# COMPARATIVE STUDY OF THE EFFECTIVENESS BETWEEN USED AND NON-USED NOISE WARNING APPLICATION ON PROMOTING THE WEARING OF HEARING PROTECTION AMONG STEEL INDUSTRY WORKERS IN SAMUT PRAKAN PROVINCE THAILAND

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A Dissertation Submitted in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy in Public Health
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# การศึกษาเปรียบเทียบประสิทธิผลของการใช้และไม่ใช้แอพลิเคชั่นเตือนเสียงดังรบกวนต่อการส่งเสริมพฤติกรรมการใส่อุปกรณ์ป้องกันเสียงดังของคนงานในโรงงานอุตสาหกรรมเหล็กในจังหวัดสมุทรปราการ ประเทศไทย

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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาสาธารณสุขศาสตรดุษฎีบัณฑิต
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เพชรรัตน์ เกิดดอนแฝก : การศึกษาเปรียบเทียบประสิทธิผลของการใช้และไม่ใช้แอพลิเคชั่นเตือนเสียงดังรบกวนต่อการส่งเสริมพฤติกรรมการใส่อุปกรณ์ป้องกันเสียงดังของคนงานในโรงงานอุตสาหกรรมเหล็กในจังหวัดสมุทรปราการ ประเทศไทย. ( COMPARATIVE STUDY OF THE EFFECTIVENESS BETWEEN USED AND NON-USED NOISE WARNING APPLICATION ON PROMOTING THE WEARING OF HEARING PROTECTION AMONG STEEL INDUSTRY WORKERS IN SAMUT PRAKAN PROVINCE THAILAND) อ.ที่ปรึกษาหลัก : สุรศักดิ์ ฐานีพานิชสกุล, อ.ที่ปรึกษาร่วม : วินัย แวดวงธรรม

การสัมผัสเสียงดังจากการประกอบอาชีพเป็นปัญหาสาคัญของผู้ปฏิบัติงานในโรงงานผลิตเหล็ก ผู้ปฏิบัติงานจะสัมผัสเสียงดังจากเครื่องจักรที่ใช้ในการผลิตเหล็กรูปแบบต่าง ๆ ตลอดเวลา ซึ่งเสียงดังเหล่านี้อาจส่งผลกระทบต่อการได้ยินของผู้ปฏิบัติงานได้ซึ่งโรงงานเองก็ได้มีการจัดทำโครงการอนุรักษ์ได้ยินซึ่ง ซึ่งองค์ประกอบหนึ่งคือการจัดหาอุปกรณ์ป้องกันเสียงดังให้แก่คนงานที่ปฏิบัติงานในพื้นที่เสียงดัง แต่ก็พบว่าผู้ปฏิบัติงานยังคงไม่ใส่อุปกรณ์ปกป้องการได้ยินตลอดระยะเวลาการทำงานในพื้นที่ ๆ มีเสียงดัง  การศึกษานี้มีวัตถุประสงค์หลักเพื่อเพื่อศึกษาประสิทธิผลของการใช้แอพลิเคชั่นเตือนเสียงดังรบกวนมาเป็นตัวกระตุ้นส่งเสริมให้มีการใส่อุปกรณ์ป้องกันเสียงดังของคนงานในโรงงานอุตสาหกรรมผลิตเหล็ก บริเวณจุดที่มีเสียงดังเกินมาตรฐาน ของโรงงานเหล็กในจังหวัดสมุทรปราการ วัตถุประสงค์เฉพาะคือ 1) เพื่อสำรวจการใช้อุปกรณ์ป้องกันเสียงดังในคนงานโรงงานเหล็ก 2) เพื่อเปรียบเทียบการใช้อุปกรณ์ป้องกันเสียงดังของคนงาน ที่ก่อนและหลังการใช้แอพลิเคชั่นเตือนเสียงดังรบกวน 3) เพื่อระบุรายละเอียดและเปรียบเทียบระดับเสียงต่ำสุดที่เริ่มได้ยินของคนงาน ที่ก่อนและหลังการใช้แอพลิเคชั่นเตือนเสียงดังรบกวน 4) เพื่อเปรียบเทียบความรู้เกี่ยวกับการใช้อุปกรณ์ป้องกันเสียงดังของคนงาน ที่ก่อนและหลังการใช้แอพลิเคชั่นเตือนเสียงดังรบกวน 5) เพื่อเปรียบเทียบทัศนคติเกี่ยวกับการใช้อุปกรณ์ป้องกันเสียงดังของคนงาน ที่ก่อนและหลังการใช้แอพลิเคชั่นเตือนเสียงดังรบกวน  การศึกษานี้เป็นการศึกษากึ่งทดลองโดยทำการสุ่มอย่างเป็นระบบและมีเกณฑ์การคัดเลือกระดับโรงงานภายหลังการได้โรงงานแล้วก็จะมีเกณ์การคัดเลือกแผนกงานที่เสียงดังและคัดเลือกทุกคนในพื้นที่ที่ผ่านเกรฑ์การคัดเลือก กลุ่มตัวอย่างจากพนักงานโรงงานผลิตเหล็ก 2 โรงงานในจังหวัดสมุทรปราการ ขนาดตัวอย่างที่คำนวณได้เท่ากับ 44 คน ซึ่งกลุ่มทดลองมีกลุ่มตัวอย่าง 44 คน  ส่วนกลุ่มควบคุมกลุ่มตัวอย่าง 46 คน การเก็บข้อมูลจากกลุ่มตัวอย่างทั้งสองกลุ่มจะเก็บข้อมูลจากการสัมภาษณ์ด้วยแบบสอบถาม การตรวจวัดระดับการสัมผัสเสียงดัง การตรวจการได้ยิน และการตรวจสอบการใส่อุปกรณ์ป้องกันสียงดังของพนักงานในโรงงานเหล็กดังกล่าว

ผลการศึกษาพบว่ากลุ่มตัวอย่างส่วนใหญ่ในโรงงานทั้งสองโรงงานสัมผัสเสียงดังเกิน 85 เดซิเบลเอ และทำโครงการอนุรักษ์การได้ยินในบริเวณดังกล่าวอยู่แล้ว กลุ่มตัวอย่างซึ่งเป็นกลุ่มทดลองที่จะเป็นกลุ่มที่ใช้แอพลิเคชั่นเตือนเสียงดังรบกวนซึ่งผู้วิจัยโหลดใส่ลงในโทรศัพท์มือถือรุ่นที่หาซื้อได้ง่ายและผ่านการทดสอบความเที่ยงตรงในการประเมินระดับเสียงจากสถาบันมาตรวิทยาแห่งชาติโดยใช้อย่างต่อเนื่องจะมีการเพิ่มความถี่ของการใช้การใช้อุปกรณ์ป้องกันเสียงดังอย่างสม่ำเสมอสม่ำเสมอจากร้อยละ 61.4 เป็นร้อยละ 95.5 และช่วงระยะเวลาการใส่อุปกรณ์ป้องกันเสียงดังซึ่งคิดเป็นเปอร์เซ็นซึ่งเทียบจากช่วงเวลาการใส่ตลอดระยะเวลา  8 ชั่วโมงเท่ากับ 100 เปอร์เซ็นพบว่าเปอร์เซ็นการใส่อุปรณ์ตลอดระยะเวลาการทำงานในพื้นที่เสียงดังของกลุ่มทดลองเพิ่มขึ้น จากประมาณ ร้อยละ 57 เป็นประมาณร้อยละ 73 มีการใช้แอพลิเคชั่นเตือนเสียงดังรบกวนตลอดระยะเวลา 6 เดือนและเมื่อทำการทดสอบด้วยการทดสอบ ที พบว่ามีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) ในขณะที่กลุ่มควบคุมไม่มีแอพลิเคชั่นเตือนเสียงดังรบกวนตลอดระยะเวลาเดียวกันพบว่ามีเปอร์เซ็นการใส่อุปกรณ์ป้องกันเสียงดังเพิ่มขึ้นเล็กน้อยและพบว่าไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ นอกจากนี้ยังพบว่าผลการเปรียบเทียบระดับการได้ยินที่ ก่อนและหลังการใช้แอพลิเคชั่นเตือนเสียงดังรบกวน พบว่าเมื่อทดสอบด้วยการทดสอบ ที พบว่าไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ ($p>0.05$) ซึ่งในกลุ่มควบคุมก็ให้ผลการทดสอบไม่แตกต่าง ($p>0.05$) นอกจากนี้พบว่าในเรื่องของความรู้เกี่ยวกับการใช้อุปกรณ์ป้องกันเสียงดังพบว่าที่ก่อนและหลังการใช้แอพลิเคชั่นเตือนเสียงดังรบกวนในกลุ่มทดลองพบว่าเมื่อทำการทดสอบด้วยการทดสอบทีพบว่า มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติทั้งสองกลุ่ม ($p<0.05$) ในขณะที่ ทัศนคติเกี่ยวกับการใช้อุปกรณีป้องกันเสียงดัง พบว่าที่ก่อนและหลังการใช้แอพลิเคชั่นเตือนเสียงดังรบกวน มีความแตกต่างกัน อย่างมีนัยสำคัญทางสถิติพาะกลุ่มทดลอง ($p<0.05$).ในขณะที่พบว่ากลุ่มควบคุมไม่มีความแตกต่างกัน  การใช้อุปกรณ์ป้องกันเสียงดังอย่างต่อเนื่องตลอดระยะเวลา 6 เดือนน่าจะส่งผลต่อการกระตุ้นพฤติกรรมการใส่อุปกรร์ป้องกันเสียงดังของคนงานได้ซึ่งเห็นได้จากความถี่และเปอร์เซ็นการใส่อุปกรร์ป้องกันที่มากขึ้น

สาขาวิชา สาธารณสุขศาสตร์ ลายมือชื่อนิสิต ................................................

ปีการศึกษา 2562 ลายมือชื่อ อ.ที่ปรึกษาหลัก

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KEYWORD: Hearing protection devices, Noise induced hearing loss, Audiometric testing, Steel industry

Petcharat Kerdonfag : COMPARATIVE STUDY OF THE EFFECTIVENESS BETWEEN USED AND NON-USED NOISE WARNING APPLICATION ON PROMOTING THE WEARING OF HEARING PROTECTION AMONG STEEL INDUSTRY WORKERS IN SAMUT PRAKAN PROVINCE THAILAND. Advisor: SURASAK TANEEPANICHSKUL Co-advisor: WINAI WADWONGTHAM

The exposure to loud noises from occupational performance is a major problem for workers in steel mills. The operators have to be exposed to loud noises from various types of steel production machinery at all times. These noises may affect to the operator's hearing perception in spite the factories themselves have set up hearing conservation program whereas one element is the procurement of loud noise protection equipment to workers working in loud noise area. But it is still found that the operators hardly prefer wearing hearing protection devices during their working hours to work without wearing them. The main objective of this study is to study the effectiveness of the usage of loud noise warning application as an enhancement to encourage the wearing of anti-loud noise devices for workers in the steel industrial factories at the noisy area over the allowable standard of some steel factories in Samut Prakan Province. The study’s specific objectives are 1) To survey the usage of anti-loud noise devices in steel factory’s workers, 2) To compare the usage of anti- loud noise devices of workers, before and after using the noisy alarm application, 3) To specify the details and compare the lowest noise level that the workers begin to hear before and after using the loud noise warning application, 4) To compare the knowledge about how to use the anti- loud noise equipment of workers, before and after using the loud noise warning application and 5) To compare attitudes about the usage of loud noise prevention devices of workers, before and after using the application warning of loud noises. This study is a semi-experimental study, systematically randomized sampling, with selection criteria of the proper factories. After the proper factories had been selected, there were selecting criteria for the noisy departments and selection of participants in such area. The sample groups which had passed the criteria consisted of 2 steel factories’ employees in Samut Prakan Province. The calculated sample size was 44 workers, whereas the experimental group consisted of 44 workers while the controlled group consisted of 46 workers. Data collection from both sample groups were conducted from the interviews with questionnaires, measurement the level of exposed noise loudness, hearing detection and checking the wearing frequency of protective devices by workers of such steel factories.

The study result was found that the majority of sample groups in both factories were exposed to noise above 85 decibels (dBA) and they were already under hearing conservation programs in such area. The experimental group would use the loud alarming application which the researcher had uploaded in their mobile phones of version easily purchasable and had passed their accuracy test to assess the noise level from the National Institute of Metrology. The device usage was quite continuous and, the frequency of usage would be consistently increased, until from 61.4 per cents, it was raised up to 95.5 per cents. And the period of noise protective equipment wearing, calculated as in percentage, throughout 8-hours of wearing period would equal to 100 per cents. It was found that in the experimental group, the percentage of device wearing during working in noisy area was increased from average 57 per cents to average 73 per cents. There was usage of loud noise warning applications throughout 6 months period, when tested by t-test method, it was found that there was a statistically significant difference ($p < 0.05$) while in the controlled group which did not have a loud noise warning application throughout the same period, there was a little increased percentage of wearing anti-noise devices and found no statistically significant difference. In addition, it was found that the comparison of hearing threshold levels, before and after using the loud noise warning application, it was found that when tested with t-test method, it showed no statistically significant differences ($p > 0.05$). In the controlled group, the result came out without any difference ($p > 0.05$). Besides, it was found that, regarding the knowledge about the use of loud noise protective device, it was found that before and after using the loud noise warning application in the experimental group, when tested with t- test method, was found that there were statistically significant differences in both groups ($p < 0.05$) while the attitudes regarding the usage of loud noise protective devices, before and after using the application to warn on loud noise, were found statistically significant difference, especially in the experimental group ($p < 0.05$) while there was no significant difference found in the controlled group. The continuous usage of loud noise protective equipment throughout a period of 6 months would likely affect to the behavioral stimulation of workers to wear loud noise protective devices, as noticeable from the increased frequency and percentage of protective devices wearing.

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Student's Signature ..............................
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Co-advisor's Signature ........................

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Petcharat Kerdonfag

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# ABBREVIATION

| | |
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| NIHL | Noise Induced Hearing Loss |
| HLPP | Hearing Loss Prevention Program |
| HPDs | Hearing protection devices |
| dBA | A – weighted decibels |
| STS | Standard threshold shifts |
| TTS | Temporary threshold shift |
| PTS | Permanent threshold shift |
| TWA | Time Weighted Average |
| PELs | Permissible Exposure Limits |
| WHO | World Health Organization |
| OSHA | Occupational Safety and Health Administration |
| NIOSH: | National Institute for Occupational Safety and Health |
| Nowa App. | Noise warning Application |
| ANSI: | American National Standards Institute |
| ASHA: | American Speech Language Hearing Association |
| OEM: | Occupational and environmental medicine |

# CHAPTER I

# INTRODUCTION

## 1.1 Background and Rationale

Noise-induced hearing loss (NIHL) is a significant occupational health problem, worldwide happening. Generally, effects of the exposure to the occupational noise are larger in males than in females (Nelson et al., 2005), and the higher prevalence rate of the noise-induced hearing loss was found in the developing regions (Nelson et al., 2005), regularly found in the factories, especially in steel factories. Kerketta, Dash, and Narayan (2009) surveyed the noise level at Aarti steel factory in India and found that the average noise level ($L_{eq:}$ 8 hours) of the factory was 91 dBA. In Thailand, the average noise level ($L_{eg:}$ 8 hours) in a steel industry was found to be in 64.01-104.1 dBA range (Samutprakarn Provincial Office of Labor Protection and Welfare, 2015). The noises level over 85 dBA can cause hearing loss so noise pollution in a steel factory can affect to its employees' health. The Safety and Health at Work Promotion Association of Thailand stated that employees working at a steel factory are at risk of noise-induced hearing loss (NIHL). According to the World Health Organization or WHO's survey (2010), in developing countries, approximately 278 million people were suffering from hearing loss up to 80%. In the United States of America, it was estimated that the noise exposure able to cause impact to over 30 million workers, resulting in the significant monetary costs for workers' compensation (Nelson et al., 2005). When considering the similar cases in Thailand, it can be seen that while the nation has been developing to become an industrialized country, the National Statistical Institute Survey (2008) on public illnesses in

Thailand during 1991 to 2007 had a result that hearing loss of both ears had climbed up to the second rank among the causes of disability, following only after blurred visions of both eyes. Furthermore, the statistics on occupational diseases reported by the Office of the Workmen's Compensation Fund with Social Security Office (2012) conducted a survey during 2008 to 2010. The outcome indicated that there were 36 cases of 4,977 patients in 2008, 36 cases of 4,575 patients in 2009 and 21 cases of 5,047 patients in 2010, respectively, suffering from ear degeneration or impairment.

NIHL is caused by prolonged exposure to loud noise which gradually and irreversibly deteriorates sensory hair cells in the inner ear. These damages may not show the obvious symptoms or appearances, such as pain, bleeding, or deformity. As a result, hearing loss often continues unnoticeable and affects to persons who have impaired communications ability (National Institutes of Health, 1990; Hearing Conservation Committee, 2003). NIHL also interferes with workers' communications ability, substantially affecting their social participation, self-esteem, quality of life, and personal safety (National Institutes of Health, 1990). Hearing loss is caused by chronic exposure to loud noise, and it was reported that workers suffering from NIHL frequently found between their ten to 15 years exposure period, and this period apparently decreases while their hearing threshold increases. This is contrast against age-related loss, which is accelerated over the length of time (Hearing Conservation Committee, 2003).

NIHL still has no efficient cure or treatment, but it is completely preventable. Prevention of this condition or disease in early stage is important because the threshold of hearing loss which is caused by a loud noise, firstly appears in high frequencies (3,000 to 6,000 Hertz) and gets worse to speech frequencies (500 to 3,000 Hertz) in later phases, leading to verbal communication disorders and ultimately functional loss. The best way to prevent NIHL is to eliminate noise through engineering control, but it is often impractical and costly, or scientifically impossible to full achievement (Groenewald, Masterson, Themann, & Davis, 2014). Hearing protection devices (HPDs) have also proven effective in NIHL prevention because they can reduce intensity of noise passing into the ears. Despite their benefits, previous research had shown that workers did not consistently wear or use such useful devices (Brink, Talbot, Burks, & Palmer, 2002; Hong & Kim, 2000; Hassel, 2000; Hong, 2005). A research study which investigated the impact of hearing conservation program on the hearing incidents during 1979 to 1996, found that persons who regularly used ear-plugs or hearing protectors could reduce the risk of threshold shift by 30% and delayed the median time their hearing shift occurred by 2.4 years (Davies Hugh, Marion Steve, & Teschke Kay, 2008).Tsukada and Sakakibara (2008) suggested that the individual training might be an effective means to increase both the usage rate and the proper use of HPDs. Also, Seixas et al. (2011) pointed out that education or training is proved to be a generally effective means of behavioral change (Seixas et al., 2011).

However, Occupational Safety and Health Administration (OSHA) provided the occupational noise standard regulation for employers to have workers enrolled in hearing conservation program when ambient noise exposure equals to or higher than 85 A-weighted decibels (dBA), based on an eight-hour time weight average (TWA). These programs consist of administrative control, engineering control, training, annual audiometry, and personal use of hearing protection devices (U.S. Department of Labor, 1983). In Thailand, the Ministry of Labor has established the occupational noise standard regulation for employers to have the employees enrolled in hearing conservation program when ambient noise exposure equals to or higher than 85 A-weighted decibels (dBA) based on an eight-hour time weight average (TWA) with the condition that person cannot avoid noise exposure in order to meet the occupational noise standard safety requirement. Employers have to encourage workers to wear the personal safety protection devices to prevent and decrease risks of hearing loss (Ministry of Labor, 2006).

While OSHA has provided the occupational noise standard regulation, workers working in the high-risk environment with noise still do not realize about this important health problem. Furthermore, most workers do not know they are at risk of hearing loss or how effective or useful HPDs are. Some workers also felt that these devices caused irritation to them (Hong et al., 2008; Hong, Chin, & Ronis, 2013) and limit their communications ability (Hong, Chin, & Ronis, 2013). Based on review of previous literature, most conservation programs had reported on problem of NIHL that it occurred in the areas having moderate noisy jobs more than the area of ambient noisy jobs (Rabinowitz et al., 2003). However, Rabinowitz et al. (2003) conducted a research study and found that workers living in the place with a high level of noise had less NIHL than those workers living in the area with moderate ambient noise. The OSHA specified the occupational noise standard regulation at the cut-off point of 85 dBA or higher.

In Thailand, the usage of HPDs among employees is still low because employees hardly wear or resist to use hearing protective devices, whereas there are workers who have never used HPDs at alarming rate, ranging from 17% to 100% ( Lormphongs, Thiramanus, & Thiravirojana, 2000; Kongthong, 2007). In addition, Peera Kongthong (2007) revealed that approximately 52% of sawmill workers who were exposed to loud noise without ear-plugs had hearing loss in both ears. Moreover, Brink et al. (2002) indicated that the most consistent predictor of hearing loss was the percentage of the workers' operating time without wearing the hearing protection devices. Therefore, an effective intervention to encourage them to use HPDs is required.

Nowadays smart phones are not only the key computing and communication mobile devices, but they are also rich sets of embedded sensors which can collectively run state of art applications across wide various domains, for example, home care, healthcare, social network, safety, environmental monitoring, e-commerce, and transportation (Rana et al., 2010). Digital sensors become much more prevalent in mobile devices over the last few years by incorporating more and more sensors into mobile phones. As the sensor, they serve us to collect, process and distribute data for all people.

Besides, warning on clinical device usage is intended to call for attention of caregivers to patients or device conditions which deviate from the predetermined "normal" status. They are generally considered to be a key tool to improve the patients' safety. The purpose of alarm systems is related to "communicating information that requires a response or awareness by the operator" (Simons & Fredericks, 1997).

A mobile phone application is a software developed specifically for use on small, wireless computing devices, such as smartphones and tablets etc. The technological capabilities of mobile phones are continuously progressing at a giant leap while such capabilities allow low cost interventions while they are technically easy to deliver interventions to the large group of population. For example, mobile technology applications can easily be downloaded and automated systems can be delivered to a large number of people at low cost. Mobile technology is a means for providing each level support to healthcare consumers because of widely advanced mobile technology. Many studies had revealed the positive effect of usage of mobile health interventions to deliver health behavior change interventions or reminders for various purposes such as smoking cessation (Obermayer et al., 2004; Rodgers et al., 2005), physical activity (Hurling et al., 2007), anti-obesity behavior modification (Joo & Kim, 2007), Vitamin C adherence (Cocosila et al., 2009), and reducing risk for sexually transmitted diseases (Suffoletto et al., 2013), etc. In Thailand, a rapidly increasing rate of use of communication technology can be seen from the existing data which revealed that 52.8%, 56.8%, 61.8%, 66.4%, and 70.2% of the total population were utilizing mobile phones during 2008-2012, respectively.

Based on the aforementioned reasons, the use of a sensor and alarm to create a new technology “Noise Warning Application [NoWa app.]” to promote the use of hearing protection devices may be an appropriate action to motivate people to adopt the use of HPDs. However, it is worth noting that using the NoWa app. to promote usage of HPDs has rarely been publicized. Therefore, the present study is interested in investigation of the usage of the NoWa app. to promote usage of hearing protection devices among steel industry workers in Samut Prakan Province, Thailand so as to determine the potential for motivating behavioral changes resulting in adoption of the HPD usage. It was hypothesized that the NoWa app would be the highest-intensity intervention to promote the HPD usage among steel factory workers.

## 1.2 Research Question

1) Is there any difference in HPD usage between steel industry workers who use and who do not use the Noise Warning Application?

2) Is there any difference in Hearing threshold level between steel industry workers who use and who do not use the Noise Warning Application?

## 1.3 Research Objectives

### General objective

The present study is aimed to determine the effectiveness of the Noise Warning Applications to promote the use of hearing protection devices among steel industry workers.

### Specific objectives

1) To explore the use of HPDs among steel industry workers.

2) To specify and compare the hearing threshold level among steel industry workers, before and after receiving the intervention.

3) To compare the use of HPDs among steel industry, before and after receiving the intervention.

4) To compare knowledge about HPD use among steel industry, before and after receiving the intervention.

5) To compare attitude about HPD use among steel industry, before and after receiving the intervention.

## 1.4 Research Hypotheses

### Hypotheses 1

$H_o$: There is no difference in HPD use between the intervention and control groups.

$H_a$: There is a difference in HPD use between the intervention and control groups.

### Hypotheses 2

$H_o$: There is no difference in hearing threshold level between the intervention and control groups.

$H_a$: There is a difference in hearing threshold level between the intervention and control groups.

## 1.5 Conceptual Framework of the Study

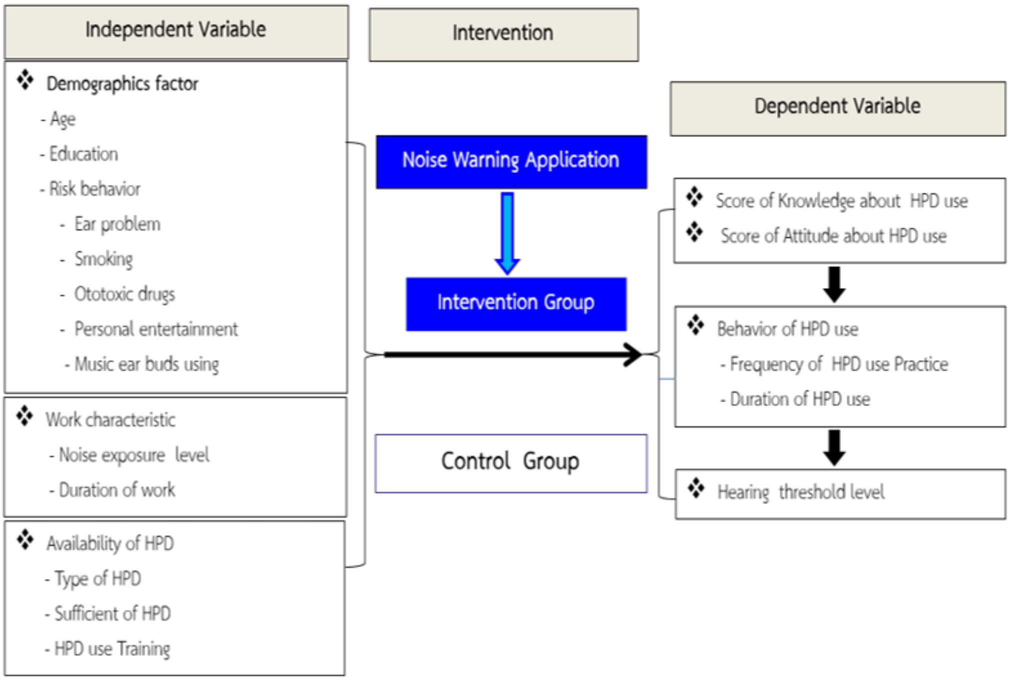

**Figure 1** Conceptual Framework of the Study

## 1.6 Definitions of Terms

1) Noise Warning Application (NoWa App.) refers to an intervention that is created by using a concept sensor and alarm to promote the HPD use among steel industry workers. The application involves the mechanism designs as a noise dosimeter that is put into a mobile phone that will send out warning signals by shaking and lighting when the level of noise calculated for eight hours is over 85 dBA.

2) Effectiveness of intervention is defined as positive changes of HPD use, including increment in percentage of HPD using time and increment in proportion of HPD use that is higher than 50 per cents of the shift, after implementation of the intervention.

3) Risk behavior refers to the behavior that can affect the workers' hearing, including riding ear disease, cigarette smoking, use of ototoxic drugs, as well as personal entertainment such as singing, playing music, going to a discotheque, shooting, riding a motorcycle, and using music earphone buds.

4) Work characteristic refers to noise environment in the workplace which is related to worker's hearing, consisting of noise level which worker exposure and duration of work.

5) Noise exposure level refers to the level of noises the steel factory workers are exposed to as determined by using an equipment called a noise dosimeter attached to the workers during their shift. The equivalent continuous sound level (Leq) is computed by a noise dosimeter, with the unit is decibel (A) or (dBA).

6) Duration of work refers to the working period in the noisy areas. It is composed of total office hours and over time working in hours per week.

7) Hearing protection devices (HPDs) refer to ear-plugs which can be worn to reduce the volume of loudness transmitted into the ears.

8) Availability of HPD refers to continuously procurement ability of hearing protection devices to support workers in noisy area. It comprises of availability from both industry management and worker’s self-procurement, properly and sufficiently for all time of working among loud noise environment.

9) Knowledge of HPD use is defined as workers’ realization to understand and recognize the susceptibility of noise, severity of effects from noise exposure, benefits of HPDs usage, and how to use the HPDs properly.

10) Accepting Attitude is defined as predisposition to accept the proposed objects in favorable or unfavorable manner. It is usually measured by defining the attitude of acceptor’s feeling in one choice of options: agree or disagree, like or dislike. In this attitude referred to steel workers’ response to HPD usage into 4 levels i.e. strongly agree, agree, and disagree to strongly disagree.

11) The use of HPDs refer to behavior of HPD use in steel worker who work in loud noise

12) Behavior of HPD use refers to the reaction of workers who use hearing protection devices to reduce the risk of hearing loss due to prolonged exposure to loud noise. Human behavior results from beliefs, social norms, personality, and the expected outcome of a particular person (Suvan, 1983). Practice or behavior evaluation requires a great deal of observation, both in the process and the reaction outcome. In this study, the evaluation applied both the frequency of HPD usage practice and duration of HPD use.

12.1) Frequency of HPD Usage Practice refers to the good or poor reaction of the workers who practice HPD usage in their one first week usage.

12.2) Duration of HPD Use refers to mean use of HPDs in each shift of eight hours (480 minutes). Mean use of HPDs was calculated using workers' reported use of HPDs in percentage of the time (0-100%) when working in loud noise area.

13) Hearing threshold level refers to the starting point of sound level that a worker's ear can hear. It is measured with an equipment called "audiometer" to examine at various frequencies of 0.5, 1, 2, 3, 4, and 6 kHz, respectively with the unit of loudness in decibel (dB).

## 1.7 Expected Benefits and Applications

1) Steel industry workers will increase their time of HPD usage during their working shift.

2) Increment of HPD using time during the working shift can help prevention of NIHL.

3) The intervention can be subsequently implemented to promote the HPD usage to prevent NIHL in factory workers who have to be exposed to loud noise.

# CHAPTER II

# LITERATURE REVIEW

In this chapter, related literatures are reviewed to understand the concept of occupational noise-induced hearing loss and impact of hearing loss, measures to prevent hearing loss from noise exposure, the use of hearing protectors, predictive models of use of hearing protectors, predicting factors used for hearing protection, and intervention to prevent occupational noise-induced hearing loss as follows:

2.1 Occupational noise-induced hearing loss

2.1.1 Definition of occupational noise-induced hearing loss

2.1.2 Causes and mechanisms of occupational noise-induced hearing loss

2.1.3 Type of occupational noise-induced hearing loss

2.1.4 Hearing threshold level

2.2 Factors related to occupational noise-induced hearing loss

2.3 Standard prevention of occupational noise-induced hearing loss

2.4 Hearing conservation program (HCP)

2.5 Usage of hearing protection devices

2.6 Behavior related to HPD usage

2.7 Previous researches about intervention to promote wearing of hearing protection devices

2.8 Mobile phone technologies, Application, and Effectiveness of mobile-health technology-based to health behavioral change

2.9 Effect of alarm to behavior

## 2.1 Occupational noise-induced hearing loss

Hearing loss is a chronic medical condition that can affect individuals of all ages. The ability to listen decreases or changes from normal (Chaikittiporn, BE.2541; Grundfast, Siparsky, & Chuong, 2000) which is caused by many reasons, such as defects of hearing nerves of the inner ear, viral or bacterial infections, drugs usage, exposure to chemicals, and continuous exposure to noise which is louder than 85 dBA over a period of eight hours per day. In addition, hearing loss may be caused by a head injury or a serious accident (Arehart, 2005; May, 2000). Increasing age is a cause of hearing loss as well (Office of the Workmen's Compensation fund, 2012; Sataloff, 2006). However, the issue to be considered and focused on in this study is hearing loss from noise exposure necessary by occupation. This is considered as a major problem in industrialized countries (Hong, Lusk, & Ronis, 2005; Sataloff, 2006). The World Health Organization has described hearing loss as a common medical condition among industrial professionals, and such conditions cannot be restored to normal. In the year 2000, it was reported that hearing loss of approximately 1.4 million workers around the world, excluding the United States, was caused by excessive noise exposure that was higher than the standard (over 85 dBA), calculated to be 16% of hearing loss (Nelson, Nelson, Concha-Barrientos, & Fingerhut, 2005). In fact, in each year, approximately 1.6 million workers suffer from occupational noise-induced hearing loss(Centre, 2004).

### 2.1.1 Definition of occupational noise-induced hearing loss

Occupational noise-induced hearing loss, as opposed to occupational acoustic trauma, is hearing loss that refers to loss of ears’ function caused by continuous or intermittent noise exposure, which usually develops gradually over several years. This is in contrast to acoustic trauma, which is characterized by a sudden change in hearing as the result of a single exposure to a sudden burst of sound, such as an explosive blast. The diagnosis of NIHL were made by the occupational and environmental medicine (*OEM)* physicians, by first taking the worker's noise exposure history into account and then considering the following characteristics (DeHart, 2012; Office of the Workmen's Compensation fund, 2012):

Noise-induced hearing loss is a permanent hearing impairment resulted from prolonged exposure to high level of noise. One of ten Americans has hearing loss which affects his or her ability to understand a normal speech. Excessive noise exposure is the most common cause of hearing loss. The National Institute of Health reported that about 15% of Americans, aged 20 to 69 years, had high frequency hearing loss related to occupational or leisure activities (Foundation, 2014).

### 2.1.2 Causes and mechanisms of occupational noise-induced hearing loss

For causes of NIHL, we have to know that a noise can be measured scientifically in two ways - intensity and pitch. Both of these factors can affect the degree which the sound (noise) damages hearing.

I) Intensity of sound is measured in decibels (dB). The scale runs from the faintest or feeblest sound the human ear can detect, which the normal hearing range is labeled from 0 dB, to180 dB, the noise at a rocket launching structure, its echoed sound intensity may be given in two different units. Persons interested in the actual physical quantification of sound use units of sound pressure level (SPL). SPL is calibrated to a constant sound pressure level that does not vary with frequency. On audiograms, however, sound intensity is calibrated in hearing level (Lusk & Kelemen), it means that the reference sound is one that just barely heard by a normal person. Hence, HL units are relative measurement and not generally correspond to SPL units. Higher intensity (dB) of sound causes more damage. Many experts agree that continual exposure to more than 85 decibels may deteriorate the hearing ability.

II) Pitch is measured in frequency of sound vibrations per second, called Hertz (Hz). Frequency is measured in cycles per second, or Hertz (Hz). The higher the pitch of the sound is, the higher the frequency is. A low pitch such as a deep voice of a tuba makes fewer vibrations per second than a high voice or violin. Generally, noise induce hearing loss occurs at a pitch range of about 2000-4000 Hz. Frequency is measured in cycles per second, or Hertz (Hz). The higher the pitch of the sound is, the higher the frequency is. Young children, who generally have the best hearing, can often distinguish a sound of approximately from 20 Hz, such as the lowest note on a large pipe organ, to 20,000 Hz. For example, the high shrill of a dog whistle which many people are unable to hear. Human speech, which ranges between 300 to 4,000 Hz, sounds louder to most people than noises at very high or very low frequencies. When hearing impairment begins, the high frequencies are often lost first, which is why people with hearing loss often have difficulty in hearing the high-pitched voices of women and children. Loss of high frequency hearing also can distort sound, so that a speech is difficult to understand even though it can be heard. Hearing impaired people often have difficulty to detect differences between certain words which sound alike, especially words that contain S, F, SH, CH, H, or soft C, sounds, because the sound of these consonants is in a much higher frequency range than vowels and other consonants.

In addition, the duration (how long you are exposed to a noise) can affect the extent of noise induced hearing loss. The longer you are exposed to a loud noise, the more damage it can cause. Every gunshot produces a noise that could damage the ears of anyone in closely hearing range. Large bore guns and artillery are worst because they generated the loudest noise. But even cap guns and firecrackers can damage your hearing ability if the explosion is close to your ear. Anyone who uses firearms without some form of ear protection, is risky to hearing loss. Excessive noise can occur in many situations. Some of ordinary ones include occupational noise (machinery, etc.), loud music, and non-occupational.

NIHL can be caused by a single time exposure to an intense “impulse” sound, such as an explosion, or by continuous exposure to loud sound over a prolongated period of time, such as noise generated in a woodworking shop. Recreational activities which can put people at risk for NIHL include target shooting and hunting, snowmobile riding, listening to MP3 player at high volume through ear buds or headphones, playing in a band, and attending loud concerts. Harmful noises at home may come from sources including lawnmowers, leaf blowers, and woodworking tools. Sound is measured in units called decibels. Sounds of less than 75 decibels, even after long exposure, are not likely to cause hearing loss. However, long or repeated exposure to sounds at or above 85 decibels can cause hearing loss. The louder the sound is, the shorter time it takes for NIHL to happen. The average decibel ratings of some familiar sounds such as the humming of a refrigerator is 45 decibels, normal conversation is 60 decibels, noise from heavy city traffic is 85 decibels, motorcycles roar is 95 decibels, an MP3 player at maximum volume is 105 decibels, siren is 120 decibels, and firecrackers and firearms are 150 decibels. The distance from the source of the sound and the length of time individuals exposed to the sound are also important factors in protecting hearing. A good rule of thumb is to avoid noises which are too loud, too close, or last too long.

To understand how loud noises can deteriorate individuals' hearing. How hearing mechanism works is to be understood. Hearing depends on a series of organ's functions making sound wave in the air into electrical signal. The auditory nerve then carries these signals to the brain through a complex series of steps.

### Mechanisms of hearing loss due to noise exposure

Mechanisms begin when an individual hears a sound which resembles a wave. Sound waves enter the outer ear and travel through a narrow passageway called the ear canal, which leads to the tympanic membrane acting like the eardrum which vibrates from the incoming sound waves, resulting in transforming sound waves in the form of mechanical energy. This causes bone shifting of three tiny bones in the middle ear. These bones are called the malleus, incus, and stapes. The bones in the middle ear couple the sound vibrations from the air to fluid vibrations in the cochlea of the inner ear, which is shaped like a snail shell filled with fluid. An elastic partition runs from the beginning to the end of the cochlea, splitting it into an upper and lower part. This partition is called the basilar membrane because it serves as the base, or ground floor, on which key hearing structures sit. Once the vibrations cause the fluid inside the cochlea to ripple, a traveling wave forms along the basilar membrane. Hairs cells—sensory cells sitting on top of the basilar membrane—ride the wave. While the hair cells move up and down, microscopic hair-like projections (known as stereocilia) that perch on top of the hair cells bump against an overlaying structure and bend. Bending causes pore-like channels, which are at the tips of the stereo cilia, to open up. When that happens, chemicals rush into the cell, creating an electrical signal. The auditory nerve carries this electrical signal to the brain, which translates it into a sound that individual recognize and understand (Arehart, 2005; Ektasang, B.E. 2546; Sataloff, 2006; Wacharatrakul, B.E. 2550).

Humans generally hear sounds in the frequency range of 20-20,000 Hz (Arehart, 2005; Kongtip, B.E. 2545; Sataloff, 2006; u-suke, 2006) and the noise level in the range 0-140 dBA(Arehart, 2005). If every organ in the normal hearing mechanism functions properly, hearing will continue as in the steps mentioned above. However, many studies have shown that the volume higher than 85 dBA can cause the hair cells of the inner ear to vibrate more than usual. Cells develop fatigue, resulting in a condition to enter the temporary loss of hearing. If the noise continues for a long period of time, it will cause the vibration of the cells to destroy hair cells, which constantly deteriorate them and then gradually fall to the inability to change the sound waves into electrical energy into nerves (Ektasang, B.E. 2546; Sataloff, 2006). This causes hearing loss or permanent loss of hearing to the extent of deafness, which cannot be restored to normal (Control & Prevention, 2004; Nakai, 2003; Sataloff, 2006). Furthermore, when individuals are exposed to loud noise over a long period of time, they may slowly start to lose their hearing. They may not notice it, or they may ignore the signs of hearing loss until they have to accept louder pronounced to. Over a period, incoming sounds may become distorted or muffled, and individuals may confront that it is difficult to understand other people’s speaking when they talk or have to tune up the volume on the television. The damage from NIHL, combined with aging, can lead to severe hearing loss to th extent those individuals need hearing aids to magnify or amplify the sounds around them to help their hearing to communicate, and participate efficiently with the other in daily activities. NIHL can also be caused by extremely loud bursts of sound, such as gunshots or explosions, which can rupture the eardrum or damage the bones in the middle ear. This kind of NIHL can be immediately and permanently affected. Sometimes exposure to impulse or continuous loud noise causes a temporary hearing loss for 16 to 48 hours and recoverable later. Recent research suggests, however, that although the loss of hearing seems to disappear, there may be residual long-term damage to hearing of individuals.

### 2.1.3 Type of occupational noise-induce hearing loss

Hearing loss can be divided into two categories (Chaikittiporn, BE.2541; Sriwanyong, B.E. 2544) as follows:

1) Temporary threshold shift (TTS) is caused by hair cells or neurons that have been tired of hearing from exposure to loud noise for a long time to the extent that they cannot convert the vibrations into nervous waves. This cause temporary deafness. In the beginning, the noise exposure is felt that the sound echoed in the ears or tinnitus, particularly after the end of each work day. This condition is often associated with noise in the ears. The hearing will return to normal, slow or fast, depending on the volume and duration of noise exposure. If noise grows louder and individuals have prolonged exposure, how long the hearing will return to normal varies, possibly from few minutes to several weeks after exposure to the sound has stopped.

2) Permanent Threshold Shift (PTS) is caused by hair cells or neurons exposure to loud noise over a long period of time until hair cells are permanently destroyed. In the early stages of hearing loss, it will begin to malfunction at high frequency range of 3,000-6,000 Hz. This is because of the anatomy of the ear. Hair cells that receive high frequency sound is located at the base of the spiral organ and

hair cells which receive sound at a frequency of 4,000 Hz are likely sensitive to damage than other organs. Iris hair cells show hearing loss at frequencies of 4,000 Hz (Ologe, Akande, & Olajide, 2006; Sataloff, 2006; Sriwanyong, B.E. 2544). Consequently, the hearing loss may spread to the low frequency of conversations at 500-2,000 Hz. Individuals feel that the ability to hear their own voice feels like a clock movement. They have to turn on the radio or TV louder than normal. There are communication problems which affect to comprehension in conversation with other persons as well. Hearing loss in this case will not recover to normal**.**

### 2.1.4 Hearing Threshold Level

Pure tone audiometric testing, which assesses the ability to hear various standardized frequencies, is the main stay of evaluation. During the test, the tones in the frequency range of 25 - 8,000 Hz are increased in volume until the person perceives the sound. The decibel reading at which the sound is first recognized is the hearing threshold for that frequency. Normal threshold values range from -0.5 dB to 20 dB; those who have perceivable frequency at or above 25 dB are considered abnormal and are especially important when the speech frequency ranges (500 to 4,000 Hz) are affected (Rom and Markowitz, 2007).

WHO classified hearing impairment according to the pure tone average in the better hearing ear. Categories range from “no impairment” to “profound impairment” according the hearing threshold level. The hearing threshold level, using audiometry, is to be taken as the better ear average for four frequencies 0.5, 1, 2, and 4 kHz. WHO levels of hearing impairment is shown in Table 2.1.

The one-third octave band ears covered maximum permissible ambient noise levels for frequency range of 500 - 8,000 Hz as specified in ANSI S3.1-1991. When ears covered testing is done using a supra-aural earphone at frequencies of 125, 250, 500, 800, 1000, 1600, 2000, 3150, 4000, 6300 and 8000 Hz were 42.5, 28.5, 14.5, 16.5, 21.5, 21.5, 23.0, 28.5, 29.5, 33.0 and 38.5 dB, respectively (American National Standards Institute [ANSI], 1991).

**Table 1** WHO levels of hearing impairment

| **Level of impairment** | **Hearing threshold level (average of 0.5, 1, 2, 4 kHz)** | **Impairment description** |
|---|---|---|
| 0 (No impairment) | 25 dB or less (better ear) | No or very slight hearing problems. Able to hear whispers |
| 1 (Slight impairment) | 26-40 dB (better ear) | Able to hear and repeat words spoken in normal voice at 1meter distance |
| 2 (Moderate impairment) | 41-60 dB (better ear) | Able to hear and repeat words using raised voice at 1meter distance |
| 3 (Severe impairment) | 61-80 dB (better ear) | Able to hear some words when shouted into better ear |
| 4 (Profound impairment including deafness) | 81 dB or greater (better ear) | Unable to hear and understand even a shouted voice |

**Source**: WHO (1991)

## 2.2 Factors related to occupational noise-induced hearing loss

### 1) Demographic factors

The structure of demographic factors is an individual’s personal factors that affect whether the new behavior is adopted, including age, education, years of work, Risk Behavior (ear disease, smoking, ototoxic drugs, duration of continuous noise exposure at work, personal entertainment, music ear plugs usage), etc.

**Age**: The hearing is declined with age increment. This age-related hearing loss is called presbycusis and found to be greater in males than females (Lass, 2007). Aging hair cells or neurons hearing deterioration will naturally decline. This causes hearing loss coming along with age. Generally, hair cells begin to decline around the age of 40 and the deterioration is increased by increasing age (Sataloff, 2006). A previous study was found that people aged over 59 years without history of noise exposure from working in the industry, would have a hearing loss about 20% of all workers. When individuals have been exposed to the noise level of 90 dBA in their workplace, the incidence of hearing loss calculated to 27% of all workers (Kongtip, B.E. 2545). Also, Orawan Kaewboonchoo et al. (2004) measured the hearing threshold at frequencies of 0.5, 1, 2, 4 and 8 kHz in 1,110 Thai females and 805 Thai males who were not exposed to occupational noise, with age range of 7-89 years. After selection of the normal ear subjects (1,783 female ears and 1,291 male ears), found that the hearing threshold of Thai people gradually increased with age and speedily over 50 years. In addition, a study of the relationship between age and hearing loss of Montha Klaisripo (2002) found that 83.3% of people aged 50 years and over, have hearing loss, while 10.0% to 82.4% of workers under the age of 50 have hearing loss. Additionally, Landen et al.(2004) found that among workers over the age of 60 years, 92.3% had hearing decline, while 8.6% to 66.0% of workers aged younger than 60 years suffered from hearing decline (Klaisripo, B.E 2545).

**Education**: The level of education results in different individual preventive behaviors. Individuals with low levels of education are less likely to have information seeking skills. They also have fewer educational benefits compared to those with higher education (Pender, 2006).The study of Supaporn Tarnpeam et al. (2007) which investigated hearing capacity and noise hazard preventive behaviors among workers in a sugar refinery factory found that protection from harmful projector noise was lower (27.57%) among workers who completed only primary education when compared to those with a high education level (72.42 %) with statistical significance (p-value = 0.05).

**Duration of work**: Work duration is important because it gives workers the opportunity to be exposed to loud noise at work which can cause hearing loss (Sataloff, 2006; Sriwanyong, B.E. 2544). A study conducted by Theeranate Panicharoen (UN ACC Sub-Committee on Nutrition) found that those who had worked for longer than five years had 1.3 times higher probability to develop hearing impairment than those who had work experience of shorter than five years. In another study, Santi Jaijong (1999) explored noise and hearing loss in a department of a factory with noise levels between 95 and 105 dBA. According to the study results, 35.6% and 40% of the workers working in the mill for a period of one to five years and over six years suffered from hearing loss, respectively(Jaijong, B.E.2542). In addition, the study of hearing loss in the workplace of paint repairing and spray painting showed that 92.3% of the technicians who had been working for longer than 20 years had hearing loss, while 57.1% to 78.3% of the technicians who had been working for less than 20 years, suffered from hearing loss (Uraiwan Inmuang, B.E. 2545). Similar findings have been reported by studies conducted abroad. In one study, it was found that 38.7% of the workers at a metal production factory in Brazil who had been exposed to noise for a long period of 20 years suffered from hearing loss, whereas the rate of hearing loss was only 8.3% to 20% among workers who had been exposed to noise for less than 20 years (Guerra, Lourenço, Bustamante-Teixeira, & Alves, 2005). In addition, a study on the risk factors associated with the changes of the ability to hear based on the standard among employees at a factory manufacturing productivity of motor, compressors, carried out by Savitri Chairath, Adul Bandhukul, and Pen Patra Sripaibulya (2013), showed that workers who had worked for 14 years were likely to experience changes in the ability to hear with statistical significance (OR = 3.84, 95%, CI = 1.54 – 9.56).

**Duration of continuous noise exposure at work**: Noise can damage hearing to a certain extent, depending on the duration of noise exposure. The duration of exposure to noise is increasing, and this may result in higher number of cases of hearing loss. A study carried out by Pornchai Khunkongmee (UN ACC Sub-Committee on Nutrition) found that 76.5% of workers exposed to noise over a period of eight hours of work lost their hearing, while only 69.7% of workers exposed to noise for only five to six hours. Savitri Chairath, Adul Bandhukul, and Pen-patra Sripaibulya (2013) studied the risk factors associated with the changes of the ability to hear based on the standard on employee productivity of motor compressors and reported that duration of noise exposure over eight hours per day was correlated with changes in the ability to hear with statistical significance (Savitri Chairath, 2013).

**Risk Behavior**:

***Ear disease*****:** Infections such as rubella in the mother's womb or infections after delivery, including viral infections, bacterial infections, including syphilis, and use of some drugs can affect hearing. Furthermore, exposure to chemicals such as toluene, xylene, and benzene, as well as a head injury or a serious accident can lead to hearing loss (Arehart, 2005; May, 2000). All of the above reasons result in the risk to the degeneration of nerves in the ear. Previous studies have shown that workers who had a history of injuries to the head and ears as well as those who had experienced otitis dive deep, rubella, measles, mumps, chickenpox, and tinnitus were found to have hearing loss more than those who had no such history with statistical significance.

***Smoking***: According to a study conducted by Puwasit Singpoom, Srirat Lormphongs, and Jittrapun Pusapukdepob (2013) to determine the combined effect of noise exposure and smoking to hearing loss among casting factory workers in Panthong District, Chon Buri Province, it was found that the average age of the workers was 27.2 years old, with 51.7% being smokers. Of the total workers, 66.8% were exposed to noise of 85 dBA and higher, while 33.2% were exposed to the noise level lower than 85 dBA. The Chi-square test showed the relationship between smoking and hearing loss (p-value < 0.05). The OR for hearing loss among smokers was 11.91 (95% CI 7.17 – 19.78), whereas the OR for hearing loss among noise exposure and smoking was 7.76 (95% CI 4.10 – 14.68). The results indicated the relationship between smoking and hearing loss among the studied population (Puwasit Singhapoom, 2013).

***Ototoxic drugs***: Many drugs are poisonous to the auditory system. Many antibiotics, especially aminoglycoside, such as neomycin and streptomycin, can be toxic to the hair cells. The diuretics can also affect the hearing, such as furosemide and ethacrynic acid. Other drugs such as quinine and salicylates, an active ingredient in aspirin, can cause tinnitus or hearing loss. (Yost, 2000)

***Personal entertainment***: The definition of entertainment, it has the meaning as the action of providing or being providing with amusement or enjoyment of an event, performance, or activity designed to entertain others or the action of receiving a guest or guests and providing them with food and drink (Dictionary, 2013). Nowadays, in Australian, adults may be at risk of noise induce hearing loss because, they found that five selected high-noise leisure activities popular among young adult Australian, namely 1) nightclubs; 2) pubs, bars, and registered clubs; 3) fitness classes; 4) live sporting events; 5) concerts and live music. From this point of view, it seems as same as Thai young adult. From Nipaporn Charoenrit, 2005 revealed that the noise exposure from activities such as riding a motorcycle, listening to music through earphones, singing and playing music, and going to discotheque with high hearing level were significantly related. Furthermore, shooting can affect hearing as well. Olszewski et al. (2005) found that the gunshot impulse noise caused TTS. Besides, smoking can expedite NIHL (Pouryaghoub, Mehrdad, and Mohammadi, 2007). That means they have more risk than other people who did not work in high level of noise in workplace. This reason why personal entertainment is one of the interested factor to assess (Beach, Gilliver, & Williams, 2013).

***Music ear buds using***: Adults and children are commonly exposed to loud music. Between ear buds connected to iPods or MP3 players and music concerts, loud music can cause hearing loss. Because of the inner part of the ear contains tiny hair cells (nerve ending). The hair cells change sound into electric signals. Then nerves carry these signals to the brain, which recognizes sound. These tiny hair cell are easily damaged by loud sounds. The human ear is like any other body part—too much use and it may become damaged. Overtime, repeated exposure to loud noise and music can cause hearing loss (Foundation, 2014; Glorig, 1979; Mostafapour, Lahargoue, & Gates, 1998).

## 2.3 Standard prevention of occupational noise-induced hearing loss

Standards to prevent hearing loss from noise exposure can be used to reduce the noise in the working environment, as determined by experts inside and outside the country. Standard prevention of occupational noise-induced hearing loss consists of the following three main measures (Goetsch, 2011; Kongtip, B.E. 2545; Silpasuwan, B.E. 2548).

**1) Engineering controls:** To reduce the noise exposure of workers due to all machines, engineering controls can be implemented. Standard tone control that works best is suggested to perform the steps, from initial design process, including the installation of machine noise mufflers, installation of sound absorption wall and ceiling, sound-proof material covered partition, and regular maintenance (Goetsch, 2011; Office of the Workmen's Compensation fund, 2012; Suthammasa, B.E. 2547). The study of Somchart Arjkamol et al. (2005) to investigate the effects of the noise levels in the workplace during the years 2000 to 2004 at Gateway Chachoengsao showed that the establishment updated noisy machines by using springs and dampers to reduce the impact of farming on the floor, using a glass partition between the machines and the workers, and ensuring the quality of the whole production line. It was found that the noise was reduced from 96.1 dBA to 85.9 dBA, this demonstrates effective engineering controls (Somchart Arjkamol, B.E. 2548). However, it is worth noting that the reduced sound levels remained at levels that exceeded the acceptable standard.

**2) Administration controls:** For workers who are exposed to minimal risk, administration controls can be used in cases where engineering controls are not available or are not sufficient to reduce the noise level (Goetsch, 2011; Services, 1998). Administrative controls involve policies and effective maintenance, as well as reducing the duration of the noise exposure of workers with a turnover of work shifts. Workers' exposure to noise is reduced to a minimum level if the machine is noisy and needs to be running all day (Goetsch, 2011; Services, 1998; Suthammasa, B.E. 2547; u-suke, 2006). This will be effective and efficient to be implemented in a systematic manner. The policy is clear. There is a responsibility and a written evaluation.

**3) Personal controls:** To reduce the noise exposure by requiring workers to wear hearing protection devices at all times during noise exposure. Soundproofing will act as a sound barrier between the organs that receives the loud noise in the ear. This reduces the noise level down. The use of hearing protection to prevent hearing loss from noise is effective (Lusk & Kelemen, 1993), especially, if workers use hearing protection correctly and consistently. This is considered the best way to reduce hearing loss. A study that compared workers with and without the use of hearing protection, reported that workers who did not use hearing protectors are two times more likely to suffer hearing loss than workers who used hearing protectors. Moreover, a study conducted by Thidathip Harnchumpol (2003) found that at the factory where noise levels ranged of 92.67 to 102.07 dBA, 42.86% to 48.05% of workers who used ear plugs had temporary hearing loss, while 100% of those who did not use ear plugs suffered from permanent hearing loss (Harnchumpol, B.E. 2546; Levy, 2000; Roger, 2003; Suthammasa, B.E. 2547). However, it is possible that in the actual workplace, the controls are not sufficient to reduce the volume to a level that is safe for all workers (Levy, 2000; Roger, 2003; Sataloff, 2006). In practice, it is difficult to accomplish due to the high cost and the fact that it is time-consuming (Office of the Workmen's Compensation fund, 2012; Raymond, Hong, Lusk, & Ronis, 2006; Sataloff, 2006; Silpasuwan, B.E. 2548). In a study that developed a model system in factory health and environmental surveillance to prevent pollution of noise, (Sunan Sukolrattanamethee & B.E. 2540) implemented the engineering controls and administrative controls in some of the steps, but not all steps could not be made because of the high cost. Therefore, the control of male practiced hearing protection by wearing hearing protection devices. This behavioral control confirmed that there is a great need for workers who are exposed to noise levels higher than the standard criteria to use protective gears (Dear, 1998; Services, 1998). According to the aforementioned discussion, in Thailand, the Ministry of Labor has determined that the establishments or the employers need to control the noise volume to the acceptable level the employees are exposed to for an average duration of eight hours of work to not exceed 85dBA. In case they fail to do so, workers must be provided with hearing protection devices to reduce the risk of hearing loss (Ministry of Labor, B.E. 2549).

## 2.4 Hearing Conservation Program (HCP)

HCP had been introduced by Occupational Safety and Health Administration (OSHA) for many decades. It is required when a time-weighted average (TWA) exposure more than 85 dB (decibel) exists. It is now mandatory in many countries including Thailand. If this is not accomplished, the employers will be considered to be at fault (Glorig 1979; Osguthorpe1991; Dobie 1993). According to HCP, the managers were responsible for controlling loud noise, beginning with engineering (noise source and path) or administrative control. These are usually not functioning due to several reasons such as more cost to pay for new machine or building noise barrier for worker, lack of union rule, difficult to rotate worker to other stations, time consuming and interrupted process of production. If this control measure fails, then the hearing protective devices to high-risk workers should be applied.

In order to understand the HCP, it can be categorized as follow:

1) Hearing conservation policy and responsibilities.

2) Noise monitoring, noise survey and measurement, time exposure study and noise exposure assessment.

3) Noise control: administrative control, engineering control and hearing Protective devices (earplug, earmuffler etc.).

4) Hearing monitoring audiometry, consulting and referral system.

5) Educational training and motivation.

6) Record keeping: documentation, notification and audit.

Dobie (Dobie 1995) found several studies suggested that HCP could prevent NIHL but none of these were conclusive. He found that there was no randomized controlled trial or most of them suffered from the following shortcomings: failure to match treatment and control groups, failure to control for audiometric learning effects such as inclusion of workers who had already worked for a long time without hearing protection before performing audiometry. Meanwhile many authors agreed that the failure of the HCP might often be traced to a lack of education and training (Leinster, Baum et al. 1994; Dobie 1995; Pelausa, Abel et al. 1995). Only a few previous studies have been conducted or attempted to deal with or search more for a real practical point or more effective educational and training. Reynolds (Reynolds, Royster et al. 1990) introduced a new work-shift criterion, which had no impact on the effectiveness of HCP to use instead of old criteria. Finally, these were not imitated in many countries because of the administrative problems. Malchaire (Malchaire 2000) proposed a method that could be used by the workers themselves first, and then, in later stages, call in the assistance of specialist to identify more complex solution and medical surveillance. But his strategies were not clear enough to be repeated by other studies such as timing, monitoring, management, maintenance, media instruction etc. They only proposed strategies in many aspects for possible success in control noise.

## 2.5 The use of hearing protection

The use of hearing protection is a preventive behavior to reduce the risk of hearing loss from exposure to loud noise. Correct use of hearing protectors is the best way to reduce the loss of hearing. The ideal method is practical and comes with low operating costs (Hong et al., 2005).The use of hearing protection can be categorized as shown below: 1) Proper use and wearing, 2) Acoustic maintenance, and 3) Proper use of hearing protection (Sataloff, 2006; Services, 1998).

2.5.1 Proper use and wearing: The noise protection devices must be used and worn properly according to the intensity or loudness of sound (Yusuk, B.E. 2549). As such, each of the protective features to prevent sounds is different from one another. The features can be generally classified according to the ability to reduce noise. They include ear protective devices inserted in the ear, ear muffs, and ear plugs (Services, 1998; Suthammasa, B.E. 2547), which can be further described as follows:

2.5.1.1 Ear protective devices inserted in the ear are inserted into the ear of a size suitable for the ears of the individuals. The material is mostly made up of cotton wax, silicone, rubber, or plastic. Key features are small, portable, and easy and comfortable to wear (Sataloff, 2006; Services, 1998). These devices can reduce noise by approximately 15-25 dBA, depending on the materials (Office of the Workmen's Compensation fund, 2012; Yusuk, B.E. 2549). The sound reduction of at least 15 dBA is one of the criteria. They can be applied to noisy areas with noise louder than 90 dBA, such as noises caused by metal stamping, textile machine, grinding, polishing surfaces, wood cutting, and welding (Limited, B.E 2550).

Wearing ear protective devices is recommended. The handedness reaches back over a worker's head and pulling the ear on the opposite side to the back to the right ear, then with the other hand the ear plugs are gently pushed until they snugly fit the ears. To unplug, the workers grasp the plug, and then slowly pull them out without pulling on the rope. As for wearing foam ear plugs, they expand the regular ear plugs into the ear canal. The workers use their fingers to roll the foam to the smallest size possible. After inserting ear plugs into the ear for 30 seconds, the workers use the finger to fully expand the earplugs (Opasmongkolchai, B.E.2550; Suthammasa, B.E. 2547). A study conducted by Chatchanee Kampibal (UN ACC Sub-Committee on Nutrition) found that worker 87.5% of workers did not know how to put ear plugs on correctly. As a result, the use of hearing protectors was not effective to reduce noise as much as they could have (Kampibal, B.E. 2543).

2.5.1.2 An ear muff is used all around the ear cups and the like, with a steel rod wrapped with a plastic interlayer that covers both ears. Key features include sound insulation material which is liquid, foam, plastic, or rubber lining recited inside to absorb sound passing to the inner ear. Ear muffs can reduce noise by about 30-40 dBA, depending on the type of materials, but the limit is it is not easily portable. In cases of the workers are wearing glasses, the ear muff cannot be used to cover the ears. Moreover, cleaning is hard, and they are more expensive than ear plugs (Office of the Workmen's Compensation fund, 2012; Yusuk, B.E. 2549). Ear muffs can be applied to noise levels higher than 90 dBA, such as metal stamping, textile machine, grinding, polishing surfaces, wood cutting, and welding((Limited, B.E 2550).

Precautions are needed to be kept in mind when wearing ear muffs because obstructions such as hair, ornaments, or glasses allow noise to creep into the ear (Opasmongkolchai, B.E.2550; Suthammasa, B.E. 2547).

2.5.1.3 Ear plugs offer hearing protection, and they are specially made for the size of each ear. By applying them from ear to ear, they are easy to wear. Ear plugs are made of silicone, and some of them can reduce noise by 14 dBA on the outside of the inserted ear. Ear resembling earplugs are attached to the head strap to help push the device into the ear canal(Yusuk, B.E. 2549).

Wearing headphones can be done by properly using the hand to reach back over the head and pull the ear on the opposite side to the back. Then, the other hand is used to grasp the handle and gently push it in a straight line to fit the ear. The removable handle is inserted to hold the plug, then it is slowly pulled out without pulling the headband (Suthammasa, B.E. 2547).

2.5.1.4 Correct maintenance of sound: To maintain a sound and effective way of protecting the wearer's health, the device has to be cleaned after usage through the simple method specified by the manufacture. For example, for ear plugs and ear muffs, use a paper towel to eliminate the dirt. Thereafter, they are washed with water and mild soap before being wiped or dried in a clean storage place. There must be a good ventilation, as well as flexible monitoring. Cleaning the cap is similar to checking each piece of equipment that is damaged or torn (Opasmongkolchai, B.E.2550; Sataloff, 2006; Suthammasa, B.E. 2547). Although maintenance of hearing protection is necessary, a study of Nattaya Mapradit (1999), found that only 19.5% of the workers cleaned hearing protection devices after work every time, while 80.5% of them did not clean their hearing protection devices. Only 28.3% of the workers correctly cleaned their devices with water and mild soap.

2.5.1.5 Consistent use of hearing protectors: Consistent use of hearing protectors is essential in order to effectively use audio equipment to reduce the noise exposure. Workers should correctly and safely use hearing protection devices consistently throughout the duration of the noise exposure. Studies have shown that the use of hearing protectors correctly can reduce hearing loss effectively (Sataloff, 2006; Services, 1998). In practice, there are workers who do not use hearing protection at all. The use of hearing protection is one of the important measures that has low investment and yields good results. According to previous studies (Landen, Wilkins, Stephenson, & McWilliams, 2004; Mapradit, B.E. 2542) reported that 56.7% to 91.3% of workers did not regularly use hearing protection devices. Furthermore, studies have shown that 44.2% to 74.0% of workers who were exposed to loud noise intermittently never used hearing protection devices (Guerra et al., 2005; Hong et al., 2005; Suter, 2002). Moreover, some studies have found that 8.7% to 44.5% of workers exposed to noise would use the hearing protection devices at all times (Landen et al., 2004; Mapradit, B.E. 2542). According to previous studies, the reasons for refusal to use hearing protection devices as a barrier to prevent noise interference included their interference with communication and warning alarms, feeling of discomfort (Arezes & Miguel, 2005; Neitzel & Seixas, 2005; Suter, 2002), and inability of hearing protection to offer adequate soundproof. Thus, these workers felt that there was no need to use hearing protection devices. Also, it is possible that the workers do not know that they work in a noisy environment and do not see the benefit of using the device to prevent the noise impact ((Urajjananon, B.E. 2549).

A study of the National Committee on Noise Pollution Control measured hearing impairment in various occupational groups in Thailand found 21.1% to 37.7% suffering from NIHL among other kind of impairments (WHO, 1997). Also, a large-scale study including nearly 7,499 people from different regions of Thailand revealed that on average 13.6 per cents of sample population were suffering from different degrees of hearing loss (> 40 dB at 0.5, 1 and 2 kHz in better hearing, respectively) (Prasansuk, 2000). Since many studies about hearing impairment in several countries used different hearing loss criteria and different age groups, standardized prevalence of adult-onset hearing loss had been developed. Figures 2.1 and 2.2 summarize the estimated age-standardized prevalence of adult-onset hearing loss at 41+ dBHLT and 61+ dBHLT, respectively.

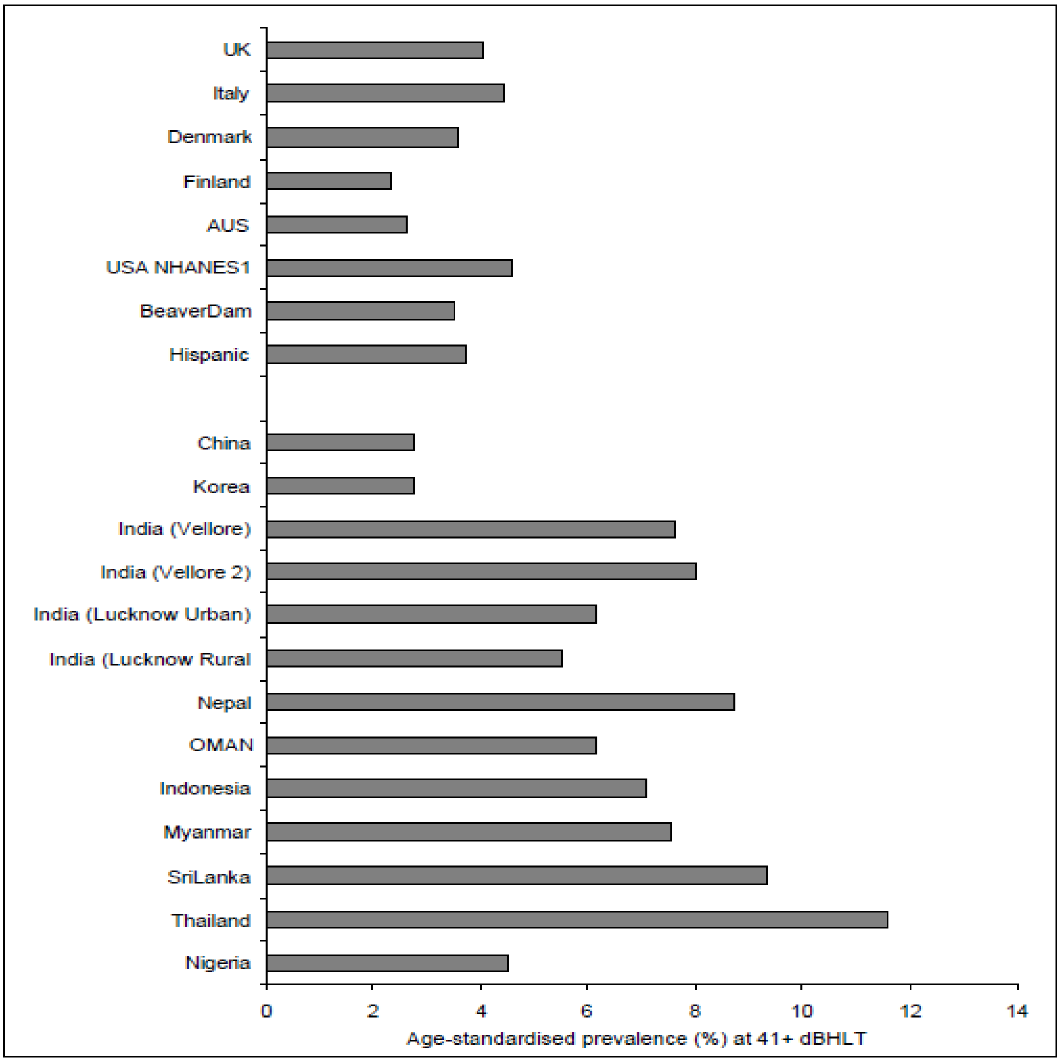

**Figure 2** Estimated age-standardized adult-onset hearing loss prevalence rates, 41+ dBHLT

**Source:** WHO (UN ACC Sub-Committee on Nutrition)

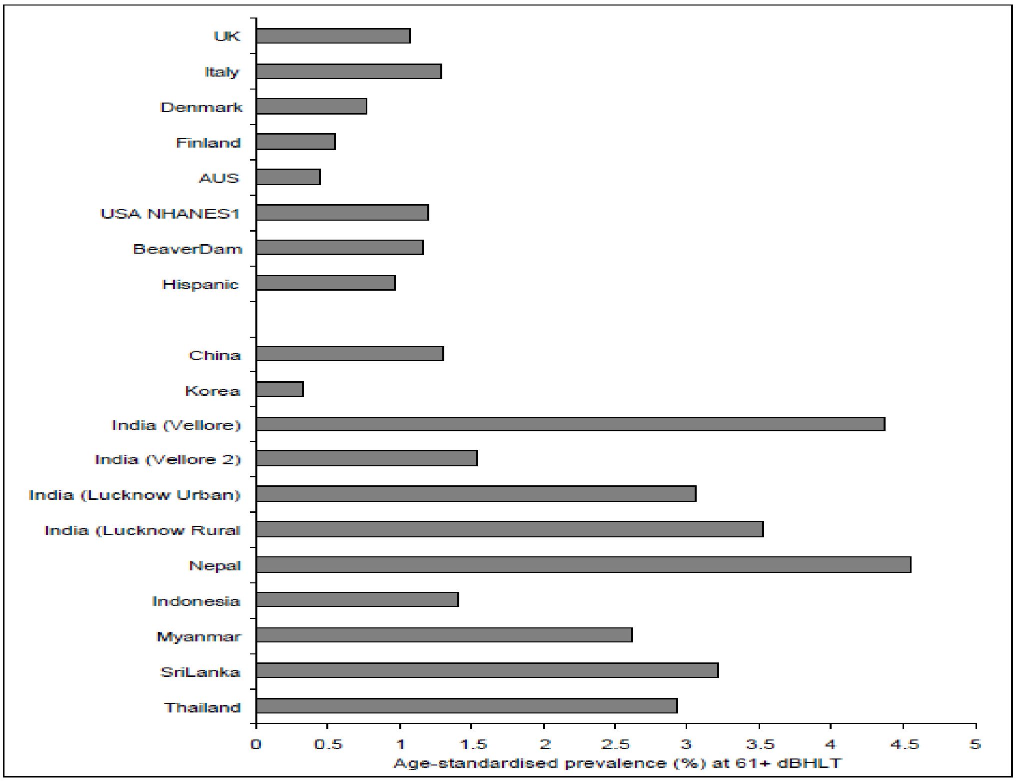

**Figure 3** Estimated age-standardized adult-onset hearing loss prevalence rates, 61+ dBHLT

**Source:** WHO (UN ACC Sub-Committee on Nutrition)

Therefore, the behavior of using hearing protection to reduce the risk of hearing loss is necessary, but the factors that influence the use of hearing protectors of the workers need to be taken into careful consideration.

### 2.6 Behavior related to HPD use

To reduce the noise exposure by requiring workers to wear hearing protection devices at all times during noise exposure. The use of hearing protection to prevent hearing loss from noise is effective (Lusk & Kelemen, 1993), especially if workers use hearing protection correctly and consistently. This is considered to be the best way to reduce hearing loss. Thidathip Harnchumpol (2003) found that at the factory where noise level was in 92.67 to 102.07 dBA range, 42.86% to 48.05% of workers who used ear plugs had temporary hearing loss, while 100% of those who did not use ear plugs suffered from temporary hearing loss. A study, conducted by Chatchanee Kampibal (UN ACC Sub-Committee on Nutrition), found that 87.5% of workers did not know how to wear ear plugs correctly. As a result, the use of hearing protectors was not effective to reduce noise as much as they could be. Landen, Wilkins, Stephenson, & McWilliams, 2004; Nattaya Mapradit, 1999 reported that 56.7% to 91.3% of workers did not regularly use hearing protection devices. Guerra, - Lourenço, Bustamante-Teixeira, & Alves, 2005; Hong et al., 2005; Suter, 2002 studies had shown that 44.2% to 74.0% of workers who were exposed to loud noise intermittently, never used hearing protection devices. Moreover, some studies had found that 8.7% to 44.5% of workers exposed to noise would use the hearing protection at all times. Landen, Wilkins, Stephenson, & McWilliams, 2004; Nattaya Mapradit, 1999 reported that 56.7% to 91.3% of workers did not regularly use hearing protection devices. The reasons for not using hearing protection devices were their interference with communication & warning alarms, feeling of discomfort, inability of hearing protection to offer adequate soundproof. Hence, these workers felt that there was no need to use hearing protection devices. The workers did not realize that they were working in noisy environment and did not see the benefit of using the device to prevent noise disturbance.

## 2.7 Previous research about interventions to promote wearing hearing protection devices

**Table 2** Literature review of previous studies

| Intervention | Outcome measurement | result |
|---|---|---|
| **Berg 2009:** Hearing conservation program for agricultural students: short-term outcomes from a cluster randomized trial with planned long-term following-up. | | |
| Classroom instruction | - Audiometric threshold changes<br>- Self reported on use of hearing protection devices when exposed to noisy environments , assessed using a three-point Likert-type scale (never, sometimes, always/almost always). | There was no statistically significant difference between the intervention group (mixed intervention) and the control group |
| **Hong 2006:** Efficacy of a computer-based hearing test and tailored hearing protection intervention | | |
| A tailored intervention which was developed on the basis of the participants' hearing test results | - Self reported on hearing protection device use<br>- Mean usage of hearing protection devices | the difference in the mean use of hearing protection devices did not reach statistical significance |
| **Kerr et al. 2007**: Effectiveness of computer-based tailoring versus targeting to promote use of hearing protection | | |
| Tailored education or targeted education , with or without booster messages | - Use of hearing protection devices,<br>- Benefits of hearing protection device use<br>- Barriers to hearing protection device use | the tailored participants improved their hearing protection device use by 8.3%, while the control group improved their use by 6.1%. The tailored intervention plus booster group, expected to be the best intervention, improved hearing protection device use by 12.6% |
| **Knobloch 1998:** A hearing conservation program for Wisconsin youth working in agriculture | | |
| The intervention consisted of four years of a strategy comprising five components: classroom style education, reminders through periodic school visits and direct mailings, noise level assessments, distribution of a variety of free hearing protection devices provided and replaced on a regular basis, annual hearing tests | - Percentage of participants who used hearing protection devices | At the start of the study only 23% of the intervention group and 24% of the control group wore hearing protection "at least sometimes". At the end of three years this reaction had increased to 83% in the intervention group and 35% in the control group |

<table>
<tr><td colspan="3"><b>Lusk et al., 2003:</b> Effectiveness of a tailored intervention to increase factory workers’ use of hearing protection devices</td></tr>
<tr><td>Hearing Conservation Programme</td><td>- Self reported type of HPD used; perceived hearing ability; self-reported use of hearing protection devices and perceptions of benefits, barriers and self-efficacy</td><td>There was no statistically significant difference between the non-tailored information group and the control group (a commercially available video on the use of hearing protection)</td></tr>
<tr><td colspan="3"><b>Seixas et al., 2011:</b> A multi-component intervention to promote hearing protector use among construction workers</td></tr>
<tr><td>Trainings, Toolbox training and use of a personal noise level indicator (NLI)</td><td>Mean percent use of time<br>Prevalence in using 50% of the time</td><td>Prior to intervention, HPDs were used an average of 34.5% of the time and increased significantly, up about 12.1% after intervention and 7.5% two months after interventions were completed</td></tr>
</table>

## 2.8 Effect of the alarm to behavior

Alarms were added to alert the operator to a condition that was about to exceed a designed limit, or had already exceeded a designed limit. Alarms were indicated to the operator by annunciator horns, and pilot lights of different colors. Alarms on clinical device are intended to call the attention of caregiver to patient or device conditions that deviate from a predetermined “normal” status. They are generally considered to be a key tool in improving the safety of patient. The purpose of alarm systems is related to “communicating information that requires a response or awareness by the operator” (Simons & Fredericks, 1997). By these reasons, the use of alarm concept to create a new technology “noise warning application” on promoting the hearing protection device is an interesting innovation intervention that answers the purpose of this study.

## 2.9 Mobile technologies, Application, and Effectiveness of mobile-health technology-based to health behaviors change

Mobile technologies are the people’s mobile phone usage versatilities, whereas many people carry their mobile phones with them wherever they go. Mobile technologies include mobile phones; personal digital assistants (PDAs) and PDA phones (e.g., BlackBerry, Palm Pilot); smartphones (e.g., iPhone); enterprise digital assistants (EDAs); portable media players (i.e., MP3-players, MP4-players, e.g., iPod); handheld video-game consoles (e.g., PlayStation Portable [PSP], Nintendo DS); handheld and ultra-portable computers such as tablet PCs (e.g., iPad), and Smartbooks.These devices have diversified range of functions from mobile cellular communication using text messages (SMS), photos and video clips (MMS), telephone, and World Wide Web access, to multi-media playback and software application support. Technological advancement and improved computer processing power mean that single mobile device, such as smart phones and PDA phones are increasingly capable of high performance in many or all of these functions. The features of mobile technologies which may make them particularly appropriate for providing individual level support to health care consumers related to their popularity, their mobility, and their technological capabilities. The popularity of mobile technologies has led to high and increasing ownership of mobile technologies, which means interventions can be delivered to a large number of people. In 2009, more than two-thirds of the world’s population could own mobile phones and 4.2 trillion text messages were sent (Union IT, 2010). In many high-income countries, the number of mobile phone subscriptions outstripped the population (Ofcom, 2009). In low income countries, mobile communication technology was the fastest growing sector of the communications industry and geographical coverage was high (Banks K, Burge R ,2004; Donner J, 2008; Feldmann V, 2003; Sciadas G, Guigue`re P, Adarn L,2005).

This phenomenon allows temporal synchronization of the intervention delivery and allows the intervention to claim people’s attention when it is most relevant. For example, health care consumers can be sent messages designed to sustain their motivation to quit smoking throughout the day. Temporal synchronization of the intervention delivery also allows interventions to be accessed or delivered within the relevant context, i.e., the intervention can be delivered at any time and extra-support can be requested wherever and whenever it is needed. For example, smokers who are trying to quit smoking, can send text messages requesting extra-support while they are experiencing craving due to withdrawal from nicotine, or those with asthma can access advice regarding how to increase the use of inhalers during an exacerbation of asthma. The technological capabilities of mobile technologies are continuing to advance at a great pace. Current technological capabilities allow low cost interventions. There are potential economy of scale as it is technically easy to deliver interventions to large populations (for example, mobile technology applications can easily be downloaded and automated systems can deliver text messages to large numbers of people at low cost). The technological functions that have been utilized for health care consumers include text messages (SMS), software applications, and multiple media (SMS, photos) interventions. The technology supports interactivity, which allows people to obtain extra-help when needed (Rodgers A, et al., 2005; Free C, et al., 2009). Motivational messages, monitoring, and behavior change tools used in face-to-face support can be modified for delivery via mobile phones. Interventions can be personalized with the content tailored to the age, sex, and ethnic group of the participant or to the issues they are confronting (Rodgers A, et al., 2005; Free C, et al., 2009).

## 2.10 Previous research about Effectiveness of mobile technologies to change behavior

Hurling et al. (2007) who studied using SMS to support physical activity among 77 healthy adults in Bedfordshire, UK, found that the intervention group showed significantly more moderate-intensity physical activity than the control group at 9 weeks ($p < 0.02$).

Joo and Kim (2007) who studied using SMS to modify anti-obesity behavior among 927 healthy adults in Korean public health clinics revealed that at 12 weeks, there were mean decrement in weight, waist circumference and BMI in those who completed the 12-week program. Also, these changes showed significance.

Cocosila et al. (2009) who studied the effectiveness of wireless text messaging for improving adherence to a healthy behavior among 102 sample group, found that participants receiving mobile phone messaging reminders to take vitamin C tablets for preventive reasons, showed significantly higher self-reported adherence, and a marginal reduction in the number of missed tablets in the last 7 days compared to those who did not receive any reminders

# CHAPTER III
# RESEARCH METHODOLOGY

In this chapter, the following topics will be discussed:

3.1 Research design

3.2 Study area

3.3 Study period

3.4 Study population and sample

3.5 Intervention design

3.6 Measurement tools

3.7 Data collection

3.8 Data analysis

3.9 Ethical consideration

## 3.1 Research design

This study was an quasi-experimental methods to determine the effectiveness of the noise warning application [Nowa App.] to promote use of hearing protection devices among steel industrial workers in Samut Prakan Province, Thailand. The intervention was implemented at individual level. The study sample was divided into two groups: 1) the control group (no intervention) and 2) the intervention group (used noise warning application)

## 3.2 Study Area

The recruitment of participants for this study was conducted at a steel industrial factory in Samut Prakan Province which is situated in the central region of Thailand. Samut Prakan Province is an important source of raw materials from overseas and warehouses, and it is a province where many factories are established. The location of the steel industry in Samut Prakan Province was selected as the research site in this study as shown in Figure 3.1.

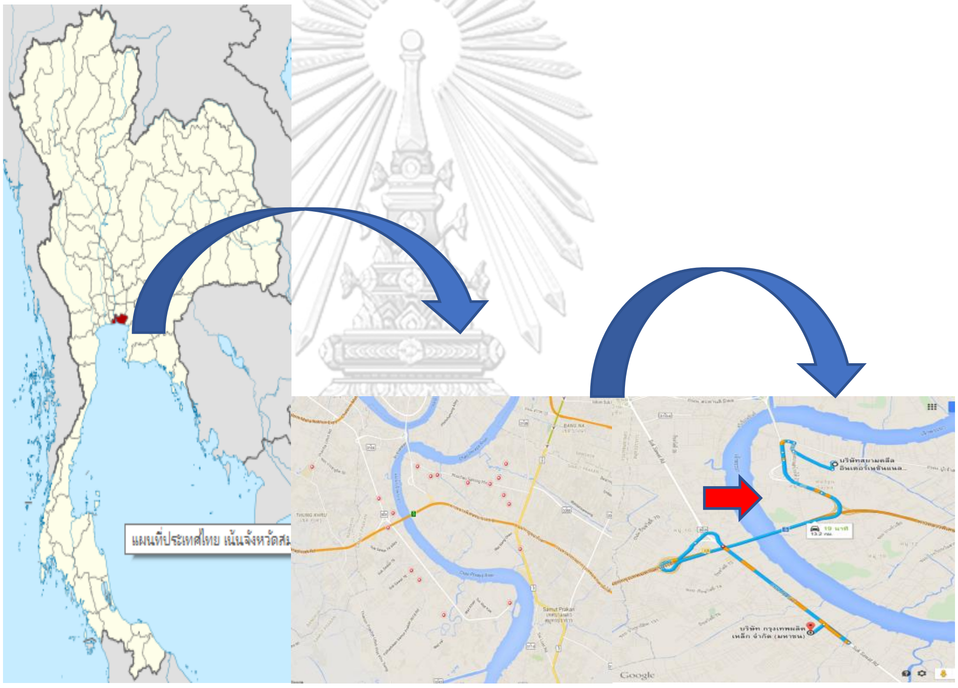

**Figure 4** Location of Samut Prakan Province

(Source: www.google.com; http://en.wikipedia.org)

## 3.3 Study period

The total period of the study had been continued for seven months, which could be divided into one month of baseline data and six months of intervention.

## 3.4 Study population and sampling

Workers who were working at a steel factory in Samut Prakan Province constituted the population of this study. The study participants were selected by based on the following selection criteria:

### 3.4.1 Selection criteria of steel factories

#### 3.4.1.1 Inclusion criteria

1) They are factories manufacturing and forming steel.

2) Their number of workers was more than 200 persons.

It was worthwhile noted that each factory has adequate number of participants and the size of factory is considered large enough to have safety officer/supervisor and occupational nurses available.

3) The operating background noise was louder than 85 dB (A). This is because the loudness of noise level over 85 dB (A) can cause hearing loss that the HPDs is apparently necessary.

4) The factory's staff had undergone the training and passed the Hearing Conservation Program to ensure that factory workers were educated with necessary knowledge. In fact, the training had been proved to be a generally effective means to enhance behavioral change in individual. Moreover, the factory had already been providing HPDs for workers who were at risk of hearing loss.

#### 3.4.1.2 Exclusion criterion

1) The workers who refused to participate in the study.

### 3.4.2 Selection criteria of study participants

#### 3.4.2.1 Inclusion criteria

1) They were Thai male worker with the age range of 18 - 60 years old.

2) They had been working at the steel factory and their line of work involved the process of steel manufacturing and forming or assembling operation.

3) They had been working eight hours per day, five days a week, for at least one year

4) They did not have severe or profound impairment or ear problems, including unilateral deafness and chronic middle ear infection, or they did not have ear anomalies that made them unable to use HPDs.

5 The factory was considered large enough to have safety officer/ supervisor and occupational nurses who used mobile phones in the android system.

6) They were literate in Thai language.

#### 3.4.2.2 Exclusion criteria

1) The workers who were unwilling to participate in the study.

2) They could not participate in the study throughout from the beginning to the end of the study.

3) They had history of illness during the study, such as head injury or concussion, ear trauma, otitis, etc.

4) They regularly use HPD at all time

There were total 136 steel factories, located in Samut Prakan Province, which were registered to the Office of Social Security. When selection criteria had been applied to screen factories, it could be seen that factories which had more than 200 workers, had a similar process of steel manufacturing. Is shown in Appendix A

Furthermore, it was found that there were ten factories which were running some steps of steel manufacturing with accumulative noise greater than 85 dBA. All steel factories had been approved by the Hearing Conservation Program; then, two factories will be randomly arranged into 2 groups, one was the control group and another as the intervention group.

After recruiting two steel factories to participate in this research study, it was found that both factories had similar procedures in the manufacturing process, including the processes of smelting and reforming. Each process, smelting or reforming, had similar components of sub-section. The process of smelting included three sections of smelting, raw material handling and maintenance. The section of smelting involved in accumulative noise that exceeded 85 dBA, so steel workers who worked in this section were the target population of the study. On the other hand, the sections of raw material handling and maintenance hardly had accumulative noise that exceeded the limit.

The process of reforming or shaping included three sections of reforming, raw material handling, and maintenance. The section of reforming or shaping had accumulative noise that exceeded 85 dBA, so the steel workers who had to work in this section were the target population. The sections of raw material handling and maintenance hardly had the accumulative noise exceeding the loudness limit. Additionally, there were two other divisions which comprised of the back office and transportation. These two divisions did not have accumulative noise that exceeded the limit. Therefore, the participants who were eligible to participate in this research study came from the sections of smelting and reforming. Unfortunately, due to economic recess, the section of smelting had stopped its operation. Consequently, the only section available for the study was the reforming section where steel workers continued to work with high level of noise. In the end, there were total of 68 steel workers participating in this intervention research. Although all 68 participants were willing to take part in this study, in order to reassure sufficient samples, power analysis was performed. According to Noordzij et al. (2010), at least 44 participants were needed to achieve the power of 0.80. Therefore, with 68 participants, the present research study had sufficient power.

Since the power analysis for sample size calculation, the minimum and appropriate sample size for continuous outcome of the intervention group and the waitlist control group, the influential parameters were defined as follows (Noordzij et al., 2010):

n = the sample size in each groups
μ1 = population mean in the treatment Group 1
μ2 = population mean in the treatment Group 2
μ1- μ2 = the difference the investigator wishes to detect
σ2 = population variance (SD)
a = conventional multiplier for alpha = 0.05
b = conventional multiplier for power = 0.80

This formula is generally used to estimate the Type I error probability associated with this test of the null hypothesis of 0.05. The power analysis to detect the difference between the intervention and control groups was set at 0.80. This was based on a previous study (Hong et al., 2006) reporting efficacy of a computer-based hearing test and tailored hearing protection intervention. The results showed that the effect which was measured after the intervention showed an increase in HPD use (8%

in the tailored intervention group and 2% in the control intervention group, SD = 10).

Thus,

$$n = 2 \times [(1.96 + 0.842)^2 \times 10^2] / 6^2$$

$$= 43.62, \text{ approximately 44 workers per group}$$

Therefore, the total number of participants should not be fewer than 44 workers for the intervention and control groups. However, in this study, up to 5% of the calculated sample size were added into the study sample in order to avoid the problem of subject mortality or dropout. In the end, the sample size was close to equal by 44 workers in intervention factory and 46 workers in control factory. The sampling technique is shown in Figure 3.2 below.

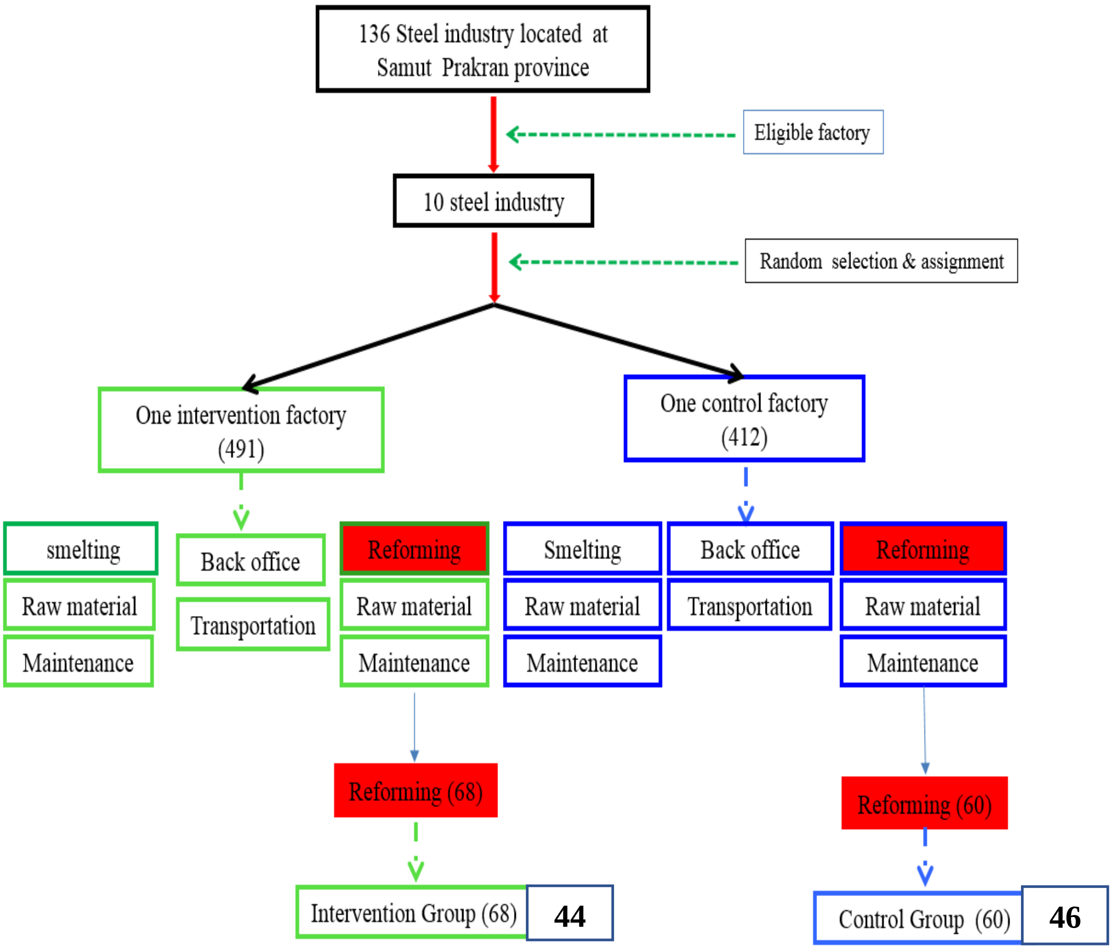

**Figure 5** Sampling Technique and Sample Recruitment

## 3.5 Intervention Design

The main intervention was the Noise Warning Application [Nowa App.] to promote the HPD use among steel workers.  The Nowa App. started operating one month after baseline data collection. This Nowa App. was provided to the intervention group for six months with 6 observation

The image of the Nowa App.Is shown in Appendix B. The lesson plan for the training is included in Appendix C.

### 3.5.1 Main part of intervention: Noise warning Application [Nowa App.]

The NoWa App. has been designed by computer engineer to calculate 8 hours cumulative volume of noise of loudness level <85 decibels A. It will process the average noise level exposed for 1 minute and compare for 8 hours, if the value exceeds, there will be signaling alarm by the pilot light and/or vibration showing which is set to each alarm for about 30 seconds. Due to the target group always work in the noisy environmental area, therefore, if the warning too frequently occurs, it may interfere with their working, so the alarm can be adjusted to every 30 minutes or every specific hour or hours, depending on the priority of the work at that moment. Both types of warning can be controlled on the monitoring panel screen which is easy to its application.

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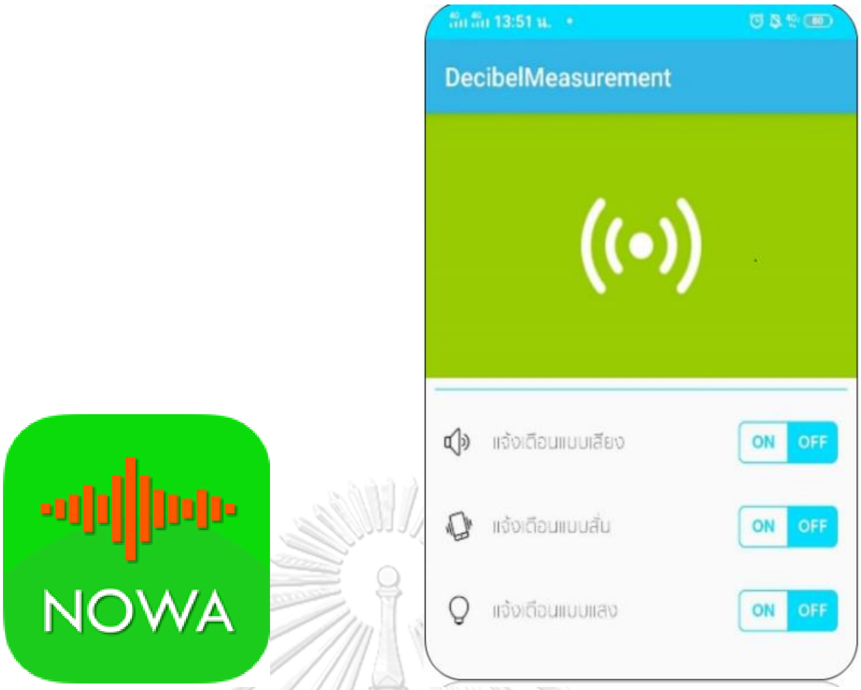


**Figure 6** Noise Warning Application [NoWa App]

NoWa App is designed to follow the pattern of loud noise source warning by vibration and pilot light when the cumulative noise exposure is over the work allowable limit. This program will enhance motivation of the HPDs use. The Noise Warning Application will be downloaded to mobile phone and it will perceive for noise measured over the standards before running out for 6 months service life. Every NoWa App. will be provided to mobile phone used by principal investigator /research assistant in every working hour only. The intervention group will receive the training about using the NoWa App., such as the reason to used it, benefit of using NoWa App, how to use it, the optional way to response, effectiveness of NoWa App., and calling for problems necessary for assistance.

## 3.6 Measurement Tools

### 3.6.1 Questionnaire

The questionnaire was used to collect data regarding factors associated with the use of hearing protection devices among steel industry workers. The questionnaire were shown in Appendix D, E, F, G. It consisted of six parts as follows:

**Part I: Demographic characteristics and experiences with noise exposure**

Data regarding demographic characteristics and experiences with noise exposure were collected including age, education background, noise exposure, duration of work, risk behaviors (ear disease, smoking, ototoxic drugs, personal entertainment (riding a motorcycle, singing and playing music, going to discotheque, shooting), and use of music ear buds), as well as past experience of noise exposure.

**Part II: Work Characteristic**

The Work Characteristic were including Duration year of working in steel industry, working time in one day (including regular work hour and over time) and all week, duration time to stay in the loud noise area, history of work in loud noise area in previous job, and the knowing information of the level of noise to which they were exposed.

**Part III: Availability of HPD** were elicited into two part:

1) Availability of HPDs from part of industry to support the worker both policy measure and HPDs (proper and enough)

2) Availability of HPDs from part of worker to use the HPDs

### Part IV: Knowledge on hearing protection device use

The questionnaire on the knowledge on hearing protection device use had been designed, based on literature review and was evaluated to confirm its content validity by a research team consisting of three experts. However, no reliability testing was conducted. The reliability coefficient would then be tested before use it in the main study with 30 factory workers whose characteristics were similar to those of the participants of the study. The validity of the questionnaire would be examined by experts in the area of occupational health and public health before the questionnaire was revised according to the experts' comments and suggestions. The questionnaire on knowledge on hearing protection device use contained 12 questions which covered the topics in the HPD usage. The answering choices for these questionnaire's items were arranged in a three-point rating scale of "Yes," "No," and "Don't know." A score of 1 point was given to each correct answer, and no score was given to incorrect answers. The scale score range from 0 - 12 for total knowledge on hearing protection device use. The questionnaire is deliberatively shown in Appendix D & F

### Part V: Attitudes toward use of hearing protection devices

The questionnaire on attitudes toward use of hearing protection devices had been designed, based on literature review and has been evaluated to confirm its content validity by a panel of three experts. However, no reliability testing was conducted. The reliability coefficient had been tested before it was administered in the main study with 30 factory workers whose characteristics were similar to those of the participants in the study. The validity of the instrument had been examined by experts in the area of occupational health and public health and the questionnaire would be revised according to their comments and suggestions before its actual use in the study. The instrument comprised 12 items arranged in a five-point rating scale (1-5). The scale score range from 1- 60 for total attitudes on hearing protection device use. The attitudes toward the use of hearing protection devices questionnaire were shown in Appendix D & F.

**Part VI: Behavior of hearing protection device use**

The questionnaire on the behavior of hearing protection device use had been designed, based on literature review and was evaluated to confirm its content validity by a panel of six experts in the area of occupational health and public health, and the questionnaire would be revised according to the experts' comments and suggestions. The questionnaire on behavior of hearing protection device use contained 1 questions that covered the topics related to use of HPDs in weekly working of workers. The questionnaire on the behavior of hearing protection device use is shown in Appendix D, F.

### 3.6.2 HPD using report

The HPD using report was a self-reported form on which the workers recorded their HPD using time during their daily working. Accurate measurement would be inspected by a safety officer/supervisor and observed by research assistants. The data of appropriate workers' self-reported HPD use in a previous study and the factory workers' HPD using report data were compared with the data obtained from a supervisor's observation. A high level of correlation between self-reported use and the supervisor's observation was revealed ($r = 0.89$, $P < 0.01$) (Lusk, Ronis, & Baer, 1995). For this study the correlation between self-reported use and the supervisor's observation was revealed ($r = 0.86$, $P < 0.01$)

The use of HPDs among workers in this study was calculated into the mean percentage time of HPD use during the shift. The self-administered HPD use report data were shown in Appendix E, G.

### 3.6.3 Audiometry

An audiometric test was conducted with the equipment called “audiometer” to examine the workers’ hearing ability. The descending technique (the intensity level of tone was variously adjusted to be decreased by 10 dB and increased by 5 dB) was used to determine hearing threshold at the frequencies of 500, 1000, 2000, 3000, 4000, and 6000 Hz. respectively, To ensure the accuracy of audiometric test results, the noise levels measured by the sound level meter in an audiometric test booth would not exceed the criteria of maximum permissible ambient noise levels for audiometric test rooms (ANSI, 1991). Also, the audiometer was calibrated before starting the study. The image of an audiometry is illustrated in Appendix H and the Audiometry record form of data is shown in Appendix I.

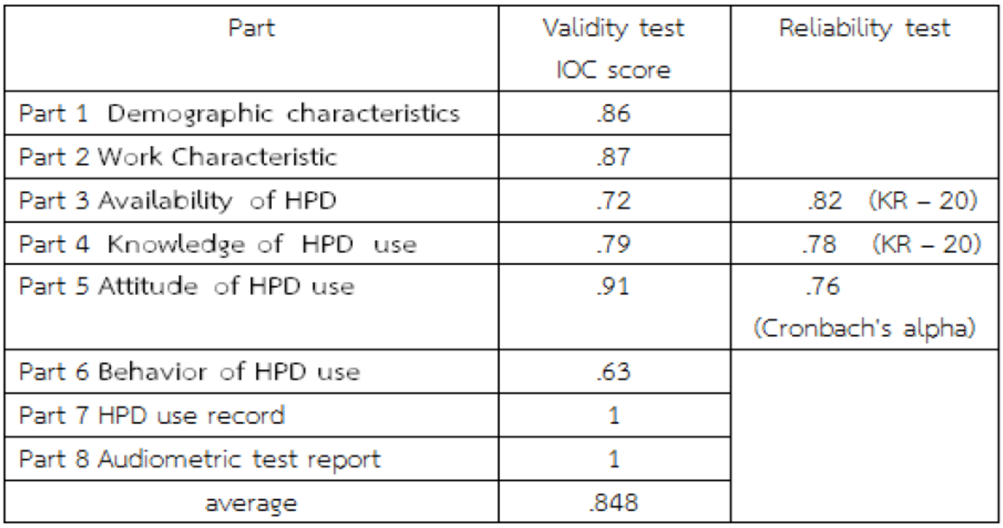
### 3.6.4 Validation of the Tests for the research instrument

The questionnaire has been designed based on a literature review. The instrument for data collection were assessed into 2 issue:

**1. Content validity:** the questionnaire for evaluation knowledge, attitude, and behavioral gain were investigated by six experts: one occupational medicine doctor, one otorhinolaryngology doctor, one occupational nurse, association president of occupational health and safety, association president of occupational Health Nurse of Thailand and one Assistant professor in public health. The first Index of Item Objective Congruence (IOC) of evaluation test was shown in Table 3. After that the questionnaire revised according to the experts’ comments and suggestions. The Index of Item Objective Congruence (IOC) of evaluation test was 1 after improving by 6 experts.

**2. Reliability:** the questionnaire for evaluation knowledge, attitude, and behavioral gain were tested with 30 factory workers in Samut Prakarn province with similar characteristics to those of the participants of the main study before it was used. The Kuder-Richardson Method (KR-20 method) were employed to assess the reliability for knowledge about HPDs use. The cut-point was Alpha 0.7. The questionnaire was qualified when the Alpha was more than 0.7. After considering reliability coefficient, the questionnaire was improved. The questionnaire with the reliability for evaluation of knowledge gain as Alpha of 0.78 was used to collect data from the subjects. Furthermore, The Cronbach’s alpha were employed to assess the reliability for attitude about HPDs use. The cut-point was Alpha 0.7. The questionnaire was qualified when the Alpha was more than 0.7. After considering reliability coefficient, the questionnaire was improved. The questionnaire with the reliability for evaluation of attitude gain as Alpha of 0.76 was used to collect data from the subjects.

**Table 3 Validation of the Tests for the research instrument**



| Part | Validity test<br>IOC score | Reliability test |
|---|---|---|
| Part 1 Demographic characteristics | .86 | |
| Part 2 Work Characteristic | .87 | |
| Part 3 Availability of HPD | .72 | .82 (KR – 20) |
| Part 4 Knowledge of HPD use | .79 | .78 (KR – 20) |
| Part 5 Attitude of HPD use | .91 | .76<br>(Cronbach's alpha) |
| Part 6 Behavior of HPD use | .63 | |
| Part 7 HPD use record | 1 | |
| Part 8 Audiometric test report | 1 | |
| average | .848 | |

## 3.7 Data Collection

Data collection conducted with factory workers was divided into three phases, namely, the baseline data, the intervention program, and the end of program. During the baseline and the end, data were similarly collected by means of interviews, self-reports with inspection, audiometry, and noise exposure assessment. The baseline data collection lasted one month. Then, the intervention program would be delivered for six months to 6 observations of HPD use during the shift. All six research assistants were trained on how to conduct data collection before starting the study. Besides, all workers were asked to sign the inform in the consent forms to indicate their willingness to participate in the data collection. The diagram of data collection is shown in Figure 3.3.

### 3.7.1 Baseline

All workers were interviewed to elicit data regarding their demographic characteristics and noise exposure experience, as well as their knowledge on and attitudes toward hearing protection device use. They were asked to respond to the use of HPDs and were given an audiometric test and a noise exposure assessment.

#### 3.7.1.1 Questionnaires

The general questionnaire was used to interview the factory workers. Furthermore, the self-administered HPD use report would be distributed among the workers. An inspection of the research assistants would be done at the same time.

#### 3.7.1.2 Audiometry

The workers in both groups would be tested to determine their hearing threshold at the frequencies of 500, 1000, 2000, 3000, 4000, and 6000 Hz., respectively with an audiometer. Prior to the audiometric test, the workers would be asked not to be exposed to loud noises for at least 12-16 hours. The steps involved in the audiometry test are as follows:

1) The procedure of the audiometric test was explained to the workers and the instructions on the tone and response when the workers heard the noises were given.

2) The workers were asked to remove earrings, eyeglasses, or anything that might interfere with the test.

3) The workers were asked to sit in the audiometric test booth. Then, earphones were carefully covered on the workers' ears (the blue cup for the left ear; the red cup for the right ear).

4) The audiometer was run, and the workers had to respond by pressing the button when they heard the tone.

5) After the procedure had been completely carried out, the results from the audiometric test indicating the workers' hearing threshold level in each frequency

would be recorded, including the frequencies of 500, 1000, 2000, 3000, 4000, and 6000 Hz. respectively.

### 3.7.2 Intervention phase

The ear plugs/ear muffs type of HPD would be given to factory workers who did not have HPDs. The intervention would be delivered for total period of six months. The training intervention would also be provided to the factory workers in the intervention group. The training program were delivered for approximately three hours in one day with a lecture, demonstration, and back-demonstration on the use of the Nowa App. Besides, the Nowa App. downloaded onto mobile phones would be provided to participants in every working day. The self-administered HPD use report would be conducted among workers once a month for monitoring.  The research assistants simultaneously inspected the workers' HPD use once a month.

### 3.7.3 The end program

At the end of the six-month intervention period, data would be collected by self-administered HPD use report duration of HPDs use which was similar to that in the pre-intervention phase.  The audiometric test was used only during the baseline and the end of program. The effectiveness of the intervention to promote the HPD use would be determined by monitoring the change pro rata of the actually using time percentage and the full-time of HPD use.

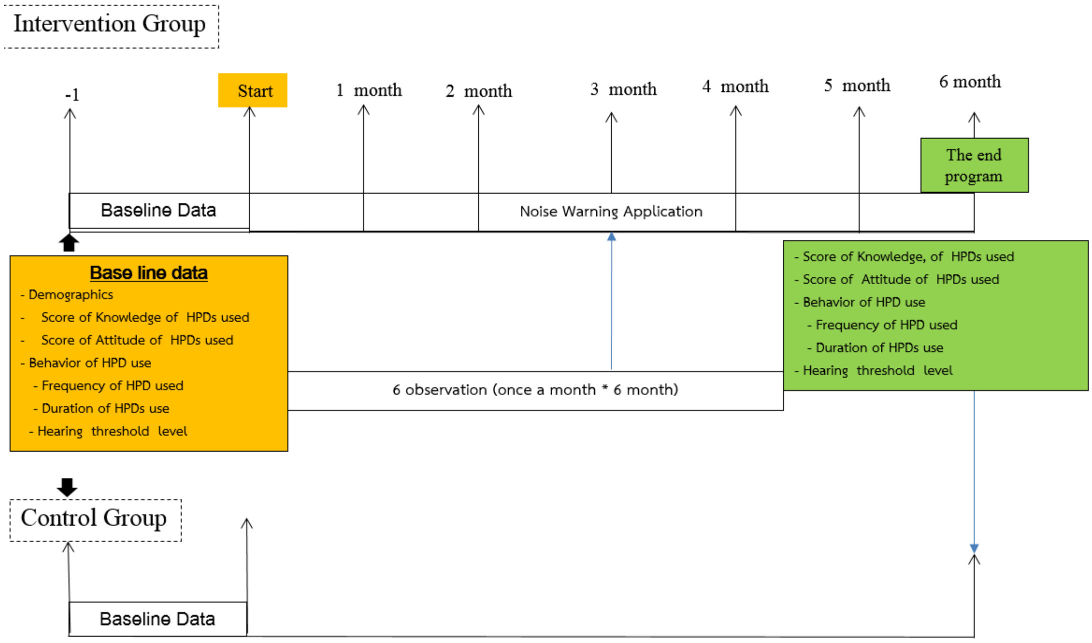


**Figure 7 Data collection**

### 3.8 Data Analysis

The SPSS for Windows Program (version 16) was used for statistical analysis. The data were analyzed as follows:

**Baseline characteristics**

The analysis results of the participants' demographic characteristics and baseline outcome variables would be summarized by using descriptive statistics measures:

For continuous variables, mean (standard deviation), median, and range were calculated, and for categorical variables, frequency and percentage would be calculated.

A comparison of significant differences between the intervention and control groups in terms of general characteristics of workers came out as follows:

- The independent t-test was used to compare the differences of continuous variables among workers.

- The Chi-square test was also employed to compare the differences of categorical variables among workers.

**Outcome variables:**

1. Duration of HPD use: The difference between pre-intervention and post-intervention in percent time of HPD use during the shift (continuous variable).

- Paired T-test for comparing the differences in the Duration of HPD use between pre-intervention and post-intervention.

- Used differences in differences methods to analysis mean differences of percent time of HPD (pre-post-intervention) between intervention and control groups.

- The Chi-square test was utilized to compare the differences in the proportion of frequency of HPDs use between pre-intervention and post-intervention.

- ANCOVA to adjust the confounding between the intervention and control groups.

### 3.9 Ethical consideration

The research protocols were submitted to the Ethics Review Committee for Research Involving Human Research Subjects, Health Science Group, Chulalongkorn University, for approval of this research. Informed consent was sought from the participants prior to the commencement of the study. The Research Ethicl Approval ducuments were shown in Appendix J.

# CHAPTER IV

# RESULTS

This quasi-experimental research study aimed to determine the effectiveness of Noise Warning Applications (NOWA app.) to promote the use of hearing protection devices among steel industry workers. Ninety male subjects were recruited from one hundred twenty-eight male workers employed at two steel industry production facilities. The quasi-experiment study divided the two steel industry facilities into two groups. Employees at one factory were labeled the intervention group, while the employees at the other factory were identified as the control group. All of the employees working in the hazardous area of each factory were considered for this study. The intervention group recruited a total of 68 male workers at a steel production facility located in Samut Prakarn Province, of which only forty-four workers passed the selection criteria. The control group recruited 60 male workers from the steel production facility in Samut Prakarn Province, of which only forty-six workers passed the selection criteria. The subjects were all male Thai workers between 18-60 years of age who had worked in the steel industry for at least 8 hours/day, 5 days/week for more than 1 year. During this time, these male workers had been exposed to continuous noise levels of more than 80 dB (A) for at least 8 hours of each working day. Any of the workers who were identified as being unilateral deaf workers, as well as those with chronic middle ear infections and ear anomalies such as HPDs, were excluded. The effectiveness of the noise warning application systems at the facilities was assessed through use of the HPD evaluation system. The Practice and Duration values of the HPD system were assessed in terms of the proportion of hearing protection devices being using by workers during the periods of inspection, and the percentage of time these devices were used in the work place. Consequently, the hearing thresholds were found to have shifted by assessment of the first audiogram. The results are presented in 2 separate parts. Part 1 includes relevant baseline data and part 2 describes the elements of the quasi-experiment.

### 4.1 Baseline data analysis

#### 4.1.1 Demographic characteristics of participants

Table 4 presents data comprised of the demographic characteristics of the subjects and a comparison of the demographic characteristics of all of the participants in the intervention and the control groups. The average (± SD) age of subjects in the intervention group was 46.25 ± 8.33, while the average age in the control group was 42.98 ± 9.22 years. Accordingly, no significant differences were identified ($p > 0.05$, Independent t-test). The age of subjects in the intervention group ranged from 28 to 59 years old and from 26 to 57 years old in the control group. In terms of the subjects in the intervention group, 20.5% were ≤ 40 years, while 79.5% were > 40 years old. With regard to the percentage of the subjects in the control group, 37.0% were ≤ 40 years, while 63.0 % were > 40 years, while no significant differences were observed ($p > 0.05$, Pearson’s chi-squared test).

Most subjects (43.2 %) in the intervention group had graduated from primary school, 40.9%had graduated from secondary school and 9.1% had graduated with a Bachelor’s Degree or higher. Table 10 presents a comparison of the mean score of the level of knowledge of HPD for the subjects before and after intervention. In both the control and the intervention groups, 6.8% of the subjects were found to have graduate from college. Most subjects (84.8%) in the control group had graduated from secondary school, 8.7% had graduated from college, 4.3% had graduated from primary school and 2.2% had graduated with a Bachelor’s Degree or higher. In some instances, significant differences were observed ($p < 0.05$, Pearson’s chi-squared test).

**Table 4** Numbers and percentages related to the demographic characteristics of the intervention group (n=44) and the control group (n=46) at the baseline

| **Demographic characteristics** | **Intervention Gr.**<br>**n = 44 (%)** | | **Control Gr.**<br>**n = 46 (%)** | | **p-value** |
|---|---|---|---|---|---|
| Age (year) | | | | | |
| ≤ 40 | 9 | 20.5 | 17 | 37.0 | .084$^{ns*}$ |
| > 40 | 35 | 79.5 | 29 | 63.0 | |
| Mean ± SD | 46.25 ± 8.33 | | 42.98 ± 9.22 | | 0.08$^{ns**}$ |
| Min – Max | 28 - 59 | | 26 - 57 | | |
| Education | | | | | |
| Primary School | 19 | 43.2 | 2 | 4.3 | <0.001* |
| Secondary School | 18 | 40.9 | 39 | 84.8 | |
| College School | 3 | 6.8 | 4 | 8.7 | |
| Bachelor or higher | 4 | 9.1 | 1 | 2.2 | |
| **Risk behavior** | | | | | |
| Ear problem<br>Yes | 11 | 25 | 9 | 19.6 | 0.28$^{ns**}$ |
| Smoking<br>Never | 22 | 47.8 | 24 | 54.5 | 0.31$^{ns*}$ |
| Ever, Currently, I’ve given up | 8 | 17.4 | 3 | 6.8 | |
| Ever, Current use | 16 | 34.8 | 17 | 38.6 | |
| Ototoxic drugs | | | | | |
| Overall Use | 13 | 29.5 | 18 | 39.1 | 0.34$^{ns*}$ |
| - Neomycin<br>Use | 1 | 2.3 | 0 | 0 | |
| -Streptomycin<br>Use | 1 | 2.3 | 1 | 2.2 | |
| -Diuretics<br>Use | 1 | 2.3 | 3 | 6.5 | |
| -Aspirin<br>Use | 13 | 29.5 | 16 | 34.8 | |
| Personal entertainment<br>Yes | 7 | 15.9 | 14 | 30.4 | 0.22$^{ns*}$ |
| Music ear buds using<br>Yes | 30 | 68.2 | 30 | 65.2 | 0.77$^{ns*}$ |
| History of impact noise<br>Yes | 24 | 54.5 | 25 | 54.3 | 0.98$^{ns*}$ |
| History of audiometric test<br>Yes | 43 | 97.7 | 44 | 95.7 | 0.58$^{ns*}$ |

* Chi-square test ** T-test

Risk behavior involved those subjects who suffered from ear problems, were smokers, used ototoxic drugs, extensively used personal entertainment devices and/or listened to music through ear buds. Notably, 25 % of the subjects in the intervention group and 19.6 % of the subjects in the control group had ear problems; however, there were no significant differences observed among these subjects ($p > 0.05$, Pearson’s chi-squared test). Smoking behavior was separated into 3 categories as follows; 47.8 % of the subjects in the intervention group and 54.5 % of the subjects in the control group never smoked. Additionally, 34.8 % subjects in the intervention group and 38.6% in the control group currently smoked. Lastly, 17.4 % of the subjects in the intervention group had smoked at some time in their lives but had now given it up, and this was true for 6.8 % of the subjects in the control group. No significant differences were observed ($p > 0.05$, Pearson’s chi-squared test). Ototoxic drug use included the use of 4 types of drugs such as neomycin, streptomycin, diuretics, and aspirin. With regard to ototoxic drug use, 29.5 % of the subjects in the intervention group and 39.1 % of the subjects in the control group used these substances, while no significant differences were observed ($p> 0.05$, Pearson’s chi-squared test). The use of personal entertainment devices included individuals who engaged in hobbies and took part in activities that exposed them to loud noises. With regard to this category, 15.9 % of the subjects in the intervention group had experienced some level of exposure to loud noises as a consequence of using personal entertainment devices, and the same was true for 30.4% of the subjects in the control group, while no significant differences were observed ($p > 0.05$, Pearson’s chi-squared test). Among subjects in the intervention group, 68.2 % of the individuals frequently used ear buds when on their mobile phones, while this was true of 65.2 % of the subjects in the control group. No significant differences were observed (p > 0.05, Pearson’s chi-squared test).

### 4.1.2 Work characteristics of participants

Table 5 presents the noise exposure levels that were measured over 8 hours. The results indicate that the average levels of noise exposure at the baseline were 95.79 dB (A) in the intervention group and 96.07 dB (A) in the control group.

**Table 5** Mean and standard deviations of the work characteristics of participants in the intervention group (n=44) and the control group (n=46) at the baseline

| Work characteristics | Intervened Gr. n = 44 (%) | Controlled Gr. n = 46 (%) | P-value |
|---|---|---|---|
| Noise exposure level; $L_{eq}$ 8 hrs. (Mean ± SD) | 95.79 dB (A) | 96.07 dB (A) | - |
| Length of employment (years) | 16.70 ± 10.05 | 15.11 ± 9.11 | $.43^{ns**}$ |
| Min – Max (years) | 3- 41 | 3-31 | |
| ≤10 | 15 (34.1) | 19 (41.3) | $.48^{ns*}$ |
| >10 | 29 (65.9) | 27 (58.7) | |
| Duration of work (hrs./ weeks ) (Mean ± SD) | 49.09 ± 2.77 | 49.22 ± 2.91 | $.83^{ns**}$ |
| Min – Max (years) | 48-56 | 48-56 | |
| Know the level of noise in work place<br>Yes | 2 (4.5) | 3 (6.5) | $.68^{ns*}$ |

* Chi-square test ** T-test

The length of employment was calculated by the mean duration of employment in years. The average value (± SD) of employment duration was 16.07 ± 10.05 years in the intervention group and 15.11 ± 9.11 years in the control group, while no significant differences were observed (p > 0.05, Independent t-test). The range of employment duration was 3 to 41 years in the intervention group and 3 to 31 years in the control group.

The duration of work hours per week was calculated by adding the full-time hours plus the over-time hours. The average value (± SD) of duration of work was

49.09 ± 2.77 hours in the intervention group and 49.22 ± 2.91 hours in the control group, while no significant differences were observed ($p > 0.05$, Independent t-test). The range of duration of work hours for subjects of both the intervention and control groups were 48 to 56 hour per week.

### 4.1.3 Availability of HPD

Table 6 presents the level of availability of HPD, which was divided into 3 dimensions: self-use of HPD, sufficient use of HPD and HPD-use in training. Accordingly, 56.8 % of the subjects were classified in the self-use HPD class in the intervention group and 54.8% were in the control group, for which there were no significant differences ($p > 0.05$, Pearson's chi-squared test). Additionally, 97.7 % of subjects in the intervention group and 89.1% of subjects in the control group found the availability of HPD sufficient, while no significant differences were observed ($p > 0.05$, Pearson's chi-squared test). Accordingly, 79.7 % of the subjects had received some training on noise hazard prevention, 79.5 % had been trained on HPDs use, 61.4 % had been trained on HPD's maintenance, 61.4 % had been trained on HPD cleaning in the intervention group, while the same was true for 56.5%, 58.7%, 39.1%, and 34.8% of the subjects in the control group, respectively. For this group, no significant differences were observed ($p > 0.05$, Pearson's chi-squared test) with regard to HPD maintenance among the subjects of the intervention and control groups. With regard to the values of HPD training on noise hazard prevention, HPD use and HPD cleaning among members of the intervention and control groups were found to be significantly different ($p < 0.05$, Pearson's chi-squared test).

**Table 6** Numbers and percentages of availability of HPDs of the intervention group (n=44) and the control group (n=46) at the baseline

| **Availability of HPD** | **Intervention Gr.**<br>**n = 44 (%)** | **Control Gr.**<br>**n = 46 (%)** | **P-value** |
|---|---|---|---|
| Self- HPD Used Yes | 25(56.8) | 26(54.8) | .39$^{ns}$* |
| Sufficient of HPD Yes | 43(97.7) | 41(89.1) | .36$^{ns}$* |
| HPD use Training about | | | |
| - Hazard and hazard prevention from noise Yes | 35 (79.5) | 26 (56.5) | 0.025* |
| - Using HPDs Yes | 35 (79.5) | 27 (58.7) | 0.041* |
| - Maintenance HPDs Yes | 27 (61.4) | 18 (39.1) | 0.57$^{ns}$* |
| -Cleaning HPDs Yes | 27 (61.4) | 16 (34.8) | 0.02* |

* Chi-square test

### 4.1.4 Knowledge and Attitude scores with regard to HPD use

Table 7 shows the mean and standard deviations of the Knowledge and Attitude scores with regard to HPD use. The average value (± SD) of the knowledge score in the intervention group was 10.41 ± 0.87 and 10.50 ± 0.84 in the control group, while no significant differences were observed ($p > 0.05$, Independent t-test). The average value (± SD) of the attitude score among subjects in the intervention group was 34.41 ± 5.39 and 36.39 ± 4.46 in the control group, for which no significant differences were observed ($p > 0.05$, Independent t-test).

**Table 7** Mean and standard deviation values of the knowledge score for the HPDs use of the participants of the intervention group (n=44) and the control group (n=46) at the baseline.

| **Factor** | **Intervention Gr.**<br>(n=44) | **Control Gr.**<br>(n=46) | **p-value** |
|---|---|---|---|
| Score Knowledge about HPD use (X ± SD) | 10.41 ± 0.87 | 10.50 ± 0.84 | 0.62$^{ns}$** |
| Score of Attitude about HPD use (X ± SD) | 34.41 ± 5.39 | 36.39 ± 4.46 | 1.44 $^{ns}$** |

** T-test

### 4.1.5 Behavior of HPD use

Table 8 presents HPD use in terms of the percentage of time in which HPDs were used (mean and standard deviations, SD) and the number (and percent) of workers using HPDs for at least 60% of the time with noise levels at or above 85 dBA. The average value (± SD) of HPD used in terms of the percentage of time was 57.27 ± 20.73 among subjects in the intervention group and 60.00 ± 22.21 in the control group, while no significant differences were observed ($p > 0.05$, Independent t-test). The percentage of time used in the intervention group was < 60 percent, while members in the control group ranged from 26 to 57 years old.

The subjects in the intervention group recorded 50 % in terms of time used at < 60 percent and 50.0 % in terms of time used at ≥ 60 percent. Additionally, the percent of time used by the subjects in the control group was 54.3% in terms of time used at < 60 percent and 45.7 % in terms of time used at ≥ 60 percent, while no significant differences were observed ($p > 0.05$, Pearson's chi-squared test).

**Table 8** Behavior of HPD use of the participants of the intervention group (n=44) and the control group (n=46) in the baseline data

| **Behavior of HPD use** | **Intervention Gr.** (n=44) | **Control Gr.** (n=46) | **p-value** |
|---|---|---|---|
| Duration of HPD use in percentage of time (X ± SD) | 57.27 ± 20.73 | 60.00 ± 22.21 | 0.55$^{ns}$** |
| Proportion of HPD use | | | |
| < 60 | 22 (50.0) | 25 (54.3) | 0.83$^{ns}$* |
| ≥ 60 | 22 (50.0) | 21 (45.7) | |

* Chi-square test ** T-test

### 4.1.6 Results of the hearing threshold levels (HTL) at 500, 1000, 2000, 3000, 4000, and 6000 Hz in the left and right ears of subjects in the intervention and control groups at the baseline

Audiometry was performed using an Audiometer GSI 18 device. This calibrated audiometer met the required specifications and had been maintained according to ISO 389-3 1994/American National Standard Specifications for Audiometers, S3.6-1969. The audiometric test was conducted in an audiometric booth. Hearing thresholds were examined by the same audiologist for all subjects. A pure tone air conduction audiometric test was performed to determine the hearing thresholds at frequencies of 500, 1000, 2000, 3000, 4000, and 6000 Hz in each ear of each subject by using an audiometer with ear phones. Measurements of the hearing thresholds were taken at increments of 5 dB. The subjects were tested by using an audiometer on Monday morning after avoiding exposure to excessive noise levels for at least 14 hours. Subsequently, if subjects had to work in the hours before the audiogram test, they were given earplugs to use in order to prevent potential exposure to excessive levels of noise.

Table 9 shows the hearing threshold levels (HTL) at the base line at frequencies of 500, 1000, 2000, 3000, 4000, and 6000 Hz for both ears among subjects of the intervention and control groups. For the right ear, the mean value (± SD) of HTL among subjects in the intervention group was 20.23 ± 8.35 and 20.43 ± 8.22 in the control group at 500 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL among subjects in the intervention group was 19.89 ± 10.02 and 22.28 ± 5.13 in the control group at 1,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL among subjects in the intervention group was 20.68 ±

10.65 and 18.59 ± 5.64 in the control group at 2,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL among subjects in the intervention group was 22.27 ± 15.68 and 22.72 ± 8.80 in the control group at 3,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test).

The mean value (± SD) of HTL among subjects in the intervention group was 32.05 ± 14.19 and 32.07 ± 14.36 in the control group at 4,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL among subjects in the intervention group was 32.38 ± 18.85 and 31.96 ± 18.54 in the control group at 6,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). For the left ear, the mean value (± SD) of HTL among subjects in the intervention group was 16.14 ± 9.69 and 16.74 ± 9.90 at 500 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL among subjects in the intervention group was 16.48 ± 10.76 and 16.96 ± 10.77 in the control group at 1,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL among subjects in the intervention group was 21.14 ± 7.46 and 20.76 ± 7.67 in the control group at 2,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL among subjects in the intervention group was 23.41 ± 9.51 and 23.47 ± 9.30 in the control group at 3,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL among subjects in the intervention group was 40.91 ± 13.13 and 42.17 ± 13.65 in the control group at 4,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of

HTL among subjects in the intervention group was 34.20 ± 21.53 and 35.00 ± 14.57 in the control group at 6,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test).

**Table 9** Mean and standard deviations of hearing thresholds of the participants of the intervention group (n=44) and the control group (n=46) at the **baseline**

| **Frequency (Hz.)** | **Mean ± SD** | | |
|---|---|---|---|
| | **intervention group (n=44)** | **control group (n=46)** | **P-value** |
| **Right ear** | | | |
| R500 | 20.23 ± 8.35 | 20.43 ± 8.22 | 0.906$^{ns}$** |
| 1,000 | 19.89 ± 10.02 | 22.28 ± 5.13 | 0.155$^{ns}$** |
| 2,000 | 20.68 ± 10.65 | 18.59 ± 5.64 | 0.244$^{ns}$** |
| 3,000 | 22.27 ± 15.68 | 22.72 ± 8.80 | 0.868$^{ns}$** |
| 4,000 | 32.05 ± 14.19 | 32.07 ± 14.36 | 0.995$^{ns}$** |
| 6,000 | 32.38 ± 18.85 | 31.96 ± 18.54 | 0.913$^{ns}$** |
| **Left ear** | | | |
| 500 | 16.14 ± 9.69 | 16.74 ± 9.90 | 0.771$^{ns}$** |
| 1,000 | 16.48 ± 10.76 | 16.96 ± 10.77 | 0.833$^{ns}$** |
| 2,000 | 21.14 ± 7.46 | 20.76 ± 7.67 | 0.814$^{ns}$** |
| 3,000 | 23.41 ± 9.51 | 23.47 ± 9.30 | 0.972$^{ns}$** |
| 4,000 | 40.91 ± 13.13 | 42.17 ± 13.65 | 0.655$^{ns}$** |
| 6,000 | 34.20 ± 21.53 | 35.00 ± 14.57 | 0.837$^{ns}$** |

** T-test

Table 10 presents abnormal hearing values when applying a cut-off value of more than 25 dB for the hearing thresholds. The number and percentage of abnormal hearing levels at single frequencies indicated more variations in frequencies at 4 and 6 kHz. The prevalence of hearing loss at the baseline increased as frequencies became higher. Almost 50% to 90 % of the subjects in both the intervention group and the control group experienced hearing loss at 4 kHz and 6 kHz. There were no significant differences among subjects in both groups at every single frequency (p- value > 0.05).

**Table 10** Pearson's chi-squared test for hearing loss of participants of the intervention group (n=44) and the control group (n=46) at the **baseline**

| **Frequency (Hz.)** | **n (%) of Hearing loss (HTL > 25 dB)** | | | | | |
|---|---|---|---|---|---|---|
| | **Right ear** | | | **Left ear** | | |
| | **intervention group (n=44)** | **control group (n=46)** | **P-value** | **intervention group (n=44)** | **control group (n=46)** | **P-value** |
| 500 | 3 (6.8) | 3 (6.5) | .95 $^{ns*}$ | 3 (6.8) | 5 (10.9) | .71 $^{ns*}$ |
| 1,000 | 5 (11.4) | 6 (13.0) | .81 $^{ns*}$ | 4 (9.1) | 5 (10.9) | .78 $^{ns*}$ |
| 2,000 | 7 (15.9) | 2 (4.3) | .09 $^{ns*}$ | 6 (13.6) | 6 (13.0) | .93 $^{ns*}$ |
| 3,000 | 11 (25) | 12 (26.1) | .91 $^{ns*}$ | 14 (31.8) | 14 (30.4) | .89 $^{ns*}$ |
| 4,000 | 27 (61.4) | 28 (60.9) | .96 $^{ns*}$ | 36 (81.8) | 41 (89.1) | .32 $^{ns*}$ |
| 6,000 | 23 (52.3) | 23 (50.0) | .83 $^{ns*}$ | 21 (47.7) | 27 (58.7) | .29 $^{ns*}$ |

* Chi-square test

Table 11 presents abnormal hearing values when applying a cut-off value of more than 25 dB for the hearing thresholds in subjects who difference length ≤ 10 years and > 10 years, in hearing threshold level at 4,000 Hz and 6,000 Hz. There. The number and percentage of abnormal hearing levels at single frequencies indicated more variations in length of employment group > 10 years. The prevalence of hearing loss at the baseline increased as length of employment became higher. Almost 60% to 70 % of the subjects in both the intervention group and the control group experienced hearing loss in both ear at 4 kHz and 6 kHz.

**Table 11** Number and Percentage of hearing loss of subject in diffence length of employment and hearing threshold level of subjects **at baselin**e

| **Category** | **n (%) of hearing loss (HTL > 25 dB) of subject** | | | |
|---|---|---|---|---|
| | **Right ear** | | **Left ear** | |
| | **intervention group (n=44)** | **control group (n=46)** | **intervention group (n=44)** | **control group (n=46)** |
| Subject profile and status of HTL at 4,000 Hz | | | | |
| Length of employment (years) | | | | |
| ≤ 10 | 9 (33.3) | 8 (28.6) | 11 (30.6) | 16 (39) |
| > 10 | 18 (66.7) | 20 (71.4) | 25 (39.4) | 25 (61) |
| Subject profile and status of HTL at 6,000 Hz | | | | |
| Length of employment (years) | | | | |
| ≤ 10 | 8 (34.8) | 5 (27.8) | 6 (28.6) | 12 (37.5) |
| > 10 | 15 (65.2) | 13 (72.2) | 15 (71.4) | 20 (62.5) |

## 4.2 Quasi-experimental study

### 4.2.1 Comparison Knowledge, Attitude and Behavior of HPD use

**Table 12** Comparison of mean knowledge scores with regard to HPD use before and after the intervention period for both the control and intervention groups.

| **Knowledge Score of HPD** | **Mean ± SD** | | |
|---|---|---|---|
| | **Before** | **After** | **P-value** |
| Intervention group (n = 44) | 10.41 ± 0.87 | 11.57 ± 0.69 | < 0.001** |
| Control group (n = 46) | 10.50 ± 0.84 | 11.65 ± 0.67 | < 0.001** |

** T-test

Table 12 presents a comparison of the mean values of the knowledge score with regard to HPD use before and after intervention for both the control and intervention groups. The average value (± SD) of the knowledge score with regard to HPD use for the intervention group was10.41 ± 0.87 before the intervention and 11.57 ± 0.69 after the intervention, for which significant differences were observed ($p < 0.05$, Independent t-test). The average value (± SD) of the knowledge score with regard to HPD use of the control group was 10.50 ± 0.84 before the intervention and

11.65 ± 0.67 after the intervention, for which significant differences were observed ($p < 0.05$, Independent t-test).

**Table 13** Comparison of the mean values of the knowledge scores for HPD use among subjects of the intervention group (n=44) and those of the control group (n=46) both before and after the intervention period

| **Knowledge Score of HPD** | **Mean ± SD** | | |
|---|---|---|---|
| | **Intervention Gr. (n = 44)** | **Control Gr. (n = 46)** | **P-value** |
| Before | 10.41 ± 0.87 | 10.50 ± 0.84 | 0.62$^{ns**}$ |
| After | 11.57 ± 0.69 | 11.65 ± 0.67 | 0.56$^{ns**}$ |

** T-test

Table 13 presents a comparison of the mean values of the knowledge score with regard to HPD use among members of both the intervention group and the control both before and after the intervention period. The average value (± SD) of the knowledge score with regard to HPD use before the intervention period was recorded at 10.41 ± 0.87 for members of the intervention group and 10.50 ± 0.84 for those of the control group, while significant differences were observed ($p < 0.05$, Independent t-test). The average value (± SD) of the knowledge scores in terms of HPD use after the intervention was 11.57 ± 0.69 in the intervention group and 11.65 ± 0.67 in the control group, while significant differences were observed ($p < 0.05$, Independent t-test).

**Table 14** Comparison of mean values of attitude scores for HPD use before and after the intervention period for both the control and intervention groups

| Attitude toward HPD | Mean ± SD | | |
|---|---|---|---|
| | **Before** | **After** | **P-value** |
| Intervention group (n = 44) | 34.41 ± 5.39 | 37.64 ± 4.53 | < 0.001** |
| Control group (n = 46) | 36.39 ± 4.46 | 36.63 ± 3.84 | $0.23^{ns}$** |

** T-test

Table 14 presents a comparison of the mean values of the attitude scores for HPD use before and after the intervention period for subjects of both the intervention and control groups. The average value (± SD) of the attitude scores in terms of HPD use of the intervention group was 34.41 ± 5.39 before the intervention and 37.64 ± 4.53 after the intervention, while significant differences were observed ($p < 0.05$, Independent t-test). The average value (± SD) of the attitude scores with regard to HPD use of the control group was 36.39 ± 4.46 before the intervention and 36.63 ± 3.84 after the intervention, while no significant differences were observed ($p > 0.05$, Independent t-test).

**Table 15** Comparison of mean values of Attitude scores toward HPD use among members of the intervention group (n=44) and the control group (n=46) before and after intervention

| Attitude toward HPD | Mean ± SD | | |
|---|---|---|---|
| | **Intervention Gr. (n = 44)** | **Control Gr. (n = 46)** | **P-value** |
| Before | 34.41 ± 5.39 | 36.39 ± 4.46 | $0.06^{ns}$** |
| After | 37.64 ± 4.53 | 36.63 ± 3.84 | $0.26^{ns}$** |

** T-test

Table 15 presents a comparison of the mean values of the attitude score toward HPD among subjects of the control and the intervention groups before and after the intervention. The average value (± SD) of the attitude score toward HPD before intervention was 34.41 ± 5.39 in the intervention group and 36.39 ± 4.46 in the control group, while significant differences were observed ($p < 0.05$, Independent t-test). The average value (± SD) of the attitude score toward HPD after intervention was 37.64 ± 4.53 in the intervention group and 36.63 ± 3.84 in the control group, while significant differences were observed ($p < 0.05$, Independent t-test).

**Table 16** Comparison of behavior of HPD use among subjects of the intervention group (n=44) and Control groups (n=46) before and after intervention

| **Behavior of HPD use** | **Intervention Gr. n (%)** | **Control Gr. n (%)** | **P-value** |
|---|---|---|---|
| **Before** | | | |
| HPD use Practice | | | |
| Occasionally and Often | 17 (38.6) | 15 (32.6) | $0{\cdot}057^{ns\ *}$ |
| Always | 27 (61.4) | 31 (67.4) | |
| Duration of HPD use in percentage of time (Mean ± SD) | 57.27 ± 20.73 | 60.00 ± 22.21 | $0.55^{ns\ **}$ |
| Proportion of HPD use (%) | | | |
| < 60 | 22 (50.0) | 25 (54.3) | $0.83^{ns}$* |
| ≥ 60 | 22 (50.0) | 21 (45.7) | |
| **After** | | | |
| HPD use Practice | | | |
| Often | 2 (4.5) | 15 (32.6) | 0.001*** |
| Always | 42 (95.5) | 31 (67.4) | |
| Duration of HPD use in percentage of time (Mean ± SD) | 73.41 ± 12.00 | 62.17 ± 14.59 | < 0.001** |
| Proportion of HPD use | | | |
| < 60 | 4 (9.1) | 17 (37.0) | 0.002*** |
| ≥ 60 | 40 (90.9) | 29 (60.3) | |

*Chi-square **T-test *** Fisher's exact test

Table 16 presents a comparison of HPD use of the subjects for the Practice category. The value before intervention was 38.6 % in terms of occasional and often use for subjects in the intervention group and 32.6 % in the control group. Additionally, 61.4 % were identified in the always used class in the intervention group and 67.4% in the control group for the same class, while no significant differences were observed ($p > 0.05$, Pearson’s chi-squared test). Comparison of mean duration of HPD use in terms of time before intervention among subjects of the control and the intervention groups. The average values (± SD) of the duration of HPD use in terms of time were 57.27 ± 20.73 in the intervention group and 60.00 ± 22.21 in the control group, while no significant differences were observed ($p > 0.05$, Independent t-test). The percentage of subjects before intervention was 50 % in terms of time used at < 60 percent among subjects of the intervention group and 54.3% in the control group. Additionally, the percentage of time used at ≥ 60 of the subjects in the intervention Gr group was 50.0% and the percentage of time used was 45.7 in the control group, while no significant differences were observed ($p > 0.05$, Pearson’s chi-squared test). The average value (± SD) of the knowledge scores with regard to HPD use after intervention was 11.57 ± 0.69 in the intervention group and 11.65 ± 0.67 in the control group, while significant differences were observed ($p > 0.05$, Pearson’s chi-squared test). After the intervention, a comparison of the HPD use in terms of the Practice of the subjects was made. Accordingly, 4.5 % of subjects were in the often used class of the intervention group and there were 32.6 % in the control group. Additionally, 95.5 % of subjects were in the always used class of the intervention group and 67.4% were in the control group, while significant differences were observed ($p < 0.05$, *Fisher's exact test*). A comparison was made of the mean duration values of HPD use before the intervention for subjects of both the control and intervention groups. The average value (± SD) of the duration of time for HPD use in terms of the amount of used was 73.41 ± 12.00 in the intervention group and 62.17 ± 14.59 in the control group, while no significant differences were observed ($p < 0.05$, Independent t-test). The subjects after intervention reported 9.1 % for time used at < 60 percent in the intervention group and 37.0 % in the control group. Additionally, the percentage of time used at ≥ 60 of the subjects in the intervention group was 90.9 % and 60.3 % in control group, while no significant differences were observed ($p < 0.05$, *Fisher's exact test*).

**Table 17** Effectiveness of Noise Warning Applications (Nowa app.) to promote the use of hearing protection devices before and after intervention at each steel production facility

| **Behavior of HPD use** | **Before** **n (%)** | **After** **n (%)** | **P-value** |
|---|---|---|---|
| **Intervention Gr. (n = 44)** | | | |
| HPD use Practice | | | |
| Often | 17 (38.6) | 2 (4.5) | .649$^{ns}$*** |
| Always | 27 (61.4) | 42 (95.5) | |
| Duration of HPD use in percentage of time (Mean +SD) | 57.27 ± 20.73 | 73.41 ± 12.00 | < 0.001$^{**}$ |
| **Control Gr. (n = 46)** | | | |
| HPD use Practice | | | |
| Occasionally and Often | 15 (32.6) | 15 (32.6) | 0.001* |
| Always | 31 (67.4) | 31 (67.4) | |
| Duration of HPD use in percentage of time (Mean +SD) | 60.00 ± 22.21 | 62.17 ± 14.59 | 0.43$^{ns}$** |

* Chi-square test ** T-test *****Fisher's exact test

Table 17 presents a comparison of HPD use in terms of the Practice of subjects in the intervention group before the intervention. There were 38.6 % in often used class before intervention and 4.5 % after the intervention. Additionally, there were 61.4 % in the always used class before intervention and 95.5% after intervention, while no significant differences were observed ($p > 0.05$, *Fisher's exact test*). A comparison was made of the mean values of the duration of HPD use in terms of duration of time before and after the intervention for subjects of the intervention group. The average values (± SD) of duration of HPD use were 57.27 ± 20.73 before intervention and 73.41 ± 12.00 after intervention, while significant differences were observed ($p < 0.05$, Independent t-test). Accordingly, there were 32.6 % of subjects in the occasionally and often-used class control group before the intervention and 32.6% after the intervention. Additionally, there were 67.4 % of subjects in the always used class before the intervention and 67.4 % after the intervention, while significant differences were observed ($p < 0.05$, *Fisher's exact test*).

A comparison was made of the mean duration of HPD use among subjects in the control group before and after intervention. The average value (± SD) of duration of HPD use was 60.00 ± 22.21 before intervention and 62.17 ± 14.59 after intervention, while no significant differences were observed ($p > 0.05$, Independent t-test).

Table 18 presents the hearing threshold levels (HTL) after intervention at frequencies of 500, 1000, 2000, 3000, 4000, and 6000 Hz for both ears of subjects in the intervention and control groups. For the right ear, the mean value (± SD) of HTL among subjects in the intervention group was 20.34 ± 8.17 and 20.76 ± 7.96 in the control group at 500 Hz, while no significant differences were observed ($p > 0.05$, Independent t-test). The mean value (± SD) of HTL in the intervention group was 20.22 ± 9.76 and 22.50 ± 4.68 in the control group at 1,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL among subjects in the intervention group was 20.91 ± 10.36 and 18.80 ± 5.49 in the control group at 2,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL among subjects in the intervention group was 22.50 ± 15.46and 22.93 ± 8.40 in the control group at 3,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL among members in the intervention group was 32.50 ± 13.32 and 32.82 ± 13.28 in the control group at 4,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL among subjects in the intervention group was 32.84 ± 18.31 and 32.50 ± 18.00 in the control group at 6,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). For the left ear, the mean value (± SD) of HTL among subjects in the intervention group was 16.36 ± 9.48 and 16.96 ± 9.57 in the control group at 500 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL among subjects in the intervention group was 16.70 ± 10.50 and 17.17 ± 10.57 in the control group at 1,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL among subjects in the intervention group was 21.25 ± 7.32 and 21.09 ± 7.06 in the control group at 2,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL among subjects in the intervention group was 23.75 ± 8.90 and 23.80 ± 8.96 in the control group at 3,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL among subjects in the intervention group was 41.02 ± 12.92 and 42.72 ± 12.94 in the control group at 4,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL among subjects in the intervention group was 34.77 ± 20.93 and 35.65 ± 13.96 in the control group at 6,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test).

**Table 18** Mean and standard deviations of the hearing thresholds of participants of the intervention group (n=44) and the control group (n=46) at after intervention

| **Frequency (Hz.)** | **Mean ± SD** | | |
|---|---|---|---|
| | **intervention group (n=44)** | **control group (n=46)** | **P-value** |
| **Right ear** | | | |
| R500 | 20.34 ± 8.17 | 20.76 ± 7.96 | $0.81^{ns**}$ |
| 1,000 | 20.22 ± 9.76 | 22.50 ± 4.68 | $0.16^{ns**}$ |
| 2,000 | 20.91 ± 10.36 | 18.80 ± 5.49 | $0.23^{ns**}$ |
| 3,000 | 22.50 ± 15.46 | 22.93 ± 8.40 | $0.87^{ns**}$ |
| 4,000 | 32.50 ± 13.32 | 32.82 ± 13.28 | $0.91^{ns**}$ |
| 6,000 | 32.84 ± 18.31 | 32.50 ± 18.00 | $0.93^{ns**}$ |
| **Left ear** | | | |
| 500 | 16.36 ± 9.48 | 16.96 ± 9.57 | $0.76^{ns**}$ |
| 1,000 | 16.70 ± 10.50 | 17.17 ± 10.57 | $0.83^{ns**}$ |
| 2,000 | 21.25 ± 7.32 | 21.09 ± 7.06 | $0.92^{ns**}$ |
| 3,000 | 23.75 ± 8.90 | 23.80 ± 8.96 | $0.98^{ns**}$ |
| 4,000 | 41.02 ± 12.92 | 42.72 ± 12.94 | $0.54^{ns**}$ |
| 6,000 | 34.77 ± 20.93 | 35.65 ± 13.96 | $0.81^{ns**}$ |

** T-test

**Table 19** Pearson's chi-squared test for hearing loss of participants of the intervention group (n=44) and the control group (n=46) at **after intervention**

| **Frequency (Hz.)** | **n (%) of Hearing loss (HTL > 25 dB)** | | | | | |
|---|---|---|---|---|---|---|
| | **Right ear** | | | **Left ear** | | |
| | **intervention group (n=44)** | **control group (n=46)** | **P-value** | **intervention group (n=44)** | **control group (n=46)** | **P-value** |
| 500 | 3 (6.8) | 3 (6.5) | .95 $^{ns*}$ | 3 (6.8) | 5 (10.9) | .71 $^{ns*}$ |
| 1,000 | 5 (11.4) | 6 (13.0) | .81 $^{ns*}$ | 4 (9.1) | 5 (10.9) | .78 $^{ns*}$ |
| 2,000 | 7 (15.9) | 2 (4.3) | .09 $^{ns*}$ | 6 (13.6) | 6 (13.0) | .93 $^{ns*}$ |
| 3,000 | 11 (25) | 12 (26.1) | .91 $^{ns*}$ | 14 (31.8) | 14 (30.4) | .93$^{ns*}$ |
| 4,000 | 27 (61.4) | 29 (63.0) | .87 $^{ns*}$ | 36 (81.8) | 41 (89.1) | .052 $^{ns*}$ |
| 6,000 | 23 (52.3) | 23 (50.0) | .83 $^{ns*}$ | 21 (47.7) | 27 (58.7) | .29 $^{ns*}$ |

* Chi-square test

Table 19 shows abnormal hearing levels when applying a cut-off value of more than 25 dB for the hearing thresholds. The number and percentage of abnormal hearing at single frequencies revealed more variations in frequencies at 4, and 6 kHz. The prevalence of hearing loss after intervention increased as frequencies became higher. Almost 50% to 90 % of the subjects in both the control and intervention groups experienced hearing loss at 4 kHz and 6 kHz. No significant differences were observed among subjects in both groups for every single frequency (p- value > 0.05).

**Table 20** Mean and standard deviations of the hearing thresholds of participants of the **intervention group** (n=46) before and after intervention

| Frequency (Hz.) | Mean ± SD | | |
|---|---|---|---|
| | Before intervention | After intervention | P-value |
| **Right ear** | | | |
| R500 | 20.23 ± 8.35 | 20.34 ± 8.17 | 0.32 $^{ns**}$ |
| 1,000 | 19.89 ± 10.02 | 20.22 ± 9.76 | 0.80 $^{ns**}$ |
| 2,000 | 20.68 ± 10.65 | 20.91 ± 10.36 | 0.16 $^{ns**}$ |
| 3,000 | 22.27 ± 15.68 | 22.50 ± 15.46 | 0.16 $^{ns**}$ |
| 4,000 | 32.05 ± 14.19 | 32.50 ± 13.32 | 0.10 $^{ns**}$ |
| 6,000 | 32.38 ± 18.85 | 32.84 ± 18.31 | 0.10 $^{ns**}$ |
| **Left ear** | | | |
| 500 | 16.14 ± 9.69 | 16.36 ± 9.48 | 0.16 $^{ns**}$ |
| 1,000 | 16.48 ± 10.76 | 16.70 ± 10.50 | 0.16 $^{ns**}$ |
| 2,000 | 21.14 ± 7.46 | 21.25 ± 7.32 | 0.32 $^{ns**}$ |
| 3,000 | 23.41 ± 9.51 | 23.75 ± 8.90 | 0.18 $^{ns**}$ |
| 4,000 | 40.91 ± 13.13 | 41.02 ± 12.92 | 0.66 $^{ns**}$ |
| 6,000 | 34.20 ± 21.53 | 34.77 ± 20.93 | 0.17 $^{ns**}$ |

** T-test

Table 20 shows the hearing threshold levels (HTL) of subjects of the intervention group at frequencies of 500, 1000, 2000, 3000, 4000, and 6000 Hz for both ears of all subjects before and after the intervention period. For the right ear, the mean value (± SD) of HTL before intervention was 20.23 ± 8.35 and 20.34 ± 8.17 after intervention at 500 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL before intervention was 19.89 ± 10.02 and 20.22 ± 9.76 after the intervention at 1,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL before intervention was 20.68 ± 10.65 and 20.91 ± 10.36 after intervention at 2,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL before intervention was 22.27 ± 15.68 and 22.50 ± 15.46 after intervention at 3,000 Hz, while not significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL before intervention was 32.05 + 14.19 and 32.50 ± 13.32 after intervention at 4,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL before intervention was 32.38 + 18.85 and 32.84 ± 18.31 after intervention at 6,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). For the left ear, the mean value (± SD) of HTL before intervention was 16.14 ± 9.69 and 16.36 ± 9.48 after intervention at 500 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL before intervention was 16.48 ± 10.76 and 16.70 ± 10.50 after intervention at 1,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL before intervention was 21.14 ± 7.46 and 21.25 ± 7.32 after intervention at 2,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL before intervention was 23.41 ± 9.51 and 23.75 ± 8.90 after intervention at 3,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL before intervention was 40.91 + 13.13 and 41.02 ± 12.92 after intervention at 4,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL before intervention was 34.20 ± 21.53 and 34.77 ± 20.93 after intervention at 6,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test).

**Table 21** Mean and standard deviations of the hearing thresholds of participants of the control group (n=46) before and after intervention

| Frequency (Hz.) | Mean ± SD | | |
|---|---|---|---|
| | Before intervention | After intervention | P-value |
| **Right ear** | | | |
| R500 | 20.43 ± 8.22 | 20.76 ± 7.96 | 0.08 $^{ns**}$ |
| 1,000 | 22.28 ± 5.13 | 22.50 ± 4.68 | 0.16 $^{ns**}$ |
| 2,000 | 18.59 ± 5.64 | 18.80 ± 5.49 | 0.42 $^{ns**}$ |
| 3,000 | 22.72 ± 8.80 | 22.93 ± 8.40 | 0.16 $^{ns**}$ |
| 4,000 | 32.07 ± 14.36 | 32.82 ± 13.28 | 0.051 $^{ns**}$ |
| 6,000 | 31.96 ± 18.54 | 32.50 ± 18.00 | 0.058 $^{ns**}$ |
| **Left ear** | | | |
| 500 | 16.74 ± 9.90 | 16.96 ± 9.57 | 0.42 $^{ns**}$ |
| 1,000 | 16.96 ± 10.77 | 17.17 ± 10.57 | 0.16 $^{ns**}$ |
| 2,000 | 20.76 ± 7.67 | 21.09 ± 7.06 | 0.18 $^{ns**}$ |
| 3,000 | 23.47 ± 9.30 | 23.80 ± 8.96 | 0.08 $^{ns**}$ |
| 4,000 | 42.17 ± 13.65 | 42.72 ± 12.94 | 0.34 $^{ns**}$ |
| 6,000 | 35.00 ± 14.57 | 35.65 ± 13.96 | 0.16 $^{ns**}$ |

** T-test

Table 21 shows the hearing threshold levels (HTL) of members of the control group at frequencies of 500, 1000, 2000, 3000, 4000, and 6000 Hz for both ears of the subjects before and after the intervention. For the right ear, the mean value (± SD) of HTL before the intervention was 20.43 ± 8.22 and 20.76 ± 7.96 after the intervention at 500 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL before the intervention was 22.28 ± 5.13 and 22.50 ± 4.68 after the intervention at 1,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL before the intervention was 18.59 ± 5.64 and 18.80 ± 5.49 after the intervention at 2,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL before intervention the was 22.72 ± 8.80 and 22.93 ± 8.40

after the intervention at 3,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL before the intervention was 32.07 ± 14.36 and 32.82 ± 13.28 after the intervention at 4,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL before intervention was 31.96 ± 18.54 and 32.50 ± 18.00 after intervention at 6,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). For the left ear, the mean value (± SD) of HTL before intervention was 16.74 ± 9.90 and 16.96 ± 9.57 after intervention at 500 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL before intervention was 16.96 ± 10.77 and 17.17 ± 10.57 after intervention at 1,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL before intervention was 20.76 ± 7.67 and 21.09 ± 7.06 after intervention at 2,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL before intervention was 23.47 ± 9.30 and 23.80 ± 8.96 after intervention at 3,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL before intervention was 42.17 ± 13.65 and 42.72 ± 12.94 after intervention at 4,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test). The mean value (± SD) of HTL before intervention was 35.00 ± 14.57 and 35.65 ± 13.96 after intervention at 6,000 Hz, while no significant differences were observed (p > 0.05, Independent t-test).

**Table 22** Pairwise comparisons of the mean differences in differences of the percentages of time used for HPDs among subjects of the intervention and control groups

| (I) Group | (J) Group | Mean Difference (I-J) | Std. Error | Sig.[b] | 95% Confidence Interval for Difference[b] | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| control | intervention | -13.965* | 4.052 | .001 | -22.018 | -5.912 |
| intervention | Control Group | 13.965* | 4.052 | .001 | 5.912 | 22.018 |

Based on estimated marginal means
*. Mean difference was considered significant at a level of .05.
b. Adjustment for multiple comparisons: Bonferroni.

Table 22 presents a comparison of the mean values in terms of the mean differences in differences of percentage of time used for HPDs between the two groups of participants. The results from an analysis of covariance reveal that there were statistically significant differences among subjects of the intervention and control groups in terms of percentage of time used for HPDs after the intervention period (p=0.005).

**Table 23** Pairwise comparisons of the mean differences of the percentages of time used for HPDs among subjects of the intervention and control groups after the adjusted variables of the levels of education and training with regard to HPDs were applied (ANCOVA)

| (I) Group | (J) Group | Mean Difference (I-J) | Std. Error | Sig.[b] | 95% Confidence Interval for Difference[b] | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| control | intervention | -11.981[*] | 4.127 | .005 | -20.188 | -3.774 |
| intervention | Control Group | 11.981[*] | 4.127 | .005 | 3.774 | 20.188 |

Based on estimated marginal means

*. Mean difference was considered significant at a level of .05.

b. Adjustment for multiple comparisons: Bonferroni.

Table 23 presents a comparison of the mean differences in terms of the percentage of time used for HPDs between the two groups. This was done under an adjustment variable (level of education and attendance of seminars regarding HPDs) for the differences presented at the baseline**.** The results from the analysis of covariance with adjusted variables indicate that there were statistically significant differences between the intervention and control groups in terms of the mean percentage of time used for HPDs after the intervention period (p=0.005).

# CHAPTER V

# DISCUSSION and RECOMMENDATIONS

The aims of this quasi-experimental study that involved a control group were to assess the effects of Noise Warning Applications (NOWA app.) in order to promote the use of hearing protection devices among steel industry workers. The specific objectives were; 1) to explore the use of HPDs among workers in the steel industry; 2) to compare the use of HPDs among steel industry workers before and after the intervention was implemented; 3) to identify and compare the hearing threshold levels among steel industry workers before and after implementing the intervention. Thus, in order to make the results of this study more easily understandable, this section will be followed by an account of the objectives of the study. Prior to that, we need to outline and discuss both the general and workplace characteristics of the industry, along with the present level of accessibility to information on HPDS for workers in the industry. All of which will help all stakeholders to better understand the current situation.

## 5.1 General characteristics of the participants and industry workplace characteristics as baseline data before intervention

All workers who participated in this study were men who presently work in the steel industry. This type of work is extremely demanding and the industry standards require that only male workers be allowed in the zones of operation. The results of this study indicate that steel industry employees who work in areas with high noise level standards experience a high risk for NIHL. NIHL among subjects in the intervention group was found to be caused by exposure to noise at levels of 95.79 dB (A) and above and 96.07 dB(A) and above in the control group, both of which were over the safe standard of 85 dB(A) ($L_{eq}$ 8 hour). Importantly, OSHA recommends that noise exposure level should not exceed 90 dB(A) for eight hours of work, but that the specific action level be set at 85 dB(A) for eight hours. This figure is the same as that of the Thai regulation (OSHA, 1991; Department of Labour Protection and Welfare, B.E 2549). In addition, the American Conference of Governmental Industrial Hygienists has recommended the same standard of safe noise exposure level at 85 dB(A) for eight working hours as the threshold limit to protect employees from hearing loss. Furthermore, the National Institute for Occupational Safety and Health [NIOSH] limits the exposure of noise to 85 dB(A) in order to protect hearing loss (NIOSH, 1998). However, these findings may suggest that steel workers could have been overexposed to other sources of noise during their work shifts. These findings are consistent with those of the previous study by Chai et al (Zohouri FV et al.) who measured personal noise exposure in steel cold rolling mills. The results of that study showed that the noise levels in steel rolling mills varied within a range of 81–100 dB(A) among all sections, but the noise exposure levels of all participating groups in this study were >85 dB(A) (Chai, et al.,2006). These findings suggest that steel workers may have been overexposed to noise during their work shifts. This can also support the findings (Tables 4-6, 4-7) that state that >80% of the steel industry workers in our study had suffered hearing loss at specified noise-sensitive frequencies (4–6 kHz), with a mean HTL value of ~34–42 dB. These findings are consistent with those of previous studies which found that occupational NIHL occurs primarily at high frequencies. For example, Çelik et al (1998) collected data from a hydroelectric power plant for a research study that involved 130 industrial workers who were exposed to high noise levels. The results revealed that the sensorineural hearing loss detected in 71 workers was bilateral, symmetrical, and mainly occurred at frequencies in a range of 4–6 kHz. Additionally, the results of a study by Pourabdiyan et al (2009) which investigated the hearing standard threshold shifts (STS) of Isfahan metal industry workers, revealed that only 29.9% of the workers met the requirements of the STS. There were significant relationships between age, exposure time, noise level, and wearing time of HPDs. The strongest risk factors that can help researchers predict hearing loss were noise exposure levels and duration of exposure. Importantly, participants with noise exposure levels of at least 86 dB(A) had a statistically and significantly higher chance of hearing loss. Furthermore, we found higher mean HTL values in the left ear than in the right ear of subjects, which was consistent with the results of other studies. This might be attributable to a greater level of sensitivity in the left ears of workers or the workers' increased level of exposure to noise sources on their left side (Cloeren, 2014; Simpson, 1993; Broste, 1989; Marvel, 1991; Pirila, 1992). *Sriopas*, A. et. al. (2017) collected data from the welding units of three auto parts factories in Thailand. Individual noise levels were measured by the researchers during 8-hour work shifts to establish a degree of consistency within the investigation. The microphone of the noise dosimeter was installed in the hearing zone in order to measure the noise exposure level for each subject. Time-weighted averages over 8 h (TWA-8 h) in terms of dB(A) were recorded by the dosimeter. The results confirmed that noise exposure levels of 86-90 dB(A) and those exceeding 90 dB(A) significantly increased the risk of hearing loss in either ear of factory workers. Notably, a noise exposure level exceeding 90 dB(A) significantly increases the prevalence of hearing loss in both ears of the average worker. In addition, the mean work hours among steel workers was

49.09 (SD =2.77) (Min-Max: 48-56) hours per week in the intervention group and 49.22 (SD =6.42) (Min-Max: 48-56) hours per week in the control group. These shift duration periods could be a major factor in contributing to the very high noise exposure levels we observed (which were over the Occupational Safety and Health Administration [OSHA] norms, 1991). Previous studies, such as one conducted by Toppila et al (UN ACC Sub-Committee on Nutrition), also noted that impulsive noise appears to be more harmful to hearing at high exposure levels. In the present study, workers were often not protected from exposure to continuous or impulsive noise levels above 90 dB(A), so the prevalence of hearing loss was higher. Moreover, factory employees were found to have worked for 48–56 hours per week, which was longer than the presently prescribed number of working hours of 48 hours per week (as per the Indian Factory Act) or 40 hours per week (in the US and European countries). Thus, hearing loss was found to be associated with overall occupational noise exposure and other risk factors similar to the findings reported by Ahmed et al, (2001) . A similar finding that NIHL could be monitored at 4 kHz with occupational exposure exceeding 17 years in two bottling plants was reported by Abbate et al. (2005). However, our present study revealed that the hearing loss of participants at 4 kHz increased more than other frequencies. Moreover, hearing loss can be associated with various other factors (Borchgrevink, 2003; Joshi, 2005; Pourabdiyan, 2009), such as exposure to different sources of noise, duration of exposure to noise, and age of the worker (Kim et al, 2000; Johansson and Arlinger, 2002; Amedofu, 2002; Abbate, 2005; McBride and Williams, 2001). The hearing ability of male steel workers exposed to noise levels of 90–99 dB(A) has been shown to be significantly affected (Howell, 1978), with a mean shift of 6.8–7.8 dB after 6–8 years of exposure. Their levels of NIHL are considered significant at 4 kHz, which is a well-established clinical sign. This degree of frequency is also speculated to be the typical notch frequency at which the largest magnitude of hearing loss is observed when compared with other high frequencies (Attarchi, 2010). Regarding the length of employment, previous studies have suggested that exposure to 85 dB(A) for 5 or more years increased the risk of hearing loss (NIOSH, 1998; U.S.Department of Health and Human Service, 1998; Thamasunthon, 2012; Sriopas, et al. 2017). This study indicated that the mean length of employment was 16.70 (SD 10.05) years in the intervention group and 15.11 (SD 9.11) years in the control group, and that the severity of NIHL among steel workers tended to accelerate in relation to the length of employment. This discrepancy might have resulted from the implementation of the preventive measure policy for hearing loss that was implemented in 2010. However, hearing loss still tended to increase along with the length of employment. In other words, actions relating to this recommendation were initiated in Thailand ~6 years before the data collection process began in the present study, whereas the participants' mean length of employment was ~14 years. The duration of employment ranged from 3 to 41 years in the intervention group and 3- 31 years in the control group. Therefore, the participants' hearing loss likely began to occur before workplace hearing conservation programs were first implemented. However, a cohort study is necessary to confirm this determination. With regard to age, we found that 79.5 % of the participants in the intervention group were aged over 40 years (min – max: 28-59 years) and 63.0 % in the control group were over 40 years of age (min – max: 26-57 years). This may be one factor affecting the high degree of prevalence of NIHL in both groups, as is indicated at the baseline. These findings are consistent with the conclusions of previous studies which found that hearing typically declines with age incrementally. This form of age-related hearing loss is called presbycusis and is found to occur more often in males than in females (Lass, 2007). As a consequence of aging, hearing will naturally decline along with the deterioration of hair cells and other neurons. This supports the contention that hearing loss occurs as a person ages. Generally, hair cells begin to decline around the age of 40, and the rate of deterioration is increased along with an increase in age (Sataloff, 2006). Johansson and Arlinger (2002) also reported a strong association between HTLs and age. They showed that HTLs increased more rapidly in those aged over 50 years at frequencies of over 3 kHz. Similarly, Edwards (2008) reported a strong association between hearing loss and age in a study conducted among gold miners. This study also indicated that hearing loss progressed in parallel with increasing 10-year age periods up to the age range of 50–60 years. Regarding the length of employment, previous studies have suggested that exposure to 85 dB(A) for 5 or more years positively increased the risk of hearing loss (NIOSH, 1998; U.S.Department of Health and Human Service, 1998; Thamasunthon, 2012; Sriopas, et al. 2017). This study indicated that employment duration periods exceeding 10 years tended to accelerate the severity of NIHL among steel workers. Moreover, over 60 % of subjects experienced hearing loss in both ears for work duration periods of >10 years. However, this outcome was inconsistent with the findings of a number of previous studies. For example, Siopas et, .al (2017) who conducted studied involving auto parts factory workers in welding units in Thailand found that subjects with employment duration periods exceeding 10 years significantly developed hearing loss in either ear. This discrepancy might have resulted from the implementation of the preventive measure policy for hearing loss in 2010. However, hearing loss still tended to increase in proportion with the length of employment. Johansson and Arlinger (2002) also reported a strong association between HTLs and age. They showed that HTLs increased more rapidly in those aged over 50 years at frequencies of over 3 kHz. Similarly, Edwards (2008) reported a strong association between hearing loss and age in a study conducted among gold miners. This study also indicated that hearing loss progressed in increasing 10-year age bins up to the age range of 50–60 years.

The Occupational Safety and Health Administration (OSHA) has established the presence of occupational noise exposure at/above 85 dB(A) as the threshold that requires the implementation of a hearing conservation program for workers (OSHA, 1991; NIOSH, 1998). The components of the hearing conservation program includes noise monitoring, noise control by engineering procedures, administrative controls, worker education, provision of hearing protection equipment for workers, and periodic audiometric assessments. Evaluation of program efficacy is an essential component of any successful program. A comparison of hearing thresholds reveals changes during exposure times using periodic audiometric evaluation as an important program evaluation method (Attarchi, 2010). In 2006, the Thai government enacted a regulation wherein workers must not be exposed to noise levels over 90 dB(A) when working for 8 hours in a single day. If exposure is found to reach or exceed 85 dB(A) throughout 8 hours of work, the employer needs to implement a workplace hearing conservation program (Morata, 2011; U.S. Department of Health and Human Services, 1998). However, serious enforcement of workplace hearing conservation programs only began in 2010. The effects of noise on the hearing among Thai factory workers have been confirmed. The present standard for hearing loss prevention was subsequently enacted after many factories in Samut Prakan Province had already been established. Most of these factories were established in the first era of factory-based industry development in Thailand. This means that many workers in Samut Prakan continue to work in old-fashioned, less technologically advanced, and noisy environments, in which it is difficult to engineer the control of noise levels. Furthermore, steel industrial establishment processes cannot be effectively accomplished without the importation of noise machines. And the hearing health of the workers that operate these machines must be preserved. Importantly, noise control cannot be addressed through engineering alone. Therefore, policies requiring that hearing protective devices be provided to steel workers, and the rules of their use, must be enforced (Sunday, 2015).

Apparently, there are no effective treatments for NIHL. However, it is considered preventable through the promotion of the use of HPDs among workers who are exposed to long-term excessive noise levels. This sort of campaign can help decrease the intensity of the noise levels that steel workers are routinely exposed to. The use of HPDs, as recommended by the National Institute for Occupational Safety and Health, has been proven to be effective as a form of NIHL prevention. However, previous research has revealed that the majority of steel workers do not consistently wear or use such helpful devices. For example, Brink et al (2002) found in cross-sectional multivariate analyses that the number of years of employment, the gender of the worker, and the proportion of time spent wearing HPDs were the factors that had the strongest association with hearing loss ($P<0.0001$). Consequently, considerations of age, transfer status (as a surrogate for previous noise exposure), race, and the average duration of noise exposure over a lifetime must be included in setting policies to prevent hearing loss among steel workers. The most consistent predictor of hearing loss in both univariate and multivariate analyses was the percentage of time having used HPDs during the workers' tenure. Further, a study by Hong (2005) revealed that over 60% of workers showed hearing loss at the noise-sensitive higher frequencies of 4 and 6 kHz. In that study, HPDs were reported to be used for only an average of 48% of the time during which they were required to be used. A significant inverse relationship was found between HPD use and hearing loss at higher frequencies (4–6 kHz). Participants in the present study wore HPDs for only 57.27 % of the time in the intervention group and 60.0 % of the time in the control group during the course of their work shifts. Previous research has determined that failure to use hearing protection 100% of the time when noise is at a high level significantly reduces HPD effectiveness (Howell, 1978; Chai, et al. 2006). However, the results presented in Table 4-2 reveal that only 4.5% of the participants in the intervention group were aware of the level of noise, and this was true of 6.5 % in the control group. This finding can serve as evidence that steel workers do not consistently use the suggested HPDs. This finding indicates that the current hearing conservation program for steel industry workers is ineffective. Moreover, data that has been collected concerning the training methods of the present hearing conservation program showed that there was no clearly defined format for the implementation of the program. Additionally, the program was only available to workers who had days off. Steel workers generally work overtime year-round, meaning that managers are typically the only workers who have time to participate in this form of training. This may be an important reason why the hearing conservation program has not yet been fully effective for this group of individuals. Although the Thai government enacted a regulation in 2006 stating that workers must not be exposed to noise over 90 dB(A) when working 8 hours in a day, serious implementation of workplace hearing conservation programs only began in 2010. In other words, action relating to this recommendation was initiated in Thailand ~8 years before the data collection process began for the present study, whereas the participants' mean length of employment was ~13 years (ranging from 1 to 39 years) in the intervention group and ~15 years (ranging from 1 to 29 years) in the control group. Therefore, the participants' hearing loss likely started before workplace hearing conservation programs were first implemented. It should be stated that a cohort study is necessary to confirm this. This suggests that these steel industry workers were overexposed to noise during their work shifts according to the standards set by the National Institute for Occupational Safety and Health, wherein it was stated that regular exposure to workplace noise was a risk factor that may affect hearing loss.

Furthermore, an important consideration for the participants of both groups was the availability of HPDs. In the past, the problem of poor HPDs use resulted from a lack of availability regarding HPDs for steel workers. After effective policies concerning HPDs use came into effect in Thailand according to OSHA recommendations, the availability of HPDs need to be better assessed. In this study, we have found that many workers responded by answering "yes" to the question of whether sufficient support for HPDs use has been provided to industrial workers? To this question, almost 100 % of those in the intervention group and almost 90 % of those in the control group answered "yes". However, when asked whether they currently own any HPDs equipment, the results revealed that only 56.8 % in the intervention group and 54.8 % in the control group answered "yes". Importantly, there were no statistically significant differences in both groups in response to these two questions. However, the results indicate that the integration of many components of effective policy-making is still needed in order to achieve optimal results. Additionally, awareness of the importance of wearing HPDs would still need to be improved in terms of the factory-sponsored availability of HPDs for these workers.

**To assess the Effectiveness of NoWa app. to promote the use of hearing protection devices in steel workers in Thailand.**

A quasi-experiment study with the control group was to assess the effects of the subjects in the intervention group assigned to receive the NoWa app., whereas the control group did not receive the intervention. The assessment of the effective of NoWa app. was the answer to the second and the third objective. The purpose of the NoWa app. was to promote the use of hearing protection devices consistently and prevent the increase of hearing threshold shift level. After implement the intervention, an evaluation of the intervention group and the control group was conducted to measure the effectiveness of the intervention. Key performance indicator of the effectiveness of the intervention was divided into 2 levels including primary and secondary outcomes. The primary outcome was HPDs using consistently which was measured in both groups before and after the intervention. The secondary outcome was the hearing threshold shift level after the end of the intervention program. The detail as follow:

### 5.2 Effectiveness of NoWa app. to promote the use of hearing protection devices

To evaluate the effectiveness of the NOWA app. In order to promote the use of hearing protection devices among steel industry workers, the assessment procedure will need to be divided into two objectives as follows. Firstly, the use of HPDs among steel industry workers must be explored. Secondly, the use of HPDs among steel industry workers before and after receiving the intervention will be compared. The HPDs use was inspected by the researcher and/or a safety officer/supervisor for both the intervention and the control groups at the pre-intervention and post intervention stages, which ranged for a period of 6 months. HPDs practice was assessed in terms of; 1) frequency of the use of HPDs and 2) the percentage of time HPDs were used (0-100 %).

This research included a comparison of HPD use and the practices among subjects in the intervention group before and after the intervention period (Table 4-12). There was an increase in the frequency of HPD use among those who always used HPDs (6-7 days a week) from 61.4 % before intervention to 95.5% after intervention, while no significant differences were observed ($p > 0.05$, Pearson's chi-squared test). The results (Table 4-11) also indicated significant differences after the intervention between the control and intervention groups after applying the chi-square test (p-value <0.05). Furthermore, when comparing the mean duration values of HPD use in terms of time before and after the intervention among subjects in the intervention group (Table 4-12), it was found that the average (± SD) value of duration of HPD use was $57.27 \pm 20.73$ before intervention and $73.41 \pm 12.00$ after intervention, while significant differences were observed ($p < 0.05$, Independent t-test). The results (Table 4-11) also revealed the presence of significant differences after intervention between the control and intervention groups after applying the t-test (p-value <0.05). Moreover, to confirm the effective administration of the intervention procedure with regard to the relevant dependence variable (ratio scale) in the quasi–experiment, any alterations in different methods were observed and noted. The results reveal the presence of significant differences in the findings ($p < 0.05$, Pairwise Comparisons). This would indicate that after the intervention period (NOWA app.), the HPDs practice was clearly better. However, the mean value of the percentage of time used did increase, but this was not completely preventable. Notably, inconsistent and/or improper use of HPDs has hindered efforts to prevent NIHL within the industry. In addition, failure to use hearing protection devices 100% of the time, when the noise was at a high level, significantly reduces HPD effectiveness (Berger, 2000; Taban, 2016). A multidimensional study would need to be implemented in order to prepare an effective intervention protocol.

This finding was consistent with those of several previous studies. Annelies Bockstael et al. in a study entitled “Hearing protection in the industry: International companies’ policies and workers’ perceptions” (Annelies Bockstael, et al. 2013) reported that an increased in the consistent use of hearing protection was dependent upon the strict enforcement of relevant policies, a culture of safety, and an improved risk perception of noise levels. However, the use of earplugs by the subjects in this study was not equal to 100%because of a lack of strict enforcement of safety policies and a poor culture of safety. Moreover, inspections by safety officers as key individuals in the management of earplug use among workers would be necessary. This may be an indication of why the effective practice of HPD use within the control group increased during the course of this study. However, there was still not adequate time allotted to effectively protecting against hearing loss within the steel industry.

Another revelation of this study was the evaluation of knowledge and attitudes toward HPDs. The mean knowledge scores for subjects of both the intervention and control groups were evaluated at the baseline and at the post-intervention stage for a period of 6 months. The average knowledge score for subjects of the intervention group (10.41 point) was equal to that of the control group (10.50 points) at the baseline. After subjects were monitored in terms of HPDs use and the hearing threshold levels, the results revealed that both groups of participants displayed increases in their knowledge scores. Additionally, an assessment of the subjects' attitude toward HPDs use revealed that the attitude scores of members of the intervention group significantly increased from 34.41 at the baseline to 37.67 at the post-intervention stage ($p<0.001$). In the control group, the baseline score for the attitude was 36.39 and increased to 36.63 at the post-intervention stage. This means that the hearing conservation program that the industry had previously set may need to be refreshed. However, an assessment of the baseline data indicates that the industry should consider raising the status of workers as a way of helping address the hearing problem. This determination is in accordance with that of the study conducted by Phil Hughes and Ed Ferret (2011) in which memory was seen as an important factor that can influence the training and experience of a workforce. The efficiency of memory can vary between people and also during the lifetime of an individual. In this study, the mean knowledge score of the subjects in the intervention group decreased after 6 months when compared with the scores recorded after the first training session. Thus, a refreshed training program should be implemented to maintain relevant knowledge and should be conducted for a period of at least 6 months (Phil Hughes and Ed Ferrett, 2011).

### 5.3 Comparison of the hearing threshold levels among steel industry workers before and after the intervention

The first audiogram was used to measure the values that would set the baseline before the intervention of the Noise Warning Applications (NOWA app.). Audiometric data collection was performed using an Audiometer GSI 18. Audiometric testing was conducted in an audiometric booth of Samut Prakarn hospital (Provincial Hospital). Hearing threshold levels were examined by the same occupational nurse from the occupatioal medicine unit and assessed report by physician in occupational medicine. This audiometric testing assessed the hearing levels of subjects in the intervention and control groups at both the initiation and termination of the Noise Warning Applications (NOWA app.). A pure tone air conduction audiometric test was performed to determine the hearing thresholds at frequencies of 500, 1000, 2000, 3000, 4000, and 6000 Hz for both ears of each subject using an audiometer that was affixed with ear phones. Measurements of the hearing thresholds were recorded in 5 dB increments. The National Health and Nutrition Examination Survey (NHNES, 2009) recommends that subjects consider applying overall abnormal hearing threshold levels if the thresholds shift at any frequency of more than 25 dB in either the right or left ear. Even though there was no one universally accepted method of defining the degree of hearing impairment. Generally, the various schemes currently in use involves normal hearing thresholds in a range of 0 to 25 dB. The audiometric test in this study was performed at least 14 hours after the last exposure to noise in the workplace. Subjects were then tested on Monday morning to avoid any temporary threshold shift. However, if subjects could not be tested before their work shifts, earplugs were used during their shifts to prevent any faulty audiogram readings of temporary threshold shifts.

Mean hearing threshold levels at the baseline were approximately 32.50–41.02 dB among subjects in the intervention group and 32.50 -42.72 dB among those in the control group. This study recorded hearing losses at noise-sensitive frequencies (4–6 kHz) and these findings were consistent with those of previous studies. Simply put, the strongest risk factors for hearing loss include noise exposure levels and exposure duration periods. Furthermore, we found a higher mean HTL in the left ear than in the right ear, which was consistent with the findings of other studies. This might be attributable to a greater level of sensitivity in the left ear of subjects or exposure of workers to a noise source from the left side (Attarchi, 2010; Chai, 2006; Singh, 2010; AGGIH, 2011). However, in the post intervention stage, it was found that there were no changes in the hearing threshold levels. This result was in accordance with the findings of published literature wherein occupational noise-induced hearing loss developed slowly over several years as a result of ongoing exposure to loud noises (ACOEM, 2003).

This finding was consistent with those of previous studies. A study conducted by the Health and Safety Authority, Ireland (Health and Safety Authority, 2007) stated that noise-induced hearing loss (NIHL) typically results at a ‘notch’ often starting around 4000 Hz, but sometimes 6000 Hz, then gradually deepens and later extends to nearby frequency ranges. The study by Hong et al.,(2005) entitled “Hearing loss among operating engineers in American construction industry”, found that hearing threshold levels (Madbuli, 2013) increased at high frequencies between 4000 to 6000 Hz and revealed significantly poorer hearing levels in the left ear of subjects (Hong et al., 2005). The study by Ologe FE. et al. entitled “Occupational noise exposure and sensorineural hearing loss among workers of a steel rolling mill” (Ologe, 2005) reported that about 28.3% of 103 workers who had been exposed to noise levels between 49 to 93 dB (A) had mild to moderate sensorineural hearing loss in their better ear. Incidentally, most of them (56.8%) revealed mild to moderate sensorineural hearing loss in their worse ear. The average hearing threshold levels at a frequency of 4000 Hz for the intervention group was significantly increased along with an increase in noise exposure levels. The study of Rachiotis G. et al. (Zohouri FV et al.) entitled “Occupational exposure to noise, and hearing function among electro production workers” reported that electro production workers who were routinely exposed to high noise levels experienced sensorineural hearing loss mainly at 4000 Hz.

In point of view on comparison of the knowledge and attitude about HPDs use among steel industry workers before and after the intervention;

In this issue, if we mainly consider at the intervention, it is found that it concerned just the use of NoWa App. only and training was focused about the reason why we had to use NoWa app, the benefits of using it, the efficiency of usage, and the use would include the request for various assistances which had no tutorial about how to wear such equipment or devices preventing directly loud noise exposure. But in this study, their knowledges and attitudes were evaluated before and after using NoWa App. In both groups of workers because we believed that their operation would often relate to knowledges and attitudes so as not to cause error or discrepancy in the processing. From the study, it was found that the behavior of wearing loud protective devices in both groups of workers had been improved for betterment, but only the group which used NoWa App had significantly higher frequency usage than they previous did. While their knowledge about the protective devices in both groups statistically significant increased and different from theirs before. Regarding on their attitudes about wearing protective devices, it was found that only the experimental group had significantly better attitude while the controlled group still had the same attitude. In such regard, it was obvious that our evaluation of the data and the notification of the result of the data collection to the factory might affect to the knowledge, attitude or even the wearing behavior of the preventive devices as well. The factory selected in this study participation, had already announced the hearing conservative program, their knowing the result of data evaluation might cause deviation to the hearing conservative project being conducted while we were conducting the study. A part of it might arise due to the joint prejudice or from the cointervention bias.

Final issue, the noise warning application, which was considered as the main intervention of this research, it was found that it must still be developed continuously due to the fact that there is still a limitation in the sound signal of the device to be uploaded with the applied software. In this study, the easily and cheap phones available in any convenience store. Generally, the quality of sound receivability might not be as good as it was hoped for. Because we had conducted the experiments in the laboratory of the National Metrology Center on varios models of phones, it was found that their processing speed and their tolerances detectability were hardly much. If the phones uploaded with the required Application had a good quality capable to sense audio signal, their measurable values would be close to actuality, consequently result in correctly accurate processing. If the accumulated noise was slowly detected, the response shown in the warning form would be slower than its actuality. However, for this research, the Application had been sent to be checked for the standard when working with the phones in noisy environment and adjust its standard had been calibrated and adjusted able to measure the noise as same as the standard equipment before all phones were used in this research. Therefore, the accuracy of our intervention was in the standard criteria, whether if used for the purpose as a trigger to alert the hazardous situation of ear health, it can stimulate workers to know that they must wear hearing protective devices. Using noise warning Application can still be a good answer. In addition, in the next study, which may take longer period, repetitive calibration of concerned equipment is a thing to be considered as appropriate.

### 5.4 Limitations of the study

There are noted limitations of this study as follows:

1) This study included data collected at only two steel factories in Thailand. Therefore, the findings cannot be generalized and practically applied to other industries.

2) This study involved a quasi-experimental design, in which randomization was not implemented in the intervention process, thus the equality of the sample could not be assumed and there were limitations to controlling any extraneous variables. Confounding factor were not truly control.

3) Inspection of HPDs use was done once a month by the researcher as observations on the use of earplugs could not be done on a daily basis. May cause information bias.

4) Co intervention from Hearing conservation program may be affected to the results.

### 5.5 Conclusion

1. The noise warning application has led to a significant increase in the percentage of HPDs use by subjects of the intervention group when compared with those of the control group.

2. The noise warning application has led to a significant increase in the consistent use of HPDs among subjects of the intervention group when compared with those of the control group.

3. The noise warning application has led to a significant increase in the levels of knowledge and awareness in subjects of the intervention group when compared with those of the control group.

4. The noise warning application has led to a significant increase in the attitudes of members of the intervention group when compared with those of the control group.

## 5.6 Recommendations

Future research should include the following:

1) A longer follow-up time is needed to evaluate the present HPDs use among workers and to process audiogram results.

2) An extended refresher training course should be implemented to offer guidance and advice on consistent earplug use.

3) Relevant and effective noise warning applications should be offered and applied to other major industrial manufacturers.

# REFERENCES

Abbate C, Concetto G, Fortunato M, Brecciaroli R, Tringali MA, Beninato G, et al. Influence of environmental factors on the evolution of industrial Noise-Induced Hearing Loss. *J Env Monitoring Assessment*. 2005; 7(1-3):351–361.

Ahmed HO, Dennis JH, Badran O, Ahmad HO, et al. Occupational noise exposure and hearing loss of workers in two plants in eastern Saudi Arabia. Ann Occup Hyg. 2001;45(5):371–380.

Arehart, K. H. (2005). The nature of hearing and hearing loss. Soundscape The Journal of Acoustic Ecology, 6 (1), 11-14.

Arezes, P. M., & Miguel, A. S. (2005). Hearing protection use in industry: The role of risk perception. Safety science, 43(Zohouri FV et al.), 253-267.

American National Standards Institute.(1991). Maximum permissible ambient noise levels for audiometric test rooms, ANSI S3.1-1991. New York.

American Hearing Research Foundation. (2014). Noise Induced Hearing Loss. Retrieved 12 August, 2014, from http://american-hearing.org/disorders/noise-induced-hearing-loss/

American speech language hearing association.(1978). Manual pure-tone threshold audiometry.*ASHA, 20,* 297-301.

Attarchi M, Sadeghi Z, Dehghan F, Sohrabi M, Mohammadi S. Assessment of hearing standard threshold shift based on audiometric findings in steel company workers. Iranian Red Crescent Medical Journal. 2010; 2010(Zohouri FV et al.):644-9.

Banks K, Burge R (2004) Mobile phones: an appropriate tool for conservation and development: by Fauna & Flora International, Cambridge, UK.

Beach, E. F., Gilliver, M., & Williams, W. (2013). Leisure noise exposure: participation trends, symptoms of hearing damage, and perception of risk. Int J Audiol, 52 Suppl 1, S20-25. doi: 10.3109/14992027.2012.743050

Berg RL, PickettW, Fitz-RandolphM, Broste SK, KnoblochMJ, Wood DJ, et al.Hearing  Conservation program for agricultural students: short-term outcomes from a cluster randomizedtrial with planned long-term follow-up. Preventive Medicine 2009;49:546–52.

Brink, L. L., Talbott, E. O., Burks, J. A., & Palmer, C. V. (2002). Changes over time in audiometric thresholds in a group of automobile stamping and assembly workers with a hearing conservation program. AIHA J (Fairfax, Va), 63(Zohouri FV et al.), 482-487.

Chai DL, Lü JQ, Zeng L, Su YG, Lei Z, Zhao YM. [Measurement of personal noise exposure in a cold rolling mill] Zhonghua Yu Fang Yi Xue Za Zhi. 2006;40(2):93–96. Chinese.

ChalermchaiChaikittiporn. (1998).  *Environment and safety industry*. PathumThanienwrite concept. Centers for Disease Control Prevention. (2004). NIOSH 2004: Publication.

ChatchaneeKampibal. (UN ACC Sub-Committee on Nutrition).  *Habits of ear protection from noise hazard of textile industrial worker* (Master of social science), Mahidol university, NakornPathom.

Cocosila, M., Archer, N., Haynes, R. B., & Yuan, Y. (2009). Can wireless text messaging improve adherence to preventive activities? Results of a randomised controlled trial. *International journal of medical informatics,* *78*(Zohouri FV et al.), 230-238. Arehart, K. H. (2005). The nature of hearing and hearing loss. *Soundscape The Journal of Acoustic Ecology, 6* (1), 11-14.

Arezes, P. M., & Miguel, A. S. (2005). Hearing protection use in industry: The role of risk perception. *Safety science, 43*(4), 253-267.

Beach, E. F., Gilliver, M., & Williams, W. (2013). Leisure noise exposure: participation trends, symptoms of hearing damage, and perception of risk. *Int J Audiol, 52 Suppl 1*, S20-25. doi:10.3109/14992027.2012.743050

Centre, E.-E. P. (2004). Noise at work. Retrieved from http://www.ehstrends.com/2004Forecast_Noise.htm

Chaikittiporn, C. (BE.2541). *Environment and safety industry*. Pathum Thani enwrite concept.

Control, C. f. D., & Prevention. (2004). NIOSH 2004. In: Publication.

Davies Hugh, Marion Steve, & Teschke Kay. (2008). The impact of hearing conservation programs on incidence of noise-Induced hearing loss in Canadian workers. *American journal of industrial medicine, 51*(12), 923-931.

Dear, T. (1998). Updating damage risk criteria to include per- formance under workplace noise regulations  *Journal of Occupational Hearing Loss, 1*(1), 61-65.

DeHart, R. (2012). JOEM r Volume 54, Number 11, November 2012.

Ektasang, U. (B.E. 2546). *Occupational Diseases*. Paper presented at the Seminar for Occupational Nurse Who working in hospital.

Foundation, A. H. R. (2014). Noise Induced Hearing Loss. Retrieved from http://american-hearing.org/disorders/noise-induced-hearing-loss/

Glorig, A. (1979). Industrial hearing conservation. *Otolaryngologic clinics of North America, 12*(3), 609-621.

Goetsch, D. L. (2011). Occupational Safety and Health for Technologists, Engineers, and. Grundfast, K. M., Siparsky, N., & Chuong, D. (2000). Genetics and molecular biology of deafness: Update. *Otolaryngologic Clinics of North America, 33*(6), 1367-1394.

Guerra, M. R., Lourenço, P. M. C., Bustamante-Teixeira, M. T., & Alves, M. J. M. (2005). Prevalence of noise-induced hearing loss in metallurgical company. *Revista de saúde pública, 39*(2), 238-244.

Harnchumpol, T. (B.E. 2546). *The study of  the suitability of hearing protection device in difference level.* Graduated school, King Mongkut's University of Technology North Bangkok, Bangkok.

Hong, O., Lusk, S. L., & Ronis, D. L. (2005). Ethnic differences in predictors of hearing protection behavior between Black and White workers. *Research and theory for nursing practice, 19*(1), 63-76.

Jaijong, S. (B.E.2542). *Working conditions of workers in the hoof hearing, timber processing plant. Trang Year 2552*. Retrieved from Trang:

Kampibal, C. ( B.E. 2543). *HABITS OF EAR PROTECTION FROM NOISE HAZARD OF TEXTILE INDUSTRIAL WORKER.* (Master of social science). Mahidol university, NakornPathom.

Klaisripo, M. (B.E 2545). *Plevalence and factor related to noise induce hearing loss in Village forest craft knife worker at Ayutaya province* (Master oc science). Chulalongkorn University Bangkok.

Kongtip, P. (B.E. 2545). *Occupational Health*. Bangkok: Numaugsorn Publisher.

Landen, D., Wilkins, S., Stephenson, M., & McWilliams, L. (2004). Noise exposure and hearing loss among sand and gravel miners. *Journal of occupational and environmental hygiene, 1*(8), 532-541.

Levy, B., & Wegman, D. H. . (2000). Preventing occupational disease and injury. In B. L. D. H.Wegman (Ed.), *Occupational health: Recognizing and preventing work- Related disease and injury* (4 ed., pp. 123-142). Philadelphia: Lippincott Williams & Wilkins.

Limited, M. T. C. (B.E 2550). 3M Safety Solutions for protection of health and life.

Lusk, S. L., & Kelemen, M. J. (1993). Predicting use of hearing protection: a preliminary study. *Public Health Nursing, 10*(3), 189-196.

Mapradit, N. ( B.E. 2542). *To study the prevalence of NIHL, the worker's preventive behaviors of thermal power plants and combined cycle plants of EGAT.* (Master of science). Chulalongkorn University, Bangkok.

May, J. J. (2000). Occupational hearing loss. *American Journal of Industrial Medicine, 37*(1), 112-120. (B.E. 2549).

Mostafapour, S. P., Lahargoue, K., & Gates, G. A. (1998). Noise-induced hearing loss in young adults: The role of personal listening devices and other sources of leisure noise. *The Laryngoscope, 108*(12), 1832-1839.

Nakai, Y. (2003). *Noise-induce hearing loss IFOS NIHL Standing Committee's report and NIHL in Japan*. Paper presented at the International Congress Series 1240, 273-275.

Neitzel, R., & Seixas, N. (2005). The effectiveness of hearing protection among construction workers. *Journal of occupational and environmental hygiene, 2*(4), 227-238.

Nelson, D. I., Nelson, R. Y., Concha-Barrientos, M., & Fingerhut, M. (2005). The global burden of occupational noise-induced hearing loss. *Am J Ind Med, 48*(6), 446-458. doi:10.1002/ajim.20223

Noordzij, M., Tripepi, G., Dekker, F. W., Zoccali, C., Tanck, M. W., & Jager, K. J. (2010). Sample size calculations: basic principles and common pitfalls. *Nephrol Dial Transplant, 25*(5), 1388-1393. doi:10.1093/ndt/gfp732

Office of the Workmen's Compensation fund, S. S. O. (2012). *Occupational diseases classified by degree of loss and condition of work*. Retrieved from

Ologe, F. E., Akande, T. M., & Olajide, T. G. (2006). Occupational noise exposure and sensorineural hearing loss among workers of a steel rolling mill. *European Archives of Oto-Rhino-Laryngology and Head & Neck, 263*(7), 618-621.

Opasmongkolchai, P. (B.E.2550). *Principle in the use of personal protective equipment*. Paper presented at the Workshop for assessing the performance of individual workers, Chaing Mai.

Pender, N. J., Murdaugh, C. L., & Parsons, M. A. . (2006). *Health promotion in nursing practice (5th ed.).* New York: Appleton & Lange.

Puwasit Singhapoom, S. L., Jitrapun Pusapukdepob. (2013). Combined Effect of Noise Exposure and Smoking to Hearing Loss among Casting Factory Workers, Panthong District, Chon Buri Province. *The Public Health Journal of Burapha University :, 8*(2), 100-108.

Raymond, D. M., Hong, O., Lusk, S. L., & Ronis, D. L. (2006). Predictors of hearing protection use for Hispanic and non-Hispanic White factory workers. *Research and theory for nursing practice, 20*(2), 127-140.

Roger, B. (2003). *Occupational and environmental health nursing: Concept and practice* (2 ed.). Philadelphia: Saunders.

Sataloff, J., Sataloff, R. T., & Sataloff,Robert Thayer. (2006). Occupational hearing loss (Eds.). In *Occupational hearing loss (3rd ed.)*. . Boca Raton, FL: CRC Taylor & Francis.

Savitri Chairath, A. B., and Pen Patra Sripaibulya (2013). Factors related to standard threshold shift in mortor compressor workers. *Thammasat Medical Journal, 13*(1).

Services, U. D. o. H. a. H. (1998). Chapter 5: Hearing loss prevention programs (HLPP's). In NIOSH (Ed.), *Occupational noise exposure: Revised criteria 1998* (pp. p 36–60.). Cincinnati, Ohio

Silpasuwan, P. (B.E. 2548). *Occupational Health Nursing: Theory and practice*. Bangkok: Chuanpit.

Somchart Arjkamol, S. K., Amon Premjai. (B.E. 2548).

Effect of Hearing Concervation Program in High level of Noise industriy of Chachoengsao Industrial Estate *Journal of Health Science 13*(1), 519-524.

Sriwanyong, S. (B.E. 2544). Occupational noise induce hearing lossand calculatingforcompensation found fromnoise induce hearing loss

In S. p. a. S. kunchak (Ed.), *Otolaryngology* (pp. 138-142). Bangkok: Holistic publishing.

Sunan Sukolrattanamethee, R. R., Ankana Noimuangpleuy and Wanlee Theeranantachai , & ( B.E. 2540). *The development of health and environment surveillance in industry  for prevent noise hardzard*. Ratchaburi.

Suter, A. H. (2002). Construction noise: exposure, effects, and the potential for remediation; a review and analysis. *AIHA Journal, 63*(6), 768-789.

Suthammasa, S. (B.E. 2547). *Management of noise polution from industrial*. Bangkok: see and eas printing.

u-suke, W. (2006). *Occupational Health and Safety*. Bangkok:  limited partnership of Best graphic place,.

UN ACC Sub-Committee on Nutrition. (2000). Low Birth Weight. In Judith Pojda & Laura Kelley (Eds.), *The UN System's Forum For Nutrition*: United Nations.

Uraiwan Inmuang, L. L., faungfar karnnopasu and chardchanee khumpibarn. (B.E. 2545). The hearing loss in the establishment of a technician to repair and spray paint. *Mahasarakham University, 20*(2), 121-136.

Urajjananon, K. (B.E. 2549). *Noise Exposure and Risk Perception of Noise Exposure Among Workers in Large Lumber Mill.* (Master of Nursing science (Occupational Nursing)). ChiangMai University ChiangMai.

Wacharatrakul, W. (B.E. 2550). *Assessing  the performance of hearing of worker in workplace*     Paper presented at the Workshop for assessing  the performance of individual workers  Chiang Mai.

Yusuk, W. (B.E. 2549). *Occupational Health and Safety*. Bangkok: Best graphic place.

Zohouri FV, Swinbank CM, Maguire A, PJ., M., fluoride/creatinine, I. t., Community, r. o. a. s. u. s. i. o.-h. u. f., & Dent Oral Epidemiol 2006; 34: 130–8. ✓

Blackwell Munksgaard. (2006). Is The Fluoride/Creatinine Ratio Of A Spot Urine Sample Indicative Of 24-H Urinary Fluoride.

WHO. (1986) Hearing impairment cause by noise. In: Early detection of occupational disease. Geneva: WHO; 160-9.

World Health Organization. In report of the informal working group on prevention of deafness and hearing impairment programed planning, Geneva, 1991.

World Health Organization.(1997) Prevention of noise-induced hearing loss. *In report of an informal consultation*, Geneva.

World Health Organization (UN ACC Sub-Committee on Nutrition).World Health Report 2003, Geneva.

WHO | Deafness and hearing loss [Internet].2010 [cited 2010 November 14]. Available from: http://www.who.int/mediacentre/factsheets/fs300/en/

Yost, W.A. (UN ACC Sub-Committee on Nutrition)*Fundamentals of hearing: an introduction*. 4th ed. Academic Press.

# APPENDIX

# Appendix A

## List of steel Industry

### List of 10 steel Industry that number of workers more than 200 persons

| No. | Name | Address | Worker (persons) |
|---|---|---|---|
| 1 | บริษัท ไทยสตีลบาร์ส จำกัด | 98 ม.6 ถ.ปู่เจ้าสมิงพราย ต.สำโรงใต้ อ.พระประแดง จ.สมุทรปราการ | 202 |
| 2 | บริษัทไทรอัมพ์สตีล จำกัด | 200/1 ม.7 ซ.บุญล้อม ต.สำโรงใต้ อ.พระประแดง จ.สมุทรปราการ | 240 |
| 3 | บริษัท เมืองไทยเหล็กกล้า จำกัด | 215 ม.1 ถ.สุขสวัสดิ์ ต.ปากคลองบางปลากด อ.พระสมุทรเจดีย์ จ.สมุทรปราการ | 242 |
| 4 | บริษัท นครหลวงพัฒนาวิศวกิจ จำกัด | 597 ม.4 ถ.สุขุมวิท ต.แพรกษา อ.เมือง สมุทรปราการ จ.สมุทรปราการ | 256 |
| 5 | บริษัท ป้อมพระจุลสตีล จำกัด | 115 ม.1 ถ.สุขสวัสดิ์ ต.แหลมฟ้าผ่า อ.พระสมุทรเจดีย์ จ.สมุทรปราการ | 294 |
| 6 | บริษัท ผลิตเหล็กไทยพัฒนา จำกัด | 592 ถ.สุขุมวิท ต.แพรกษา อ.เมือง สมุทรปราการ จ.สมุทรปราการ | 373 |
| 7 | บริษัทยูไนเต็ด สตีลไพพ์ จำกัด | 199 ม.4 ถ.สมุทรปราการ-สมุทรสาคร ต.ในคลองบางปลากด อ.พระสมุทรเจดีย์ จ.สมุทรปราการ | 409 |
| 8 | บริษัท สยามสติลซินดิเกต จำกัด | 211 ม.6 ถ.ท้ายบ้าน ต.ท้ายบ้าน อ.เมือง สมุทรปราการ จ.สมุทรปราการ | 412 |
| 9 | บริษัท กรุงเทพผลิตเหล็ก จำกัด (มหาชน) | 27 ม. 10 ซ.กลับเจริญ ถ.ปู่เจ้าสมิงพราย ต.บางหญ้าแพรก อ.พระประแดง จ.สมุทรปราการ | 491 |
| 10 | บริษัท โรงเหล็กกรุงเทพ จำกัด | 42 ม.4 ถ.สุขสวัสดิ์ ต.บางครุ อ.พระประแดง จ.สมุทรปราการ | 510 |

# Appendix B

## Picture of Noise warning Application

แจ้งเตือนแบบเสียง ON OFF

แจ้งเตือนแบบสั่น ON OFF

แจ้งเตือนแบบแสง ON OFF

# Appendix C

## Training program for intervention device

The training is the onsite training. It will be delivered approximately a-3 hour for 1days.The training is designed to give knowledge about the NoWa App. compose of the reason to used it, benefit of using NoWA App , the way to use, the way to response, effectiveness of applying NoWa App, and calling for assisting problems. Then, it will be practicing the Nowa app. use which is based on real material Nowa app. within the mobile phone. Outline of all training is the followings.

**Schedule of the Training for study participants**

| **Training** | **Detail** | **Time (hour)** |
|---|---|---|
| Section 1<br>9.00-10.00 | 1.The reason for use NoWa app to promoting the wearing of HPDs use<br>2.Benefit of using NoWa App<br>3. Effectiveness of applying NoWa App | 1 hour |
| 10.00-10.15 | Break | 15 min. |
| Section 2<br>10.15-11.00 | The way to use Nowa App.<br>The way to response<br>Calling for assisting problems | 45 min. |
| Section 3<br>11.15-12.00 | Practicing the Nowa app. with real instrument | 1 hour |

# Appendix D

## General Questionnaire (English version)

**Dear Participants**

The researcher conducted this survey together with Samut prakan Hospital to provide a program to prevent hearing loss among worker in factory. The hospital providers know about this survey and support it. However, your participation in this study is voluntary and the information you give us will be confidential, which means your name will not be mentioned anywhere and information provided by you will be presented only in a summarized form.

Please select carefully the answer for each question and the possible responses. Choose and mark (√) the response option that best represents you opinion and knowledge, attitude, and practice. Please note that if you any concern about of the questions or other problem, refer to the healthcare provider.

### Introduction of the questionnaire

The questionnaire is divided into 6 parts present as follows;

Part I Demographic characteristics (4 questions)
Part II Work Characteristic (6 questions)
Part III Availability of HPD (2 questions)
Part IV Knowledge related to use of hearing protection devices (12 questions)
Part V Attitude related to use of hearing protection devices (12 questions)
Part VI Behavior related to use of hearing protection devices (1 questions)

**Thank you for information**

**Part I:** Demographic characteristics and experiences with noise exposure

-----------------------------------------------------------------------------------------------------

**Guidance:** Please select carefully the answer for each question and choose the answer by marking (√) the response option that best represents. Part

**1.1 Demographic characteristics**

1. Age………………..Years…………month

2. Position ☐ Head ☐ Practitioner ☐ Other…

3. Education Level ☐ Uneducated ☐ Primary School
☐ Seconder School ☐ College Graduate
☐ Bachelor or higher

4. Risk Behaviors

4.1. Have you ever had any ear problem before?

☐ No ☐ Yes
- ☐ Otorrher
- ☐ Perforation of eardrum
- ☐ The accident of the ears or head
- ☐ Impacted Earwax
- ☐ Noise in the ear
- ☐ Hearing decreased
- ☐ Tinnitus after cold……last date……
- ☐ Other……

4.2 Smoking

☐ Never ☐ Ever
- ☐ Currently, I've given up
- ☐ Current smoke
- ☐ Type…………………………………….
- ☐ amount of cigarette …………per day………
  - ☐ How often?.........................

4.3 Do you take ototoxic drugs?

4.3.1 Neomycin…..Please identify dose/frequency/ duration

☐ Never ☐ Ever last date…………………

4.3.2 Streptomycin…..Please identify dose/frequency/ duration…

☐ Never ☐ Ever last date…………………

4.3.3 Diuretics …..Please identify dose/frequency/ duration…

☐ Never ☐ Ever last date…………………

4.3.4 Aspirin…..Please identify dose/frequency/ duration…

☐ Never ☐ Ever last date…………………

4.4 Do you have noisy hobbies?

☐ No ☐ Yes please identify … (can answer more than one item)

- ☐ Riding a motorcycle
- ☐ Listening to music through earphones with high volume
- ☐ Singing and playing music
- ☐ Going to discotheque
- ☐ Shooting
- ☐ Other……………………………..

4.5 Ear buds use (music/telephone)

☐ Never ☐ Ever

- ☐ Currently, I've given up
- ☐ Current use
- ☐ Type
  - ☐ Inner ear
  - ☐ Cover ear
- ☐ Time of use
  - ☐ All day both working hours and free time
  - ☐ Only free time
  - ☐ Only working hours
  - ☐ Other... Please identify……………………….
- ☐ How often?...../hour/day……....day/weeks

4.6 Have you ever had the history of loud noise before (such as firecrackers, gun sound, and explosion)?

☐ Never ☐ Ever

4.7 Have you ever received the audiogram testing before?

☐ Never ☐ Ever

**Part II: Work characteristics**

-----------------------------------------------------------------------------------------------

5. How long have you worked as a steel worker? Years……………month

6. Duration of normal work shift………………hours/day……………….day/week

7. How many hours that you work in this area a day ……..../hour/day…...day/weeks

8. Do you have over time work?

○ No ○ Yes, please specify............................

9. Have you ever worked in the noise environment before going to work in a steel factory?

○ No ○ Yes, Please specify.................... for...........Years……month

Do you always use hearing protection devices while running?

○ No

○ Yes, please specify............................

10. Do you know the noise level in your working area?

○ No ○ Yes, please specify............................

**Part III:** Availability of HPD

---

**11. Factory's readiness about the use of noise protection devices**

11.1 Does the factory you are working for, have announcement or policy about hearing conservation project ?

○ Yes ○ No ○ I don't know

11.2 Does the factory you are working for, have training about hearing conservation program ?

○ Yes ○ No ○ I don't know

11.3 Has the factory you are working for, arranged the risky area set up and thoroughly announced to all workers?

○ Yes ○ No ○ I don't know

11.4 Has the factory you are working for, provided loud noise protective devices adequately for all workers working in the risky area?

○ Yes ○ No ○ I don't know

11.5 Has the factory you are working for provided soundproof devices conveniently to be used by the workers or not?

○ Convenient, by providing them at.......

○ Not convenient by providing them at

11.6 Does the factory have a measurement to punish workers for not wearing loud noise protective devices, such as wage reduction, bonus reduction?

○ Yes ○ No ○ I don't know

11.7 Does the factory have a reward or special bonus for workers who wear loud noise protective device?

○ Yes ○ No ○ I don't know

**12. The workers' readiness**

12.1 Do you presently have loud noise protective device?

○ No, I don't, because

☐ The factory does not provide them.

☐ The factory provides them but they are not sufficient.

☐ The factory has sufficiently provided them, but now they are lost / worn out

☐ The factory has sufficiently provided them but I forgot to bring them to use.

○ Yes, I do, they are in a type of

☐ Ear inserting in or ear-plugs I got these devices from ☐ the factory

☐ I buy them myself ☐ others......................

☐ Ear covering over or ear-muffs

I got these devices from

☐ The factory ☐ I buy them myself ☐ others......................

☐ Other types, please specify.....................................

I got these devices from

☐ The factory ☐ I buy them myself ☐ Others......................

12.2. Have you ever been trained about the danger and protection from noise hazards or not?

☐Never ☐ Used to, specify ............ number of times/year

12.3 Have you ever been trained on how to use the loud noise protective devices?

☐Never ☐ Used to, specify ............ number of times/year

12.4. Have you ever been trained on how to keep the loud noise protective devices properly?

☐Never ☐Used to, specify ............ number of times/year

12.5 Have you ever been trained on how to clean the loud noise protective devices?

☐Never ☐ Used to, specify ............ number of times/year

## Part IV: Knowledge related to use of hearing protection devices

----------------------------------------------------------------------------------------------------

**Guidance**: Please select carefully the answer for each question and choose the answer by marking (√) corresponding to reality. Please keep in mind your standards, hopes, pleasures and concerns.

| Knowledge | Yes | No | Don't know |
|---|---|---|---|
| 1. When working in an area with loud noises, hearing protection devices should be applied. | | | |
| 2. Using hearing protection devices during the work hour can help decrease extremely loud noises exceeding the standard to a safe level. | | | |
| 3. The appropriate hearing protection devices are importantly examined for the noise reduction rating in workplace. | | | |
| 4. If hearing protection devices are not applied during the work hour with loud noise machines, hearing capacity may decrease. | | | |
| 5. Wearing hearing protection devices at all time continuously will be able to protect hearing loss. | | | |
| 6. Wearing hearing protection devices is not necessary to wear all day but it should be applied during the work hour in the areas with loud noise only. This is able to prevent hearing loss as well. | | | |
| 7. If you are not sure whether hearing protection devices are fitted with the workplace with loud noise, you are able to ask for advice from the supervisor or guard officers in the workplace. | | | |
| 8. When using ear plugs, you do not need to concern their cleanliness before use. | | | |
| 9. When wearing hearing protection devices, they are not necessary to be checked whether it is in a good condition before wearing. | | | |
| 10. Hearing protection devices can be stored with any other equipments or tools. | | | |
| 11. After each use, ear plugs and ear muffs can be kept anyplace where they are convenient for the next use. | | | |
| 12. Audiometric Test is the monitor used for preventing hearing loss. | | | |

**Part V: Attitude related to use of hearing protection devices**

-----------------------------------------------------------------------------------------------------

**Guidance**: Please select carefully the answer for each question and choose the answer by marking (√) corresponding to reality. Please keep in mind your standards, hopes, pleasures and concerns.

| **Attitude** | **Strongly agree** | **Agree** | **Un-certain** | **Dis-agree** | **Strongly disagree** |
|---|---|---|---|---|---|
| 1. You think the proper use of ear plugs can helps to reduce the risk of hearing loss in workplace. | | | | | |
| 2. You think prevention of hearing loss in workplaces is able to do with wearing hearting protection devices. | | | | | |
| 3. You think wearing ear plugs during the work hour will help reduce ear ringing after work. | | | | | |
| 4 You think even though wearing hearing protection devices is applied when working with loud noise machine, hearing loss is still able to occur. | | | | | |
| 5. You think wearing ear plugs or ear muffs will make more earache. | | | | | |
| 6. You think wearing hearing protection devices make you feel embarrassed and cowardly. | | | | | |
| 7. You think every time of wearing hearing protection devices either ear plugs or ear muffs, it makes irritated and inconvenient. | | | | | |
| 8. You think wearing hearing protection devices frequently makes you faint | | | | | |
| 9. You think wearing hearing protection devices burdens you when cleaning | | | | | |
| 10. You think the use of ear plugs during the work hour causes the barrier in communication with the team | | | | | |
| 11. You think the use of ear plugs or ear muffs causes barriers in hearing, especially alarm signal leading an accident | | | | | |
| 12. You think wearing hearing protection devices irregularly makes no difference of hearing loss when compared with not wearing the hearing protection devices. | | | | | |

## Part VI: Behavior related to use of hearing protection devices

---

**Guidance**: Please select carefully the answer for each question and choose the answer by marking (√) corresponding to reality. Please keep in mind your standards, hopes, pleasures and concerns.

1. Use of hearing protection devices while working

   ☐ Once in a while (at least 1 day/week)

   ☐ Occasionally (2–3 days/week)

   ☐ Often (4–5 days/week)

   ☐ Always (6–7 days/week)

## Appendix E

## The use of hearing protection devices report

**ID number.....................**

---

**Guidance**: Please select carefully the answer for each question and choose the answer by marking (√) corresponding to reality. Please keep in mind your standards, hopes, pleasures and concerns.

| Time of work | HPD Using | | Remark |
|---|---|---|---|
| | yes | No | |
| 8.00 - 9.00 | | | |
| 9.01-10.00 | | | |
| 10.01-11.00 | | | |
| 11.01-12.00 | | | |
| 12.01-13.00 | | | |
| 13.01-14.00 | | | |
| 14.01-15.00 | | | |
| | | | |
| | | | |
| 7.01-8.00 | | | |

**Self –report of Percentage of time of HPD used (0-100 %)** (8 hour = 100)

| ≤ 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |

# Appendix F

## General Questionnaire (Thai version)

**แบบสอบถาม มีทั้งหมด 6 ส่วน ได้แก่**

| | | |
|---|---|---|
| ส่วนที่ 1 | ลักษณะบุคคลโดยทั่วไป | (4 ข้อ) |
| ส่วนที่ 2 | ลักษณะการทำงาน | (6 ข้อ) |
| ส่วนที่ 3 | ความพร้อมสำหรับการใช้อุปกรณ์ป้องกันเสียงดัง | (2 ข้อ) |
| ส่วนที่ 4 | ความรู้เกี่ยวกับการใช้อุปกรณ์ป้องกันเสียงดัง | (12 ข้อ) |
| ส่วนที่ 5 | ทัศนคติเกี่ยวกับการใช้อุปกรณ์ป้องกันเสียงดัง | (12 ข้อ) |
| ส่วนที่ 6 | พฤติกรรมการใช้อุปกรณ์ป้องกันเสียงดัง | (1 ข้อ) |

# แบบสอบถาม (ฉบับภาษาไทย)

## ส่วนที่ 1 : ลักษณะบุคคลโดยทั่วไป

---

**คำชี้แจง:** **กรุณาตอบคำถามอย่างระมัดระวังโดยตอบคำถามให้ตรงกับตัวท่านในปัจจุบันมากที่สุด ในข้อที่มีให้เติมคำตอบ และ ทำเครื่องหมาย (✓) ในข้อที่มีตัวเลือกตอบ**

### 1.1 ข้อมูลส่วนบุคคล

1. อายุ………………….ปี.......................เดือน

2.ตำแหน่งงาน

○ หัวหน้างาน ○ พนักงานปฏิบัติ ○ อื่นๆ.............................

3. ระดับการศึกษาสูงสุด

○ ไม่ได้เรียนหนังสือ ○ ประถมศึกษา

○ มัธยมศึกษา/ ปวช ○ อนุปริญญา/ ปวส

○ ปริญญาตรี หรือสูงกว่า

4. พฤติกรรมเสี่ยงของการสูญเสียการได้ยิน

4.1.ท่านเคยมีอาการผิดปกติเกี่ยวกับหูมาก่อนหรือไม่

○ ไม่เคย ○ เคย ได้แก่

○ หูน้ำหนวก

○ แก้วหูทะลุ

○ ได้รับอุบัติเหตุที่หูหรือศรีษะ

○ ขี้หูอุดตัน

○ มีได้ยินเสียงดังหึ่งๆ ในหู หรือเสียงจิ้งหรีดร้องในหู

○ มีอาการผิดปกติเกี่ยวกับการได้ยินที่ลดลง หรือได้ยินไม่ชัด

○ หูอื้อขณะเป็นหวัดมาก่อน……....
ล่าสุดเป็นเมื่อ……………………........

○ อื่นๆ โปรดระบุ..........................................

4.2 ท่านสูบบุหรี่หรือไม่

○ ไม่สูบ

○ เคยสูบแต่ปัจจุบันเลิกสูบแล้ว เลิกมา .............ปี............เดือน

○ ปัจจุบันสูบ

☐ ประเภทยาสูบ…….……......ปริมาณการสูบ จำนวน......มวน/วัน

4.3. ท่านเคยใช้ยาดังกล่าวต่อไปนี้หรือไม่?

4.3.1 นีโอมัยซิน โปรดระบุ (ขนาด/ความถี่ /ระยะเวลา).................

○ ไม่เคยใช้ ○ เคยใช้ ใช้ครั้งสุดท้ายเมื่อ............

4.3.2 สเตบโตมัยซิน โปรดระบุ (ขนาด/ความถี่ /ระยะเวลา)..............

○ ไม่เคยใช้ ○ เคยใช้ ใช้ครั้งสุดท้ายเมื่อ............

4.3.3 ยาขับปัสสาวะ โปรดระบุ (ขนาด/ความถี่ /ระยะเวลา).............

○ ไม่เคยใช้ ○ เคยใช้ ใช้ครั้งสุดท้ายเมื่อ............

4.3.4 ยาแอสไพริน โปรดระบุ (ขนาด/ความถี่ /ระยะเวลา)................

○ ไม่เคยใช้ ○ เคยใช้ ใช้ครั้งสุดท้ายเมื่อ............

4.4 .ท่านมีกิจกรรมยามว่าง /งานอดิเรก/ กิจกรรมเสริมนอกจากงานประจำ ที่มีเสียงดังหรือไม่?

○ ไม่มี

○ มี โปรดระบุ……… (ตอบได้มากกว่า 1 ข้อ)………..

○ ขี่มอเตอร์ไซด์ ○ ฟังซาวด์เบาร์

○ ไปดิสโก้เทค ○ นั่งรถที่ติดเครื่องเสียง/ลำโพงเสียงดัง

○ ร้องเพลง/เล่นดนตรีในคอนเสริต์

○ ยิงปืน ○ อื่นๆ................................(โปรดระบุ)

4.5 การใส่หูฟังสำหรับ

| ฟังเพลง | โทรศัพท์ |
|---|---|
| ○ ไม่เคย ○ เคย | ○ ไม่เคย ○ เคย |
| ○ ปัจจุบันไม่ใช้แล้ว ○ ปัจจุบันยังใช้อยู่ | ○ ปัจจุบันไม่ใช้แล้ว<br>○ ปัจจุบันยังใช้อยู่ |
| ชนิดที่ใช้<br>☐ สวมเข้าไปในหู<br>☐ ครอบแนบทับใบหู ................ | ชนิดที่ใช้<br>☐ สวมเข้าไปในหู<br>☐ ครอบแนบทับใบหู................... |
| ช่วงเวลาที่ชอบใส่<br>☐ ตลอดวัน ทั้งช่วงทำงานและไม่ทำงาน<br>☐ เฉพาะช่วงเวลาว่าง<br>☐เฉพาะช่วงเวลาทำงาน<br>☐อื่นๆ โปรดระบุ.......................... | ช่วงเวลาที่ชอบใส่<br>☐ ตลอดวัน ทั้งช่วงทำงานและไม่ทำงาน<br>☐ เฉพาะช่วงเวลาว่าง<br>☐เฉพาะช่วงเวลาทำงาน<br>☐อื่นๆ โปรดระบุ.......................... |
| ○ ความถี่<br>…………..../ชั่วโมง /วัน<br>……....วัน/สัปดาห์ | ○ ความถี่<br>…………..../ชั่วโมง /วัน<br>……....วัน/สัปดาห์ |

4.6 ท่านเคยได้ยินเสียงดัง เช่น เสียงประทัด เสียงปืน เสียงระเบิด ในระยะใกล้ๆจนทำให้รู้สึกหูอื้อ

○ ไม่เคย ○ เคย

4.7 ท่านเคยได้รับการตรวจสมรรถภาพการได้ยินหรือไม่

○ ไม่เคย ○ เคย ผลการตรวจแพทย์/พยาบาลบอกว่าเป็นอย่างไร

○ ปกติ

○ ผิดปกติ

○ อื่นๆ............................(โปรดระบุ)

**ส่วนที่ 2 : ลักษณะการทำงาน**

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**คำชี้แจง: กรุณาตอบคำถามอย่างระมัดระวังโดยตอบคำถามให้ตรงกับตัวท่านในปัจจุบันมากที่สุด ในข้อที่มีให้เติมคำตอบ และ ทำเครื่องหมาย (✓) ในข้อที่มีตัวเลือกตอบ**

5. ท่านเป็นคนงานที่โรงงานเหล็กนี้มาเป็นระยะเวลา.................ปี................ เดือน

6. ช่วงระยะเวลาทำงานปกติ................ชั่วโมง/วัน.................วัน/สัปดาห์

7. ระยะเวลาที่ต้องทำงานอยู่ในบริเวณโรงผลิตนี้................ชั่วโมง/วัน (ส่วนของโรงหลอม /รีด /สังกะสี)

8. การทำงานล่วงเวลา (OT)

○ ไม่เคย ○ เคย ...........ชั่วโมง/วัน ..............วัน/สัปดาห์

9. ท่านเคยทำงานในสถานที่ที่มีเสียงดังก่อนที่จะมาทำงานในโรงงานเหล็กหรือไม่

○ ไม่เคย

○ เคย, ได้แก่...................... เป็นระยะเวลา...........ปี ......เดือน

แล้วท่านได้มีการใช้อุปกรณ์ป้องกันเสียงดังหรือไม่?

○ ไม่เคยใช้ ○ ใช้

☐ บางครั้ง ☐ บ่อยครั้ง ☐ สม่ำเสมอ

10. ท่านทราบระดับเสียงในจุดที่ท่านทำงานเป็นประจำหรือไม่

○ ไม่ทราบ ○ ทราบ คือ......................เดซิเบล

**ส่วนที่ 3 ความพร้อมสำหรับการใช้อุปกรณ์ป้องกันเสียง**

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11 ความพร้อมของโรงงานเกี่ยวกับการใช้อุปกรณ์ป้องกันเสียง

11.1 โรงงานที่ท่านทำงานอยู่มีการประกาศหรือนโยบาย เกี่ยวกับโครงการอนุรักษ์การได้ยินหรือไม่

○ มี ○ ไม่มี ○ ไม่ทราบ

11.2โรงงานที่ท่านทำงานอยู่มีการอบรมเกี่ยวกับโครงการอนุรักษ์การได้ยินหรือไม่

○ มี ○ ไม่มี ○ ไม่ทราบ

11.3 โรงงานที่ท่านทำงานอยู่มีการจัดทำพื้นที่เสี่ยงและประกาศให้คนงานทราบอย่างทั่วถึงหรือไม่

○ มี ○ ไม่มี ○ ไม่ทราบ

11.4โรงงานที่ท่านทำงานอยู่มีการจัดเตรียมอุปกรณ์ป้องกันเสียงดังพอกับคนงานทุกคนในพื้นที่เสี่ยงหรือไม่

○ มี ○ ไม่มี ○ ไม่ทราบ

11.5 โรงงานที่ท่านทำงานอยู่ได้จัดเตรียมอุปกรณ์ป้องกันเสียงไว้ให้คนงานใช้ได้อย่างสะดวกหรือไม่

○ สะดวก โดยจัดไว้ให้ที่............

○ ไม่สะดวก โดยจัดไว้ให้ที่..................

11.6 โรงงานมีระบบ ลงโทษคนงานที่ไม่ใส่อุปกรณ์ป้องกันเสียงดัง เช่น ลดค่าจ้าง ลดโบนัสหรือไม่

○ มี ○ ไม่มี ○ ไม่ทราบ

11.7 โรงงานมี รางวัล หรือโบนัสพิเศษให้แก่คนงานที่ใส่อุปกรณ์ป้องกันเสียงดัง หรือไม่

○ มี ○ ไม่มี ○ ไม่ทราบ

12.ความพร้อมของคนงาน

12.1ปัจจุบันท่านมีอุปกรณ์ป้องกันเสียงดังใช้หรือไม่

○ ไม่มี เพราะ

☐ โรงงานไม่มีให้ ☐ โรงงานมีให้แต่ไม่พอ

☐ โรงงานมีให้พอแต่ทำหาย/พังไปแล้ว ☐ โรงงานมีให้พอแต่ ลืมเอามาใช้

○ มี ประเภท

☐ ประเภทเสียบเข้าในหู หรือเอียปลั๊ก

อุปกรณ์นี้ได้มาจาก

☐ โรงงานแจกให้ ☐ ซื้อมาเอง ☐ อื่นๆ......................

☐ ประเภทครอบแนบทับใบหู หรือเอียมั๊บ

อุปกรณ์นี้ได้มาจาก

☐ โรงงานแจกให้ ☐ ซื้อมาเอง ☐ อื่นๆ......................

☐ แบบอื่น ๆ โปรดระบุ................

อุปกรณ์นี้ได้มาจาก

☐ โรงงานแจกให้ ☐ ซื้อมาเอง ☐ อื่นๆ......................

12.2 ท่านเคยได้รับการอบรมเรื่องอันตราย และการป้องกันอันตรายจากเสียงหรือไม่

☐ ไม่เคย ☐ เคย ระบุ............จำนวนครั้ง/ปี

12.3 ท่านเคยได้รับการฝึกอบรมเรื่องการใช้อุปกรณ์ป้องกันเสียงดังมาแล้วหรือไม่

☐ ไม่เคย ☐ เคย ระบุ............จำนวนครั้ง/ปี

12.4.ท่านเคยได้รับการอบรมเรื่องการเก็บรักษาอุปกรณ์ป้องกันเสียงดังมาแล้วหรือไม่

☐ ไม่เคย ☐ เคย ระบุ............จำนวนครั้ง/ปี

12.5 ท่านเคยได้รับการอบรมเรื่องการทำความสะอาดอุปกรณ์ป้องกันเสียงดังมาแล้วหรือไม่

☐ ไม่เคย ☐ เคย ระบุ............จำนวนครั้ง/ปี

**ส่วนที่ 4: ความรู้เกี่ยวกับการใช้อุปกรณ์ป้องกันการสูญเสียการได้ยิน**

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**คำชี้แจง:** กรุณาตอบคำถามแต่ละข้อคำถามอย่างระมัดระวัง โดยทำเครื่องหมาย (✓) ในข้อที่ตรงกับตัวท่านมากที่สุด

| ข้อความรู้ | ใช่ | ไม่ใช่ | ไม่ทราบ |
|---|---|---|---|
| 1.เมื่อต้องทำงานในบริเวณที่มีเสียงดัง ควรสวมอุปกรณ์ป้องกันเสียง | | | |
| 2.การใช้อุปกรณ์ป้องกันเสียง ในขณะทำงาน จะช่วยลดการสัมผัสระดับเสียงที่เกินมาตรฐานลง ให้อยู่ในระดับที่ปลอดภัย | | | |
| 3.อุปกรณ์ป้องกันเสียงดังที่เหมาะสมจะมีการพิจารณาค่าการดูดซับเสียงที่เหมาะสมกับเสียงดังในสถานที่ทำงานเป็นสำคัญ | | | |
| 4.การไม่ใช้อุปกรณ์ป้องกันเสียง ในขณะที่ทำงานกับเครื่องจักรที่มีเสียงดัง อาจทำให้สมรรถภาพการได้ยินลดลง | | | |
| 5.การใส่อุปกรณ์ป้องกันเสียงต้องใส่อย่างต่อเนื่องตลอดระยะเวลาการสัมผัสเสียงดังจึงจะสามารถป้องกันหูเสื่อมได้เต็มที่ | | | |
| 6.การใส่อุปกรณ์ป้องกันเสียงไม่จำเป็นต้องใส่ทั้งวัน แต่ให้ใส่เฉพาะช่วงเวลาที่เราทำงานในพื้นที่ ๆ มีเสียงดังตลอดเวลาเท่านั้น ก็สามารถป้องกันหูเสื่อมได้เช่นกัน | | | |
| 7.หากท่านไม่แน่ใจว่าที่อุดหูหรือที่ครอบหูเหมาะสมกับงานที่มีเสียงดังหรือไม่ ท่านสามารถขอคำแนะนำได้จากหัวหน้างาน หรือเจ้าหน้าที่ความปลอดภัยในที่ทำงานได้ | | | |
| 8.เวลาที่ท่านใช้ที่อุดหู ท่านไม่จำเป็นต้องคำนึงถึงความสะอาดก่อนการใช้ | | | |
| 9.การสวมใส่อุปกรณ์ป้องกันเสียง ไม่จำเป็นต้องตรวจสอบก่อนทุกครั้งว่าอยู่ในสภาพดีหรือไม่ | | | |
| 10.อุปกรณ์ป้องกันเสียง สามารถเก็บรวมไว้กับเครื่องมือ เครื่องใช้อย่างอื่นได้ | | | |
| 11.ที่อุดหูหรือที่ครอบหู เมื่อใช้เสร็จแล้วควรเก็บรักษาไว้ในบริเวณใดก็ได้ที่สามารถหยิบใช้ได้สะดวก | | | |
| 12.การตรวจสมรรถภาพการได้ยินเป็นการเฝ้าระวังการสูญเสียการได้ยิน | | | |

**ส่วนที่ 5: ทัศนคติเกี่ยวกับการใช้อุปกรณ์ป้องกันการสูญเสียการได้ยิน**

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**ชี้แจง:** กรุณาตอบคำถามแต่ละข้อคำถามอย่างระมัดระวัง โดยทำเครื่องหมาย (✓) ในข้อที่ตรงกับตัวท่านมากที่สุด

| ทัศนคติ | เห็นด้วยอย่างยิ่ง | เห็นด้วย | ไม่แน่ใจ | ไม่เห็นด้วย | ไม่เห็นด้วยอย่างยิ่ง |
|---|---|---|---|---|---|
| 1.ท่านคิดว่าการใช้ที่อุดหูอย่างถูกต้อง จะช่วยป้องกันการเกิดหูเสื่อมจากเสียงดังในขณะทำงานได้ | | | | | |
| 2.ท่านคิดว่าการป้องกันหูตึงจากการทำงานสามารถทำได้ด้วยการใช้อุปกรณ์ป้องกันเสียงดัง | | | | | |
| 3.ท่านคิดว่าการใช้ที่อุดหูขณะทำงานจะทำให้อาการหูอื้อหลังเลิกงานลดน้อยลง | | | | | |
| 4.ท่านคิดว่าถึงแม้จะใช้อุปกรณ์ป้องกันเสียงในขณะที่เครื่องจักรมีเสียงดัง ก็ยังสามารถเกิดหูเสื่อมได้ | | | | | |
| 5.ท่านคิดว่าการใส่ที่อุดหูหรือที่ครอบหูยิ่งทำให้รู้สึกปวดหูมากยิ่งขึ้น | | | | | |
| 6.ท่านคิดว่าการใช้อุปกรณ์ป้องกันเสียงดังทำให้เกิดความรู้สึกอาย แสดงถึงความขี้ขลาด | | | | | |
| 7.ท่านคิดว่าทุกครั้งที่ใช้อุปกรณ์ป้องกันเสียงดังไม่ว่าจะเป็นที่อุดหูหรือที่ครอบหูจะรู้สึกอึดอัด เกะกะ ความรำคาญ ทำให้ทำงานไม่สะดวก | | | | | |
| 8.ท่านคิดว่าการใส่อุปกรณ์ป้องกันเสียงดังทำให้ท่านรู้สึกหน้ามืดเป็นลมบ่อยๆ | | | | | |
| 9.ท่านคิดว่าการใส่อุปกรณ์ป้องกันเสียงดัง ทำให้เพิ่มภาระในการล้างทำความสะอาด | | | | | |
| 10.ท่านคิดว่าการใช้ที่อุดหูขณะทำงานเกิดอุปสรรคในการสื่อสารกับผู้ร่วมงานในทีม | | | | | |
| 11.ท่านคิดว่าการใช้ที่อุดหูขณะทำงานเกิดอุปสรรคในการรับฟังเสียงต่างๆ โดยเฉพาะสัญญาณเตือนซึ่งอาจก่อให้เกิดอุบัติเหตุได้ | | | | | |
| 12.ท่านคิดว่าการใส่อุปกรณ์ป้องกันเสียงได้ไม่สม่ำเสมอ ให้ผลในการป้องกันหูเสื่อมได้ไม่ต่างจากการไม่ใส่ | | | | | |

## ส่วนที่ 6 พฤติกรรมการใช้อุปกรณ์ป้องกันการสูญเสียการได้ยิน

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**ชี้แจง:** กรุณาตอบคำถามแต่ละข้อคำถามอย่างระมัดระวัง โดยทำเครื่องหมาย (✓) ในข้อที่ตรงกับตัวท่านมากที่สุด

**การปฏิบัติเกี่ยวกับการใช้อุปกรณ์ป้องกันหู**

6.1. การใช้อุปกรณ์ป้องกันเสียงดัง ในขณะปฏิบัติงานในพื้นที่เสียงดัง ในช่วง 1 สัปดาห์ที่ผ่านมา

☐ นานๆครั้ง (ใส่ 0 - 1วันใน 1 สัปดาห์)
☐ เป็นบางครั้ง (ใส่ 2-3 วันขึ้นไปใน 1 สัปดาห์)
☐ เป็นประจำ (ใส่ 4-5 วันขึ้นไปใน 1 สัปดาห์)
☐ เป็นประจำสม่ำเสมอ (ใส่ 6 วันขึ้นไปใน 1 สัปดาห์)

| เหตุผลที่ทำให้ท่าน<u>**ไม่ใช้**</u>อุปกรณ์ป้องกันเสียง | เหตุผลที่ทำให้ท่าน<u>**ใช้**</u>อุปกรณ์ป้องกันเสียง |
|---|---|
| ☐ ไม่ได้ทำงานในที่ ๆ มีเสียงดัง | ☐ ทำงานในพื้นที่ๆมีเสียงดัง |
| ☐ หูตึงไม่เกี่ยวข้องกับการทำงานในที่มีเสียงดัง | ☐ กลัวอันตรายที่จะเกิดขึ้น เช่น หูไม่ได้ยิน |
| ☐ บริษัทไม่ได้มีนโยบายให้ใส่อุปกรณ์ป้องกันเสียงดัง | ☐ รู้ว่าการใส่อุปกรณ์ป้องกันเสียงช่วยป้องกันการเกิดการสูญเสียการได้ยินจากการทำงานได้ |
| ☐ บริษัทมีนโยบายให้ใส่แต่มีอุปกรณ์ไม่เพียงพอ | ☐ บริษัทมีนโยบายให้ใส่<br>☐ มีระบบการเตือนให้ใส่ จาก |
| ☐ บริษัทไม่ได้จัดหาให้ต้องหามาใช้เอง | ○ จป.หัวหน้างานมาตรวจ |
| ☐ บริษัทจัดหาให้แต่พังไปแล้ว<br>เพราะแจกตั้งแต่........ | ○ เพื่อนร่วมงานช่วยกันกระตุ้นเตือนกันให้ใส่ |
| ☐ บริษัทจัดหาให้แต่ทำหายไปแล้ว | ○ มีสัญญาณเตือนเสียงดังให้ใส่ |
| ☐ อึดอัด รำคาญ เจ็บหูเวลาใส่ | ☆ มีการทำโซนสีไว้ |
| ☐ พูดคุยไม่รู้เรื่อง เวลาใส่อุปกรรีป้องกันเสียงดัง | ☆ อุปกรณ์เตือนเมื่อเสียงดังเกินมาตรฐาน |
| ☐ ใช้แล้วเกิดอาการแพ้เวลาทำงานไม่สะดวก | ☐ บริษัทมีระเบียบลงโทษหากตรวจพบ |
| ☐ คิดว่าใช้แล้วก็ไม่ได้ช่วยอะไรมากเพราะหูเสื่อมไปแล้ว | ☐ บริษัทมีแจกให้คนงานที่ทำงานในพื้นที่เสี่ยง |
| ☐ คิดว่าใช้แล้วก็ไม่ได้ช่วยอะไรมากเพราะก่อนหน้านี้ไม่เคยใส่อยู่แล้วก็ไม่เห็นเป็นอะไรหูก็ยังปกติ | ☐ คิดว่าใส่ดีกว่าไม่ใส่เพราะคนอื่นๆก็ใส่กัน |
| ☐คิดว่าสัมผัสเสียงแค่ช่วงสั้นๆ ไม่มีความจำเป็น | ☐ เคยมีปัญหาที่เกิดขึ้นกับหูและแพทย์แนะนำให้ใช้เครื่องป้องกันเสียง |
| ☐ลืมนำอุปกรณ์มา | |

**เหตุผล**ที่ทำให้ท่าน<u>**ใช้หรือไม่ใช้**</u>อุปกรณ์ป้องกันหูในขณะทำงาน (ตอบได้มากกว่า 1 ข้อ)

# Appendix G

# The use of hearing protection devices report (Thai version)

**บันทึกการใช้อุปกรณ์ป้องกันเสียงดัง**

**วัน /เดือน/ปี..........................................................**

| เวลาทำงาน | การอุปกรณ์ป้องกันเสียงดัง | | หมายเหตุ |
|---|---|---|---|
| | ใช้ | ไม่ใช้ | |
| 8.00 - 9.00 | | | |
| 9.01-10.00 | | | |
| 10.01-11.00 | | | |
| 11.01-12.00 | | | |
| 12.01-13.00 | | | |
| 13.01-14.00 | | | |
| 14.01-15.00 | | | |
| | | | |
| | | | |
| 7.01-8.00 | | | |

แบบบันทึกการใส่อุปกรณ์ป้องกันเสียงดังคิดเป็นเปอร์เซ็นต์ (0-100 %) (โดยตลอดระยะเวลาการทำงาน 8 ชั่วโมงที่อยู่ในพื้นที่เสียงดัง คิดเป็น 100 )

| ≤ 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |

# Appendix H

## Picture of Audiometer: (ANSI, 1991)

# Appendix I

# Audiometry record form

ID number......................

Audiometric test results

| Phase | Hearing Threshold Levels in dB | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Right Ear (Frequency : kHz ) | | | | | | Left Ear (Frequency : kHz) | | | | | |
| | 0.5 | 1 | 2 | 3 | 4 | 6 | 0.5 | 1 | 2 | 3 | 4 | 6 |
| Baseline | | | | | | | | | | | | |
| 1st follow-up | | | | | | | | | | | | |
| 2nd follow-up | | | | | | | | | | | | |

# VITA

| | |
|---|---|
| **NAME** | Petcharat Kerdonfag |
| **DATE OF BIRTH** | 1 December 1975 |
| **PLACE OF BIRTH** | NAKHON SAWAN |
| **INSTITUTIONS ATTENDED** | Community Health Nursing, Ramathibodi School of Nursing, Faculty of Medicine Ramathibodi Hospital, Mahidol University, 270 Rama 6 Road, Bangkok, Thailand, 10400 |
| **HOME ADDRESS** | 99/228 M.6 Praricat – Suvarnabhumi village<br>Khum kola Rd., Lumpra-till, Lat krabang,<br>Bangkok 10520,<br>THAILAND |
| **PUBLICATION** | Kerdonfag, P., Wadwongtham, W., & Taneepanichskul, S. (2019). Hearing threshold levels among steel industry workers in Samut Prakan, Thailand. Risk management and healthcare policy, 12, 57.<br>Leelachara.S, Kerdonfag.P, Chontichachalalauk.J, Sanongdej. W. (2515). Illness perceptions, Lifestyle behaviors, Social support, and cardiovasculars risks in people with hypertention in urban and rural areas of Thailand. Pacific Rim International Journal of Nursing Research, 19(3), 245-256<br>Lundberg, P., & Kerdonfag, P. (2010). Spiritual care provided by Thai nurses in intensive care units. Journal of Clinical Nursing. 19, 1121-1128. |