PREVALENCE OF NOISE-INDUCED HEARING LOSS AND THE EFFICACY OF A TARGETED INTERVENTION METHOD TO PROMOTE THE USE OF HEARING PROTECTION DEVICES AMONG PALM OIL MILL WORKERS IN PAHANG

By

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بسم الله الرحمن الرحيم

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i) Manuscript one:

Title: Screening for Noise-Induced Hearing Loss Among Palm Oil Mill Workers in Peninsular Malaysia: A Comparison Across Noise Exposure Levels

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Journal: Standards (JCR Q2)

Status: Published 10th January 2022

ii) Manuscript two:

Title: Efficacy of a Targeted Intervention Method to Improve the Use of Hearing Protection Devices Among Agro-industrial Workers in Malaysia

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iii) Poster presentation

Title: High Frequency Audiometric Notches in Noise-Exposed Palm Oil Mill Workers

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LIST OF ABBREVIATIONS

ANOVA	analysis of variance
CI	confidence interval
dB	decibel
df	degree of freedom
DOSH	Department of Occupational Safety and Health
HCP	hearing conservation program
HPD	hearing protection devices
HTL	hearing threshold level
ICOP	Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019
NEL	noise exposure limit
NIHL	noise-induced hearing loss
NMRR	National Medical Research Registry
PTA	pure-tone audiometry
PEL	permissible exposure limit
SD	standard deviation
WHO	World Health Organization

LIST OF SYMBOLS

>	More than
<	Less than
=	Equal to
≥	More than and equal to
≤	Less than and equal to
α	Alpha
β	Beta
Δ	Delta
%	Percentage

ABSTRAK

PREVALENS KEHILANGAN PENDENGARAN AKIBAT KEBISINGAN DAN KEBERKESANAN KAEDAH INTERVENSI BERSASAR UNTUK MENGGALAKKAN PENGGUNAAN PELINDUNG PENDENGARAN DIRI DALAM KALANGAN PEKERJA KILANG KELAPA SAWIT DI PAHANG

Latar belakang

Kehilangan pendengaran akibat kebisingan (*Noise-induced hearing loss, NIHL*) adalah penyakit pekerjaan yang paling banyak dilaporkan di Malaysia. Walau bagaimanapun, data mengenai prevalens penyakit ini dalam pelbagai sektor pekerjaan adalah terhad. Industri minyak sawit merupakan salah satu penyumbang yang paling penting kepada pertumbuhan ekonomi negara. Proses penghasilan minyak sawit mentah melibatkan jentera berat yang menghasilkan bunyi bising yang memudaratkan kesihatan pendengaran pekerja. Pewartaan Peraturan-Peraturan Keselamatan dan Kesihatan Pekerjaan (Pendedahan Bising) 2019 merupakan satu langkah positif ke arah penyediaan perlindungan yang lebih komprehensif untuk kesihatan pendengaran pekerja. Majikan kini dikehendaki mengambil tindakan pencegahan pada paras pendedahan bunyi bising harian yang lebih rendah iaitu 82 dB(A) berbanding 85 dB(A). Namun, penggunaan pelindung pendengaran diri (PPD) tetap menjadi komponen penting dalam memelihara kesihatan pendengaran pekerja yang terdedah kepada bunyi bising. Kajian terdahulu mengenai topik ini secara amnya menunjukkan tahap pematuhan terhadap PPD yang rendah dalam kalangan pekerja tempatan.

Objektif

Objektif kajian ini ialah menentukan prevalens NIHL dan keberkesanan kaedah intervensi bersasar untuk meningkatkan penggunaan PPD di kalangan pekerja kilang kelapa sawit di Pahang.

Metodologi

Bahagian pertama dalam kajian ini merupakan kajian keratan rentas menggunakan data ujian audiometrik sedia ada bagi pekerja kilang kelapa sawit di Pahang. Para pekerja dikategorikan kepada kumpulan pendedahan bunyi bising tahap rendah, sederhana, dan tinggi berdasarkan paras bunyi di stesen kerja mereka. Audiogram pekerja telah dianalisis dengan menggunakan regresi logistik berganda untuk menentukan prevalens NIHL, yang ditakrifkan sebagai kehilangan pendengaran pada frekuensi tinggi (3000 Hz hingga 6000 Hz) di kedua-dua belah telinga, sama ada dengan takuk audiometrik atau tanpa takuk audiometrik. Bahagian kedua kajian ini adalah kajian kuasi-eksperimen yang melibatkan pekerja yang terdedah kepada bunyi bising dari dua kilang kelapa sawit. Untuk menilai faktor penentu penggunaan PPD di kalangan pekerja, kajian ini menggunakan satu borang soal selidik yang telah diterjemahkan dan disahkan. Kumpulan intervensi telah menerima satu modul latihan bersasar, manakala kumpulan kawalan menerima modul latihan standard yang disediakan oleh majikan. Perbandingan telah dibuat ke atas kesan modul latihan yang berbeza terhadap penggunaan PPD dan niat untuk menggunakan PPD di kalangan pekerja. Analisis statistik dilakukan dengan menggunakan ujian-t bersandar dan analisis varians pengukuran berulang.

Keputusan

Prevalens NIHL secara keseluruhan adalah 50.8%. Paras pendedahan bunyi bising dan umur merupakan faktor penting yang menyumbang kepada NIHL di kalangan pekerja. Risiko mendapat NIHL adalah tinggi walaupun bagi pekerja yang terdedah kepada paras bunyi bising di bawah had pendedahan bising. Modul latihan bersasar telah meningkatkan penggunaan PPD dengan signifikan daripada 60.7% kepada 77%, empat bulan selepas latihan dijalankan. Niat untuk menggunakan PPD juga meningkat dengan signifikan daripada 77.3% kepada 89.3%. Sebaliknya, tidak ada perbezaan yang signifikan dalam penggunaan PPD atau niat untuk menggunakan PPD di kalangan pekerja dalam kumpulan kawalan.

Kesimpulan

Hasil kajian menunjukkan prevalens NIHL yang tinggi di kalangan pekerja kilang kelapa sawit. Justeru, pendekatan berjaga-jaga perlu diambil dalam usaha melindungi mereka daripada bahaya bunyi bising di tempat kerja. Kajian ini juga telah menunjukkan keberkesanan intervensi bersasar dalam meningkatkan pematuhan kepada penggunaan PPD di kalangan pekerja yang terdedah kepada bunyi bising. Secara keseluruhan, langkah-langkah yang lebih berkesan perlu dilaksanakan untuk memelihara kesihatan pendengaran pekerja dalam industri ini.

Kata kunci

kehilangan pendengaran akibat kebisingan; undang-undang bunyi bising; minyak sawit; Malaysia; paras pendedahan bising; intervensi bersasar; pelindung pendengaran diri

ABSTRACT

PREVALENCE OF NOISE-INDUCED HEARING LOSS AND THE EFFICACY OF A TARGETED INTERVENTION METHOD TO PROMOTE THE USE OF HEARING PROTECTION DEVICES AMONG PALM OIL MILL WORKERS IN PAHANG

Background

Noise-induced hearing loss (NIHL) is the most commonly reported occupational disease in Malaysia. However, there is limited data on the prevalence of this disease across different occupational sectors. The palm oil industry is one of the main contributors to the nation’s economic growth. Crude palm oil production involves heavy machinery that poses considerable noise hazards to the workers. The introduction of the Occupational Safety and Health (Noise Exposure) Regulations 2019 was a positive step towards providing more comprehensive protection for workers’ hearing health. Employers are now required to take preventive actions at a lower daily noise exposure level of 82 dB(A) instead of 85 dB(A). Nonetheless, the use of hearing protection devices (HPD) remains a crucial component in preserving the hearing health of noise-exposed workers. Previous research on this topic has generally shown a low compliance level to HPD among local workers.

Objectives

This study aimed to determine the prevalence of NIHL and the efficacy of a targeted intervention to improve the use of HPD among palm oil mill workers in Pahang.

Methodology

Part One of this study was a cross-sectional study using existing screening audiometric data of palm oil mill workers in Pahang. The workers were categorized into low, moderate, and high exposure groups based on their workstation noise levels. Their audiograms were analysed to determine the prevalence of NIHL, defined as bilateral high-frequency hearing loss (3000 Hz to 6000 Hz) with or without an audiometric notch. Multiple logistic regression was used to determine the factors associated with NIHL. Part Two of this study was a quasi-experimental study involving noise-exposed workers from two palm oil mills. A translated and validated questionnaire was used to assess the determinants of HPD use among the workers. The intervention group received a targeted training module, while the control group received a standard employer-provided training module. Comparisons were made on the effect of different training modules on the workers' self-reported HPD use and the intention to use HPD. Statistical analysis was conducted using paired t-test and repeated measure analysis of variance (ANOVA).

Results

The overall NIHL prevalence was 50.8%. Noise exposure level and age were significant predictors of NIHL among the workers. The risk of developing NIHL was high even for workers exposed to occupational noise levels below the noise exposure limit. The targeted training module was shown to have significantly improved HPD use from 60.7% to 77% after four months post-training. The workers' intention to use HPD also increased significantly from 77.3% to 89.3%. On the contrary, there was no significant difference in HPD use or intention to use HPD among workers in the control group.

Conclusion

The findings showed a high prevalence of NIHL among palm oil mill workers, emphasizing the importance of a precautionary approach in protecting them from occupational noise hazards. This study also demonstrated the efficacy of a targeted intervention in improving compliance to HPD among noise-exposed workers. Overall, there is a need for more effective measures to conserve the hearing health of workers in this industry.

Keywords

noise-induced hearing loss; noise legislation; palm oil; Malaysia; exposure level; targeted intervention; hearing protection devices

CHAPTER 1 : INTRODUCTION

1.1 Overview of the prevalence of hearing loss

Hearing loss is a significant public health concern and has been identified as the fourth leading cause of disability worldwide (World Health Organization, 2018). In 2019, the estimated global prevalence of hearing loss was 1.57 billion people, equivalent to 20.3% of the total world population. Of these, 430 million people or 5.6% of the total population had disabling hearing loss, consisting of those with moderate-to-complete hearing loss. The western pacific region had the largest population of people living with disabling hearing loss, with an estimated prevalence of 127.1 million individuals. As a member state of this region, Malaysia was estimated to have a hearing loss prevalence of 21.5% or 6.4 million cases, 1.3 million of which were considered to be disabling (Haile *et al.*, 2021). Globally, the number of people living with disabling hearing loss is projected to grow to over 9.6% of the world population by the year 2050, equivalent to over 900 million individuals (World Health Organization, 2018). Common aetiologies of hearing loss include excessive noise exposure (recreational or occupational), ear infections, meningitis, ototoxic hearing loss, and congenital birth defects (Haile *et al.*, 2021; World Health Organization, 2018).

1.2 Noise-induced hearing loss (NIHL)

One of the most common forms of hearing loss is noise-induced hearing loss (NIHL), a condition in which the cochlear hair cells of the inner ear are permanently damaged due to excessive noise exposure (Azizi, 2010). The occurrence of NIHL can be attributed to two primary sources: occupational noise exposure and recreational noise exposure (World Health Organization, 2018). Chronic exposure to noise levels exceeding 85 dB(A) is a known risk factor for developing NIHL (Concha-Barrientos *et al.*, 2004; Goelzer *et al.*, 2001). However, there are also evidences to suggest that hearing loss can occur after prolonged exposure to noise levels of 80 dB and above (Sayapathi *et al.*, 2014). Sudden exposure to impulsive noise can lead to acoustic trauma resulting in acute onset of hearing loss (Azizi, 2010; Le *et al.*, 2017).

NIHL is associated with several symptoms and medical conditions, which can lead to severe implications for an individual's overall health. Tinnitus is commonly seen in NIHL patients and can present with varying degrees of severity. In some cases, noise-induced tinnitus can be severe enough to affect the quality of life and the ability to perform at work. Another condition related to NIHL is vestibular dysfunction, which can cause dizziness and balance disorders (Le *et al.*, 2017). In addition, excessive noise exposure can also result in various other problems such as sleeping difficulties, hypertension, and stress (Nelson *et al.*, 2005). More specifically for workers, NIHL can lead to communication difficulties, poor job performance, and an increased risk of work-related injuries (Girard *et al.*, 2015; Themann and Masterson, 2019). Although noise-related illnesses rarely cause severe health outcomes to individuals, the public health impact of noise-induced hearing loss is still immensely significant due to its high prevalence (Rabinowitz, 2012). On a large scale, permanent hearing loss could lead to economic, social and emotional impairment, affecting the quality of life for those affected by NIHL and the people around them (Concha-Barrientos *et al.*, 2004).

1.3 Occupational noise-induced hearing loss

Occupational noise exposure has been estimated to cause 16% of the total disabling hearing loss among adults globally (Nelson *et al.*, 2005). It has been shown that workers in industries with high noise exposure levels such as mining, construction, manufacturing, shipyard, and military are at increased risk of developing NIHL (Chen *et al.*, 2020; Lie *et al.*, 2016). Other causes of occupational NIHL include age, sex, genetic predisposition, socioeconomic status, ethnicity, smoking, blood pressure, diabetes, vibration, and chemical exposure. Reports from various studies have indicated that the incidence of NIHL among workers in industrialized countries is declining due to the implementation of preventive measures. Conversely, an upgoing trend is seen in developing countries worldwide (Lie *et al.*, 2016). Rapid industrialization, especially in Asian countries, has caused a surge in the population of workers exposed to hazardous levels of noise at the workplace. Industrial operations involving noise-emitting machinery and the widespread use of ototoxic chemicals have substantially increased the risk of hearing loss among these workers. In recent years, the labour force in the region has seen major a shift from agriculture to the manufacturing sector. Despite this trend, the agricultural workforce is still facing an increased risk of NIHL due to the utilization of heavy machinery in the industry (Fuente and Hickson, 2011). As a developing country, Malaysia has also seen a rise in occupational NIHL cases among its workforce. The latest annual report by the Department of Occupational Safety and Health (DOSH) showed that NIHL accounted for almost 90% of all reported occupational diseases in the country for the past three years (Department of Occupational Safety and Health, 2021).

1.3.1 Prevalence of occupational NIHL

Estimation of prevalence of NIHL, primarily occupational NIHL, has been inconsistently reported due to several reasons, including the lack of standard case definition, difficulties in differentiating between NIHL and presbycusis, and difficulties in determining the number of noise-exposed persons (Rabinowitz, 2012). Although there have been numerous researches on the prevalence of occupational NIHL worldwide, data from developing countries would provide better comparisons for our study.

A study conducted in Thailand reported that 45.1% of automotive workers exposed to noise levels exceeding 85 dB(A) had NIHL, defined as an average hearing threshold level (HTL) shift of more than 25 dB at 3, 4, 6, and 8 kHz on air conduction (Sriopas *et al.*, 2017). In Indonesia, two separate studies were conducted involving palm oil mill workers. Sari *et al.* (2017) defined NIHL as an average HTL of more than 25 dB at 0.5, 1, 2, and 4 kHz. 89.3% of workers were found to have NIHL, all of whom were exposed to noise levels exceeding 85 dB(A). Juwarna *et al.* (2018) defined NIHL as the presence of an audiometric notch at 3, 4, or 6 kHz with recovery at 8 kHz. The reported prevalence was lower at 35%, but only 3 in 4 study subjects were exposed to noise levels exceeding 85 dB(A).

A study among textile mill workers in Myanmar showed a prevalence of 25.7% (Zaw *et al.*, 2020). In this study, 66% of workers were exposed to noise levels exceeding 85 dB(A). NIHL was defined as an average HTL of more than 25 dB at 4, 6, and 8 kHz. Nyarubeli *et al.* (2019) reported that 48% of noise-exposed Tanzanian metal workers had NIHL, defined as HTL of equal or greater than 25 dB at 3, 4, or 6 kHz. In Nepal, Whittaker *et al.* (2014) also conducted a study involving metal workers and reported a lower prevalence of NIHL at 30.4%. NIHL was defined as peak HTL between 3 and 6 kHz.

A study on NIHL among Iranian workers in the tile and ceramic industry showed a prevalence of 44.5% (Mehrparvar *et al.*, 2017). The study subjects were exposed to noise levels exceeding 80 dB(A). NIHL was defined as the presence of an audiometric notch at 3, 4, or 6 kHz; or an average HTL of more than 15 dB at 3, 4, and 6 kHz. In China, Chen *et al.* (2019) conducted a study among automotive workers, 63% of whom were exposed to hazardous noise levels at work. It was reported that 28.8% of workers had adjusted high-frequency NIHL, defined as HTL of equal or greater than 30 dB at 3, 4, or 6 kHz after adjusting to age and sex.

The variations in NIHL definition are also seen in local studies on this topic. Sam *et al.* (2017) reported a prevalence of 73.3% among manufacturing workers in Selangor. NIHL was defined as HTL equal or greater than 25 dB at any tested frequency. Jaafar *et al.* (2017) conducted a study among grass-trimming workers, which reported an even higher prevalence of 82.6%. In this study, NIHL was defined as HTL of more than 20 dB at 3, 4, or 6 kHz with recovery at 8 kHz. In a study involving vector control workers, the reported prevalence was relatively low at 26%. NIHL was characterized by the presence of a bilateral audiometric notch at 4 kHz with a history of occupational noise exposure (Masilamani *et al.*, 2014). In another local study, 42.6% of noise-exposed airport workers were reported to have NIHL, defined as HTL of more than 25 dB at 3, 4, or 6 kHz bilaterally (Nasir and Rampal, 2012).

1.3.2 Clinical features of occupational NIHL

The diagnosis of occupational NIHL is made based on two main components: history of occupational noise exposure and pure tone audiometric profile. A detailed medical history is vital to establish occupational risk and rule out other hearing loss causes. A proper clinical examination of the ear is also necessary to detect any abnormality contributing to hearing loss. Pure tone audiometry (PTA) is the gold standard in assessing a person's hearing threshold level (HTL). Air conduction PTA is used for screening, while bone conduction PTA is added for diagnostic purposes. The typical audiometric characteristics of occupational NIHL are bilateral sensorineural hearing loss with a notch at high frequencies of 3, 4, or 6 kHz with recovery at 8 kHz (Mirza *et al.*, 2018; Razali and Rampal, 2017).

The presence of an audiometric notch is considered a classical sign but not pathognomonic of NIHL. A clinician's judgement is vital in interpreting audiograms due to the lack of a standard quantitative definition of "notching". Nonetheless, studies have shown that the presence of an audiometric notch is useful in clinical practice to establish a diagnosis of NIHL (McBride and Williams, 2001a; McBride and Williams, 2001b; Rabinowitz *et al.*, 2006).

Unilateral hearing loss due to noise exposure is known to occur in situations where the exposure is asymmetrical, for example, gunshot noise for firearm handlers or wind noise for drivers (Le *et al.*, 2017; Mirza *et al.*, 2018). However, unilateral hearing loss is more commonly associated with retro cochlear lesions, such as acoustic neuroma, instead of occupational NIHL (Le *et al.*, 2017).

Exposure to loud noises can result in temporary hearing loss, especially during the initial stages of hearing damage. When this happens, audiometry will show a standard threshold shift that will subsequently revert to normal. However, if the exposure continues, the condition would progress to a permanent threshold shift or NIHL (Mirza *et al.*, 2018).

1.4 Palm oil industry in Malaysia

The palm oil industry in Malaysia started with the first commercial plantation in 1917 in Selangor. Since then, the industry has emerged as one of the major contributors to the nation's economic growth. Advancements in agricultural and manufacturing technologies have enabled Malaysia to become the world's second largest producer of crude palm oil (Nambiappan *et al.*, 2018). In 2020, the country's total oil palm plantation area was 5.87 million hectares. Sarawak has the largest plantation area with 1.58 million hectares, followed by Sabah and Pahang with 1.54 million hectares and 0.78 million hectares, respectively. There are 457 palm oil mills in operation, 242 of which are located in Peninsular Malaysia. In total, Malaysia produced almost 20 million tonnes of crude palm oil last year (Ghulam Kadir *et al.*, 2021).

The production of crude palm oil begins with the harvesting and transporting of fresh fruit bunches to mills, which are usually located in the vicinity of the plantation areas. The fruit bunches are sterilized using low-pressure steam to deactivate lipolytic enzymes and loosen the fruits from the bunches. The bunches are transferred into a rotary drum to separate the fruitlets from the bunches in a process called threshing. Next, the fruitlets are transported through the digester and the press machine to extract crude palm oil. The oil will undergo a clarification process before leaving the mill as crude palm oil. The pressed digested fruitlets are further processed to produce fibres, palm shells, and kernels (Shukri *et al.*, 2020).

Most of the workstations along the production line have been shown to have noise levels well beyond 85 dB(A), including sterilization, press, nut plant, clarification, boiler house, and engine room. However, the noise levels at loading ramp and workshop seem to be inconsistent across different studies (Juwarna *et al.*, 2018; Naeini and Tamrin, 2014; Naeini *et al.*, 2015; Wondi *et al.*, 2020). Overall, palm oil mill workers are at risk of developing occupational NIHL due to the presence of hazardous levels of noise along the processing line.

1.5 Overview of legislations related to noise at work

Issues related to occupational noise in Malaysia are governed by the Occupational Safety and Health (Noise Exposure) Regulations 2019 under the Occupational Safety and Health Act 1994. This regulation was introduced in 2019, effectively supplanting the Factories and Machinery (Noise Exposure) Regulations 1989 under the Factories and Machinery Act 1967. The term permissible exposure limit (PEL) has been replaced by noise exposure limit (NEL), which reduces the daily exposure level from 90 dB(A) to 85 dB(A). The maximum noise level and peak sound pressure are maintained at 115 dB(A) and 140 dB(C), respectively. The term excessive noise was introduced, defined as "the daily noise exposure level exceeding 82 dB(A) or daily personal noise dose exceeding fifty percent or maximum sound pressure level exceeding 115 dB(A) at any time or peak sound pressure level exceeding 140dB(C)". The regulation outlines the responsibility of employers to identify any employee who may be exposed to excessive noise at work. Employers are then required to conduct a noise risk assessment, provide yearly training on hearing protection for workers and take necessary actions to protect their employees from the noise hazard. In the event that an employee is exposed to noise levels exceeding the NEL, employers must arrange an annual audiometric test for the employee and provide appropriate HPD (Occupational Safety and Health Act 1994).

In view of the rising trend in occupational NIHL, the enforcement of the new regulation was a positive step forward in protecting workers' hearing health in Malaysia. By lowering the action level (now termed “excessive noise”) from 85 dB(A) to 82 dB(A), more workers would be considered as being at risk and hence better protected through the implementation of preventive measures. However, it is worth noting that annual audiometric screening and provision of HPD are only mandated for workers exposed to noise levels exceeding the NEL.

In Asia, most countries including Singapore, Indonesia, Thailand, and the Philippines, have set the PEL (comparable to NEL) at 85 dB(A). The limit is set higher at 90 dB(A) in South Korea and India (Fuente and Hickson, 2011). The majority of countries in Europe and in the Americas also set their PEL at 85 dB(A). However, audiometric monitoring is required for workers in Netherland, Norway, Sweden, and Spain who are exposed to daily noise exceeding 80 dB(A) (Goelzer *et al.*, 2001). In the Americas, countries such as Brazil, Chile, Honduras, and the Dominican Republic have an action level of 82 dB(A) (Arenas and Suter, 2014).

1.6 Hearing conservation program

Hearing conservation program (HCP) is a term used to describe the actions taken in the workplace setting to prevent noise-induced hearing loss. HCP applies the basics of the hierarchy of control, with elimination, substitution, engineering controls, administrative controls, and personal protective equipment, in descending order of effectiveness (Morata and Meinke, 2016). Elimination of occupational noise hazard through engineering and administrative approach may be the most effective way to prevent occupational noise-induced hearing loss, but these measures are usually not practicable or just too costly (Hong *et al.*, 2006; Lusk *et al.*, 2003). Hence, personal level of protection via the proper use of HPD is still a vital component in preventing occupational noise-induced hearing loss.

Noise attenuation, or the average sound level reduction by HPD, is expressed as a value called Noise Reduction Rating (NRR). NRR is provided by the hearing protection device manufacturer. A higher NRR value means better hearing protection for workers. However, the level of hearing protection provided to each user is more dependent on the level of compliance to HPD (Neitzel and Seixas, 2005). When exposed to excessive noise, HPD should be worn properly at all times to ensure an optimal level of hearing protection. Non-compliance to HPD for even only 10% of the working hours will reduce the effectiveness of hearing protection to less than one-third (Arezes and Miguel, 2002). Tikka *et al.* (2017) published a systematic review on interventions to prevent occupational noise-induced hearing loss, showing evidence that HPD use can reduce the risk of hearing loss among workers. However, good quality evidence is still lacking, and thus further studies are deemed necessary to determine its effect on the prevention of noise-induced hearing loss.

1.7 Hearing protection device (HPD) use among workers

The utilization of HPD has been measured in various ways, as described in many published studies. In most studies, researchers rely upon self-reported use by study participants instead of observed use. Whenever noise hazard is present at the workplace, workers are expected to use HPD throughout the entire working duration. Hence, this self-reporting method is still the most practicable way to assess HPD use, even though this method may be susceptible to recall bias and social desirability bias.

It would almost be impossible to evaluate compliance by observing each study participant as it is tedious and time-consuming.

The percentage of rubber sawmill workers in Thailand who wear HPD regularly has been reported to be 68% (Thepaksorn *et al.*, 2018). In South Korea, 15% of power plant workers have reported using HPD all the time (Kim *et al.*, 2010). Studies conducted in Ghana by Kitcher *et al.* (2012) and Gyamfi *et al.* (2016) found that the percentages of quarry workers who claimed to have used earplugs were 5.5% and 33%, respectively.

A common measurement used to assess HPD use is the percentage of time workers use HPD when exposed to noise at the workplace. In America, the values have been reported as 34% among firefighters and 17% among farmers (Hong *et al.*, 2013b; Mccullagh *et al.*, 2002). The use of HPD among factory workers in Portugal, America, and Thailand have been described in the range of 45% to 79% (Arezes and Miguel, 2005a; Hong *et al.*, 2005; Kerr *et al.*, 2002; Raymond *et al.*, 2006; Tantranont and Codchanak, 2017).

As for studies conducted in Malaysia, Mohd Rus *et al.* (2008) reported that 9.6% of sawmill workers in Kelantan always use earplugs when working. Ismail *et al.* (2013) reported that 14% of quarry workers in Kelantan claimed to have used earplugs to protect their hearing. Sam *et al.* (2016) reported that factory workers in Selangor use HPD 39% of the time exposed to high noise at work.

We have found that measuring compliance via self-reported use of HPD as described by Lusk *et al.* (1995b) is the most practical for an interventional study. The value is measured as the percentage (0-100%) of time workers use HPD when exposed to occupational noise. The mean percentage of use in the past three months, past one month, and past one week is calculated as the final value for HPD use. This method of self-reporting has been shown to be reliable based on the high correlation (0.89) between self-reported use and observed use in a study by Lusk *et al.*(1995a).

1.8 Theoretical framework - Predictors of hearing protection device use

The theoretical framework for the predictors of hearing protection device use among workers originated from the Health Promotion Model by Pender (1987), shown in Figure 1.1. This model was initially developed to explain the factors that determine an individual's likelihood of engaging in health-promoting behaviours. Health-promoting behaviours, defined by Pender as “directed towards increasing the level of well-being and self-actualization”, would include behaviours such as regular physical activities and healthy eating. On the other hand, the use of HPD would fall under the category of health-protecting behaviours, which was defined as “directed toward decreasing the probability of experiencing illness by active protection of the body against pathological stressors or detection of illness in the asymptomatic stage”. Pender’s Health Promotion Model described two main components in determining health-promoting behaviours; modifying factors and cognitive-perceptual factors. The model's five modifying factors were demographic characteristics, biologic characteristics, interpersonal influences, situational factors, and behavioural factors. Cognitive-perceptual factors were divided into seven domains; importance of health, perceived control of health, perceived self-efficacy, definition of health, perceived health status, perceived benefits of health-promoting behaviours, and perceived barriers to health promoting behaviours. It was postulated that modifying factors would have direct influence on cognitive-perceptual factors but not on health-promoting behaviours, and that cognitive-perceptual factors have direct influence on health-promoting behaviours. This model was tested and applied in many studies on health-promoting behaviours (Duffy, 1993; Johnson *et al.*, 1993; Stuifbergen and Becker, 1994; Weitzel, 1989).

Lusk *et al.* (1994) tested the Health Promotion Model as a causal model for the use of HPD among automotive factory workers in America. The study however focused primarily on the cognitive-perceptual factors, and thus included only two modifying factors – demographic characteristics and situational factors – and excluded three other modifying factors to ensure that the questionnaire was of reasonable length. It was shown that perceived self-efficacy, perceived benefits, perceived barriers, and perceived control over health had significant direct effects on the use of HPD. These four factors explained 50.7% of the variance in HPD use.

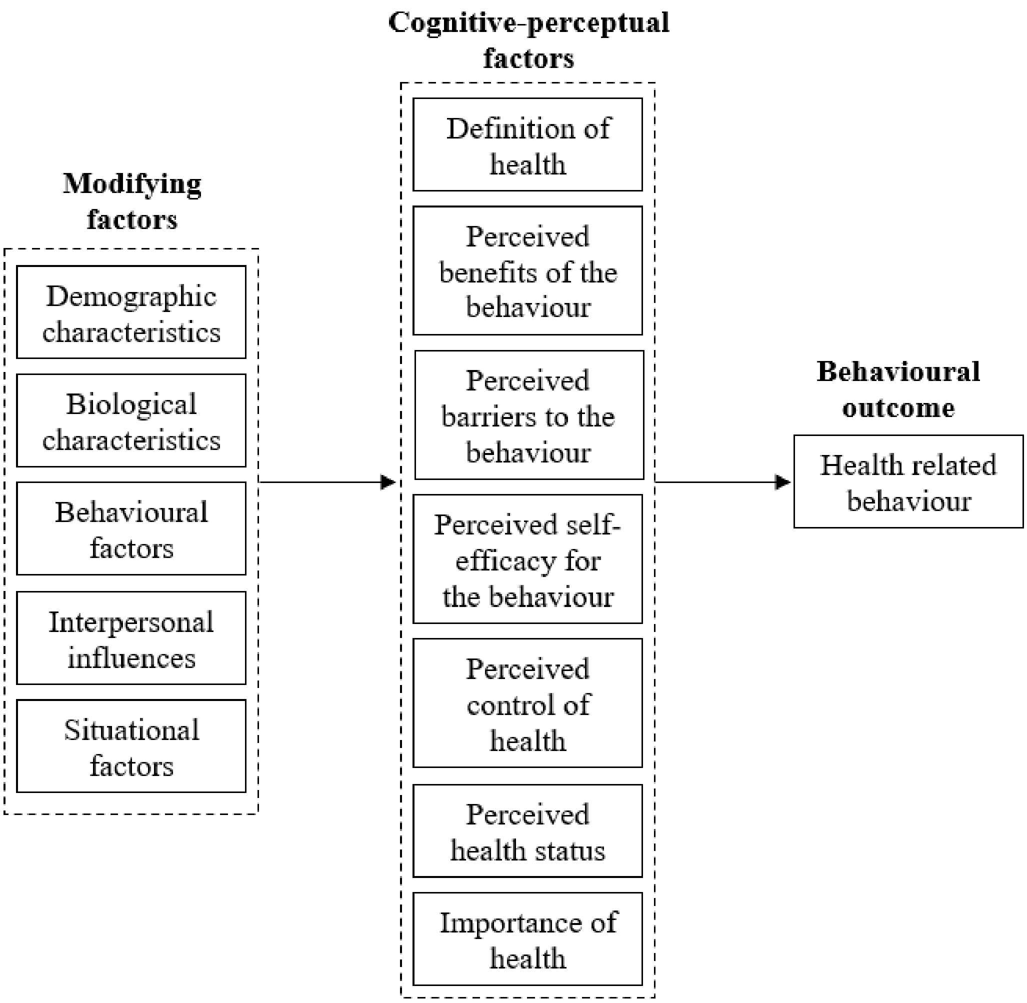

Figure 1.1: Health Promotion Model (Pender, 1987), adapted from Ronis *et al.* (2005)

Another study by Lusk *et al.* (1995b) used Pender's Health Promotion Model to determine the predictors of HPD use among factory workers and subsequently design interventions to improve compliance towards the use of HPD. The study reported four significant predictors of HPD use – perceived self-efficacy, perceived benefits, perceived value of use, and perceived barriers.

In Lusk *et al.* (1997), the Health Promotion Model was tested as a causal model for HPD use among construction workers. The authors decided to exclude one cognitive-perceptual factor and two modifying factors based on the findings from other related studies. The factors excluded from the study were the importance of health, behavioural factors, and biological characteristics. It was shown that there were three significant cognitive-perceptual factors; perceived benefits, perceived barriers, perceived self-efficacy, as well as two important modifying factors; noise exposure, and interpersonal influences-modelling. These factors explained 50.6% of the variance in HPD use. The study also showed that modifying factors directly influenced the use of HPD. This finding was consistent with the revised version of Pender's Health Promotion Model, shown in Figure 1.2.

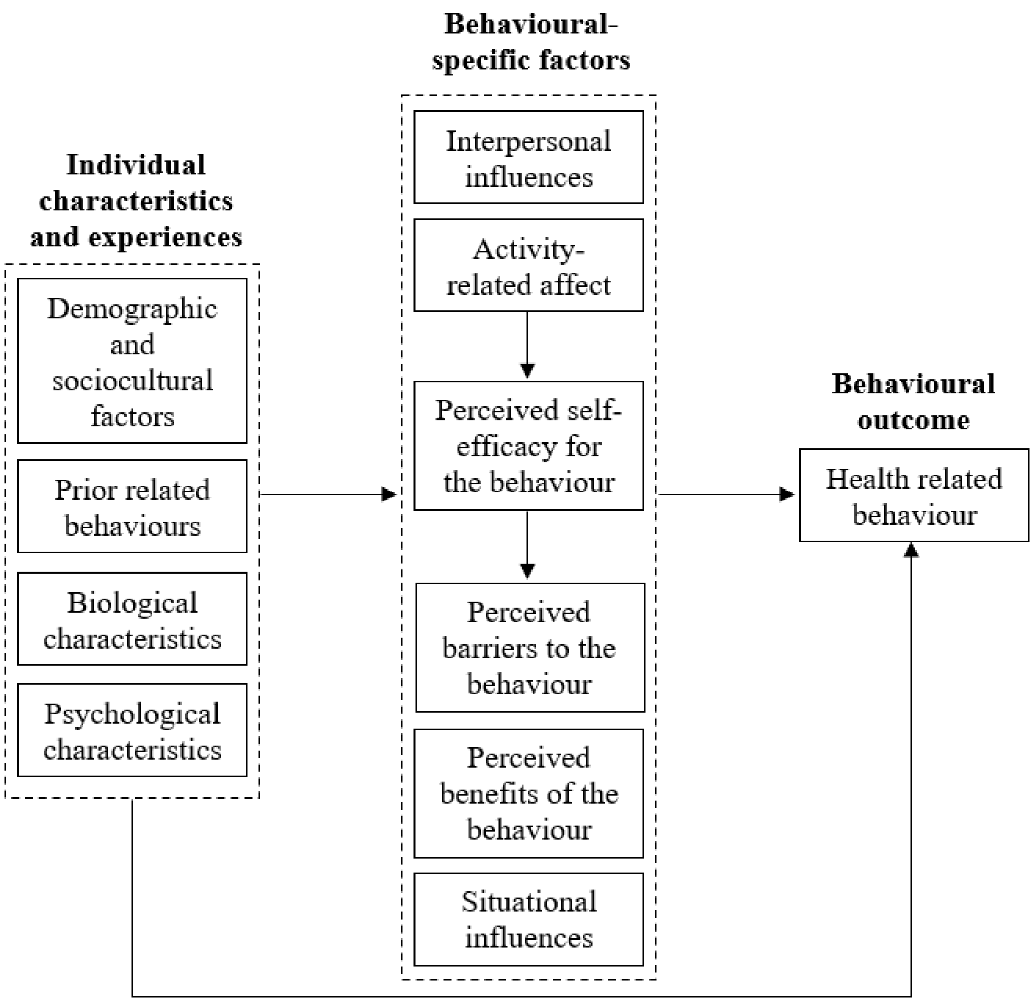

Figure 1.2: Revised structure of the Health Promotion Model (Pender, 1996), adapted from Ronis *et al.* (2005)

Kerr *et al.* (2002) tested the applicability of the Health Promotion Model to explain the use of HPD among Mexican American factory workers. However, instead of using the original Health Promotion Model framework, the authors used a framework that was identical to the one used by Lusk *et al.* (1997). The study identified five cognitive-perceptual factors that directly influenced HPD use: definition of health, perceived health status, benefits, barriers, and self-efficacy. In addition, this study also showed that situational factors, which is a modifying factor, had directly affected HPD use among workers when other factors were controlled. These six factors explained 50% of the variance in HPD use.

In Mccullagh *et al.* (2002), the Health Promotion Model was used to identify the factors that affect the use of HPD among farmers. Perceived barriers, interpersonal support, and situational influences were significant predictors of HPD use, explaining 78% of the variance in HPD use.

Hong *et al.* (2005) developed the Predictors of Use of Hearing Protection Model (Figure 1.3) using Pender's Health Promotion Model as a conceptual framework and incorporating the findings from previous studies by Lusk *et al.*, (1994, 1997). Both models share the same categorization of predictors by dividing them into two; modifying factors and cognitive-perceptual factors. The Predictors of Use of Hearing Protection Model incorporated three modifying factors and three cognitive-perceptual factors. Modifying factors included demographic/experiential factors, interpersonal influences, and situational factors; while cognitive-perceptual factors included perceived benefits, perceived barriers, and perceived self-efficacy. Comparable with the revised Health Promotion Model, this new model postulated that both modifying factors and cognitive-perceptual factors directly influence the use of HPD.

Additionally, modifying factors also indirectly affect HPD use through their effects on the cognitive-perceptual factors.

The Predictors of Use of Hearing Protection Model was tested on automotive factory workers by comparing Black and White workers (Hong *et al.*, 2005). Gender, noise level, perceived benefits, and perceived barriers were significant predictors among Black workers, explaining 12% of the variance in HPD use. Among White workers, significant predictors were working duration, noise level, perceived hearing, social norms, social modelling, interpersonal support, supervisor climate, perceived benefits, and perceived barriers. These predictors explained 36% of the variance in HPD use.

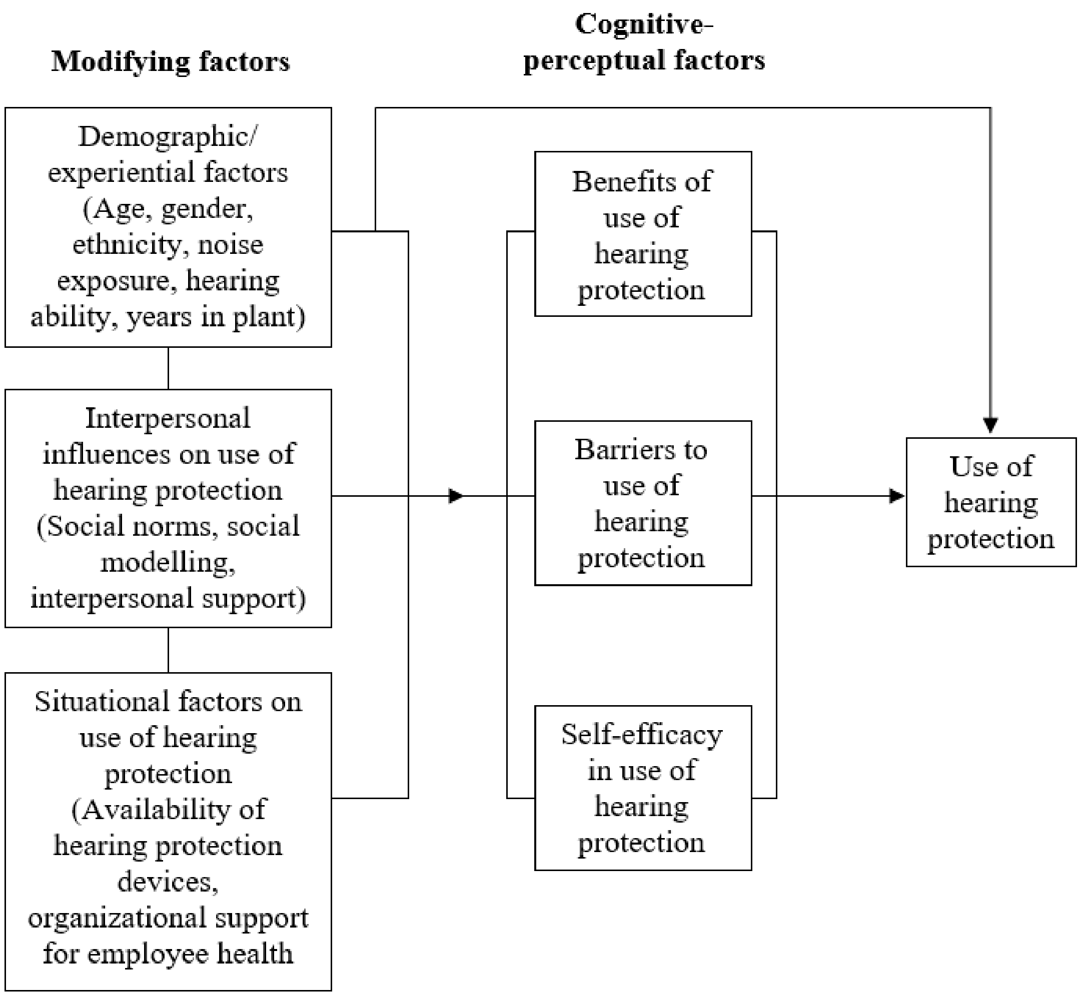

Figure 1.3: Predictors of Use of Hearing Protection Model (Hong *et al.*, 2005)

Raymond *et al.* (2006) also tested the Predictors of Use of Hearing Protection Model, comparing Hispanic and non-Hispanic factory workers. Three predictors were significant among Hispanic workers – age, noise level, and perceived benefits – explaining 20% of the variance in HPD use. Among their non-Hispanic counterparts, 37% of the variance were explained by age, noise level, social norms, social modelling, interpersonal support, supervisor climate, perceived benefits, and perceived barriers.

Arezes and Miguel (2006) specifically studied the relationship between risk recognition and the use of HPD among Portuguese industrial workers. Risk recognition was measured using a questionnaire that included questions on risk source perception, knowledge about noise, knowledge about hearing protection, and self-efficacy in using HPD. It was found that workers' perception of noise hazards at the workplace was significantly associated with HPD use. However, their knowledge and perception of hearing loss risk were low, which means that they tend to underestimate the magnitude of risk at their workplace. Sociodemographic characteristics (age, work experience, gender, and educational background), self-efficacy, perceived benefits, and perceived disadvantages of using HPD were also associated with HPD use.

Hong *et al.* (2013b) conducted a study to determine the predictors of HPD use among firefighters in America. The theoretical model used for this study resembled the Predictors of Use of Hearing Protection Model, but with some changes in the cognitive-perceptual factors. In addition to the three cognitive-perceptual factors included in the original model, two more factors were included in the new model. These predictors were perceived susceptibility to hearing loss, and perceived severity of hearing loss. It was determined that 56% of the variance in HPD use among firefighters can be explained by noise exposure, interpersonal influences, organizational support, perceived barriers, and perceived susceptibility to hearing loss.

Tantranont and Codchanak (2017) conducted a study to determine the predictors of HPD use among industrial workers in Thailand. Using the Predictors of Use of Hearing Protection Model (Hong *et al.*, 2005) as a theoretical model, the authors also added two other predictors; perceived susceptibility to hearing loss and perceived severity of hearing loss (Figure 1.4). These two predictors were included based on the findings of previous studies conducted in Thailand. As a result, the model used in this study was identical to the model used by Hong *et al.* (2013b). Only two predictors – perceived hearing status and interpersonal factors – were statistically significant, explaining 63.4% of the variance in HPD use. The location and population involved in this study made it more relevant to the Malaysian setting than other studies mentioned above, which mostly have been conducted in America. We assume that the working culture and social norms of Thai and Malaysian workers regarding hearing protection would be comparable.

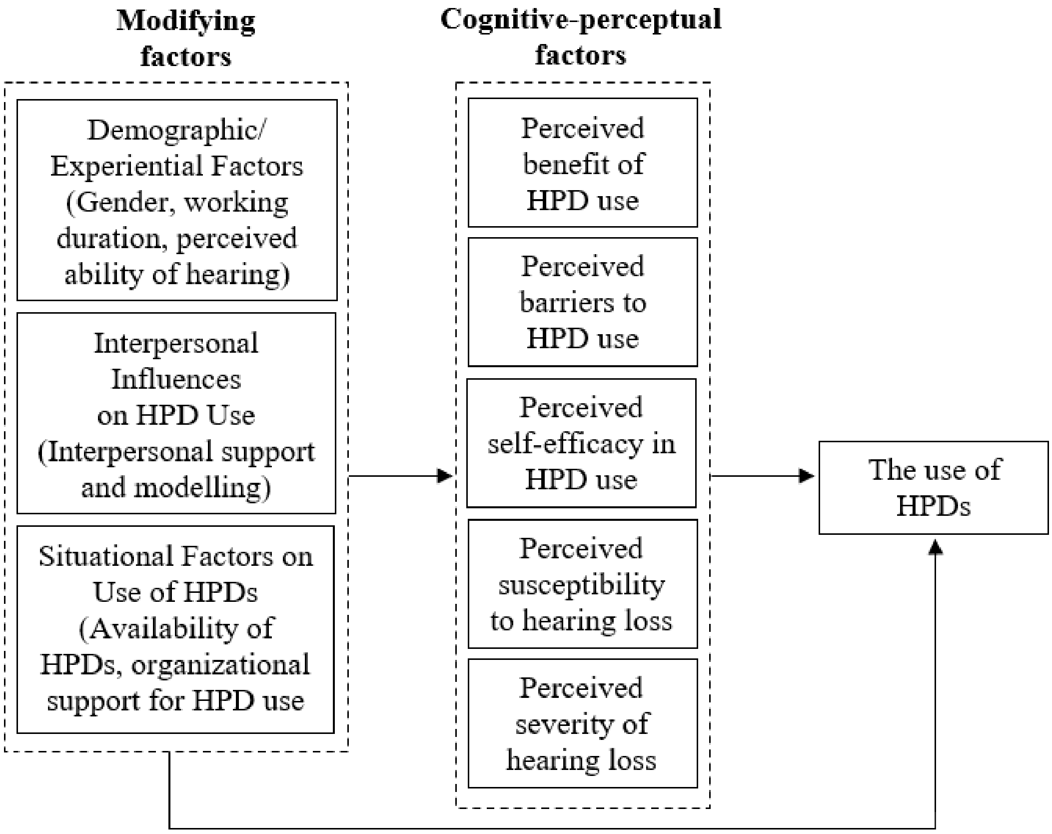

Figure 1.4: Predictors of Industrial Workers' Use of Hearing Protection Model (Tantranont and Codchanak, 2017)

1.9 Interventions to promote HPD use

Several interventional studies have been conducted with the general aim of improving HPD use among noise-exposed workers. In theory, interventions should be designed and orientated specifically to the target group of workers to produce a positive result. This can be done either through a targeted or tailored approach. A targeted intervention is an intervention developed based on the shared characteristics of members in a group. In contrast, a tailored approach considers the characteristics of an individual rather than a group to devise an intervention (Kreuter *et al.,* 2003).

Lusk *et al.* (1999) conducted a study among construction workers, comparing intervention with non-intervention group. The intervention was given in the form of videos, written hand-outs, and hands-on practice. Evaluation of effectiveness was performed 10 to 12 months after the intervention. Findings from this study showed that the intervention significantly improved HPD use but did not improve intention to use HPD in the future. However, the intervention given was neither tailored nor targeted to the participants.

A study by Seixas *et al.* (2011) also involved construction workers but utilized a different approach in designing the intervention. The study participants were divided into three interventional groups. At the beginning of the study, all participants received a baseline hearing loss prevention training. About half of them subsequently received reinforcement training in the form of "toolbox" training sessions which were conducted fortnightly. These were onsite educational sessions covering four different key topics related to hearing protection. The remaining half did not receive any kind of reinforcement intervention. Half of the participants within the two groups received a personal noise level indicator that provided real-time feedback on noise levels. The device served as a reminder to wear HPD in the presence of noise hazards. The study showed that those who received baseline training, toolbox training, and noise level indicators had significantly improved their HPD use. No significant improvement in HPD use was reported for those who did not receive personal noise level indicators. The authors suggested that the interventions were more effective for those not using HPD but were open to it. However, the provision of personal noise level indicators for individual workers might be too costly to be implemented in Malaysia.

In Lusk *et al.* (2003), comparisons were made between three intervention groups – tailored, non-tailored, and control. The tailored group received information corresponding to each person's self-reported HPD use, perceived hearing ability, types of HPD used, and responses to a questionnaire. The non-tailored group received information designed based on predictors of HPD use – perceived benefits and barriers to HPD use, perceived self-efficacy in HPD use, situational factors and interpersonal support for HPD use – but not related to their reported HPD use or questionnaire results. The control group was shown a commercially available video on hearing health. The entire process, including introduction, informed consent, answering questionnaire, and intervention, was conducted in 30 minutes. Post-intervention assessment was done in the period of 6 to 18 months after the intervention. The tailored and control groups' improvements in HPD use were seen, but the difference between both groups was not significant.

In Hong *et al.* (2006), comparisons were made between tailored intervention and control group. Both groups underwent a computer-based hearing test which produced a printed result for each participant. The tailored group received information based on the individual hearing test result, response to a questionnaire, and the theoretically