UNIVERSITI PUTRA MALAYSIA

RELATIONSHIP BETWEEN NOISE EXPOSURE LEVELS, NOISEINDUCED HEARING LOSS AND NEUROBEHAVIORAL PERFORMANCE AMONG STEEL MILL MALE WORKERS

PRIYA RATHANAK A/P EH LAI

FPSK(M) 2017 62

RELATIONSHIP BETWEEN NOISE EXPOSURE LEVELS, NOISE-INDUCED HEARING LOSS AND NEUROBEHAVIORAL PERFORMANCE AMONG STEEL MILL MALE WORKERS

By

PRIYA RATHANAK A/P EH LAI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

May 2017

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

RELATIONSHIP BETWEEN NOISE EXPOSURE LEVELS, NOISE-INDUCED HEARING LOSS AND NEUROBEHAVIORAL PERFORMANCE AMONG STEEL MILL MALE WORKERS

By

PRIYA RATHANAK A/P EH LAI

May 2017

Chair : Assoc. Prof. Shamsul Bahri Mohd Tamrin, PhD

Faculty: Medicine and Health Sciences

Noise at workplace not only can cause hearing problems but also affect the performance of workers. Noise especially within the confine of steel manufacturing cannot be avoided since the operation revolving around machineries, devices and process which emitted high level of noise reaching up to 115dB(A). Approximately half of the steel mill workforce in Malaysia were reported to endure noise induced hearing loss. Therefore, the purpose of this study is to determine the effect of noise exposure towards deterioration of hearing threshold and the effect on neurobehavioral performance among male workers in steel manufacturing industries. This comparative cross-sectional study which involved 295 male steel manufacturing workers was conducted in one of the renowned steel making industries in Kemaman, Malaysia. Data collection is comprises of Questionnaires Survey, Audiometric Test, Personal Noise Exposure Monitoring and Neurobehavioural Core Test Battery (NCTB).The noise exposure of workers were gauge through personal noise dosimeter and the prevalence of noise-induced hearing loss (NIHL) among the workers were identified through audiometric test. Subsequently noise-induced hearing loss influence on neurobehavioural performance (cognition attributes) was further investigate by utilizing a set of seven tests consist in the Neurobehavioural Core Test Battery (NCTB). The study, resulted in 109 respondents were identified as non-NIHL respondents and 186 respondents endured NIHL. There is a difference of hearing threshold level between non-NIHL and NIHL respondents. Hearing threshold of the NIHL respondents portrayed that hearing loss with median value of 25dB(A) occur at the higher fence of frequency which is 4000Hz and 6000Hz for both of the ears. There are also difference of neurobehavioural performance between non-NIHL and NIHL respondents for overall score of NCTB ($p<0.001$). Furthermore, within sets of seven NCTB, only Digit Span ($p<0.001$), Digit Symbol ($p<0.001$) and Pursuit

Aiming (p=0.008) indicates significant difference between non-NIHL and NIHL respondents where neurobehavioral performance among the NIHL respondents are lower as compared to those non – NIHL. However, the result from the study shows that there are no significant difference between personal noise dosage exposure level between non-NIHL and NIHL respondents (z=-0.366, p=0.715).The study also demonstrates there are no significant difference between personal noise exposure level (Noise Dose) and neurobehavioural performance (Overall NTB Score) among non-NIHL (r=-0.061, p=0.513) and NIHL respondents (r=-0.012, p=0.870). Finally, the study suggested that risk factor to be considered in prediction model for Neurobehavioral Performance Score is category of NIHL cases for Digit Symbol, Digit Span and Overall NCTB Score. Whereas for Pursuit Aiming, the risk factor that played important roles is the age of the respondents. The findings in this study concluded that, noise may cause some impairment in the nervous system function towards worker in metallurgical industry. On top of auditory effect of the noise on the hearing ability, non-auditory effect which is the neurobehavioural performance is also deteriorate amongst workers. Therefore, besides deterioration of hearing threshold level, changes of neurobehavioural performance could be regarded as the early exposure manifestation of the occupational noise effect among steel mill workers.

Keywords: noise induced hearing loss, neurobehavioral performance, steel mill

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

HUBUNGKAIT ANTARA TAHAP PENDEDAHAN BUNYI, KEHILANGAN PENDENGARAN AKIBAT BUNYI BISING DAN PRESTASI NEUROTINGKAHLAKU DI KALANGAN PEKERJA LELAKI KILANG BESI

Oleh

PRIYA RATHANAK A/P EH LAI

Mei 2017

Pengerusi: Prof. Madya. Shamsul Bahri Mohd Tamrin, PhD

Fakulti: Perubatan dan Sains Kesihatan

Bunyi bising di tempat kerja bukan sahaja menyebabkan kehilangan pendengaran malah boleh menjejaskan prestasi pekerja. Kebisingan terutamanya di dalam sektor pembuatan besi tidak dapat dielakkan memandangkan operasi pembuatan besi melibatkan jentera, peralatan dan proses yang mencetuskan tahap bunyi bising menjangkau 115dB(A). Lebih kurang separuh daripada tenaga kerja di dalam kilang pembuatan besi dilaporkan mengalami masalah kehilangan pendengaran akibat bunyi bising.mDengan itu, tujuan kajian ini adalah untuk menentukan kesan pendedahan bunyi bising terhadap kemerosotan ambang pendengaran dan seterusnya kesan terhadap prestasi neurotingkahlaku di kalangan pekerja lelaki di industri pembuatan besi. Kajian keratan rentas perbandingan ini melibatkan 295 pekerja lelaki di salah sebuah kilang pembuatan besi yang terkemuka di Kemaman, Terengganu.Proses pengumpulan data terdiri daripada kaji soal selidik, pengujian audiometri, pemantauan bunyi bising individu dan ujian teras bateri neurotingkahlaku. Pendedahan bunyi bising pekerja diukur menggunakan alat dosimeter peribadi dan kelaziman kehilangan pendengaran akibat bunyi bising dikalangan pekerja dikenalpasti melalui ujian audiometrik. Seterusnya, pengaruh kehilangan pendengaran akibat bunyi bising terhadap prestasi neurotingkahlaku (sifat –sifat kognitif) dikaji dengan menggunapakai tujuh set ujian yang terkandung dalam Ujian Teras Bateri Neurotingkahlaku (*NCTB*). Keputusan kajian menunjukkan 109 orang responden telah dikenalpasti sebagai bukan mengalami masalah kehilangan keupayaan mendengar akibat bunyi bising (*non-NIHL*) dan selebihnya 186 responden mengalami kehilangan keupayaan mendengar akibat bunyi bising (*NIHL*). Selain itu, terdapat perbezaan dalam ambang pendengaran di antara non-NIHL dan NIHL responden, dimana kekurangan pendengaran dengan nilai median 25kHz wujud di ambang pendengaran yang berfrekuensi tinggi iaitu 4000Hz dan 6000Hz bagi

kedua- dua belah telinga. Terdapat juga perbezaan yang ketara terhadap prestasi neurotingkahlaku di antara *non-NIHL* dan NIHL responden bagi skor keseluruhan *NCTB* ($p<0.001$). Tambahan pula, antara tujuh set ujian yang terkandung di dalam NCTB, hanya tiga ujian iaitu; Ujian Jarak Digit ($p<0.001$), Ujian Simbol Digit ($p<0.001$) dan Ujian Sasaran Mengejar ($p=0.008$) yang menunjukkan perbezaan yang signifikan di kalangan non- NIHL dan NIHL responden dimana prestasi neurotingkahlaku dikalangan non-NIHL responden adalah rendah berbanding kepada NIHL responden.
Namun, keputusan dari kajian menunjukkan tiada perbezaan dos bunyi dari pemantauan bunyi bising individu di antara responden ($z=-0.366$, $p=0.715$). Kajian ini juga mendapati tidak terdapat perbezaan yang nyata di antara tahap pendedahan bunyi bising (dos bunyi) dan prestasi neurotingkahlaku di kalangan *non-NIHL* ($r=-0.061$, $p=0.513$) dan *NIHL* responden ($r=-0.012$, $p=0.870$). Akhir sekali, hasil kajian juga mencadangkan faktor risiko yang diambil kira dalam model ramalan bagi Skor Prestasi Neurotingkahlaku adalah kategori kes kehilangan pendengaran (NIHL) untuk Ujian Jarak Digit, Ujian Digit Simbol dan Skor Keseluruhan Prestasi Neurotingkahlaku. Manakala bagi Ujian Sasaran Mengejar, faktor risiko yang memainkan peranan yang penting adalah umur responden. Hasil penemuan daripada kajian ini, menyimpulkan bahawa bunyi bising boleh menyebabkan kelemahan dalam fungsi sistem saraf para pekerja di industri pembuatan besi. Di samping kesan audiotori bunyi bising terhadap kebolehan pendengaran, kesan bukan auditori iaitu prestasi neurotingkahlaku juga merosot dikalangan pekerja. Oleh itu, di samping kemerosotan tahap ambang pendengaran, perubahan dari segi prestasi neurotingkahlaku dapat dianggap sebagai manifestasi pendedahan awal terhadap kesan bunyi bising pekerjaan.

Kata kunci: kehilangan pendengaran, prestasi neurotingkahlaku, kilang besi

ACKNOWLEDGEMENTS

I am most grateful to those who help me along this journey ……

- To my supervisor Associate Professor Dr. Shamsul Bahri bin Haji Mohd Tamrin and co-supervisor Dr. Huda Zainuddin. For their guidance, understanding, space and time, encouragement and wisdom. Your valuable knowledge and support is greatly appreciated. Thank you for never given up on me.

- To the staff in steel making plant and facility which participate and contribute towards the data collection. Your involvement have enriched me with unforgettable and knowledgeable experience.

- To my dearest friend Dr. Vivien How, for her coaching, time and support have pulled me through the lane. I deeply value our friendship.

- To my beloved parents, my guardian angels; Eh Lai and Gurdev Kaur for your love flows through my veins, your spirit fills my heart and your knowledge guides me towards success.

- To my other half, my life partner; Teh Teong Beng for providing me with unfailing support and continuous encouragement throughout my prolonged years of study which at times seems to be in vain and insurmountable. Thank you for believing in me.

I certify that a Thesis Examination Committee has met on 24 May 2017 to conduct the final examination of Priya Rathanak a/p Eh Lai on her thesis entitled "Relationship between Noise Exposure Levels, Noise-Induced Hearing Loss and Neurobehavioral Performance among Steel Mill Male Workers" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

Mansor bin Haji Ahmad @ Ayob, PhD
Professor
Faculty of Science
Universiti Putra Malaysia
(Chairman)

Karmegam a/l Karuppiah, PhD
Senior Lecturer
Faculty of Medicine and Health Science
Universiti Putra Malaysia
(Internal Examiner)

Baba bin Md Deros, PhD
Professor
Faculty of Engineering
Universiti Kebangsaan Malaysia
(External Examiner)

NOR AINI AB. SHUKOR, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 8 August 2017

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Shamsul Bahri Mohd Tamrin, PhD
Associate Professor
Faculty of Medicine and Health Science
Universiti Putra Malaysia
(Chairman)

Huda Zainuddin, PhD
Senior Lecturer (Medical)
Faculty of Medicine and Health Science
Universiti Putra Malaysia
(Member)

ROBIAH BINTI YUNUS, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and Innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.

Signature: _____ Date: _____

Name and Matric No : Priya Rathanak a/p Eh Lai (GS32381)

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature:	
Name of Chairman of Supervisory Committee:	Assoc. Prof. Dr. Shamsul Bahri Mohd Tamrin
Signature:	
Name of Member of Supervisory Committee:	Dr. Huda Zainuddin

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

DOSH	Department of Occupational Safety and Health
dB	Decibel
E & I	Electrical and Instrumentation
HPD	Hearing Protective Device
HR	Human Resource
Hz	Hertz
IQR	Inter Quartile Range
Lavg	Average Noise Level (Real Time)
NCTB	Neurobehavioural Core Test Battery (*Ujian Teras Bateri Neurotingkahlaku*)
NIHL	Noise-Induced Hearing Loss *(Kehilangan Keupayaan Mendengar Akibat Bunyi Bising)*
NIOSH	National Institute of Occupational Safety and Health
OHD	Occupational Health Doctor
OSH	Occupational Safety and Health
OR	Odd Ratio
PEL	Permissible Exposure Level
PERKESO	*Pertubuhan Keselamatan Sosial*
PTS	Permanent Threshold Shift
SD	Standard Deviation
SHO	Safety and Health Officer
SLM	Sound Level Meter
SLR	Simple Linear Regression
SME	Small and Medium Industries
SPL	Sound Pressure Level
SRT	Simple Reaction Time
TTS	Temporary Threshold Shift
TWA	Time Weighted Average
USEPA	United States Environmental Protection Agency
WAIS	Wechsler Adult Intelligence Scale
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Background

Undesired, unpleasant and loud are all the ways that the Oxford English dictionary describes noise. When it comes to workplace, noise can be damaging for workers and lead to devastating consequences. The noise within the workplace not only cause hearing problems, but can also affect performance at work, including not being able to read effectively, attentiveness disrupted problem solving and memory. Who would have thought that a noise can hinders worker from remembering simple work task thus become unproductive. Noise can also be the cause of accidents due to reduced signal recognition, limited auditory localisation and speech communication, misunderstanding oral instructions and masking the sounds of approaching danger or warning (Carter, 2014).

Asia is the most populated continent and its population is estimated at four billion people. This represent 60% of the world's current human population. In China alone from 1979 to 1991, the number of industrial enterprises increased by factor of 12 and the number of employees has multiplied by 2.4 times (Carter, 2014).

Since there are high trend in the production of merchandises, it has created issues within workplaces including source of noise. Some countries within Asia will have periodic measurement and actions taken to reduce hazardous noise but this control measure cannot be conclude for all developing countries. Since there are high number noise emissions sources, most Asian labourers are exposed to uncontrollable noise within workplace every day.

Noise at workplace especially within the confine of steel manufacturing cannot be avoided since the operation revolving around machinery, devices and process which emitting high level sound. Therefore, workers in steel industries are highly likely to endure hearing problem. Occupational disease and poisoning cases reported as shown in Figure 1.1 by Department of Occupational Safety and Health (DOSH) Malaysia, out of the total of 5921 cases, 90.6 % is due to Noise Induced Hearing Loss. Figure 1.2 in the other hand, shown that metal industries are the second highest industries in this country with 55% of its workers endure noise-induced hearing loss. Besides that, Figure 1.3 portrayed a significant increasing of noise -induced hearing loss reported cases by Social Security Organization (SOCSO) Malaysia from 2001 till 2015.

Therefore, the purpose of this study is to investigate whether steel manufacturing workers who is exposed to high noise level endure deterioration in term of hearing threshold and neurobehavioral performance. Identification of tasks at

steel manufacturing plant that are associated with hearing loss and/or exposures to hazardous noise levels will allow control strategies to be targeted to the tasks that represent the most risk. The outcome of the study will raise the level of awareness among the industrialist and workers on the health risks of their workplace environment, and this will help to formulate the strategies for protection of workers from the hazardous noise levels prevailing in this industry especially.

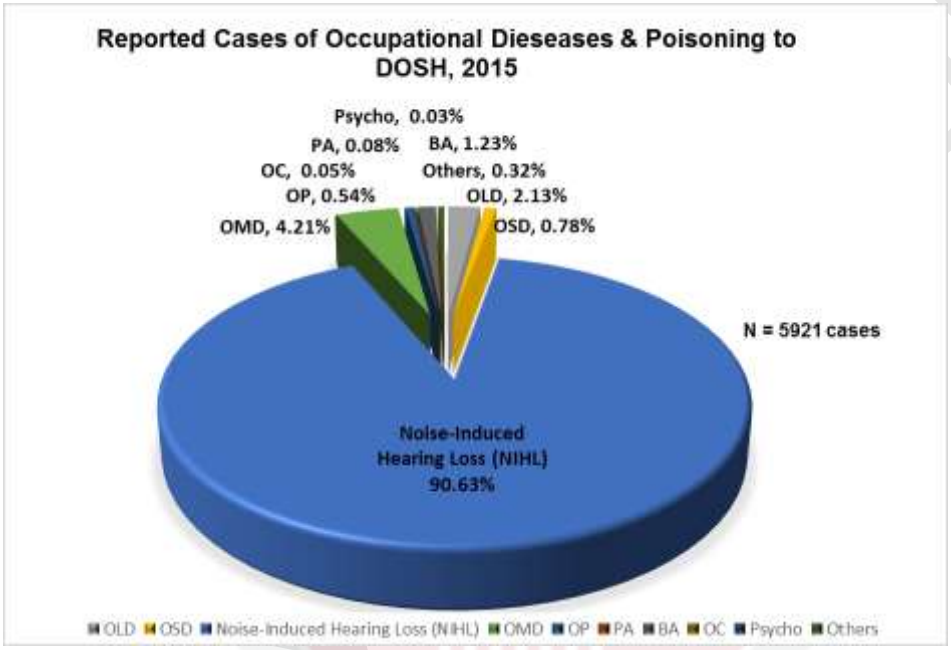

Figure 1.1 : Occupational disease and poisoning cases reported out 5921 total cases.
(Source: Department of Occupational Safety and Health Malaysia, 2015)

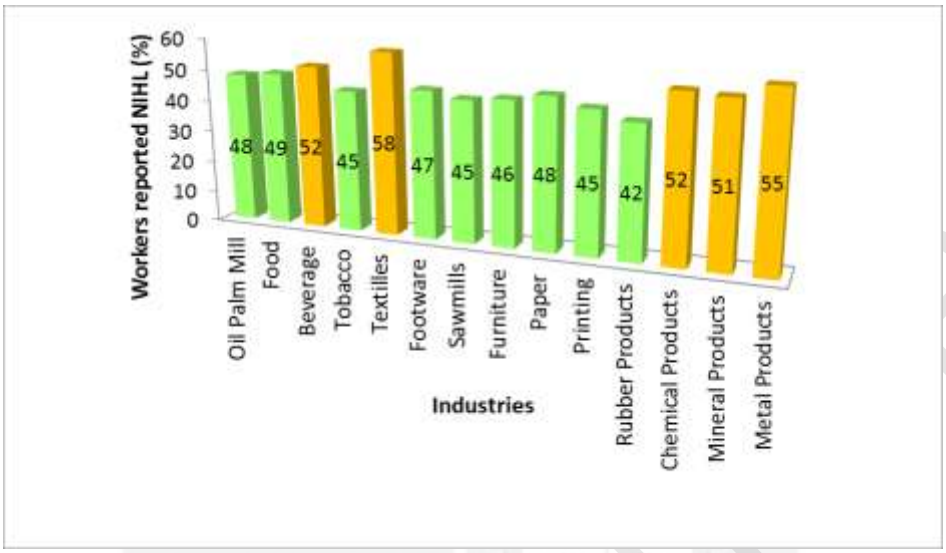

Figure 1.2 : Noise -induced hearing loss cases distribution by type of industries. (Source: Department of Occupational Safety and Health (DOSH) Malaysia, 2010)

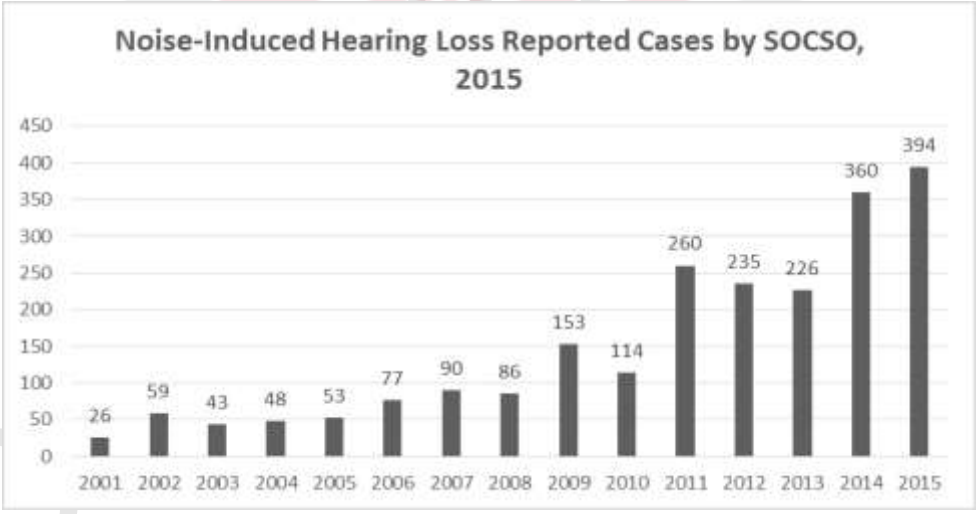

Figure 1.3: Workplace noise -induced hearing loss reported cases from 2005 to 2015. (Source: Social Security Organization Malaysia (SOSCO), 2015)

1.2 Problem statement

Seeing that natural resource abundance, human capital and economic growth in the developing Asia regions, millions of the workers are employed. Noise is known as the major hazard within the workplace around the world, particularly in the manufacturing industries. The current problem arises among industry from the Asia region is that they tend to emit noise which is either lack of legislation to control or lack of capital to ensure the noise reduction measures are carried out within their business.

Iron and steel manufacturing is one of the noisiest manufacturing industries and NIHL is common. Studies by Tahir et al., (2014) cited that occupational noise-exposed workers were observed to be highest in the metal industry followed by textile and food. This is also consistent with survey done by DOSH Malaysia in 2010 stated that metal industries are the second highest industries in this country with fifty-five percent of its workers endure noise-induced hearing loss. The major source of noise includes fume extraction system, vacuum systems using steam ejectors, electrical transformers, and the arc process in electrical arc furnaces, rolling mills and the large fans used for ventilation (Narlawar et al., 2006). The noise emission of steel making ranging from 91dB(A) to 140dB(A) is normally detected at arc furnace during electric charging of raw material and scrap to form molten steel at 1700 degree Celsius. Therefore, working in iron and steel industry were associated with the higher prevalence of hearing impairment and noise-induced hearing loss among noise-exposed workers (Pal Singh et al., 2012; Abdel-Rasoul et al., 2009). However, a standard threshold shift based on audiometric findings showed that hearing conversation program is somehow unsuccessful among the steel company workers (Attarchi et al., 2010). This may due to the long term inappropriate of the type of ear protection devices use and also duration and method of application of ear protection devices by the workers.

Noise induced hearing loss (NIHL) is among the highest reported auditory health risks among industries. It is estimated that about 600 million workers are exposed to workplace noise worldwide (Chou et al., 2009; Ferrite and Santana, 2005), and there is mounting evidence that workers exposed to noise in the workplace have an increased risk of accident (Picard et al., 2008). Even though countries in South-East Asia generally have NIHL prevention programmes and legislation, there are often poorly implemented and enforced and workers are ignorant of the problem (Palmer et al., 2002; Reilly et al., 1998; WHO, 1997).

Past record gathered by Tahir et al., (2014) showed that the total annual cost of NIHL per worker was RM 32,700 of which 14% was direct cost and 86% was indirect cost. The major payer for the cost (96%) was mainly attributed to medical care/rehabilitation, investigation procedures and benefit expenditure. Past review showed that the highest mean cost component for NIHL cases which were investigated and benefit expenditure (83%); followed by medical care and rehabilitation (14%) and loss of productive time (9%). Estimated national economic burden of NIHL was RM1.142 billion which is equivalent to 0.13% of

the Gross National Income 2011 (Tahir et al., 2014). In view of this, workplace noise exposure and hearing loss are considered as the contributing factors in accident circumstances which are of paramount importance since work-related accidents represent significant capital and productivity losses for the industry (Picard et al., 2008).

As discussed earlier, the increasing cases of NIHL among workers indicated that both the employer and employee obtained higher awareness on noise pollution and its relevant health effect. Even though the prevalence of NIHL has been reported among the steel workers, measures to deal with the risk of developing NIHL are often inadequate as in steel rolling mill (Ologe et al., 2005).

Noise pollution is not merely a form of workplace pollution; it has wide-ranging adverse health which interferes with sleep, concentration, communication and recreation (Goines & Hagler, 2007). The body reacts to noise with a fight or flight response, with resultant nervous, hormonal, and vascular changes that have far reaching consequences. For instances, chronic exposure to noise may increase the arousal and decreases attention through distraction (by noise). It may also decrease the ability to focus on stimuli peripheral to the task, altering the decision on task strategy and slowing one's memory (Söderlund et al., 2010; Clark et al., 2005; Carlson et al., 1997; Standsfeld & Haines, 1997). A number of studies have investigated the NIHL effects from chronic exposure to noise from steel making industries. However, there is still limited study on worker's neurobehavioral performance due to chronic exposure to noise from this well recognized noise polluted industry.

The research question is to find out whether long-term exposure to noise at the workplace may exacerbate the auditory effect that causing noise-induced hearing loss (NIHL), and non-auditory effect, particularly affect the neurobehavioral performance.

1.3 Study Justification

The steel market for South East Asia is expanding rapidly over the year. This region comprises several countries whose economies are growing and changing, and it is well located on major seaborne trade routes. It also has free-trade agreements in place with over half of the world's population. Therefore, Malaysian steel industry is predicting to provide an insight into the potential development of the steel industry in the region as a whole.

Despite providing efficient solutions for Malaysian economic progress, most of the major industries face the same noise pollution due to workplace environment (Gillani, 2012).

Thus far, it is importance to identify the tasks at steel making mill that are associated with hearing loss and/or exposures to hazardous noise levels which will allow control strategies to be targeted to the tasks that represent the most risk. Besides, the outcome of the study will raise the level of awareness among the industrialist and workers on the health risks of their workplace environment, and this will help to formulate the strategies for protection of workers from the hazardous noise levels prevailing in the industries.

Nevertheless, the direct effect of NIHL and its association to neurobehavioral performance among worker was kept inconclusive. Since there is a trending of increase in hearing impairment from PERKESO, this study is to evaluate the exposure-effect association between the degree of noise hazards that existed in steel making industries towards workers' health by assessing the prevalence of NIHL and their neurobehavioral performance.

1.4 Conceptual Framework

Figure 1.4 shows the conceptual framework in the study which outlines the exposure of workplace noise level by gauging through personal noise dosimeter as well as audiometric test and effect on neurobehavioral performance by utilizing the Neurobehavioral Test Battery (NCTB) (WHO, 1986) among male steel making workers in renowned steel making industries Terengganu, Malaysia.

The noise can hinder one's health through auditory effect or non-auditory effect. Through the auditory effect, sensorineural pathway is investigated where higher level of sound leads to a collapse of the stereocilia and the hair cells in the vestibulocochlear which eventually damaged permanently. If the outer hair cells are not functioning, a greater stimulation is required to initiate a nervous impulse; thus, the threshold sensitivity of inner hair cells is raised, which is perceived as a hearing loss. Audiometric test is then used to identify the noise induce hearing loss in a workers by using the arithmetic average of the individual experiencing hearing loss with a threshold shift of 25dB at a range of octave band frequencies (500, 1000, 2000, 4000, 6000, and 8000Hz).

This study applied the concept of exposure-effect principle to outline the association of auditory and non-auditory effect due to chronic noise exposure at the steel making industry. After the auditory effect of noise exposure is determined by audiometric testing, the non-auditory effect will be examined to evaluate worker's memory, sensory, motor skills and etc. by performing the Neurobehavioral Test Battery (NCTB) (WHO, 1986). NCTB Test batteries consist of seven tasks that measure performance of particular neurologic function, such as ability to learn, reaction time, memory, and coordination.

In addition, it is also noted that risk factors (e.g. age, education, working hour, and years of employment, smoking status and use of hearing protective devices) may impact on the neurobehavioral performance among the worker. For instances, the older subjects (age) made significantly more errors with increasing numbers of distractors in the serial search task (Oken et al., 1994); or female (gender) consistently outperformed males on the verbal and visual memory performance test (Trahan & Quintana, 1990). Therefore, these factors may also be considered as part of the confounding factors through self-administered questionnaire in the study.

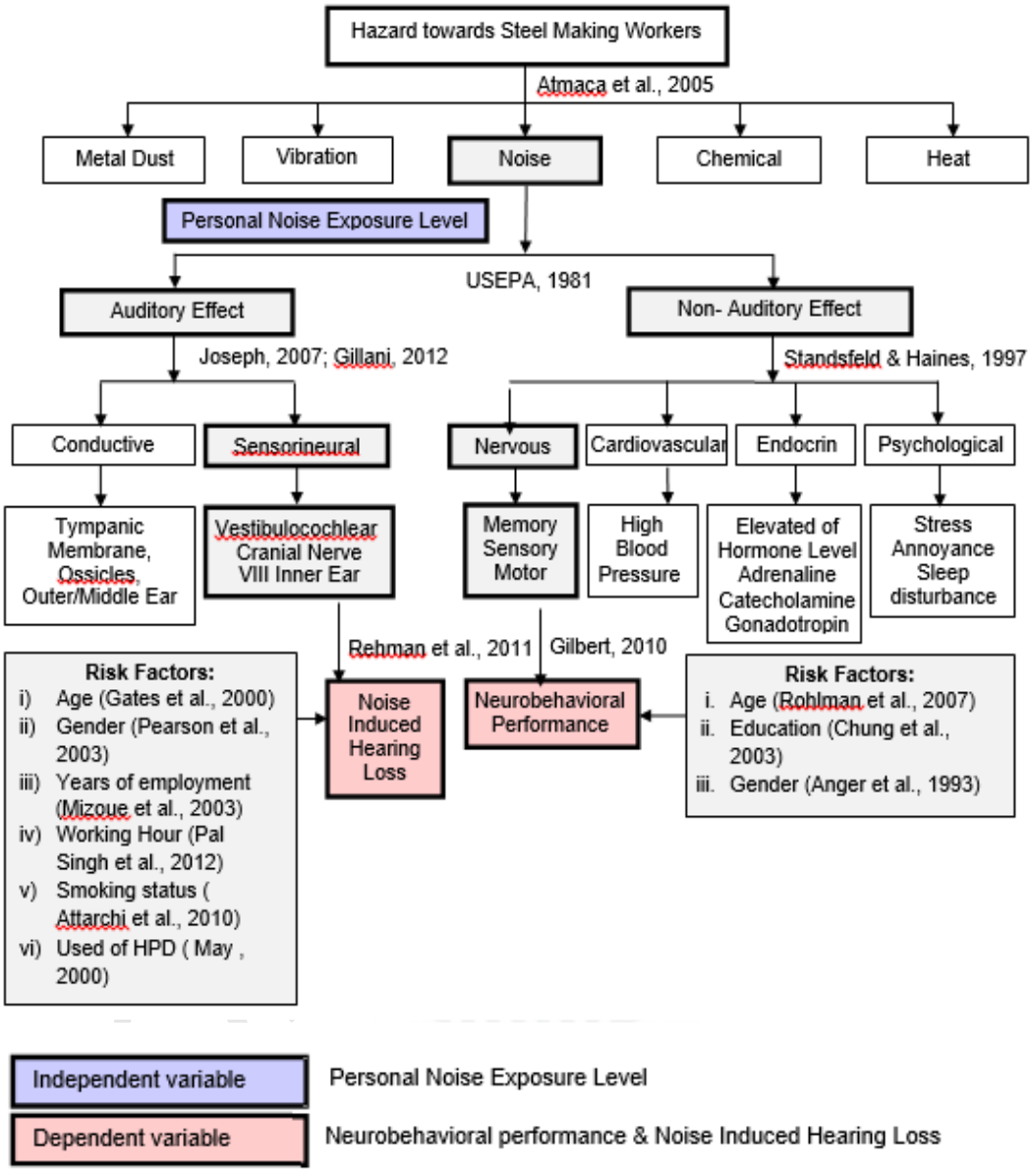

Figure 1.4 : Conceptual Framework of Noise Exposure and its relation to Noise Induced Hearing Loss and Neurobehavioral Performance

1.5 Definition

1.5.1 Conceptual Definition

i) Noise

Physically, noise is a complex sound whose characteristic are not easily amenable to analysis and uninformative signal with variable intensity. Psychologically, any sound that is unpleasant, noxious or unwanted is noise irrespective of its waveform (Alberti, 2001).

ii) Noise Induced Hearing Loss (NIHL)

NIHL occurs when too much sound intensity is transmitted into and through the auditory system. An acoustic signal from an energy source, is funneled through to the tympanic membrane (eardrum) and drives the ossicular chain of the middle ear system into motion which transfer mechanical energy to the cochlea by hammering against the oval window of the cochlea. This hammering causes the fluid within the cochlea (perilymph and endolymph) to push against the stereocilia of the hair cells. When the ear is exposed to excessive sound levels over time, the overstimulation of the hair cells leads to heavy production of reactive oxygen species, leading to oxidative cell death. Structural damage and cell death will result in noise induced hearing loss.

iii) Neurobehavioral Performance

Neurobehavioural performance is a non-invasive method used to evaluate the performance of the central nervous system in an individual or a group with similar exposures. Test batteries consist of tasks that measure performance of particular neurologic function, such as ability to learn, reaction time, memory, and coordination (Gilbert, 2010). The World Health Organization (WHO) group selected seven (7) of the most widely used tests in human behavioural neurotoxicology research which were judged to be sensitive as the marker of neurotoxic chemicals exposure. This set of test which recommended by WHO are simple reaction time (SRT), digit span, digit symbol, Benton visual retention, pursuit aiming II, and Santa Ana.

1.5.2 Operational Definition

i) Noise

Noise is level of sound that is measured using measuring equipment which known as dosimeter and sound level meter. The unit that it measured is decibel dB (A). Noise in the context of this research is sound being produce above 90dB (A) gauge by dosimeter at workplace in duration of 8 hours working hour.

ii) Noise Induced Hearing Loss

Noise induced hearing loss (NIHL) is a sensori-neural hearing deficit that begin at the higher frequencies (3000 to 6000 Hz) and develops gradually as a result of chronic exposure to excessive sound level (Harmadji & Kabullah 2004). In the context of this studies noise induced hearing loss was detected from the audiogram done where using the arithmetic average of the individual experiencing hearing loss with a threshold shift of 25dB at a range of octave band frequencies (500, 1000, 2000, 4000, 6000, and 8000Hz).

iii) Neurobehavioral Performance

In the context of this research, neurobehavioural performance was gauge by Neurobehavioural Core Test Battery (NCTB). A series of test is utilized to measure potential adverse health adverse health effect to nervous system. It is consist of six test that is Benton Visual Retention Test, Digit Span Test, Santa Ana Manual Dexterity, Time Reaction/Movement Test, Trial Making Test and Pursuit Aiming Test.

1.6 Research Objectives

1.6.1 General Objectives

To determine the effect of noise exposure towards noise induced hearing loss and the effect on neurobehavioral performance among male steel manufacturing workers.

1.6.2 Specific Objectives

i) To identify the socio-demographic information among respondent.

ii) To determine the hearing threshold (Noise-induced hearing loss (NIHL) and Non- NIHL) among the studied respondent.

iii) To determine the noise exposure level between each operation department among the steel manufacturing workers.

iv) To compare the differences of neurobehavioral performance among noise-induced hearing loss (NIHL) and Non- NIHL respondent.

v) To compare the differences between the noises exposure level and among noise-induced hearing loss (NIHL) and Non- NIHL respondent.

vi) To determine the association between personal noise exposure level and neurobehavioral performance among noise-induced hearing loss (NIHL) and Non- NIHL respondent.

vii) To develop the relationship between selected risk factors from neurobehavioral performance score among noise-induced hearing loss (NIHL) and Non- NIHL respondent.

1.7 Research Hypothesis

i) There is a difference of hearing threshold level between noise-induced hearing loss (NIHL) and Non- NIHL respondent.

ii) There is a difference of neurobehavioral performance between among noise-induced hearing loss (NIHL) and Non- NIHL respondent.

iii) There is a relationship between noise exposure level and hearing threshold level among studied population.

iv) There is an association between noise exposure level and neurobehavioral performance.

v) There is a relationship between selected risk factors from neurobehavioural performance score among noise-induced hearing loss (NIHL) and Non- NIHL respondent.

REFERENCES

Abdel-Rasoul G. M., Mahrous, O.A.E., Abou Salem, M.E., Al-Batanony, M.A., Allam, H.K. (2009). Auditory and respiratory health disorders among workers in an iron and steel factory. *Auditory and Respiratory Health,* 2(1);1-10.

Aghamollaie, M., Tahaei, A., Jafari, Z & Toufan, R. (2011). Development and evaluation of a Persian version of the dichotic auditory-verbal memory test. *Audiol,* 20(2), 86-94.

Albert, M.S, & Heaton, R.K (1998). Intelligence testing. *In* "Geriatric Neuropsychology" (M.S. Albert and M.B. Moss, eds), pp. 13-32. The Guilford Press, New York.

Alberti, P. W. (2001) "The Anatomy and Physiology of the Ear and Hearing", Evaluation, prevention, and control, 53-62, Retrieved from http://www.who.int/occupational_ health/ publications / noise2.pdf

Ali, A., Garandawa, H.I, Nwawolo, C.C, & Somefun, O.O (2012). Noise- induced hearing loss at cement company, Nigeria. Online Journal of Medicine and Medical Science Research, 1(3):49-54.

Anger, W. K. (2003). Neurobehavioral tests and systems to assess neurotoxic exposures in the workplace and community. *Occupational and Environmental Medicine*, 60, 531-538.

Anger, W.K., Cassitto, M.G., Liang, Y-X., Amador, R., Hooisma, J., Chrislip, D.W., Mergler & D., Keifer, M., (1993). Comparison of performance from three continents on the WHO-recommended Neurobehavioral Core Test Batter. *Environmental Research,* 62,125-147

Atmaca, E., Peker, I., Altin, A. (2005). Industrial noise and its effect on humans. *Polish Journal of Environmental Studies,* 14(6), 721-726.

Attarchi, M.S & Labbafinejad, Y. (2010). Contemporary exposure to cigarette smoke and noise of automobile manufacturing company workers. *Journal of Public Health,* 18, 245-249

Attarchi, M.S., Sadeghi, Z., Dehghan, F., Sobrabi, M.M., Mohammadi, S. (2010). Assessment of hearing standard threshold shift based on audiometric findings in steel company workers. *Iranian Red Crescent Medical Journal*, 12(6), 644-649

Babisch W. Noise and Health. Environ Health Perspect 2005;113: A14-15. Available at:http://www.pubmedcentral.nih.gov/articlerender.fcgi?article=1253720.Accessed October 10, 2006.

Bäckman, L., Jones, S., Berger, A.K., Laukka, E.J., & Small, B.J. (2005). Cognitive impairment in preclinical Alzheimer's disease: a meta-analysis. *Neuropsychology*, 19(4), 520-531.

Baker, M.A., Holding, D.H. (1993). The effects of noise and speech on cognitive task performance. *The Journal of General Psychology*, 120(3), 339-55.

Baldwin L.C. & Ash I.K (2011). Impact of sensory acuity on auditory working memory span in young and old adults. *Journal Psychol Aging*, 26(1):85-91. doi:10.1037/a0020360

Baldwin, C.L. & Struckman-Johnson D. (2002). Impact of speech presentation level on cognitive task performance: Implications for auditory display design. *Ergonomics*, 45(1):61–74.

Belojevic, G., Ohrstrom, E., and Rylander, R (1993). Effects of noise on mental performance with regard to subjective noise sensitivity. *Noise Public Health Probl. Proc. Int. Congr.* 6th (M.Vallet, e.d.), Vol 2, pp. 317-320, lÍNRETS, 94114 Arcuil Cedex, France

Berger, E.H., Royster, L.H., Royster, J.D., Driscoll, D.P. & Layne M. (1995). *The Noise Manual*, 5th Edition. American Industrial Hygiene Association (AIHA). USA.

Bohne, B.A. & Harding, G.W. (1999). Noise induced hearing loss. Dept. of Otolaryngology, Washington University School of Medicine, St. Louis, MO. http://oto2.wustl.edu/bbears/noise.htm

Borchgrevink, H. M. (2003). Does health promotion work in relation to noise? Noise Health, 5 (18), 25-30.

Borchgrevink, H.M. (2009). Effects of shift work and intermittent noise exposure on hearing: mechanisms and prophylactic potential. *Noise Health*, 11(45), 183-184.

Bopp, K.L. & Verhaeghen, P. (2009). Working memory and aging: Separating the effects of content and context. *Psychology and Aging*, 24(4), 968–980.

Boxtel, M.P.J., Beijsterveldt, C.E.M., & Houx P.J. (2000). Mild hearing impairment can reduce verbal memory performance in a healthy adult

population. *Journal of Clinical and Experimental Neuropsychology,* 22, 147–154.

Browning G., Gatehouse, S., Lowe, G. (1986). Blood viscosity as a factor in sensorineural hearing impairment. *Lancet,* 1, 121-123

Carlson, S., Rämä, P., Artchakov, D., and Linnankoski, I. (1997). Effects of music and white noise on working memory performance in monkeys. *NeuroReport,* 8, 2853-2856.

Carter, J. (2014). Sound Counsel: Mitigating against noise in the workplace. *Occupational Safety Asia Magazine*, 18, 35 -39.

Chang NC, Yu ML, Ho KY, Ho CK. Hyperlipidemia in noise-induced hearing loss (2007). *Otolaryngology -- Head and Neck Surgery*, 137(4), 603-6.

Chen JD, Tsai JY. Hearing loss among workers at an oil refinery in Taiwan (2003). *Archives of Environmental Health,* 58(1), 55-8

Chen, G. (2002). Effect of hypoxia on noise-induced auditory impairment. *Hearing Research,* 172, 186-195

Chen, X.J. (1997). Neurobehavioural Effects of Noise Exposure in Metallurgical Industry. *Industrial Health and Occupational Disease,1997-05.* Retrieved from http://en.cnki.cn/Article_en/CIFDTOTAL- GYWZ199705000.htm

Cheung, C.K. (2004). Organizational influence on working people's occupational noise protection in Hong Kong. *Journal of Safety Research*, 35, 465-470.

Chia, S.E., Foo, S.C., Gan, S.L., Jeyaratnam, J. & Tian, C,S., (1993). Neurobehavioral functions among workers exposed to manganese ore. *Scand J Work Environ Health* 1993;19(4):264-270. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8235515

Chittka L., Brockmann A. (2005). Perception Space:The Final Frontier. *PLoS Biology,* 3(4), 564-568

Chou, Y.F., Lai, J.S., & Kuo, H.W. (2009). Effects of shift work on noise-induced hearing loss. *Noise and Health,* 11(45), 185-188

Chung, J-H., Sakong, J., Kang, P-S., Kim, C-Y., Lee, K-S., Jeon, M-J., Sung, N-J., Ahn, S-H., and Won, K-C. (2003). Cross-Cultural comparison of neurobehavioral performance in Asian workers. *NeuroToxicology*, 24(4-5), 533-540

Cirrus Research, Plc (2013). CR:110A doseBadge User Manual. North Yorkshire, YO14 0PH, United Kingdom.

Clark, C., Martin, R., Kempen, K.V., Alfred, T., Head, J., Davies, H.W., Haines, M.M., Barrio, I.L., Matheson, M., Stansfeld, S.A. (2005). Exposure-effect relations between aircraft and road traffic noise exposure at school and reading comprehension. *American Journal of Epidemiology,* 163 (1),27-37

Cratty, B.J. & Noble, C.E (2014). "psychomotor learning." Encyclopaedia Britannica. Encyclopaedia Britannica Online Academic Edition. Encyclopædia Britannica Inc., 2014. Retried from 24 Jun. 2014. http://www.britannica.com/EBchecked/topic/481767/psychomotor-learning

Crawford, J.M., Hoppin, J.A., Alavanja, M.C., Blair, A., Sandler, D.P., Kamel, F.(2008). Hearing loss among licensed pesticide applicators in the agricultural health study. *Journal of Occupational and Environmental Medicine*, 50(7), 817-26.

Detaille, S.I., Haafkens, J.A., van Dijk, F.J. (2003). What employees with rheumatoid arthritis, diabetes mellitus and hearing loss need to cope at work. *Scandinavian Journal of Work, Environment & Health*, 29(2),134-42.

Department of Occupational Safety and Health. Occupational Diseases and Poisoning Investigation. 2015 Annual Statistic Report DOSH Malaysia.

Elias, M.F., Beiser, A., Wolf, P.A., Au, R., White, R.F., & D'Agostino, R.B. (2000). The preclinical phase of Alzheimer disease: a 22year prospective study of the Framingham Cohort. *Archives of Neurology*, 57, 808-813.

El-Shazly, A. (2006). Toxic solvents in car paints increase the risk of hearing loss associated with occupational exposure to moderate noise intensity. *BENT: A Journal of CripGay Voices*, 2(1),1-5.

Enmarker, I. (2004). The effects of meaningful irrelevant speech and road traffic noise on teachers' attention, episodic and semantic memory. *Scandinavian Journal of Psychology*, 45(5), 393-405.

Enoka, R.M., Christou, E. a, Hunter, S.K., Kornatz, K.W., Semmler, J.G., Taylor, A M. & Tracy, B.L., (2003). Mechanisms that contribute to differences in motor performance between young and old adults. *Journal Electromyogr Kinesiol,* 13, 1–12. doi:S1050641102000846

Fan, G.Q. (1996). A study on Effect of Noise on Neurobehavioural of Female Textile Workers. *Chinese Journal of Industrial Medicine,1994-05.* Retrieved from http://en.cnki.cn/Article_en/CIFDTOTAL-SOLE405.000.htm

Ferrite, S & Santana, V. (2005). Joint effects of smoking, noise exposure and age on hearing loss. *Occupational Medicine,* 55, 48-53

Frank, J.F. (2001). Occupational exposure to noise: evaluation, prevention and control: *Hearing Measurement* (pp. 183-232). Dortmund, Germany: World Health Organization.

Frost, J.L., Wortham, S.C. & Reifel, S., (2008). Play and Child Development. Prentice Hall edition, p. 126-127.

Gao, W.Z., Wang, Z.Z. & Zhang, D.F., (1999). Effects of Noise on Neurobehavioural Functions of Female Workers. *Acta Acadimae Medicinae Qingdao,1999-03.* Retrieved from http://en.cnki.cn/Article_en/CIFDTOTAL-BATE199903010.htm

Gates, G.A., Schmid, P., Kujawa, S.G., Nam, B., D'Agostino, R. (2000) .Longitudinal threshold changes in older men with audiometric notches. *Hearing Research*, 141, 220–228.

Gilbert, S.G. (2010). A small dose of toxicology- The health effects of common chemicals. 2nd edition. Healthy World Press.

Gillani, R. (2012). Predicting noise-induced hearing loss (NIHL) in TNB workers using GDAM algorithm. Thesis for Degree of Masters. University of Tun Hussein Onn Malaysia.

Gheysen, F., Loots, G., & Waelvelde, H. V. (2007). Motor development of deaf children with and without cochlear implants. *Journal of Deaf Studies and Deaf Education*, 13, 215-224.

Goines, L., & Hagler, L. (2007). Noise pollution: A modern plague. *Southern Medical Journal*, 100(3), 287-294.

Gomes, J., Lloyd, O., & Norman, N. (2002). The health of the workers in a rapidly developing country: Effects of occupational exposure to noise and heat. *Occupational Medicine,* 52(3),121-128

Guerra, M.R., Lourenco, P.M., Bustamante-Teixeira, M.T., Alves, M.J. (2005). Prevalence of noise-induced hearing loss in metallurgical company. *Revista de Saúde Pública*, 39(2), 238-44

Han BI, Lee HW, Kim TY, Lim JS, Shin KS (March 2009). "Tinnitus: characteristics, causes, mechanisms, and treatments". *Journal of Clinical Neurology*, 5 (1), 11–19.

Henry, K.R. (2003). Hyperthermia exacerbates and hypothermia protects from noise-induced threshold elevation of the cochlear nerve envelope response in the C57BL/6J mouse. *Hearing research*, 179, 88-96.

Hockey, G.R.J. & Hamilton, P. (1970). Arousal and information selection in short-term memory. *Nature, Lond*, 226, 886-867

Hong, O., & Kim, M (2001). Factors associated with hearing loss among workers of the airline industry in korea, ORL-head and neck nursing ,19, 7-13

Hygge, S. (2003). Classroom experiments on the effects of different noise sources and sound levels on long-term recall and recognition in children. *Applied Cognitive Psychology*, 17(8), 895-914.

Ising H, Kruppa B (2004). Health effects caused by noise: evidence from the literature from the past 25 years. *Noise Health*, 6, 5-13

Ismail, A.F., Daud, A., Abdullah, B. (2013). Noise-induced hearing loss among quarry workers in a North-Eastern State of Malaysia: A study on knowledge, attitude and practice. *Oman Medical Journal*, 28(5), 331-336.

Joseph, L. (2007). Current: Occupational and Environmental Medicine, 4th Edition. McGraw Hill.

Kaerlev, L., Jensen, A., Nielsen, P.S., Olsen, J., Hannerz, H., Tuchsen, F. (2008). hospital contacts for noise-related hearing loss among Danish seafarers and fishermen: a population-based cohort suty. *Noise Health,* 10 (39):41-45.

Keefover, R.W. (1998). Aging and cognition. *Neurologic Clinics.* 16(3), 635-648.

Kryter, K.D. (1994). The handbook of hearing and the effects of noise: Physiology, Psychology and Public Health. Academic Press: San Diego New York Boston & London Sydney Tokyo Toronto. ISBN. 0-12-427455-2.

Kujawa, S.G. & Liberman, M.C (2006). Acceleration of age-related hearing loss by early noise exposure: Evidence of a misspent youth. *The Journal of Neuroscience*, 15, 26(7), 2115-2123.

Laws of Malaysia. (2010). Factories and Machinery Act 1967 (Act 139), Regulations & Rules: International Law Book Services.

Leech, N.L., Barrett, K.C., & Morgan, G.A. (2005). SPSS for Intermediate Statistics: *Use and Interpretation.* (2nd ed.) (pp. 28).United States: Lawrence Erlbaum Associates, Inc., Publishers.

Lemeshow, S., Hoemer, D.W., Klar, J., & Lwanga, S.K. (1990). *Adequacy of Sample Size in Health Studies.* WHO & John Wiley & Sons Ltd: England. ISBN 0 471 92517 9.

Lezak, M.D. (1995). “Neuropsychological assessment”. Oxford University Press, 3’rd edition, New York.

Lin, C. (1998). Investigation on Neurobehavioural Function of Noise-Exposed Workers. *Industrial Health and Occupational Disease,1998-05.* Retrieved from http://en.cnki.cn/Article_en/CIFDTOTAL-GYWZ199805005.htm

Li, L., Daneman, M., Qi, J.G. & Schneider, B.A,. (2004). Does the Information Content of an Irrelevant Source Differentially Affect Spoken Word Recognition in Younger and Older Adults? *Journal of Experimental Psychology: Human Perception & Performance,* 30(6), 1077–1091.

Lin, F.R. (2011). Hearing Loss and cognition among older adults in the United States. Journal of Gerontol A Biol Sci Med Sci, 66A(10), 1131-1136. doi: https://doi.org/10.1093/gerona/glr115

Liu, S.Q., Liu, A.J., Liu, J.F., & Li, X.L (1993). Study of neurobehavioural of textile women exposed to noise. *Chinese Journal of Public Health,* 4, 205-207.

Lowe, G., Drummond, M., Forbes, C., Barbenel, J. (1980). The effects of age and cigarette smoking on blood and plasma viscosity in men. *Scottish Medicine Journal,* 25, 13-17.

Maisarah, S.Z., and Said, H (1993). The noise exposed factory workers: the prevalence of sensori-neural hearing loss and their use of personal hearing protection devices. *Medical Journal of Malaysia*, 48(3), 280-285.

Masaitis, J. (2012) Chapter 73 Iron and Steel. *ILO Encyclopedia of Occupational Health and Safety.* Retrieved from http://www.ilocis.org/en/default.html

Manninen, O. (1995). Combined effects and interactions between environmental factors. Proceedings of the International Advanced Research Workshop. G. Rossi. Edizioni Minerva Medica, Torino, pp. 156-166.

Marvel, M.E., Pratt, D.S., Marvel, L.H., Regan, M., May, J.J (2007). Occupational hearing loss in New York dairy farmers. *American Journal of Industrial Medicine*. 20(4), 517-531.

Marmon, A.R., Gould, J.R., Enoka, R.M., (2011). Practicing a functional task improves steadiness with hand muscles in older adults. *Medicine & Science in Sports & Exercise Journal of the American College of Sports Medicine*, 43, 1531–1537. doi:10.1249/MSS.0b013e3182100439

Masayuki, I. (1994). Vibration-induced white finger as a risk factor for hearing loss and postural instability. *Nagoya Journal of Medical Science*, 57, 137-145.

Masilamani, R., En, A.R., Darus, A., Ting, A.S. (2012). Noise-Induced Hearing Loss and Associated Factors Among Vector Control Workers in a Malaysian State. *Asia Pacific Journal of Public Health*, 1-9. DOI: 10.1177/1010539512444776

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

McBride, D.I. (2004). Noise-induced hearing loss and hearing conservation in mining. *Occupational Medicine*, 54(5), 290-296.

McGraw-Hill Dictionary of Scientific & Technical Terms, 6E, Copyright © 2003 by The McGraw-Hill Companies, Inc.

McGuire, P.K., Shah, G.M.S. & Murray, R. M. (1993). Increased blood flow in Broca's area during auditory hallucinations in schizophrenia. *Lancet,* 342, 703-706.

Mitchell, J., & McCombe, A. (2009). Noise-Induced Hearing Loss. *Journal of ENT Master Class*, 2 (1), 107-110.

Mizoue, T., Miyamoto, T., Shimizu, T. (2003). Combined effect of smoking and occupational exposure to noise on hearing loss in steel factory workers. *Occupational and Environmental Medicine*, 60, 56-59

Mohammadi Roozbahani, M., Nassiri, M., Jafari Shalkouhi, P (2009). Risk assessment of workers exposed to noise pollution in a textile plant. International *Journal of Environmental Science and Technology*, 6(4), 591-6.

Mohindra, N., & Wilding, J. (1983). Noise effects on rehearsal rate on short term serial order memory. *The Quarterly journal of experimental psychology*, 35A, 155-170.

Morata, T.C. (1998). Assessing occupational hearing loss: Beyond noise exposures. *Scandavian Audiology Supplement,* 48, 111-116

Nandi, S.S., & Dhatrak, S.V. (2008). Occupational noise-induced hearing loss in India. *Indian Journal of Occupational and Environmental Medicine,* 12(2), 53-56.

Narlawar, U.W., Surjuse, B.G., Thakre, S.S. (2006). Hypertension and hearing impairment in workers of iron and steel industry. *Indian Journal of Physiological and Pharmaceutical,* 50(1), 60-66

Nasir, H.M., and Rampal, K.G. (2011). Hearing loss and contributing factors among airport workers in Malaysia. *Medical Journal of Malaysia*, 67(1), 81-86.

Nelson, D.I., Nelson, R.Y., Concha-Barrientos, M., Fingerhut, M. (2005). The global burden of occupational noise-induced hearing loss. *American Journal of Industrial Medicine*, 48(6), 446-458

Nolan, B.H., Swihart, A.A., and Pirozzolo, F.J. (1986). The neuropsychology of normal aging and dementia: An introduction, *In "*The Neuropsychology Handbook: Behavioral and Clinical Persectives" (D. Wedding, A.M. Horton, Jr., and J. Webster, Eds.), pp. 410-440. Springer, New York

Nomura, K., Nakao, M., Morimoto, T. (2005). Effect of smoking on hearing loss: quality assessment and meta-analysis. *Preventive Medicine,* 40(2), 138-144.

Nomura, K., Nakao, M., & Yano, E. (2005). Hearing loss associated with smoking and occupational noise exposure in a Japanese metal working company. *International Archives of Occupational and Environmental Health,* 78, 178-184

Noven, M.L., Pereira, H.M., Yoon, T., Stevens A.A., Nielson, K.A. & Hunter, S.K., (2014). Motor variability during sustained contraction increases with cognitive demand in older adults. *Journal Frontier in Aging Neuroscience,* 6(97), 1-13

Nurul, H. (2015). Association between extreme heat exposure and acute physiological change among steel mill workers in Terengganu, Malaysia. Thesis for Degree of Masters. University Putra Malaysia.

Oken, B.S., Kishiyama, S.S., Kaye, J.A. (1994). Age-related differences in visual search task performance: relative stability of parallel but not serial search. *Journal of Geriatric Psychiatry and Neurology,* 7(3), 163-168.

Ologe, F.E., Akande, T.M., Olajide, T.G. (2005). Noise exposure, awareness, attitudes, and use of hearing protection in a steel rolling mill in Nigeria. *Occupational Medicine,* 55; 487-489

Ologe, F.E., Olajide, T.G., Nwawolo, C.C., Oyejola, B.A. (2008). Deterioration of noise-induced hearing loss among bottling factory workers. *The Journal of Laryngology & Otology*, 122(8), 786-794

Oyedepo, O.S., & Saadu, A.A. (2010). Assessment of noise level in sundry processing and manufacturing industries in Ilorin metropolis, Nigeria. *Environmental Monitoring Assessment*, 162, 453-464.

Pal Singh, L., Bhardwaj, A., Deppak, K.K. (2012). Prevalence of permanent hearing threshold shift among workers of Indian iron and steel small and medium enterprises: A study. *Noise and Health,* 14(58);119-128

Palmer, K., Grifflin M., Syddall, H., Coggon, D. (2004). Cigarette smoking, occupational exposure to noise, and self-reported hearing difficulties. *Occupational and Environmental Medicine*, 61; 340-344

Palmer, K.T., Griffin, M.J., Syddall, H.E., Davis, A., Pannett, B., Coggon, D. (2002). Occupational exposure to noise and the attributable burden of hearing impairment in Great Britain. *Occupational and Environmental Medicine,* 59; 634-639

Patel, V. S., & Ingle, S. T. (2008). Occupational noise exposure and hearing loss among pulse processing workers. The Environmentalist , 28 (4), 358-365.

PCB Piezotronics, Inc (2011). Larson Davis Spark Noise Dosimeter and Blaze Software Technical Reference Manual. USA.

Pearman, A., Friedman, L. & Brooks, J. (2000). Hearing impairment and serial word recall in older adults. *Experimental Aging Research*, 26, 383–391.

Pearson, J.D., Morrell, C.H., Gordon-Salant, S., Brant, L.J., Metter, E.J., Klein, L.L., Fozard, J.L. (1995). Gender differences in a longitudinal study of age-associated hearing loss. *The Journal of the Acoustical Society of America,* 97 (2), 1196.

Pettersson, H., Burström, L., Hagberg, M., Lundström, R., Nilsson, T (2012). Noise and hand-arm vibration exposure in relation to the risk of hearing loss. *Noise Health*, 14 (59): 159-165

Picard, M., Girard, S.A., Simard, M., Larocque, R., Leroux, T., & Turcotte, F. (2008). Association of work-related accidents with noise exposure in the workplace and noise-induced hearing loss based on the experience of some 240,000 person-years of observation. *Accident Analysis and Prevention*, 40; 1644-1652

Pichora-Fuller, M. & Singh, G. (2006). Effects of age on auditory and cognitive processing: implications for hearing aid fitting and audiologic rehabilitation. *Trends in Amplification* 10, 29-59.

Poulton, E.C. (1979). Composite model for human performance in continuous noise. *Psychological Review*, 86, 361-375

Poulton, E.C. (1980). Psychology of the scientist: XLI. Continuous noise can degrade performance when using badly designed equipment: A case history. *Percept Motor Skills,* 50, 319-330

Pyyko, I., Starck, J., Pekarinen, J. (1986). Further evidence of a relation between noise-induced permanent threshold shift and vibration-induced digital vasospasms. *American Journal of Otolaryngology*, 7, 391-398

Quest Technologies (2012). 3M Edge Personal Noise Dosimeter User Manual. USA

Rabinowitz, P. M. (2000). Noise-Induced Hearing Loss. American Family Physician, 61 (9), 2759-2760.

Rabinowitz, P., and Rees, T. (2005). Occupational hearing loss. In: Rosenstock L, Cullen M, Brodkin C, Redlich C, editors. Textbook of clinical occupational and environmental medicine, 2nd et. Philadelphia, USA: Elsevier Saunders, , p. 426-436

Ranga, R.K., Yadav, S.P.S., Yadav, A, Yadav, N., Ranga, S.B. (2014). Prevalence of occupational noise induced hearing loss in industrial workers. *Indian Journal of Otology,* 20(3), 115-118

Rehman, M. Z., Nazri, M. N., & Ghazali, M. I. (2011). Noise-Induced Hearing Loss (NIHL) Prediction in Humans using a Modified Back Propagation Neural Network. ICASEIT-2011, 185-189, Bangi.

Reilly, M.J., Rosenman, K.D., Kalinowski, D.J. (1998). Occupational noise-induced hearing loss surveillance in Michigan. *Journal of Occupational and Environmental Medicine,* 40; 667-674

Report of an informal consultation "Prevention of noise-induced hearing loss", World Health Organization (WHO), Strategies or Prevention of Deafness and Hearing Impairment, 28-30 October, 1997

Rohlman, D.S., Lasarev, M., Anger, W.K., Scherer, J., Stupfel, J., McCauley, L. (2007). Neurobehavioral performance of adult and adolescent agricultural workers. *NeuroToxicology,* 28(2), 374-380.

Rosowski JJ, Brinsko KM, Tempel BI, Kujawa SG (2003). The aging of the middle ear in 129S6/SvEvTac and CBA/CaJ mice: measurements of umbo velocity, hearing function, and the incidence of pathology. J Assoc Res Otolaryngol 4:371–383.

Sarampalis, A., Kalluri, S., Edwards, B. & Hafter, E. (2009). Objective Measures of Listening Effort: Effects of Background Noise and Noise Reduction. *Journal of Speech, Language & Hearing Research*, 52(5), 1230–1240.

Sataloff R, Sataloff J. (1993). Occupational hearing loss. New York: Marcel Dekker, Inc. p 403-414, 488-489.

Sekaran, U. & Bougie, R. (2010). Research methods for business: *A skill building approach* (5th ed.) (pp. 307-311).United States: John Willey & Sons Ltd

Shahidipour, Z., Geshani, A., Jafari, Z., Jalaie, S. & Khosravifard, E. (2013). Auditory memory deficit in elderly people with hearing loss. *Iranian Journal of Otorhinolaryngology*, 25(3), 169-176.

Sliwinska-Kowalska, M., Zamyslowska-Szmytke, E., Szymczak, W., Kotylo, P., Fiszer, M., Wesolowski, W., Pawlaczyk-Luszczynska, M. (2005). Exacerbation of noise-induced hearing loss by co-exposure to workplace chemicals. *Environmental Toxicology and Pharmacology*, 19(3), 547-553

Smith, A.P., & Broadbent, D.E. (1992). Non-auditory effects of noise at work: A review of the literature (HSE Contract Research Report No. 30), London, UK, HMSO

Social Security Organization. Number of occupational disease cases and benefit paid according to agent causes and gender. 2015 Annual Report of SOCSO Malaysia.

Söderlund, G.B.W., Sikström, S., Loftesnes, J.M., and Sonuga-Barke, E.J. (2010). The effects of background white noise on memory performance in inattentive school children. *Behavioral and Brain Functions, 6:55*

Standsfeld, S.A., & Haines, M. (1997). Environmental noise and health: A review of non-auditory effects. IEH report on the non-auditory effects of noise. Medical Research Council, Institute for Environment and Heath, Norwich.

Stansfeld, S.A., & Matheson, M.P. (2003). Noise pollution: Non-auditory effects on health. *British Medical Bulletin*, 68, 244-257.

Sulkowski, W.J., Szymczak, W., Kowalska, S., Sward-Matyja, M. (2004). Epidemiology of occupational noise-induced hearing loss (ONIHL) in Poland. *Otolaryngology Journals*, 58(1), 233-236.

Sułkowski WJ, Kowalska S, Matyja W, Guzek W, Wesołowski W, Szymczak W, Kostrzewski P. (2002). Effects of occupational exposure to a mixture of solvents on the inner ear: a field study. *International Journal of Occupational Medicine and Environmental Health, 15(3), 247-256*

Surprenant, A.M. (2010). The effect of noise on memory for spoken syllables. *International Journal of Psychology,* 34 (5-6), 328-333.

Swan G.E, Carmelli D, La Rue A.(1998). Systolic blood pressure tracking over 25 to 30 years and cognitive performance in older adults. *Stroke,* 29:2334–2340.

Tafalla, R., and Evans, G. (1993). Noise, physiology and human performance: The potential role of effort. *Noise Public Health Probl. Proc. Int. Congr.* 6th (M.Vallet, e.d.), Vol 2, pp. 317-320, IÍNRETS, 94114 Arcuil Cedex, France

Tahir, N., Mohamed Aljunid, S., Hashim, J.H. (2014). Occupational noise exposure in manufacturing industries in Malaysia. From the 7th Postgraduate Forum on Health Systems and Policies Phitsanulok, Thailand. BMC Public Health, 14 (Suppl 1):017

Tak, S., Davis, R.R., Calvert, G.M. (2009). Exposure to hazardous workplace noise and use of hearing protection devices among US workers--NHANES, 1999-2004. *American Journal of Industrial Medicine*, 52(5), 358-371

Tay, P. (1997). Severe noise-induced deafness: A ten-year review of cases. *Singapore Medicine Journal*, 3; 362-364

Tengku Hanidza, T.I., Amirah, A.M. Ramdzani, A., Madinah, A. (2013). A Preliminary Study of Noise Exposure among Grass Cutting Workers in Malaysia. *Procedia-Social and Behavioral Sciences*, 91, 661-672.

Toppila E, Pyykko I, Starck J (2001). Age and noise-induced hearing loss. Scandinavian Audiology, 30(4), 236-44.

Tracy, B.L., Dinenno, D.V., Jorgensen, B., Welsh, S.J., (2007). Aging, Visuomotor Correction, and Force Fluctuations in Large Muscles. *Medicine & Science in Sports & Exercise Journal of the American College of Sports Medicine*, 39, 469–479. doi:10.1249/mss.0b013e31802d3ad3.

Trahan, D.E., Quintana, J.W. (1990). Analysis of gender effects upon verbal and visual memory performance in adults. *Archives of Clinical Neuropsychology*, 5 (4), 325-334.

USEPA (United States of Environmental Protection Agency). Information on levels of environmental noise requisite to protect public health and welfare with adequate margin of safety (EPA/ONAC Rep. No. 550/9-74-004), 1974.

Valentijn, S.A.M., Boxtel, M.P.J. & Hooren, S.A.H. (2005). Change in sensory functioning predicts change in cognitive functioning: Results from a 6-year follow-up in the Maastricht aging study. *Journal of the American Geriatrics Society,* 53:374–380.

Voelcker-Rehage, C. (2008). Motor-skill learning in older adults- a review of studies on age-related differences. *Eur. Rev. Aging Phys. Act*. 5, 5–16. doi:10.1007/s11556-008-0030-9.

Von Wright, J. & Vauras M (1980). Interactive effects of noise and neuroticism on recall from semantic memory. *Scandinavian Journal of Psychology*, 21, 97.

Walls, C., Avery, J., Bellhouse, G., Greville, A., Rosser, J., Black, D. (1994). Hearing loss - Noise-induced hearing loss of occupational origin (A guide for medical practitioners). First Edition, April 1994, Occupational Safety and Health Service, Department of Labour, New Zealand, ISBN: 0-477-03536-1

Wang, H.Y. & Chai, X.F. (2002). Effects of neurobehavioural functions of workers exposed to noise. *Chinese Journal of Coal Industry Medicine,2002-12.* Retrieved from http://en.cnki.cn/Article_en/CIFDTOTAL-ZMGY200212063.htm

Wild, D.C., Brewster, M.J., Banerjee, A.R. (2005). Noise-induced hearing loss is exacerbated by long-term smoking. *Clinical Otolaryngology*, 30(6), 517-520

Willer, P & Neiva, J. (1986). Brief exposure to uncontrollable but not to controllable noise biases the retrieval of information from memory. *British Journal of Clinical Psychology*, 2, 93-100

World Health Organization. Prevention of noise induced hearing loss. Report of a WHO-PDH Informal Consultation Geneva, 28-30 October 1997. No. 3 in the series Strategies for prevention of deafness and hearing impairment 1997; WHO-PDH-98, 5.

World Health Organization (WHO), (1986). Operational Guide for the WHO Recommended Neurobehavioural Core Test Battery (NCTB). Office of occupational health Geneva. Retrieved on 29 May 2012 from http://whqlibdoc.who.int/hq/1987/1985-86/a78520.

Yamashita, D., Jiang, H., Schacht, J., Miller, J.M. (2004). Delayed production of free radicals following noise exposure. *Brain Research,* 1019, 201-209

Zhang, M., Wang, Y., Wang, Q, Yang, D., Zhang, J., Wang, F., & Gu Q. (2013). Ethylbenzene-induced hearing loss, neurobehavioral function, and neurotransmitter alterations in petrochemical workers. *Journal of Occupational and Environmental Medicine,* 55(9); 1001-1006