not avoid entering in a very noisy area at workplace.				
P10.	I will get information from the safety and health committee regarding noise.				

Thank you for your cooperation.

Appendix 12:

QUESTIONNAIRE OF NOISE-INDUCED HEARING LOSS AMONG WORKERS IN BAHASA MALAYSIA

SOAL SELIDIK

KEHILANGAN PENDENGARAN AKIBAT KEBISINGAN DI KALANGAN PEKERJA

ARAHAN

1. Soal selidik ini terbahagi kepada 4 bahagian iaitu:

   a. Ciri-ciri sosiodemografik

   b. Pengetahuan

   c. Sikap

   d. Amalan

2. Sila jawab semua soalan.

3. Sila jangan ambil masa yang panjang semasa menjawab setiap soalan.

4. Sila jawab berdasarkan arahan yang diberi di setiap bahagian.

5. Semua maklumat yang diberikan dalam borang ini adalah sulit.

A. Maklumat Demografik

<table>
<tr><td>Nama:</td><td></td><td>Nombor Kad Pengenalan:</td><td></td></tr>
<tr><td>Jantina:</td><td>☐ Lelaki ☐ Perempuan</td><td colspan="2">Tarikh lahir:

_____/_____/_________</td></tr>
<tr><td>Alamat:

(Semasa)</td><td colspan="3"></td></tr>
<tr><td>Telefon bimbit:</td><td></td><td>Pejabat:</td><td></td></tr>
<tr><td>Kumpulan Etnik:</td><td colspan="3">☐ Melayu ☐ Cina ☐ India

☐ Lain-lain, sila nyatakan: ____</td></tr>
<tr><td>Status Perkahwinan:</td><td colspan="3">☐ Berkahwin ☐ Bujang ☐ Bercerai ☐ Balu/Duda ☐ Berpisah

____________ (nyatakan tempoh)</td></tr>
<tr><td>Agama:</td><td colspan="3">☐ Islam ☐ Buddha ☐ Hindu ☐ Kristian

☐ Lain-lain, sila nyatakan: ____________________________</td></tr>
<tr><td rowspan="3">Maklumat Pekerjaan:</td><td colspan="3">Nama syarikat:</td></tr>
<tr><td colspan="3">Jawatan:</td></tr>
<tr><td colspan="3">Tarikh menyertai syarikat ini?

______(Hari)/______(Bulan)/ ________(Tahun)

Jika anda tidak ingat, sila nyatakan tahun sahaja: _________________</td></tr>
</table>

Pendapatan:	☐ Gaji anda: RM __________ sebulan (gaji kasar) Sila tanda “x” di bawah: ☐ <1000 ☐ ≥1000 - <2000 ☐ ≥2000 - <3000 ☐ ≥3000 - <4000 ☐ ≥4000 - <5000 ☐ ≥5000
Tahap Pendidikan:	☐ Tiada persekolahan formal (Bagi yang berikut, sila tandakan “x. Anda boleh nyatakan tahap pendidikan paling tinggi yang anda capai. ☐ Sekolah Rendah (Tahun 1-6). Belajar sehingga tahun ____________________ ☐ Sekolah Menengah (tingkatan 1-5) Belajar sehingga tingkatan ________________ ☐ Tingkatan 6 atau sijil Belajar sehingga tingkatan ________________ . ☐ Kolej atau universiti Tamat dengan ijazah ____________________

Adakah anda menghisap rokok? Tidak ☐ Ya ☐ Bekas perokok ☐

Jika “ya”, sila nyatakan berapa batang rokok anda hisap setiap hari:

Saya menghisap ____________ batang rokok sehari.

Jika “bekas perokok”, sila nyatakan bilakah anda berhenti dan berapa batang rokok anda hisap setiap hari dan berapa lama anda merokok:

Saya tidak merokok selama__________, sebelum ini saya menghisap ____________ batang rokok sehari dan selama__________bulan/tahun.

Adakah anda minum alkohol secara tetap? Tidak ☐ Ya ☐ Kadang-kala ☐

Jika “ya”, sila nyatakan berapa tin atau botol atau gelas yang anda minum setiap minggu:

Saya minum lebih kurang _________ tin atau botol atau gelas alkohol dalam seminggu.

Jika “kadang-kala”, sila nyatakan berapa tin atau botol atau gelas yang anda minum setiap bulan atau setiap tahun:

Saya minum lebih kurang _________ tin atau botol atau gelas alkohol dalam satu _______.

Pernahkah anda dirawat untuk penyakit kronik?
Tidak ☐ Ya ☐

Jika “ya”, sila nyatakan nama masalah kesihatan seperti yang disebut oleh doktor anda.
____

Pernahkah anda menjalani apa-apa pembedahan sebelum ini?
Tidak ☐ Ya ☐

Jika “ya”, sila nyatakan nama pembedahan tersebut.
____

Pernahkah anda mengalami apa-apa trauma atau kemalangan yang mengakibatkan kecederaan kekal pada telinga atau otak?
Tidak ☐ Ya ☐
Jika “ya” Sila nyatakan secara ringkas peristiwa tersebut di bawah:
____
____

Pernahkah anda bekerja di syarikat lain yang mengeluarkan bunyi bising yang kuat selain syarikat sekarang?
Tidak ☐ Ya ☐
Jika “ya”, sila isi jadual di bawah:

Bil.	Tarikh (tahun)		Nama Syarikat tersebut	Sifat Perniagaan/ Pengeluaran	Penghuraian Kerja
	Dari	Hingga			
1.					
2.					
3.					
4.					

Adakah anda mengambil apa-apa ubat untuk jangkamasa panjang: Tidak ☐ Ya ☐

Jika “ya”, sila nyatakan nama ubat tersebut atau kegunaannya jika anda tidak tahu nama ubat tersebut.
____

Adakah anda mendengar muzik yang kuat atau terlibat dalam aktiviti-aktiviti seperti menyelam scuba atau menembak?
Tidak ☐ Ya ☐

Jika “ya” Sila tandakan di bawah aktiviti-aktiviti yang anda terlibat dengan (anda boleh memilih lebih daripada 1 jawapan):

☐ Mendengar muzik yang kuat

☐ Menyelam scuba

☐ Menembak

☐ Lain-lain: Sila nyatakan ______________________________________

Adakah anda mempunyai pekerjaan lain selain daripada syarikat ini ataupun adakah anda melakukan apa-apa kerja sambilan?
Tidak ☐ Ya ☐

:
Jika “ya”, sila nyatakan di bawah:

Bil.	Syarikat	Perniagaan atau sifat pengeluaran	Penghuraian kerja	Berapa kerap anda melakukan kerja ini
1.				
2.				

B. Pengetahuan tentang Kehilangan Pendengaran

- Sila baca pernyataan berikut dari K1 ke K12, dan tanda **Benar** jika anda fikir pernyataan tersebut betul dan **Palsu** jika anda fikir pernyataan tersebut tidak betul. Jika anda tidak tahu jawapannya, tanda **Tidak Tahu**.
- Sila tandakan **satu kotak** sahaja bagi setiap soalan.

Bil.	**Perkara**	**Benar**	**Palsu**	**Tidak tahu**	**Pengkodan (Kegunaan pejabat sahaja)**
Aspek-aspek umum kehilangan pendengaran					
K1.	Kehilangan pendengaran akibat bunyi bising adalah tidak kekal.				
K2.	Pekerja-pekerja industri adalah lebih cenderung mengalami kehilangan pendengaran berbanding dengan pekerja-pekerja pejabat.				
Punca-punca kehilangan pendengaran					
K3.	Kehilangan pendengaran mungkin tidak berlaku jika pekerja terdedah kepada bunyi bising yang kuat.				
K4.	Kehilangan pendengaran mungkin berlaku jika pekerja terdedah kepada persekitaran yang bising selama bertahun-tahun.				
K5.	Kehilangan pendengaran mungkin tidak berlaku jika pekerja banyak kali terdedah kepada persekitaran yang bising.				
K6.	Hobi-hobi seperti menembak dan menyelam scuba mungkin menyebabkan kehilangan pendengaran.				
Faktor-faktor risiko kehilangan pendengaran					
K7.	Merokok meningkatkan lagi risiko kehilangan pendengaran apabila bekerja dalam persekitaran yang bising.				
Tanda-tanda & Gejala-gejala kehilangan pendengaran					
K8.	Pelepasan telinga adalah tanda paling awal kehilangan pendengaran akibat kebisingan.				

Bil.	Perkara	Benar	Palsu	Tidak tahu	Pengkodan (Kegunaan pejabat sahaja)
Rawatan kehilangan pendengaran					
K9.	Terdapat ubat untuk merawat kehilangan pendengaran akibat kebisingan.				
Pencegahan (tanggungjawab pekerja)					
K10.	Kehilangan pendengaran tidak dapat dicegah dengan memakai palam telinga atau pelindung telinga.				
Dasar melindungi para pekerja daripada kebisingan berbahaya pekerjaan					
K11.	Terdapat undang-undang yang melindungi para pekerja daripada pendedahan kepada bunyi bising yang kuat.				
K12.	Adalah menjadi tanggungjawab majikan untuk menyediakan palam telinga atau pelindung telinga kepada para pekerja secara percuma.				

C. Sikap

- Sila baca pernyataan berikut dari AB1 hingga AB8, AF1 hingga AF6 dan AJ1 hingga AJ6 dan kemudian tanda sama ada **Sangat Tidak Setuju** atau **Tidak Setuju** jika anda fikir pernyataan tersebut tidak betul, dan **Setuju** atau **Sangat Setuju** jika anda fikir pernyataan itu betul. Tanda **Tidak Pasti** jika anda tidak tahu jawapannya.
- Sila tandakan **satu kotak** sahaja bagi setiap soalan.

Bil.	**Perkara**	**Sangat Tidak Setuju**	**Tidak Setuju**	**Tidak Pasti**	**Setuju**	**Sangat Setuju**	**Pengkodan (Kegunaan pejabat sahaja)**
			Kepercayaan				
AB1.	Saya percaya kehilangan pendengaran adalah disebabkan usia dan bukan pendedahan kepada bunyi bising.						
AB2.	Saya percaya perubatan tradisional boleh merawat kehilangan pendengaran.						
AB3.	Saya fikir saya perlu menggantikan palam telinga apabila ia sudah rosak.						
AB4.	Pada pendapat saya, saya boleh memakai apa-apa bentuk palam telinga atau pelindung telinga yang disediakan oleh pihak pengurusan.						

Bil.	**Perkara**	**Sangat Tidak Setuju**	**Tidak Setuju**	**Tidak Pasti**	**Setuju**	**Sangat Setuju**	**Pengkodan (Kegunaan pejabat sahaja)**
AB5.	Saya percaya pendidikan kesihatan dan latihan diperlukan untuk mengurangkan kehilangan pendengaran.						
AB6.	Pada pendapat saya penggunaan kapas adalah lebih selesa untuk mengurangkan pendedahan kepada bunyi bising.						
AB7.	Saya percaya hanya satu palam telinga patut digunakan semasa berkomunikasi dalam persekitaran yang bising.						
AB8.	Sebagai seorang pekerja, saya fikir saya tidak perlu mengetahui undang-undang berkaitan dengan kawalan bunyi bising.						

Bil.	**Perkara**	**Sangat Tidak Setuju**	**Tidak Setuju**	**Tidak Pasti**	**Setuju**	**Sangat Setuju**	**Pengkodan (Kegunaan pejabat sahaja)**
			Perassan				
AF1.	Apabila berlakunya kes kehilangan pendengaran, saya rasa hanya pihak majikan yang terjejas (bukannya pekerja) memandangkan majikan perlu memberi pampasan wang kepada pekerja.						
AF2.	Saya tidak risau tentang pendedahan kepada bunyi bising yang kuat jika tempoh pendedahan itu singkat.						
AF3.	Saya rasa pihak majikan perlu dimaklumkan jika saya mengalami kehilangan pendengaran.						
AF4.	Saya rasa ia merupakan tanggungjawab bersama antara saya dan pihak majikan bagi mengurangkan pendedahan kepada bunyi bising.						

Bil.	**Perkara**	**Sangat Tidak Setuju**	**Tidak Setuju**	**Tidak Pasti**	**Setuju**	**Sangat Setuju**	**Pengkodan (Kegunaan pejabat sahaja)**
AF5.	Saya rasa ia bukan sesuatu yang salah jika kami tidak dimaklumkan tentang keputusan audiogram (yang menyatakan tahap kehilangan pendengaran).						
AF6.	Saya rasa ia bukan sesuatu yang salah jika kami tidak dimaklumkan tentang keputusan pemantauan pendedahan kepada bunyi bising awal.						
Kesimpulan							
AJ1.	Saya akan mengabaikan kehilangan pendengaran memandangkan ia tidak membawa maut.						
AJ2.	Saya masih menghadapi risiko kehilangan pendengaran yang tinggi walaupun saya memakai palam telinga atau pelindung telinga.						

Bil.	**Perkara**	**Sangat Tidak Setuju**	**Tidak Setuju**	**Tidak Pasti**	**Setuju**	**Sangat Setuju**	**Pengkodan (Kegunaan pejabat sahaja)**
AJ3.	Saya akan terus bekerja walaupun mengalami kehilangan pendengaran memandangkan ia boleh dipulihkan.						
AJ4.	Saya akan mengabaikan kehilangan pendengaran memandangkan ia tidak menyakitkan.						
AJ5.	Saya akan memakai palam telinga atau pelindung telinga dalam industri yang bising.						
AJ6.	Saya akan menjalani penilaian pendengaran secara tetap bagi mengesan kehilangan pendengaran.						

D. Amalan

- Sila baca pernyataan berikut dari P1 hingga P10, kemudian tanda sama ada **Tidak Pernah** jika anda tidak mengamalkannya dan **Sentiasa** jika anda selalu mengamalkannya. Jika anda mengamalkannya sekali-sekala, iaitu bukan Tidak Pernah atau Sentiasa, sila tandakan **Jarang** atau **Kadang-kala**.
- Sila tandakan **satu kotak** sahaja bagi setiap soalan.

Bil.	**Perkara**	**Tidak Pernah**	**Jarang/ Kadang-kala**	**Sentiasa**	**Pengkodan (Kegunaan pejabat sahaja)**
P1.	Saya tidak akan memaklumkan kepada pihak majikan jika saya mengalami kehilangan pendengaran.				
P2.	Saya menjalani penilaian pendengaran bagi mengesan kehilangan pendengaran.				
P3.	Saya menghadiri pendidikan kesihatan untuk mengetahui kesan-kesan bunyi bising.				
P4.	Saya tidak menghadiri latihan untuk mengetahui cara penggunaan dan penjagaan palam telinga atau pelindung telinga.				
P5.	Saya memakai palam telinga atau pelindung telinga untuk mengelakkan kehilangan pendengaran.				
P6.	Saya tidak akan memaklumkan kepada pihak majikan jika palam telinga telah rosak.				
P7.	Saya akan terus memakai palam telinga walaupun mempunyai pelepasan telinga.				
P8.	Saya hanya memakai palam telinga atau pelindung telinga yang diluluskan.				
P9.	Saya tidak akan mengelak daripada memasuki kawasan yang sangat bising di tempat kerja.				
P10.	Saya akan mendapatkan maklumat tentang bunyi bising daripada jawatankuasa keselamatan dan kesihatan.				

Terima kasih atas kerjasama anda.

Appendix 13: Questionnaire of noise-induced hearing loss among workers after reliability and exploratory factor analysis

QUESTIONNAIRE
SOAL SELIDIK

NOISE-INDUCED HEARING LOSS AMONG WORKERS
KEHILANGAN PENDENGARAN AKIBAT KEBISINGAN DI KALANGAN PEKERJA

INSTRUCTIONS

ARAHAN

1. This questionnaire is divided into 4 sections:

Soal selidik ini terbahagi kepada 4 bahagian iaitu:

a. Sociodemographic characteristics
a. Ciri-ciri sosiodemografik

b. Knowledge
b. Pengetahuan

c. Attitude
c. Sikap

d. Practice
d. Amalan

2. Please attempt all the questions.
2. Sila jawab semua soalan.

3. Please do not spend too much time in attempting to answer a question.
3. Sila jangan ambil masa yang panjang semasa menjawab setiap soalan.

4. Please answer according to instructions given in each section.
4. Sila jawab berdasarkan arahan yang diberi di setiap bahagian.

5. All the information given in this form is confidential.
5. Semua maklumat yang diberikan dalam borang ini adalah sulit.

A. Demographic Information
Maklumat Demografik

<table>
<tr><td>Name:
Nama:</td><td></td><td>Identification Number (IC):
Nombor Kad Pengenalan:</td><td></td></tr>
<tr><td>Gender:
Jantina:</td><td>☐ Male ☐ Female
☐ Lelaki ☐ Perempuan</td><td colspan="2">Date of Birth:
Tarikh lahir:

_____/_____/________</td></tr>
<tr><td>Address:
Alamat:

(Current)
(Semasa)</td><td colspan="3"></td></tr>
<tr><td>Hand-phone:
Telefon bimbit:</td><td></td><td>Office:
Pejabat:</td><td></td></tr>
<tr><td>Ethnic Group:
Kumpulan Etnik:</td><td colspan="3">☐ Malay ☐ Chinese ☐ Indian
☐ Melayu ☐ Cina ☐ India

☐ Others, please specify: ____
☐ Lain-lain, sila nyatakan: ____</td></tr>
<tr><td>Marital Status:
Status Perkahwinan:</td><td colspan="3">☐ Married ☐ Single ☐ Divorced ☐ Widow ☐ Separated
☐ Berkahwin ☐ Bujang ☐ Bercerai ☐ Balu/Duda ☐ Berpisah

____________(specify duration)
____________ (nyatakan tempoh)</td></tr>
<tr><td>Religion:
Agama:</td><td colspan="3">☐ Islam ☐ Buddhism ☐ Hinduism ☐ Christianity
☐ Islam ☐ Buddha ☐ Hindu ☐ Kristian

☐ Other, please state: _____________________________
☐ Lain-lain, sila nyatakan: _____________________________</td></tr>
<tr><td rowspan="3">Work Information:
Maklumat Pekerjaan:</td><td colspan="3">Name of company:
Nama syarikat:</td></tr>
<tr><td colspan="3">Position:
Jawatan:</td></tr>
<tr><td colspan="3">Date of joining this company:
Tarikh menyertai syarikat ini:

______(Day)/______(Month)/ ________(Year)
______(Hari)/______(Bulan)/ ________(Tahun)

If you can’t remember, please state the year only: _________________
Jika anda tidak ingat, sila nyatakan tahun sahaja: _________________</td></tr>
</table>

Income: *Pendapatan:*	☐ Your salary: RM _________ per month (gross salary) ☐ *Gaji anda: RM _________ sebulan (gaji kasar)* Please mark “x” below: *Sila tanda “x” di bawah:* ☐ <1000 ☐ ≥1000 - <2000 ☐ ≥2000 - <3000 ☐ ≥3000 - <4000 ☐ ≥4000 - <5000 ☐ ≥5000
Educational Level: *Tahap Pendidikan:*	☐ No formal Schooling ☐ *Tiada persekolahan formal* (For the following, please mark “x”. You may indicate the highest completed educational level. *(Bagi yang berikut, sila tandakan “x” walaupun anda tidak menghabiskan tahap pelajaran tersebut. Anda boleh nyatakan tahap pendidikan paling tinggi yang anda capai.* ☐ Primary School (Year 1-6). Completed till primary______________ ☐ *Sekolah Rendah (Tahun 1-6). Belajar sehingga tahun _____________* ☐ Secondary School (Form 1-5) Completed till form ______________ ☐ *Sekolah Menengah (Tingkatan 1-5) Belajar sehingga tingkatan __________* ☐ Form 6 or certificate Completed till form ________________ ☐ *Tingkatan 6 atau sijil Belajar sehingga tingkatan ____________* ☐ College or university Completed __________________ degree. ☐ *Kolej atau universiti Tamat dengan ijazah ________________*

Do you smoke cigarettes? No ☐ Yes ☐ Previous smoker ☐ *Adakah anda menghisap rokok? Tidak ☐ Ya ☐ Bekas perokok ☐* If "yes", please state how many cigarettes you smoke every day: *Jika "ya", sila nyatakan berapa batang rokok anda hisap setiap hari:* I smoke ___________ a day. *Saya menghisap ___________ batang rokok sehari.* If "previous smoker", please state when you stopped and state how many cigarettes you smoked a day and for how long: *Jika "bekas perokok", sila nyatakan bilakah anda berhenti dan berapa batang rokok anda hisap setiap hari dan berapa lama anda merokok:* I did not smoke for_________, I previously did smoke ___________ cigarettes a day and for_________months/years. *I tidak merokok selama_________, sebelum ini saya menghisap ___________ batang rokok sehari dan selama_________bulan/tahun.*
Do you consume alcohol regularly? No ☐ Yes ☐ Occasionally ☐ *Adakah anda minum alkohol secara tetap? Tidak ☐ Ya ☐ Kadang-kala ☐* If "yes", please state how many cans or bottles or glasses you drink per week. *Jika "ya", sila nyatakan berapa tin atau botol atau gelas yang anda minum setiap minggu.* I drink approximately ________ cans or bottles or glasses of alcohol in a week. *Saya minum lebih kurang ________ tin atau botol atau gelas alkohol dalam seminggu.* If "occasionally", please state how many cans or bottles or glasses you drink per month or per year. *Jika "kadang-kala", sila nyatakan berapa tin atau botol atau gelas yang anda minum setiap bulan atau setiap tahun.* I drink approximately ________ cans or bottles or glasses of alcohol per ______. *Saya minum lebih kurang ________ tin atau botol atau gelas alkohol dalam satu ______.*
Have you been diagnosed with any chronic medical illness? *Pernahkah anda dirawat untuk penyakit kronik?* No ☐ Yes ☐ *Tidak ☐ Ya ☐* If "yes", please state the name of your health problems as mentioned by your doctor. *Jika "ya", sila nyatakan nama masalah kesihatan seperti yang disebut oleh doktor anda.* ____
Have you had any surgery before? *Pernahkah anda menjalani apa-apa pembedahan sebelum ini?* No ☐ Yes ☐ *Tidak ☐ Ya ☐* If "yes", please state the name of the surgery. *Jika "ya", sila nyatakan nama pembedahan tersebut.* ____
Have you had any trauma or accident in the past resulting in permanent injury to the ears or brain? *Pernahkah anda mengalami apa-apa trauma atau kemalangan yang mengakibatkan kecederaan kekal pada telinga atau otak?* No ☐ Yes ☐ *Tidak ☐ Ya ☐* If "yes", please briefly state the traumatic event below: *Jika "ya", sila nyatakan secara ringkas peristiwa tersebut di bawahi:* ____

Have you been working in a different company other than this company which produced loud noise?
Pernahkah anda bekerja di syarikat lain yang mengeluarkan bunyi bising yang kuat selain syarikat sekarang?
No ☐ Yes ☐
Tidak ☐ *Ya* ☐
If "yes", please fill the table below:
Jika "ya", sila isi jadual di bawah:

No. *Bil.*	Date (year) *Tarikh (tahun)*		Name of the Company *Nama Syarikat tersebut*	Nature of Business/ Production *Sifat Perniagaan/ Pengeluaran*	Job Description *Penghuraian Kerja*
	From *Dari*	To *Hingga*			
1.					
2.					
3.					
4.					

Are you on any long term medication: No ☐ Yes ☐
Adakah anda mengambil apa-apa ubat untuk jangkamasa panjang: Tidak ☐ *Ya* ☐

If "yes", please state the name of the medicine or what it is used for, if you do not know the name of the medicine.
Jika "ya", sila nyatakan nama ubat tersebut atau kegunaannya, jika anda tidak tahu nama ubat tersebut.
____

Do you listen to loud music or are you involved in activities such as scuba diving or shooting?
Adakah anda mendengar muzik yang kuat atau terlibat dalam aktiviti-aktiviti seperti menyelam scuba atau menembak?
No ☐ Yes ☐
Tidak ☐ *Ya* ☐

If "yes", please tick what activities are you involved with below (you can tick more than 1 option):
Jika "ya", sila tandakan di bawah aktiviti-aktiviti yang anda terlibat dengan (anda boleh memilih lebih daripada 1 jawapan):

☐ Listening to loud music
☐ *Mendengar muzik yang kuat*

☐ Scuba diving
☐ *Menyelam scuba*

☐ Shooting
☐ *Menembak*

☐ Others: Please specify ____________________________________
☐ *Lain-lain: Sila nyatakan* ____________________________________

Do you have another job outside this company or do you do any part time job?
Adakah anda mempunyai pekerjaan lain selain daripada syarikat ini ataupun adakah anda melakukan apa-apa kerja sambilan?

No ☐ Yes ☐
Tidak ☐ *Ya* ☐

If “yes”, please specify below:
Jika “ya”, sila nyatakan di bawah:

No. *Bil.*	Company *Syarikat*	Business or Nature of Production *Perniagaan atau Sifat Pengeluaran*	Job Description *Penghuraian Kerja*	How frequently you perform this job *Berapa kerap anda melakukan kerja ini*
1.				
2.				

B. Knowledge on Hearing Loss

Pengetahuan tentang Kehilangan Pendengaran

- Please read the following statements from K1 to K12, and tick **True** if you think the statement is correct and **False** if you think the statement is incorrect. If you do not know the answer, tick **Don't Know**.

  *Sila baca pernyataan berikut dari K1 ke K12, dan tanda **Benar** jika anda fikir pernyataan tersebut betul dan **Palsu** jika anda fikir pernyataan tersebut tidak betul. Jika anda tidak tahu jawapannya, tanda **Tidak Tahu**.*

- Please tick only **one box** for each question.

  *Sila tandakan **satu kotak** sahaja bagi setiap soalan.*

No. *Bil.*	**Items** *Perkara*	**True** *Benar*	**False** *Palsu*	**Don't know** *Tidak tahu*	**Coding (Office use only)** *Pengkodan (Kegunaan pejabat sahaja)*
Causes of hearing loss and policy protecting workers *Punca-punca kehilangan pendengaran dan dasar melindungi para pekerja*					
K1.	Hearing loss due to noise is not permanent. *Kehilangan pendengaran akibat bunyi bising adalah tidak kekal.*				
K2.	Hearing loss may not occur if the worker is exposed to loud noise. *Kehilangan pendengaran mungkin tidak berlaku jika pekerja terdedah kepada bunyi bising yang kuat.*				
K3.	Hearing loss may not occur if the worker is repeatedly exposed to a noisy environment. *Kehilangan pendengaran mungkin tidak berlaku jika pekerja banyak kali terdedah kepada persekitaran yang bising.*				
Risk factors and prevention of hearing loss *Faktor-faktor risiko dan pencegahan kehilangan pendengaran*					
K4.	Hobbies such as shooting and scuba diving may cause hearing loss. *Hobi-hobi seperti menembak dan menyelam scuba mungkin menyebabkan kehilangan pendengaran.*				

No. *Bil.*	**Items** *Perkara*	**True** *Benar*	**False** *Palsu*	**Don't know** *Tidak tahu*	**Coding (Office use only)** *Pengkodan (Kegunaan pejabat sahaja)*
K5.	Smoking increases the risk of hearing loss when working in a noisy environment. *Merokok meningkatkan lagi risiko kehilangan pendengaran apabila bekerja dalam persekitaran yang bising.*				
K6.	Ear discharge is the earliest sign of hearing loss due to noise. *Pelepasan telinga adalah tanda paling awal kehilangan pendengaran akibat kebisingan.*				
K7.	There is medication available to treat hearing loss due to noise. *Terdapat ubat untuk merawat kehilangan pendengaran akibat kebisingan.*				
K8.	Hearing loss can't be prevented by wearing ear plugs or ear muffs. *Kehilangan pendengaran tidak dapat dicegah dengan memakai palam telinga atau pelindung telinga.*				
K9.	There is law in existence protecting employees from exposure to loud noise. *Terdapat undang-undang yang melindungi para pekerja daripada pendedahan kepada bunyi bising yang kuat.*				

C. Attitude
Sikap

- Please read the following statements from AB1 to AB8, AF1 to AF6 and AJ1 to AJ6 and then tick either **Strongly Disagree** or **Disagree** if you think the statement is incorrect and **Agree** or **Strongly Agree** if you think the statement is correct. If you think the statement is neither correct nor incorrect, then tick **Neither Agree nor Disagree**.
- *Sila baca pernyataan berikut dari AB1 hingga AB8, AF1 hingga AF6 dan AJ1 hingga AJ6 dan kemudian tanda sama ada **Sangat Tidak Setuju** atau **Tidak Setuju** jika anda fikir pernyataan tersebut tidak betul, dan **Setuju** atau **Sangat Setuju** jika anda fikir pernyataan itu betul. Tanda **Tidak Pasti** jika anda tidak tahu jawapannya.*
- Please tick only **one box** for each question.

  *Sila tandakan **satu kotak** sahaja bagi setiap soalan.*

No. *Bil.*	**Items** *Perkara*	**Strongly Disagree** *Sangat Tidak Setuju*	**Disagree** *Tidak Setuju*	**Neither Agree nor Disagree** *Tidak Pasti*	**Agree** *Setuju*	**Strongly Agree** *Sangat Setuju*	**Coding (Office use only)** ***Pengkodan (Kegunaan pejabat sahaja)***
1. Belief *Kepercayaan* **Hearing protection devices and law on prevention of hearing loss** *Peranti perlindungan telinga dan undang-undang berkaitan dengan kawalan bunyi bising*							
AB1.	I believe it is right to wear one ear plug only during communication in a noisy environment. *Saya percaya hanya satu palam telinga patut digunakan semasa berkomunikasi dalam persekitaran yang bising.*						

No. *Bil.*	Items *Perkara*	**Strongly Disagree** *Sangat Tidak Setuju*	**Disagree** *Tidak Setuju*	**Neither Agree nor Disagree** *Tidak Pasti*	**Agree** *Setuju*	**Strongly Agree** *Sangat Setuju*	**Coding (Office use only)** ***Pengkodan (Kegunaan pejabat sahaja)***
AB2.	As an employee, I think I do not need to know the law on noise control. *Sebagai seorang pekerja, saya fikir saya tidak perlu mengetahui undang-undang berkaitan dengan kawalan bunyi bising.*						
				1. Feeling *Perasaan* **Prevention of hearing loss** *Pencegahan kehilangan pendengaran*			
AF1.	I feel my employer should be informed if I have hearing loss. *Saya rasa pihak majikan perlu dimaklumkan jika saya mengalami kehilangan pendengaran.*						
AF2.	I feel it is my responsibility as well as the employers' to reduce noise exposure. *Saya rasa ia merupakan tanggungjawab bersama antara saya dan pihak majikan bagi mengurangkan pendedahan kepada bunyi bising.*						

No. *Bil.*	**Items** *Perkara*	**Strongly Disagree** *Sangat Tidak Setuju*	**Disagree** *Tidak Setuju*	**Neither Agree nor Disagree** *Tidak Pasti*	**Agree** *Setuju*	**Strongly Agree** *Sangat Setuju*	**Coding (Office use only)** ***Pengkodan (Kegunaan pejabat sahaja)***
Outcome of hearing loss *Kesan Kehilangan pendengaran*							
AF3.	I feel nothing is wrong if we are not informed about the results of audiogram (stating the hearing loss level). *Saya rasa ia bukan sesuatu yang salah jika kami tidak dimaklumkan tentang keputusan audiogram (yang menyatakan tahap kehilangan pendengaran).*						
AF4.	I feel nothing is wrong if we are not informed on the results of initial noise exposure monitoring. *Saya rasa ia bukan sesuatu yang salah jika kami tidak dimaklumkan tentang keputusan pemantauan pendedahan kepada bunyi bising awal.*						

No. *Bil.*	**Items** *Perkara*	**Strongly Disagree** *Sangat Tidak Setuju*	**Disagree** *Tidak Setuju*	**Neither Agree nor Disagree** *Tidak Pasti*	**Agree** *Setuju*	**Strongly Agree** *Sangat Setuju*	**Coding (Office use only)** ***Pengkodan (Kegunaan pejabat sahaja)***
1. Judgment *Kesimpulan* **Risk factors of hearing loss** *Faktor-faktor risiko kehilangan pendengaran*							
AJ1.	I can ignore hearing loss since it does not lead to death. *Saya boleh mengabaikan kehilangan pendengaran memandangkan ia tidak membawa maut.*						
AJ2.	I will ignore hearing loss since it is not painful. *Saya akan mengabaikan kehilangan pendengaran memandangkan ia tidak menyakitkan*.						
Prevention of hearing loss *Pencegahan kehilangan pendengaran*							
AJ3.	I will wear ear plugs or ear muffs in a noisy industry. *Saya akan memakai palam telinga atau pelindung telinga dalam industri yang bising.*						

No. *Bil.*	**Items** *Perkara*	**Strongly Disagree** *Sangat Tidak Setuju*	**Disagree** *Tidak Setuju*	**Neither Agree nor Disagree** *Tidak Pasti*	**Agree** *Setuju*	**Strongly Agree** *Sangat Setuju*	**Coding (Office use only)** ***Pengkodan (Kegunaan pejabat sahaja)***
AJ4.	I will undergo regular hearing assessment to detect any hearing loss. *Saya akan menjalani penilaian pendengaran secara tetap bagi mengesan kehilangan pendengaran.*						

D. Practice
Amalan

- Please read the following statements from P1 to P10, and then tick either **Never** if you don't practice and **Always** if you constantly practice. If you occasionally practice, that is neither Never nor Always, then tick **Seldom or Sometimes.**

  *Sila baca pernyataan berikut dari P1 hingga P10, kemudian tanda sama ada **Tidak Pernah** jika anda tidak mengamalkannya dan **Sentiasa** jika anda selalu mengamalkannya. Jika anda mengamalkannya sekali-sekala, iaitu bukan Tidak Pernah atau Sentiasa, sila tandakan **Jarang** atau **Kadang-kala**.*

- Please tick only **one box** for each question.

  *Sila tandakan **satu kotak** sahaja bagi setiap soalan.*

No. *Bil.*	**Items** *Perkara*	**Never** *Tidak Pernah*	**Seldom/ Sometimes** *Jarang/Kadang-kala*	**Always** *Sentiasa*	**Coding (Office use only)** *Pengkodan (Kegunaan pejabat sahaja)*
	Prevention of hearing loss *Pencegahan kehilangan pendengaran*				
P1.	I undergo hearing assessment to discover if I have hearing loss. *Saya menjalani penilaian pendengaran bagi mengesan kehilangan pendengaran.*				
P2.	I attend health education to know the effects of noise. *Saya menghadiri pendidikan kesihatan untuk mengetahui kesan-kesan bunyi bising.*				
P3.	I wear earplugs or ear muffs to protect from hearing loss. *Saya memakai palam telinga atau pelindung telinga untuk mengelakkan kehilangan pendengaran.*				
P4.	I only wear approved ear plugs or ear muffs. *Saya hanya memakai palam telinga atau pelindung telinga yang diluluskan.*				

No. *Bil.*	**Items** *Perkara*	**Never** *Tidak Pernah*	**Seldom/ Sometimes** *Jarang/Kadang-kala*	**Always** *Sentiasa*	**Coding (Office use only)** *Pengkodan (Kegunaan pejabat sahaja)*
P5.	I will get information from the safety and health committee regarding noise. *Saya akan mendapatkan maklumat tentang bunyi bising daripada jawatankuasa keselamatan dan kesihatan.*				

Thank you for your cooperation.

Terima kasih atas kerjasama anda.

Appendix 14: Pamphlet of noise-induced hearing loss among workers

General aspects and causes of hearing loss

- Exposure to noise may result in hearing loss.
- Hearing loss due to noise is permanent.
- Hearing loss may occur if one is exposed to continued loud noise, and even for a short duration of exposure, if noise intensity is high.
- Besides ageing, hearing loss may occur if workers are exposed to loud music, and activities such as scuba diving and shooting.

Risk factors of hearing loss

- Hypertension, diabetes, smoking and consumption of alcohol increases risk of hearing loss when one is working in a noisy environment.

Consequences of hearing loss

- The workers will have difficulty in understanding and discriminating words during conversation.
- The workers will be under stress and may not want to participate in activities such as meetings or discussions, training and courses at the workplace since having difficulty in hearing.
- The relationship among family members will be affected; the spouse may pay less attention since having difficulty in hearing.
- The workers may have difficulty to hear and be alert to warnings.

Symptoms and signs of hearing loss

- Hearing loss among workers.
- Ear discharge is not a sign of noise-induced hearing loss.

Treatment of hearing loss

- There is no medicine available to treat noise-induced hearing loss.
- Surgical interventions may help.

Prevention

- Hearing loss can be prevented by wearing ear plugs or ear muffs, but it is not possible by using cotton.
- It is the responsibility of employers to make available ear plugs or ear muffs to employees at no cost.
- The ear plugs should be replaced once they are damaged.
- The workers should wear appropriate ear plugs or ear muffs.
- The 2 ear plugs should be worn continuously especially during communication in a noisy environment.
- The ear plugs should not be worn if one is having ear discharge.
- Health education and training should be given and employees made to recognize the consequences of hearing loss; also usage and care of ear plugs or ear muffs should be frequently stressed.
- There is law available to protect employees from exposure to loud noise.

Practice

- Employers should inform the respective employees of their hearing loss results.
- The employers should make available the results of hearing assessment and noise area monitoring to the employees.
- It is the responsibility of both employers and employees to reduce noise exposure.
- The information regarding noise should be obtained from the safety and health committee.

Appendix 15: Pamphlet of noise-induced hearing loss among workers in Bahasa Malaysia *(Kehilangan pendengaran akibat kebisingan di kalangan pekerja)*

<u>Aspek-aspek umum kehilangan pendengaran dan punca-punca kehilangan pendengaran</u>

- Kebisingan boleh menyebabkan kehilangan pendengaran.
- Kehilangan pendengaran akibat bunyi adalah kekal.
- Kehilangan pendengaran mungkin berlaku akibat terdedah kepada bunyi bising yang kuat banyak kali, walaupun terdedah pada jangka masa pendek sekiranya bunyi bising itu sangat kuat.
- Sekiranya para pekerja mendengar muzik yang kuat, menyelam *scuba* dan menembak juga boleh menyebabkan kehilangan pendengaran, selain dari usia yang melanjut.

<u>Factor-faktor risiko kehilangan pendengaran</u>

- Penyakit darah tinggi, kencing manis, merokok dan meminum alkohol meningkatkan lagi risiko kehilangan pendengaran apabila bekerja dalam persekitaran yang bising.

<u>Kesan kehilangan pendengaran</u>

- Para pekerja akan mengalami masalah memahami dan mendikriminasikan apa yang dikatakan oleh seseorang.
- Para pekerja akan berada dalam keadaan *stress* dan tidak akan melibatkan diri dalam kegiatan-kegiatan dalam kilang seperti mesyuarat dan perbincangan di tempat kerja dan latihan atau kursus kerana tidak dapat mendengar syarahan yang dibagi.
- Perhubungan dalam keluarga juga akan terjejas kerana suami atau isteri kurang memberi perhatian kerana kurang mendengar.
- Para pekerja mungkin akan sukar mendengar bunyi amaran.

<u>Tanda-tanda dan gejala-gejala kehilangan pendengaran</u>

- Kehilangan pendengaran di kalangan pekerja.
- Pelepasan telinga (discaj dari telinga) bukanlah disebabkan kehilangan pendengaran akibat kebisingan.

Rawatan kehilangan pendengaran

- Tidak ada ubat untuk merawat kehilangan pendengaran akibat kebisingan.
- Pembedahan mungkin dapat membantu.

Pencegahan

- Kehilangan pendengaran dapat dicegah dengan memakai palam telinga atau pelindung telinga dan bukannya kapas.
- Adalah menjadi tanggungjawab majikan untuk menyediakan palam telinga atau pelindung telinga kepada para pekerja secara percuma.
- Palam telinga hendaklah digantikan apabila ia sudah rosak.
- Para pekerja hendaklah memakai palam atau pelindung telinga yang sesuai sahaja.
- 2 palam telinga patut digunakan semasa berkomunikasi dalam persekitaran yang bising.
- Palam telinga tidak dapat digunakan sekiranya ada pelepasan telinga.
- Pendidikan kesihatan dan latihan perlu dihadiri untuk mengetahui kesan-kesan bunyi bising dan cara pengunaan dan penjagaan palam telinga atau pelindung telinga.
- Terdapat undang-undang melindungi para pekerja daripada pendedahan kepada bunyi bising kuat.

Amalan

- Pihak majikan perlu memaklumkan kepada para pekerja sekiranya mereka mengalami kehilangan pendengaran.
- Pihak majikan juga perlu memaklumkan keputusan ujian tahap kehilangan pendengaran dan keputusan pemantauan pendedahan kepada bunyi bising.
- Ia adalah tanggungjawab bersama antara pihak majikan dan para pekerja mengurangkan pendedahan kepada bunyi bising.
- Maklumat tentang bunyi bising hendaklah diperolehi daripada jawatankuasa keselamatan dan kesihatan.

Appendix 16: Noise level at source and types of noise

Type of machine in production area	Noise level (dB)	Type of noise
PC Press and QC Press Departments (Factory 1)		
PC Press Department		
Portable drill	92 (≥90)	Fluctuating
Portable grinder	92 (≥90)	Fluctuating
Portable polish body	91 (≥90)	Fluctuating
Air Receiver Tank No. 1	91 (≥90)	Fluctuating
Air Receiver Tank No. 2	91 (≥90)	Fluctuating
Air Receiver Tank No. 3	91 (≥90)	Fluctuating
Air Receiver Tank No. 4	91 (≥90)	Fluctuating
Air Receiver Tank No. 5	91 (≥90)	Fluctuating
Air Receiver Tank No. 6	91 (≥90)	Fluctuating
Air Receiver Tank No. 7	91 (≥90)	Fluctuating
Air Receiver Tank No. 8	91 (≥90)	Fluctuating
Air Receiver Tank No. 9	91 (≥90)	Fluctuating
Air Receiver Tank No. 10	91 (≥90)	Fluctuating
Air Receiver Tank No. 11	91 (≥90)	Fluctuating
Air Receiver Tank No. 12	91 (≥90)	Fluctuating
Air Receiver Tank No. 13	91 (≥90)	Fluctuating
Air Receiver Tank No. 14	91 (≥90)	Fluctuating
Air Receiver Tank No. 15	91 (≥90)	Fluctuating
Air Receiver Tank No. 16	91 (≥90)	Fluctuating
Air Receiver Tank No. 17	91 (≥90)	Fluctuating
Air Receiver Tank No. 18	91 (≥90)	Fluctuating
Double Girder EOTC	91 (≥90)	Fluctuating
Double Girder EOTC	91 (≥90)	Fluctuating
Double Girder EOTC	91 (≥90)	Fluctuating
Air Compressor	91 (≥90)	Fluctuating
Scrap Conveyor	91 (≥90)	Fluctuating
Press Machine No. 1	92 (≥90)	Fluctuating
Press Machine No. 2	92 (≥90)	Fluctuating
Press Machine No. 3	92 (≥90)	Fluctuating

Press Machine No. 4	92 (≥90)	Fluctuating
Destack Robot	92 (≥90)	Fluctuating
Loading Robot	90 (≥90)	Fluctuating
Robot #1~2	90 (≥90)	Fluctuating
Robot #2~3	90 (≥90)	Fluctuating
Robot #3~4	90 (≥90)	Fluctuating
Washing Unit	90 (≥90)	Fluctuating
Dirty Tank 2700L (filter system for washing unit)	90 (≥90)	Fluctuating
Clean Tank 2000L (filter system for washing unit)	90 (≥90)	Fluctuating
Robot #4 UL (new)	90 (≥90)	Fluctuating
QC Press Department		
FR Fender Piercing MCN-L #1	89 (85-90)	Fluctuating
FR Fender Piercing MCN-L #2	89 (85-90)	Fluctuating
Welding and Maintenace Departments (Factory 1)		
Welding Department		
Double Girder EOTC	89 (85-90)	Fluctuating
Front Door Hemming	89 (85-90)	Fluctuating
Rear Door Hemming	89 (85-90)	Fluctuating
Hood & Luggage Hemming	89 (85-90)	Fluctuating
Drill Machine	89 (85-90)	Fluctuating
Maintenance Department		
Double Girder E.O.T Crane Span: 8600mm Model: NHED 30TDV-T	84 (<85)	Fluctuating
Double Girder E.O.T Crane Span: 12893mm Model: NHED 7.5 GH	84 (<85)	Fluctuating
Double Girder E.O.T Crane Span: 14884mm Model: NHED 30TDV-T	83-84 (<85)	Fluctuating
Die Sporting 100T	88 (85-90)	Fluctuating
CNC Milling Machine	87 (85-90)	Fluctuating
High Speed Precision Lathe	87 (85-90)	Fluctuating

Bandsaw Machine 700D	87 (85-90)	Fluctuating
Milling Machine	88 (85-90)	Fluctuating
Hydraulic Press Brake	87 (85-90)	Fluctuating
Welding Set (ark)	87 (85-90)	Fluctuating
Welding Set (TIG)	87 (85-90)	Fluctuating
Plasma Cutter	87 (85-90)	Fluctuating
Welding Set (petrol)	87 (85-90)	Fluctuating
Drill Machine	87 (85-90)	Fluctuating
Grinding Machine	87 (85-90)	Fluctuating
PC Resin and QC Resin Departments (Factory 2)		
Injection Mould Machine Model: 3500mm III 470	89 (85-90)	Fluctuating
Granulator/ Crusher No 1	91 (≥90)	Fluctuating
Granulator/ Crusher No 2	91 (≥90)	Fluctuating
Door Trim Bonding Machine	84 (<85)	Fluctuating
Injection 3500T #1	84 (<85)	Fluctuating
Injection Mould 450T #2	84 (<85)	Fluctuating
Injection Moulding 850T	84 (<85)	Fluctuating
Injection Moulding 450T #1	84 (<85)	Fluctuating
Hopper Dryer 450T #1 (50 kg)	88-89 (85-90)	Fluctuating
Hopper Dryer 450T #2 (50 kg)	88-89 (85-90)	Fluctuating
Hopper Dryer 450T #3 (50 kg)	88-89 (85-90)	Fluctuating
Hopper Dryer 450T #4 (100kg)	88-89 (85-90)	Fluctuating
Hopper Dryer 450T #5 (100kg)	88-89 (85-90)	Fluctuating
Auto Loader 450T #1	88-89 (85-90)	Fluctuating
Auto Loader 450T #2	88-89 (85-90)	Fluctuating
Auto Loader 850T	88-89 (85-90)	Fluctuating
Robot 850T	88-89 (85-90)	Fluctuating
Hopper Dryer 850T - Pre-heating Control Panel	88-89 (85-90)	Fluctuating
Hopper Dryer 850T - Process Panel	88-89 (85-90)	Fluctuating
Hopper Dryer 3500T #1	88-89 (85-90)	Fluctuating
Hopper Dryer 3500T #2	88-89 (85-90)	Fluctuating
Hopper Dryer 3500T #3	88-89 (85-90)	Fluctuating

Hopper Dryer 3500T #4	88-89 (85-90)	Fluctuating
Hopper Dryer 3500T #5	88-89 (85-90)	Fluctuating
Hopper Dryer 3500T #6	88-89 (85-90)	Fluctuating
Hopper Dryer 3500T #7	88-89 (85-90)	Fluctuating
Hopper Dryer 3500T #8	88-89 (85-90)	Fluctuating
Auto Loader 3500T #1	88-89 (85-90)	Fluctuating
Auto Loader 3500T #2	88-89 (85-90)	Fluctuating
Auto Loader 3500T #3	88-89 (85-90)	Fluctuating
Auto Loader 3500T #4	88-89 (85-90)	Fluctuating
Mould Cart 3500T	88-89 (85-90)	Fluctuating
Robot 3500 Tonnes #1	88-89 (85-90)	Fluctuating
Robot 3500 Tonnes #2	88-89 (85-90)	Fluctuating
Chiller Unit 3500 Tonnes #1	88-89 (85-90)	Fluctuating
Chiller Unit 3500 Tonnes #2	88-89 (85-90)	Fluctuating
1300 Tonnes Injection Machine	88-89 (85-90)	Fluctuating
Robot 1300 Tonnes	88-89 (85-90)	Fluctuating
Chiller 1300 Tonnes	88-89 (85-90)	Fluctuating
Hopper Dryer 1300 Tonnes #1	88-89 (85-90)	Fluctuating
Hopper Dryer 1300 Tonnes #2	88-89 (85-90)	Fluctuating
Transformer Step Down 415 V - 200 V (1300T)	88-89 (85-90)	Fluctuating
Transformer Step Down 415 V - 380 V (1300T)	88-89 (85-90)	Fluctuating
Mould Cart 850 Tonnes	88-89 (85-90)	Fluctuating
Chiller 850 Tonnes	88-89 (85-90)	Fluctuating
Robot 450 Tonnes #1	88-89 (85-90)	Fluctuating
Mould Cart 450 Tonnes	88-89 (85-90)	Fluctuating
Chiller 450 Tonnes	88-89 (85-90)	Fluctuating
998L RR Bumper Jig	88-89 (85-90)	Fluctuating
Kaizen and Painting Departments (Factory 2)		
Kaizen Department		
Air Compressor	89 (85-90)	Fluctuating
Up Cut Shear	95 (≥90)	Fluctuating
Drill Machine (motor)	95 (≥90)	Fluctuating
Arc Welding Set #1	95 (≥90)	Fluctuating

Arc Welding Set #2	95 (≥90)	Fluctuating
Arc Welding Set #3	95 (≥90)	Fluctuating
Arc Welding Set #4	95 (≥90)	Fluctuating
High Speed Cutter	97 (≥90)	Fluctuating
Side Outer R Punching Jig	97 (≥90)	Fluctuating
Side Outer L Punching Jig	97 (≥90)	Fluctuating
	Painting Department	
Tear Milling	87-89 (85-90)	Fluctuating
Vibration Welder	87-89 (85-90)	Fluctuating
Water Pump T1 (motor)	87-89 (85-90)	Fluctuating
Exhaust Fan T1 (motor)	87-89 (85-90)	Fluctuating
Air Supply T1 (motor)	87-89 (85-90)	Fluctuating
Paint Mixing Room T1 (motor)	87-89 (85-90)	Fluctuating
Exhaust Fan T2 #1 (motor)	87-89 (85-90)	Fluctuating
Exhaust Fan T2 #2 (motor)	87-89 (85-90)	Fluctuating
Air Release T2 (motor)	87-89 (85-90)	Fluctuating
Oven T2 (motor)	87-89 (85-90)	Fluctuating
Electrical Pump T2 (motor)	87-89 (85-90)	Fluctuating
Air Supply T2 (motor)	87-89 (85-90)	Fluctuating
Paint Mixer T2 (motor)	87-89 (85-90)	Fluctuating
Water Pump T2 (motor)	87-89 (85-90)	Fluctuating
Conveyor T2 (motor)	87-89 (85-90)	Fluctuating
Oven T3 (motor)	87-89 (85-90)	Fluctuating
Air Supply T3 (motor)	87-89 (85-90)	Fluctuating
Air Cond T3 (motor)	87-89 (85-90)	Fluctuating
Air Release T3 (motor)	87-89 (85-90)	Fluctuating
Water Pump T3 (motor)	87-89 (85-90)	Fluctuating
Exhaust Fan T3 (motor)	87-89 (85-90)	Fluctuating
Electrical Pump T3 (motor)	87-89 (85-90)	Fluctuating
Conveyor T3 (motor)	87-89 (85-90)	Fluctuating
Exhaust T4 (motor)	87-89 (85-90)	Fluctuating
Conveyor T4 (motor)	87-89 (85-90)	Fluctuating
Air Supply T4 (motor)	87-89 (85-90)	Fluctuating

Air Cond T4 & T5 (motor)	87-89 (85-90)	Fluctuating
Air Release - Wiping Room T4 & T5 (motor) #1	88-89 (85-90)	Fluctuating
Air Release - Wiping Room T4 & T5 (motor) #2	88-89 (85-90)	Fluctuating
Oven T4 (motor)	88-89 (85-90)	Fluctuating
Air Release T4 (motor)	88-89 (85-90)	Fluctuating
Exhaust T5 (motor)	88-89 (85-90)	Fluctuating
Conveyor T5 (motor)	88-89 (85-90)	Fluctuating
Air Supply T5 (motor)	88-89 (85-90)	Fluctuating
Oven T5 (motor)	88-89 (85-90)	Fluctuating
Air Release T5 (motor)	88-89 (85-90)	Fluctuating
Water Pump (motor) #1	89 (85-90)	Fluctuating
Water Pump (motor) #2	89 (85-90)	Fluctuating
Water Pump (motor) #3	89 (85-90)	Fluctuating
Water Pump (motor) #4	89 (85-90)	Fluctuating
Water Pump (motor) #5	89 (85-90)	Fluctuating
Water Pump (motor) #6	89 (85-90)	Fluctuating
Chiller T2	89 (85-90)	Fluctuating
Chiller T3	89 (85-90)	Fluctuating
Chiller T4	89 (85-90)	Fluctuating
Chiller T5	89 (85-90)	Fluctuating
Other Areas		
Area between Factory 1 and 2	72-73	Fluctuating
Office	59-60	Continuous

Appendix 17: Personal exposure noise monitoring between employees of various departments from Factory 1 and Factory 2

Workers (ID)	Factory	Department	Leq (dBA)	Maximum level (dBA)	Peak level (dBA)
1.	Factory 1	QC Press	84.38	115.4	135.7
2.		PC Press	86.9	111.6	151.6
3.		Maintenance	73.71	109.5	136.9
4.		PC Press	87.34	115.5	131.7
5.		Welding	84.24	126.2	142.6
6.	Factory 2	Kaizen	89.32	122.0	137.6
7.		PC Resin	84.27	128.7	152
8.		Painting	86.17	131.4	148.3
9.		Painting	88.22	131.6	149.7
10.		PC Resin	86.00	115.5	151.3

Appendix 18: Workers exposed to chemicals with an increased risk of hearing loss of various departments from Factory 1 and Factory 2

Factory	Department	Chemicals	Duration of exposure
Factory 1	PC Press	Solvent - alkyd resin blend (phthalic anhydride and glycerine)	8-10 hours
	QC Press	Solvent - alkyd resin blend (phthalic anhydride and glycerine)	8-10 hours
	Welding	Solvent - alkyd resin blend (phthalic anhydride and glycerine)	8-10 hours
	Maintenance	Not exposed	8-10 hours
Factory 2	PC Resin	Solvent - xylene, toluene	8-10 hours
	QC Resin	Solvent - xylene, toluene	8-10 hours
	Kaizen	Solvent - alkyd resin blend (phthalic anhydride and glycerine)	8-10 hours
	Painting	Solvent - xylene, toluene	8-10 hours

Appendix 19: Workers exposed to hand-arm vibration of various departments from Factory 1 and Factory 2

Factory	**Department**	**Hand-arm vibration**
Factory 1	PC Press	Exposed
	QC Press	Not exposed
	Welding	Exposed
	Maintenance	Exposed
Factory 2	PC Resin	Exposed
	QC Resin	Not exposed
	Kaizen	Not exposed
	Painting	Exposed

Appendix 20: Checklists of wearing hearing protection devices (assessed by the safety and health officer)

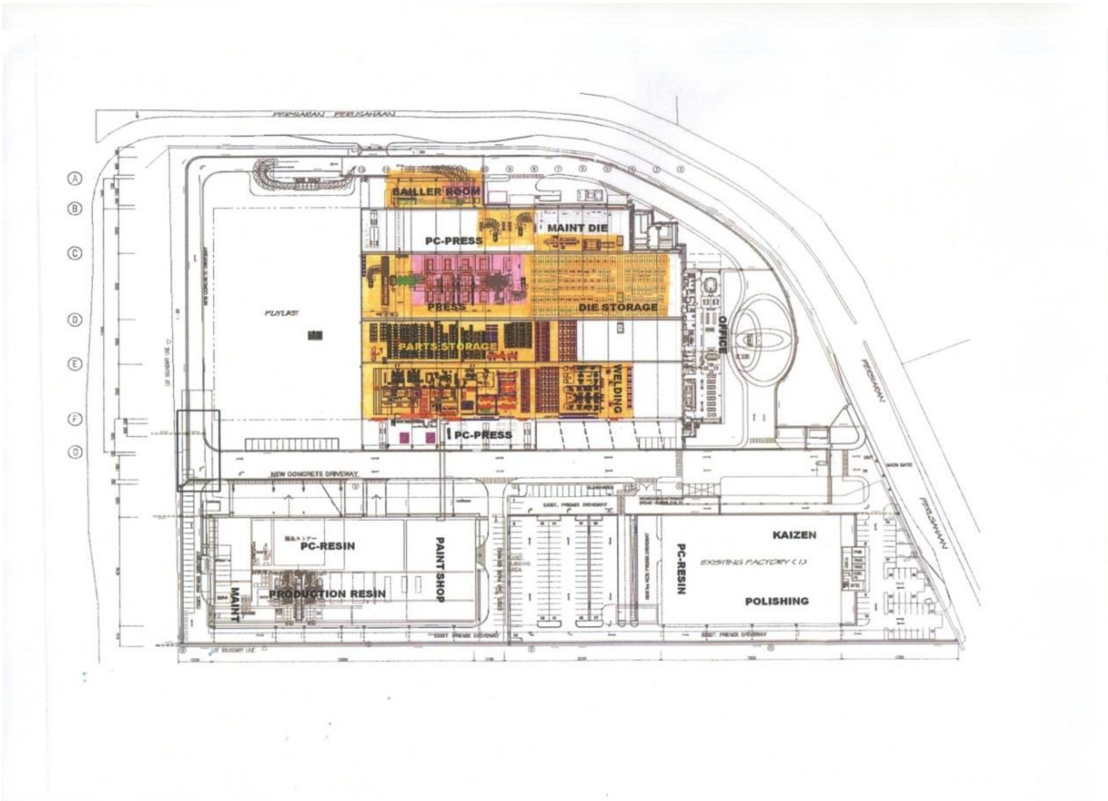
Checklist on wearing Hearing Protection Devices

DEPARTMENT / WEEK	QC-R	QC-PRESS	MAINTENANCE	KAIZEN	PC-RESIN	Signature
1	✓	✓	✓	✓	✓	
2	✓	✓	✓	✓	✓	
3	✓	✓	✓	✓		
4	✓	✓	✓	✓	✓	
5	✓	✓	✓	✓	✓	
6	✓	✓	✓	✓	✓	
7	✓	✓	✓	✓	✓	
8	✓	✓	✓	✓	✓	
9	✓	✓	✓	✓	✓	
10	✓	✓	✓	✓	✓	
11	✓	✓	✓	✓	✓	
12	✓	✓	✓	✓	✓	
13	✓	✓	✓	✓	✓	
14	✓	✓	✓	✓	✓	
15	✓	✓	✓	✓	✓	
16	✓	✓	✓		✓	
17	✓	✓	✓	✓	✓	
18	✓	✓	✓	✓	✓	
19	✓	✓	✓	✓	✓	
20	✓	✓	✓	✓	✓	
21	✓	✓	✓	✓	✓	
22	✓	✓	✓	✓	✓	
23	✓	✓	✓	✓	✓	
24	✓	✓	✓	✓	✓	

Checklist on wearing Hearing Protection Devices

WEEK \ DEPARTMENT	PC-PRESS	PROD-RESIN	PROD-PRESS	WELDING	PAINT	Signature
1	✓	✓	✓	✓	✓	
2	✓	✓	✓	✓	✓	
3	✓	✓	✓	✓	✓	
4	✓	✓	✓	✓	✓	
5	✓	✓	✓	✓	✓	
6	✓	✓	✓	✓	✓	
7	✓	✓	✓	✓	✓	
8	✓	✓	✓	✓	✓	
9	✓	✓	✓	✓	✓	
10	✓	✓	✓	✓	✓	
11	✓	✓	✓	✓	✓	
12	✓	✓	✓	✓	✓	
13	✓	✓	✓	✓	✓	
14	✓	✓	✓	✓	✓	
15	✓	✓	✓	✓	✓	
16	✓	✓	✓	✓	✓	
17	✓	✓	✓	✓	✓	
18	✓	✓	✓	✓	✓	
19	✓	✓	✓	✓	✓	
20	✓	✓	✓	✓	✓	
21	✓	✓	✓	✓	✓	
22	✓	✓	✓	✓	✓	
23	✓	✓	✓	✓	✓	
24	✓	✓	✓	✓	✓	

Appendix 21: Noise zoning of Factory 1 adopting 90 dBA as the permissible exposure limit

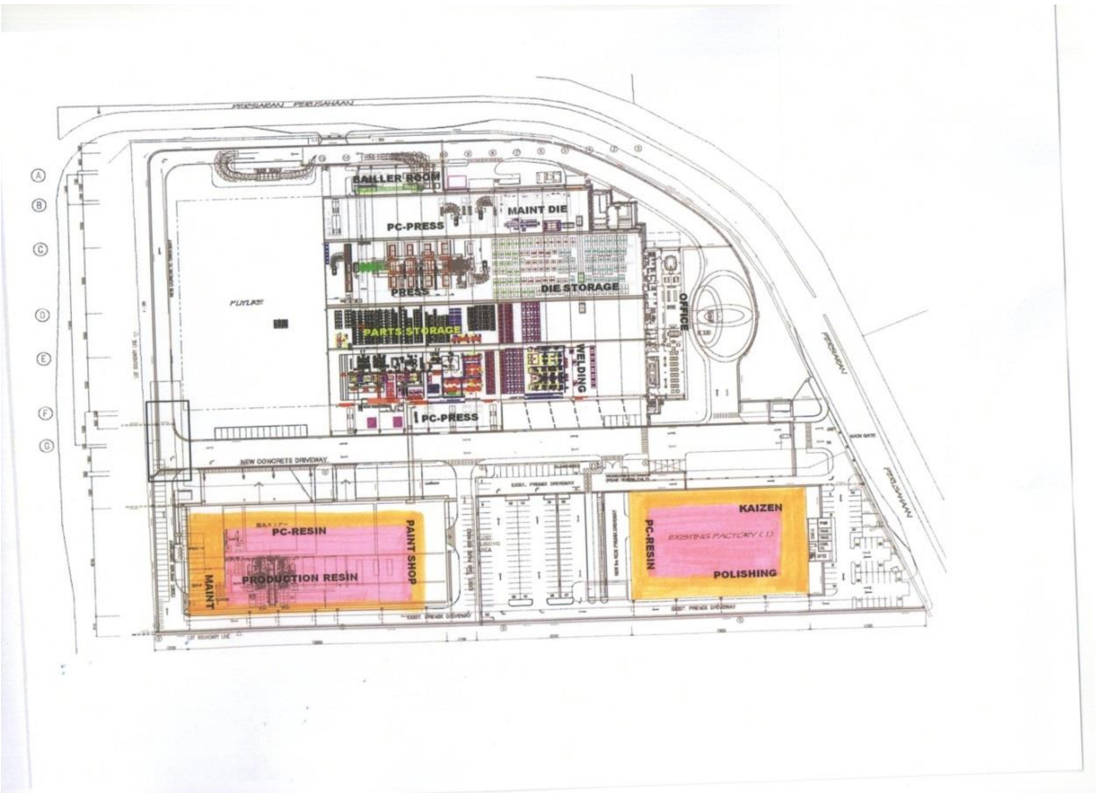


Red - > 90 dBA

Orange - 85 – 90 dBA

White - < 85 dBA

Appendix 22: Noise zoning of Factory 2 adopting 85 dBA as the permissible exposure limit

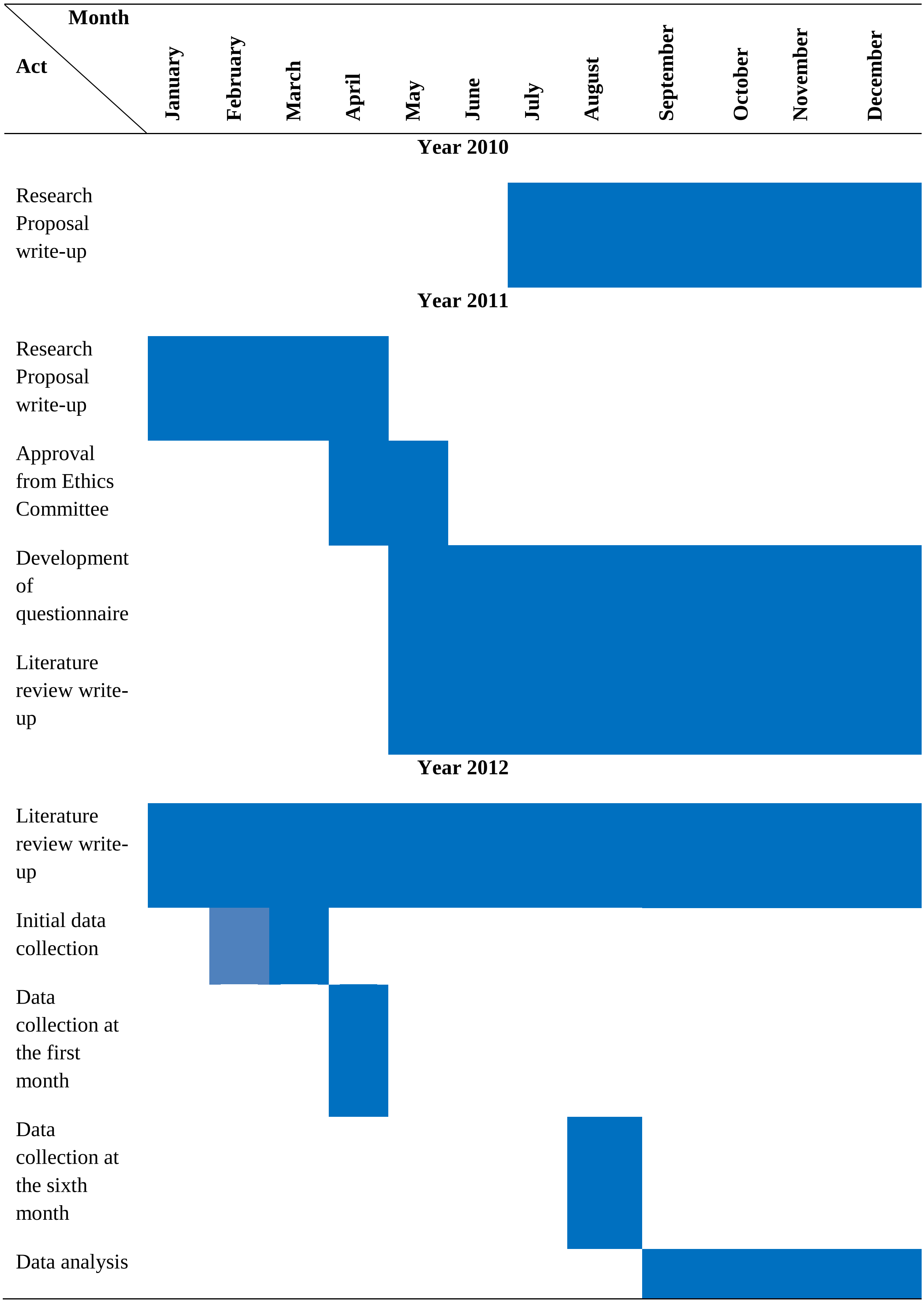


Red - > 85 dBA

Orange - 80 – 85 dBA

White - < 80 dBA

Appendix 23: Gantt chart visualizing the progress of the study



Act / Month	January	February	March	April	May	June	July	August	September	October	November	December
Year 2013												
Data analysis												
Final write-up												
Publication												
3 months submission												
Year 2014												
3 months submission												
Final Exam												

Appendix 24: Ethical approval

UNIVERSITI MALAYA
PUSAT PERUBATAN UM

JAWATANKUASA ETIKA PERUBATAN
PUSAT PERUBATAN UNIVERSITI MALAYA
ALAMAT: LEMBAH PANTAI, 59100 KUALA LUMPUR, MALAYSIA
TELEFON: 03-79493209 FAKSIMILI: 03-79494638

No. Rujukan: PPUM/MDU/300/04/03

22 April 2011

Dr. Balachandar S. Sayapathi
Jabatan Perubatan Kemasyarakatan & Pencegahan
Pusat Perubatan Universiti Malaya

Puan,

SURAT PEMAKLUMAN KEPUTUSAN PERMOHONAN MENJALANKAN PROJEK PENYELIDIKAN
Effectiveness of hearing protection device, early intervention based on audiogram finding and health education on hearing threshold levels adopting different permissible exposure levels and exchange rates among employees in an industry: A quasi experimental study
Protocol No : -
MEC Ref. No : 848.37

Dengan hormatnya saya merujuk kepada perkara di atas.

Bersama-sama ini dilampirkan surat pemakluman keputusan Jawatankuasa Etika Perubatan yang bermesyuarat pada 20 April 2011 untuk makluman dan tindakan puan selanjutnya.

2. Sila maklumkan kepada Jawatankuasa Etika Perubatan mengenai butiran kajian samada telah tamat atau diteruskan mengikut jangka masa kajian tersebut.

Sekian, terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menurut perintah,

Norashikin Mahmood
Setiausaha
Jawatankuasa Etika Perubatan
Pusat Perubatan Universiti Malaya

s.k Ketua
Jabatan Perubatan Kemasyarakatan & Pencegahan

Unit Perkembangan Perubatan
PUSAT PERUBATAN UNIVERSITI MALAYA
(University Malaya Medical Centre)
LEMBAH PANTAI, 59100 KUALA LUMPUR, MALAYSIA
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Leading Healthcare

SIRIM ISO 9001:2008 CERT.NO. AR2597 MS ISO 15189:2007

UNIVERSITY OF MALAYA
KUALA LUMPUR
UM MEDICAL CENTRE

MEDICAL ETHICS COMMITTEE
UNIVERSITY MALAYA MEDICAL CENTRE
ADDRESS: LEMBAH PANTAI, 59100 KUALA LUMPUR, MALAYSIA
TELEPHONE: 03-79493209 FAXIMILE: 03-79494638

NAME OF ETHICS COMMITTEE/IRB: Medical Ethics Committee, University Malaya Medical Centre **ADDRESS:** LEMBAH PANTAI 59100 KUALA LUMPUR	**ETHICS COMMITTEE/IRB REFERENCE NUMBER:** 848.37
PROTOCOL NO: **TITLE:** Effectiveness of hearing protection device, early intervention based on audiogram finding and health education on hearing threshold levels adopting different permissible exposure levels and exchange rates among employees in an industry: A quasi experimental study	
PRINCIPAL INVESTIGATOR: Dr. Balachandar S. Sayapathi **TELEPHONE:** **KOMTEL:**	**SPONSOR:** UM

The following item [✓] have been received and reviewed in connection with the above study to be conducted by the above investigator.

[✓] Borang Permohonan Penyelidikan	Ver date: 04 Apr 11
[✓] Study Protocol	Ver date:
[ ] Investigator's Brochure	Ver date:
[✓] Patient Information Sheet	Ver date:
[✓] Consent Form	
[ ] Questionnaire	
[✓] Investigator (s) CV's & GCP (Dr. Balachandar S. Sayapathi)	

and have been [✓]

[✓] Approved
[ ] Conditionally approved (identify item and specify modification below or in accompanying letter)
[ ] Rejected (identify item and specify reasons below or in accompanying letter)

Comments:

Investigator are required to:
1) *follow instructions, guidelines and requirements of the Medical Ethics Committee.*
2) *report any protocol deviations/violations to Medical Ethics Committee.*
3) *provide annual and closure report to the Medical Ethics Committee.*
4) *comply with International Conference on Harmonization – Guidelines for Good Clinical Practice (ICH-GCP) and Declaration of Helsinki.*
5) *note that Medical Ethics Committee may audit the approved study.*

Date of approval: 20th APRIL 2011

c.c Head
Department of Social & Preventive Medicine

Deputy Dean (Research)
Faculty of Medicine

Secretary
Medical Ethics Committee
University Malaya Medical Centre

Rm
....
PROF. LOOI LAI MENG
Chairman
Medical Ethics Committee

UNIVERSITY OF MALAYA
KUALA LUMPUR
UM MEDICAL CENTRE

MEDICAL ETHICS COMMITTEE
UNIVERSITY MALAYA MEDICAL CENTRE
ADDRESS: LEMBAH PANTAI, 59100 KUALA LUMPUR, MALAYSIA
TELEPHONE: 03-79493209 FAXIMILE: 03-79494638

MEDICAL ETHICS COMMITTEE COMPOSITION, UNIVERSITY MALAYA MEDICAL CENTRE
Date: 20th APRIL 2011

Member (Title and Name)	Occupation (Designation)	Male/Female (M/F)	Tick (✓) if present when above items were reviewed
Chairperson: Prof. Looi Lai Meng	Senior Consultant Department of Pathology	Female	✓
Deputy Chairperson: Prof. Kulenthran Arumugam	Senior Consultant Medical Education Research and Development Unit (MERDU)	Male	✓
Secretary (non-voting): Cik Norashikin Mahmood	Scientific Officer Medical Development Unit	Female	✓
Members: 1. Y. Bhg. Prof. Dato' Patrick Tan Seow Koon	Deputy Director (Professional)	Male	✓
2. Assoc. Prof. Jesjeet Singh Gill	Representative of Head Department of Psychological Medicine	Male	✓
3. Y. Bhg. Prof. Datin Zahurin Mohamed	Head Department of Pharmacology	Female	✓
4. Assoc. Prof. Tan Chong Tin	Representative of Head Department of Medicine	Male	
5. Assoc. Prof. Alizan Abdul Khalil	Representative of Head Department of Surgery	Male	
6. Tuan Haji Amrahi Buang	Head of Pharmalist Department of Pharmacy University Malaya Medical Centre	Male	
7. Y. Bhg. Assoc .Prof. Datin Grace Xavier	Representative of Dean Faculty of Law University Malaya	Female	✓
8. Y. Bhg. Datin Aminah bt. Pit Abdul Rahman	Public Representative	Female	✓
9. Madam Ong Eng Lee	Public Representative	Female	✓

Comments: The MEC of University Malaya Medical Centre is operating according to ICH-GCP guidelines and the Declaration of Helsinki. Member's no. 7, 8 & 9 are representatives from Faculty of Law in the University Malaya and the public, respectively Member no. 10 is by invitation only. They are independent of the hospital or trial site.

....
PROF. LOOI LAI MENG
Chairman
Medical Ethics Committee

Appendix 25: Approval letter to conduct research in the automobile industry

TOYOTA AUTO BODY (M) SDN. BHD. (712570-D)
Lot 11, Persiaran Perusahaan, Section 23, 40300 Shah Alam, Selangor Darul Ehsan
Tel : 603-5548 1118 Fax : 603-5541 7154

6 April 2011 Rujukan: ESH/001/11

Dr. Balachandar A/L S. Sayapathi
Calon DrPH
Social and Preventive Medicine
Universiti Malaya

Dr.,

Kebenaran Untuk Menjalankan Kajian Pendedahan Bunyi Bising di Premis TABM

Merujuk kepada surat Dr. bertarikh 29 Mac 2011, pihak Toyota Auto Body (Malaysia) Sdn. Bhd. dengan sukacitanya ingin memaklumkan bahawa pihak syarikat telah bersetuju untuk memberi kebenaran kepada pihak Dr. untuk menjalankan kajian seperti yang dinyatakan di atas.

2. Seperti yang dibincangkan terdahulu, pihak syarikat ingin mendapatkan salinan laporan-laporan berikut daripada pihak Dr.:

1. *Noise Exposure Monitoring*
2. Audiogram pekerja-pekerja
3. Laporan kajian (setelah selesai)

3. Pihak syarikat amat berharap agar kajian ini dapat memberi manfaat kepada pihak Dr. dan pihak kami khususnya, dan juga kepada industri-industri lain di Malaysia amnya.

Jika terdapat sebarang pertanyaan, sila hubungi Pegawai Keselamatan dan Kesihatan (SHO) kami di talian 03-55481118 atau 012-2579184.

Sekian. Terima Kasih

Nobuyuki Hayashi
Pengarah TABM
Tarikh: 6 April 2011

Appendix 26: Hearing protection device (Earplug- synthetic and corded type)

Appendix 27: Noise dosimeter

Appendix 28: Manual audiometer

Appendix 29: Earphone

Appendix 30: Silent cabin or Audiometric booth

Appendix 31: Certificate of monitoring noise exposure

T 4276-L

NIOSH

SIJIL KEHADIRAN

Adalah dengan ini disahkan bahawa

DR BALACHANDAR A/L S.SAYAPATHI
No. K.P. : 720917-06-5101

Monitoring Of Noise Exposure

pada

13 - 16 Jun 2011

Ir. HAJI ROSLI BIN HUSSIN
Pengarah Eksekutif
NIOSH

MOODY

ISO 9001:2008 Certified

Appendix 32: Certificate of successful completion in the Good Clinical Practice

CIC

UNIVERSITI MALAYA
KUALA LUMPUR

Certificate of Completion

This is to certify that

Balachandar a/l S.Sayapathi

has successfully attended and passed the required assessment for the

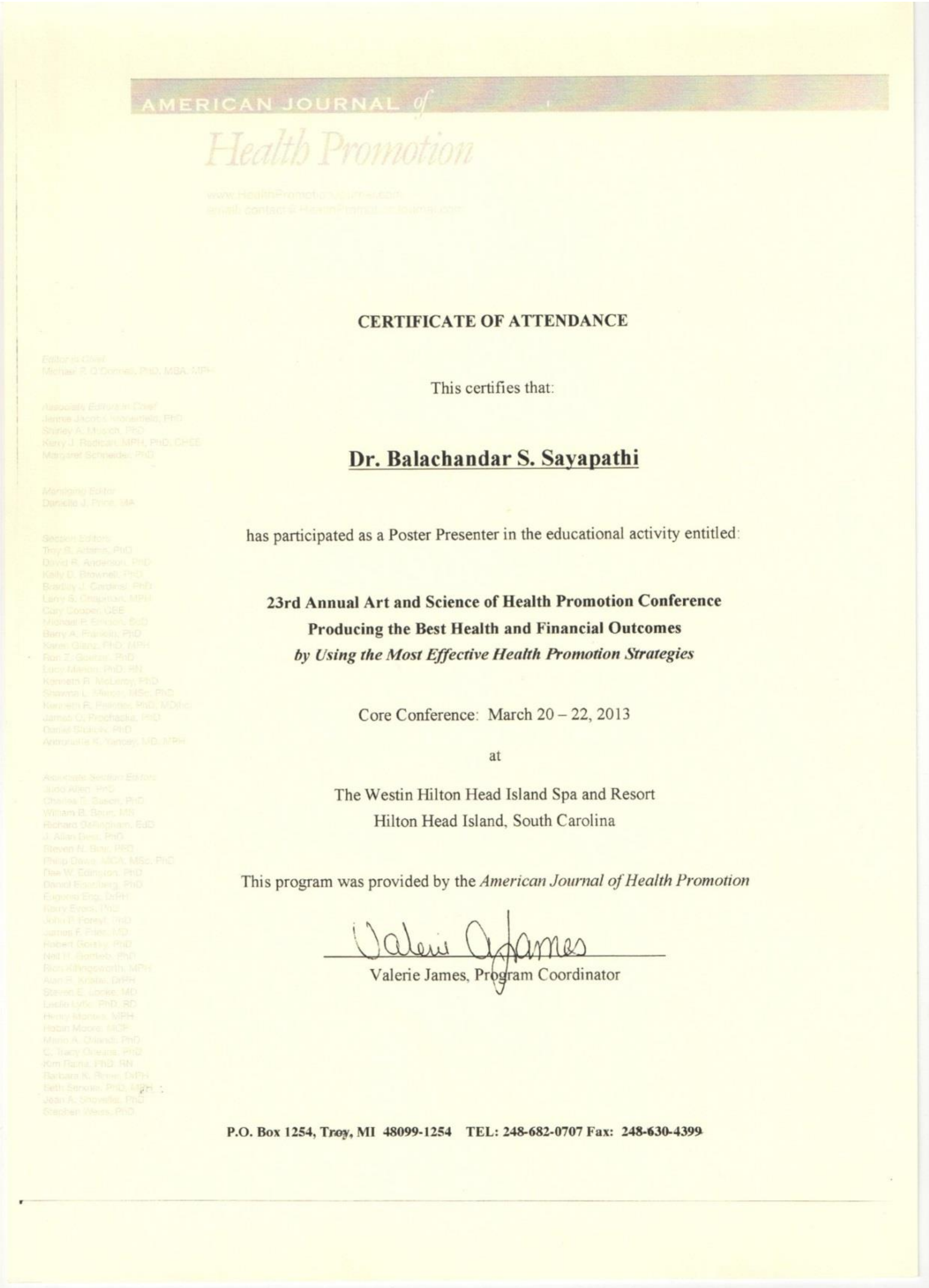
Good Clinical Practice Workshop
14 – 16 December 2010
Organised by
Clinical Investigation Centre
University Malaya Medical Centre

Tan Sri Dato' Seri Dr. Hj. Mohd Ismail Merican
Director General of Health Malaysia
Ministry of Health Malaysia

Professor Dato' Dr. Ikram Shah Ismail
Director
University Malaya Medical Centre

Appendix 33: Certificate of participation in The 4th International Conference of Occupational and Environmental Health, Hanoi, Vietnam

Appendix 34: Certificate of participation and poster presentation in the 23rd Annual Art and Science of Health Promotion Conference Producing the Best Health and Financial Outcomes, South Carolina, United States of America



AMERICAN JOURNAL *of*

Health Promotion

CERTIFICATE OF ATTENDANCE

This certifies that:

Dr. Balachandar S. Sayapathi

has participated as a Poster Presenter in the educational activity entitled:

23rd Annual Art and Science of Health Promotion Conference

Producing the Best Health and Financial Outcomes

by Using the Most Effective Health Promotion Strategies

Core Conference: March 20 – 22, 2013

at

The Westin Hilton Head Island Spa and Resort

Hilton Head Island, South Carolina

This program was provided by the *American Journal of Health Promotion*

Valerie James, Program Coordinator

P.O. Box 1254, Troy, MI 48099-1254 TEL: 248-682-0707 Fax: 248-630-4399

Appendix 35: Certificate of participation in the 21st IUHPE World Conference on Health Promotion, Pattaya, Thailand

Appendix 36: Certificate of participation and oral presentation in the Asia Pacific Safety Symposium 2013, Singapore

Asia Pacific Safety Symposium 2013

CPD/003/A1B/104
This course is accredited by the Ministry of Manpower with 14 SDUs

No. PD2013/6028

Certificate of Oral Presentation

This is to certify that

SAYAPATHI Balachandar

has presented in the above conference held on
17 - 18 October 2013

Seet C. S.
Seet Choh San
President

Singapore Institution Of Safety Officers

Making the difference in Safety
www.siso.org.sg

Asia Pacific Safety Symposium 2013

CPD/003/A1B/104
This course is accredited by the Ministry of Manpower with 14 SDUs

No. PD2013/6028

Certificate of Attendance

This is to certify that

SAYAPATHI Balachandar

has completed the above conference held on
17 - 18 October 2013

Seet C. S.

Seet Choh San
President

Singapore
Institution Of
Safety Officers

Making the difference in Safety
www.siso.org.sg

Appendix 37: Certificate of participation and oral presentation in the First World Congress for Advanced Medical Research WORMED 2013, Malaysia

Design for Scientific RENAISSANCE

WORMED

Certificate of Participation

This certificate is awarded to

Balachandar Sayapathi

for participating in

First World Congress for Advanced Medical Research WORMED2013

held at

Palace of the Golden Horses, Kuala Lumpur

21st – 23rd October 2013

for the paper entitled

Comparing Standard Threshold Shift among employees adopting different Permissible Exposure Limits

Design for Scientific Renaissance Sdn Bhd 671083-T

Prof. Imad Ibrahim Al-Sultan
Chairman, WORMED2013

Appendix 38: Certificate of participation and oral presentation in the International Conference on Innovation Challenges in Multidisciplinary Research & Practice (ICMRP-2013), Malaysia


GLOBAL ILLUMINATORS

Certificate of Presentation

This is to certify that

Dr. Balachandar S. Sayapathi

Participated and presented the paper Title "**The Mean Hearing Threshold Levels among Employees on Adopting Different Permissible Exposure Limits**" in the international conference on "Innovation Challenges in Multidisciplinary Research & Practice (ICMRP-2013)" held at Pearl International Hotel, Kuala Lumpur Malaysia, on December 13-14, 2013.

Farooq Ahmed Jam
Conference Chair
Executive Director
Global Illuminators

Dr Aini Suzana Datuk Hj Ariffin
Chair of Scientific & Review Committee
UTM Perdana School
University Technology Malaysia

Appendix 39: Proof of publication in Journal of Occupational Health

PubMed ▼ balachandar sayapathi

Display Settings: Abstract

J-STAGE FREE

J Occup Health. 2013 Nov 22. [Epub ahead of print]

The Effectiveness of Applying Different Permissible Exposure Limits in Preserving the Hearing Threshold Level: A Systematic Review.

Sayapathi BS, Ting Su A, Koh D.

Author information

Abstract

Objectives: A systematic review was conducted to identify the effectiveness of different permissible exposure limits in preserving the hearing threshold level. This review compared the limits of the US National Institute of Occupational Safety and Health with those of the US Occupational Safety and Health Administration. The prevalence of occupational noise-induced hearing loss is on an increasing trend globally. This review was performed to reduce the prevalence of noise-induced hearing loss. Methods: We searched 3 major databases, i.e., PubMed, Embase and Lippincott Williams & Wilkins Journals@Ovid, for studies published up until 1May 2013 without language restrictions. All study designs were included in this review. The studies were identified and retrieved by two independent authors. Results: Of 118 titles scanned, 14 duplicates were removed, and a total of 13 abstracts from all three databases were identified for full-text retrieval. From the full text, eight articles met the inclusion criteria for this systematic review. These articles showed acceptable quality based on our scoring system. Most of the studies indicated that temporary threshold shifts were much lower when subjects were exposed to a noise level of 85 dBA or lower. Conclusions: There were more threshold shifts in subjects adopting 90 dBA compared with 85 dBA. These temporary threshold shifts may progress to permanent shifts over time. Action curtailing noise exposure among employees would be taken earlier on adoption of 85 dBA as the permissible exposure limit, and hence prevalence of noise-induced hearing loss may be reduced.

PMID: 24270928 [PubMed - as supplied by publisher] **Free full text**

LinkOut - more resources

PubMed Commons PubMed Commons home

0 comments

Appendix 40: Proof of acceptance for publication in The Journal of International Advanced Otology

Subject:	Comparing the effect of different permissible exposure limits on hearing threshold levels above 25 dBA over six mont
From:	The Journal of International Advanced Otology (jiao@advancedotology.org)
To:	balach7777@yahoo.com;
Cc:	editor@mediotol.org;
Date:	Saturday, February 1, 2014 2:55 PM

Dear Dr. Sayapathi,

Your manuscript having the topic mentioned above has been accepted for publication in The Journal of International Advanced Otology.

We thank for your submission and will be looking for your new contributions.

With kind regards

Prof. O. Nuri Ozgirgin

Editor in Chief

Appendix 41: Proof of publication in Journal of Practical Medicine

Nội trong 11 năm (1988-1998) trên 2.149 trường hợp". *Y học thực hành* (10), (11). Tr. 71-80.

6. Lê Văn Sơn (1998), "Chấn thương vùng hàm mặt". Bài giảng Răng Hàm Mặt, Nhà xuất bản Y học, 1998. Tr. 73-77.

7. Adel R.Tawfilics: "Mandibular fractures", eMedicine 2002

8. Albertb J.Fox, Robert M.Kellman (2003), "Mandibular Angle Fractures Two miniplate fixation and complication". Arch Facial plast Surg 5.pp.464-469.

9. Ambrose CG, Clanton TO (2004), "Bioabsorbable implant: Review of clinical experience in orthopedic surgery". Ann Biomed Eng; 32, 171-177.

HIỆU QUẢ CỦA VIỆC ỨNG DỤNG GIỚI HẠN TIẾP XÚC CHO PHÉP KHÁC NHAU TRONG VIỆC DUY TRÌ MỨC NGƯỠNG NGHE Ở CÁC CÔNG NHÂN NGÀNH CÔNG NGHIỆP Ô TÔ: MỘT NGHIÊN CỨU CAN THIỆP

BALACHANDAR S. SAYAPATHI, ANSELM SU TING

Trung tâm sức khỏe nghề nghiệp và môi trường,

Khoa Y học dự phòng và xã hội, Đại học tổng hợp Malaya, Malaysia

SU TIN TIN

Trung tâm sức khỏe dân số Khoa Y học dự phòng và xã hội,

Đại học tổng hợp Malaya, Malaysia

TÓM TẮT

Mục tiêu: Hậu quả của việc công nghiệp hóa là mức ồn tăng lên rõ rệt. Mất khả năng nghe do tiếng ồn xảy ra khi người lao động tiếp xúc với tiếng ồn cao, sự tiến triển còn phụ thuộc vào tần suất, cường độ và thời gian tiếp xúc. Mục đích của nghiên cứu là so sánh hiệu quả trong việc duy trì mức ngưỡng nghe bằng việc ứng dụng các giới hạn tiếp xúc cho phép khác nhau để ngăn chặn sự phát triển mức giới hạn tức thời, là nguyên nhân của việc giảm sức nghe do tiếng ồn.

Phương pháp: Đối tượng chính trong nghiên cứu can thiệp này là những người lao động trong các nhà máy tiếp xúc với mức ồn vượt mức cho phép là 80 dBA và ở một nhà máy khác là 85 dBA và 90 dBA. Số liệu về tiếp xúc tiếng ồn của người lao động được đo bằng dụng cụ đo liều tiếng ồn tiếp xúc cá nhân và sử dụng dụng cụ đo mức áp âm khu vực kiểm soát tiếng ồn. Dữ liệu về mức ngưỡng nghe sẽ được đo bằng thính lực kế. Thiết bị bảo vệ thính giác được sử dụng để làm giảm tiếng ồn tiếp xúc cho những người tham gia nghiên cứu ở cả hai nhà máy phụ thuộc vào mức ồn và ngưỡng tiêu chuẩn hiện tại. Việc tuyên truyền để bảo vệ cơ quan thính giác sẽ được đưa ra dưới dạng những cuốn sách nhỏ ở cả hai nhà máy.

Kết quả: Kết quả thứ nhất là đánh giá sự thay đổi mức ngưỡng nghe. Kết quả thứ hai là đánh giá sự phát triển và hồi phục của giới hạn tiêu chuẩn. Các kết quả này sẽ được đo và ghi lại bằng thính lực đồ ở thời điểm trước khi làm việc, và 1 tháng sau công việc.

Kết luận: Kết quả này có thể có những tác động tới những chính sách hiện tại đối với tiếng ồn và giới hạn tiếp xúc cho phép. Nghiên cứu này sẽ cung cấp những bằng chứng nhất định trong việc áp dụng những giới hạn tiếp xúc cho phép trong việc dự phòng giảm thính lực. Mục đích cuối cùng là làm giảm mất khả năng nghe do tiếng ồn ở người lao động.

SUMMARY

Objective: A consequence due to industrialization is a significant increase in noise levels. Occupational noise-induced hearing loss occurs when employees are exposed to loud noise, where its progression depends on frequency, intensity and duration of exposure. The main goal in this study is to compare the effectiveness in preserving hearing threshold level by applying different permissible exposure limits which may prevent the development of temporary Standard Threshold Shift, which is a precursor of noise induced hearing loss.

Methods: The target population in this intervention study is participants from factories exposed to noise levels above Action Level which is 80 dBA in one factory and 85 dBA in another factory where Permissible Exposure Limit of the former factory is 85 dBA while the latter is 90 dBA. The data on noise exposure among employees is measured using personal exposure noise dosimeter while sound level meter is used for area noise monitoring. Data on hearing threshold level will be measured using audiometer. Hearing protection devices are used to reduce noise exposure among participants in both factories depending on levels of noise and presence Standard Threshold Shift. Hearing conservation education will be given in the form of pamphlets to both factories.

Results: The primary outcome is to assess the changes in hearing threshold level. The secondary outcome is to assess any new development or recovery of Standard Threshold Shift. These outcomes will be measured and recorded in audiogram which will be taken at baseline which is before work and 1st month, after work.

Conclusion: The outcome may have impact on current policy regarding noise in regards to permissible exposure limits. This study will add to limited evidences using different permissible exposure limits in preventing hearing loss. The ultimate goal is to reduce the prevalence of Noise Induced Hearing Loss among employees.

INTRODUCTION

Occupational hearing loss are emerging more in developing countries [1] due to rapid industrialization