

NOISE INDUCED-HEARING LOSS COMPENSATION MODEL FOR  
CONSTRUCTION INDUSTRY

AIN NAADIA BINTI MAZLAN

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## ABSTRACT

Noise-induced hearing loss (NIHL) is considered a chronic occupational disease with widespread prevalence among construction workers. Noise exposure is the main reason for NIHL to occur. Even though a strict regulation of permissible noise level for the industries has been introduced, NIHL cases among workers still increase annually. Severity of NIHL is influenced by multiple factors that should be incorporated to produce an accurate and comprehensive compensation system for construction related industries. The aim of this study is to develop a NIHL compensation predicting model for the construction industry. The study started by establishing the risk factors for NIHL. Subsequently, the relationship between risk factors and hearing loss was analysed and the coefficient value of the risk factors was evaluated. Finally, the NIHL compensation model was developed. NIHL risk factors data were obtained from the Malaysian Social Security Organisation (SOCSSO) reports on the workers' noise exposure, area noise, chemical and heat exposure, smoking habit, medical condition, risky hobby, and working environment site reports. Feedback from related industry and academic experts was also recorded. In addition, the Mann-Whitney U-test, correlation, and scatterplot study were executed to identify the association between risk factors and NIHL value. Three NIHL compensation models namely Models 1, 2, and 3 were developed using linear multiple regression methods based on the significant NIHL risk factors such as daily noise exposure, area noise, smoking habit, cardiovascular disease, and age. The best model was chosen by comparing the Mean Absolute Percentage Error (MAPE) value of each model with an actual compensation value from SOCSSO. Model 1 which consisted of daily noise exposure and the smoking habit was selected as the best model with the lowest MAPE value of 14.33 compared to Models 2 and 3 with MAPE values of 84.72 and 50.14, respectively. In conclusion, the study successfully proved the importance of the relationship between hearing impairment and NIHL risk factors by developing the three compensation NIHL models that can be utilised for monetary indemnity scheme in Malaysia.

## ABSTRAK

Kehilangan pendengaran yang disebabkan oleh bunyi bising (NIHL) dianggap sebagai penyakit khidmat kronik yang berlaku secara meluas di kalangan pekerja pembinaan. Pendedahan bunyi bising adalah sebab utama NIHL berlaku. Walaupun peraturan ketat mengenai tahap bunyi yang dibenarkan untuk industri telah diperkenalkan, namun kes-kes NIHL di kalangan pekerja masih meningkat saban tahun. Tahap keterukan NIHL dipengaruhi oleh pelbagai faktor yang perlu diambilkira untuk menghasilkan sistem pampasan yang tepat dan komprehensif untuk industri berkaitan pembinaan. Tujuan kajian ini adalah untuk membangunkan model ramalan pampasan NIHL untuk industri pembinaan. Kajian ini bermula dengan mengenal pasti factor-faktor risiko berkenaan NIHL. Seterusnya, hubungan antara factor-faktor risiko dan kehilangan pendengaran dianalisis dan nilai pekali faktor risiko dinilai. Akhirnya, model pampasan NIHL telah dibangunkan. Data factor-faktor risiko NIHL diperolehi daripada laporan Pertubuhan Keselamatan Sosial Malaysia (PERKESO) mengenai pendedahan bunyi bising pekerja, hingar kawasan, pendedahan kimia dan haba, tabiat merokok, sejarah perubatan, hobi berisiko, dan laporan tapak persekitaran kerja. Maklum balas daripada industri berkaitan dan pakar akademik turut direkodkan. Di samping itu, kajian *Mann-Whitney U*, ujian korelasi, dan kajian scatterplot dilaksanakan untuk mengenal pasti perkaitan antara factor-faktor risiko dan nilai NIHL. Tiga model pampasan NIHL iaitu Model 1, 2, dan 3 telah dibangunkan menggunakan kaedah regresi berganda linear berdasarkan faktor risiko NIHL yang signifikan seperti pendedahan bunyi bising harian, hingar kawasan, tabiat merokok, penyakit kardiovaskular, dan umur. Model terbaik dipilih dengan membandingkan Nilai Ralat Peratusan Maksimum (MAPE) bagi setiap model dengan nilai pampasan sebenar dari PERKESO. Model 1 yang terdiri daripada pendedahan bunyi bising harian dan tabiat merokok dipilih sebagai model terbaik dengan nilai MAPE paling rendah iaitu 14.33 berbanding Model 2 dan 3 dengan nilai MAPE 84.72 dan 50.14. Kesimpulannya, kajian ini telah berjaya membuktikan kepentingan hubungan antara kehilangan pendengaran dan factor-faktor risiko NIHL dengan membangunkan tiga model pampasan NIHL yang boleh digunakan untuk skim ganti-rugi di Malaysia

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**LIST OF ABBREVIATIONS**

AMA	-	American Medical Association
MAPE	-	Mean Absolute Percentage Error
NIOSH	-	National Institute of Occupational Safety and Health
NIHL	-	Noise Induced-Hearing Loss
OSHA	-	Occupational Safety and Health Administration
PERKESO	-	Pertubuhan Keselamatan Sosial
SOCSSO	-	Social Security Organization
WBGT	-	Wet Bulb Globe Temperature
WHO	-	World Health Organization
WPI	-	Whole Person Impairment

**LIST OF SYMBOLS**

dB	-	decibel
dB(A)	-	decibel A- weighted

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Introduction

Noise induced-hearing loss (NIHL) is a condition during which a person loses his ability to hear due to high-intensity noise exposure. It is caused by loud noise exposure intensity transmitted through the auditory system and damages the ear hair cells (Safework, 2008). It is a permanent and irreversible impairment. Furthermore, it is a nondramatic injury and occurs gradually over a longer period of time, which can be prevented (NIH, 1990; NIOSH, 1998).

NIHL is one of the most common occupational injuries, particularly in the construction industry and most prevalent among construction workers (Arndt *et al.*, 1996; Roberts, 1985). In America, more than 30 million workers are exposed to loud noise that results in hearing loss (Hong, 2005). It was published from 2006 to 2012 that a total number of 1047 cases of NIHL were reported with 499 cases involved in Malaysian manufacturing and construction industries (SOCSO, 2014).

## 1.2 Background of Study

NIHL that occurs in worksites can increase safety risks because noise distracts the worker's attention and drowns out the sound of malfunctioning machine, an alarm signal or warning shout (Edwards, 2009a), and it also interferes with communication which leads to accidents (Safework, 2008). Excessive noise can be disturbing and may harm the activity or balance of human life (Senate Public Works Committee, 1972; Hogan & Latshaw, 1973).

Hearing loss caused by exposure to work-related noise is referred to as occupational noise induced-hearing loss (NIHL) (Morata & Dunn, 1995; Tak *et al.*, 2009). This occurs when workers are exposed to loud noise (Bogardus *et al.*, 2003; Johnson & Morata, 2010; Kim, 2010). It is estimated that 24% of the cases for hearing difficulty in the United States are attributable to occupational exposure (Tak & Calvert, 2008; Masterson *et al.*, 2013). Previous researchers demonstrated that noise exposure to workers in different construction sectors, trades, and operations frequently exceed 90 dB(A) which is the recommended exposure limit by OSHA for eight hours of work duration (Neitzel *et al.*, 1999).

Furthermore, noise casualties can be very expensive. Workers do not only suffer from exorbitant health care cost to compensate hearing disability but also deal with loss of sleep, hearing problem or stress. Additionally, their productivity in the workplace is also decreasing due to communication difficulties and fatigue. Researchers have unveiled that among environmental hazards, noise exposure is only second after air pollution to cause damage (WHO, 2011; Prochnik, 2013). The Western Europeans lose more than one million healthy lives annually as the consequence of noise-related disability and disease (WHO, 2011).

### 1.3 Statement of Problem

Controlling noise exposure in occupational sites is not sufficient to stop the increasing NIHL prevalence. It must correspond with awareness on the effect of NIHL risk factors. These risk factors have synergistic and in some cases additive effect towards NIHL severity (Ferrite & Santana, 2005). Only few of the previous studies have dealt with the post-incident cost, especially for the construction industry. Although noise has been explored intensively, only a small percentage of the risk factors issue has been highlighted.

The risk factors are limited and few studies have ever related to the compensation process. PERKESO and insurance company have produced current compensation models. Studies have shown that the selection of appropriate metric for noise mechanism, either pre or post action in relation to NIHL is particularly relevant (Seixas *et al.*, 2005, Haron *et al.*, 2011). However, there is also little agreement to the standard formula for calculating impairment (Dobie, 2001; Edwards *et al.*, 2010) for the current models. Lack of a standard produced a subjective compensation process that in extreme cases will be biased and imbalanced.

### 1.4 Aim and Objectives

The aim of this study is to develop a noise induced-hearing loss compensation predicting model for the construction industry. The objectives of the study are as follows:

1. To establish the risk factors of noise induced-hearing loss,
2. To analyse the relationship between risk factors and hearing loss,
3. To evaluate the coefficient value of risk factors, and
4. To develop a noise induced-hearing loss compensation model.

## **1.5 Scope of Study**

This study was done to find out how much a noise victim (sufferer) has to pay medical-wise to reimburse for his/her hearing loss. A survey was conducted which involved the construction industry, social security organisation, health and occupational safety professionals and insurance companies. Based on the survey, 110 historical data and medical cases were evaluated to answer all the project questions (aim and objectives). A final report was produced which incorporated the analysis of the collected data, conclusion, and recommendations.

The data consist of construction related industries workers. Construction industries related are defined as a sector responsible for the preparation of land, construction, alteration, and maintenance of structure and buildings. The scope also includes manufacturing industries that produce construction materials such as cement, steel works and pavement materials. The restriction to construction related industry is limited to the researcher's ability to decipher historical data and medical cases during data analysis and extraction process.

## **1.6 Significance of the Study**

The findings of the study will contribute to the benefit of the society, especially for the construction industry. The greater demands for better health care will justify the need for more effective NIHL compensation approaches. The study outcome will directly benefit occupational safety and health practitioners, social security government, and private agency and indirectly benefit those who are affected by NIHL. The developed model could be used in appraising for the financial burden of NIHL sufferers. It can be implemented for the estimation of future expenditure in order to compensate the hearing loss.



## **1.7 Potential Impact of the Study**

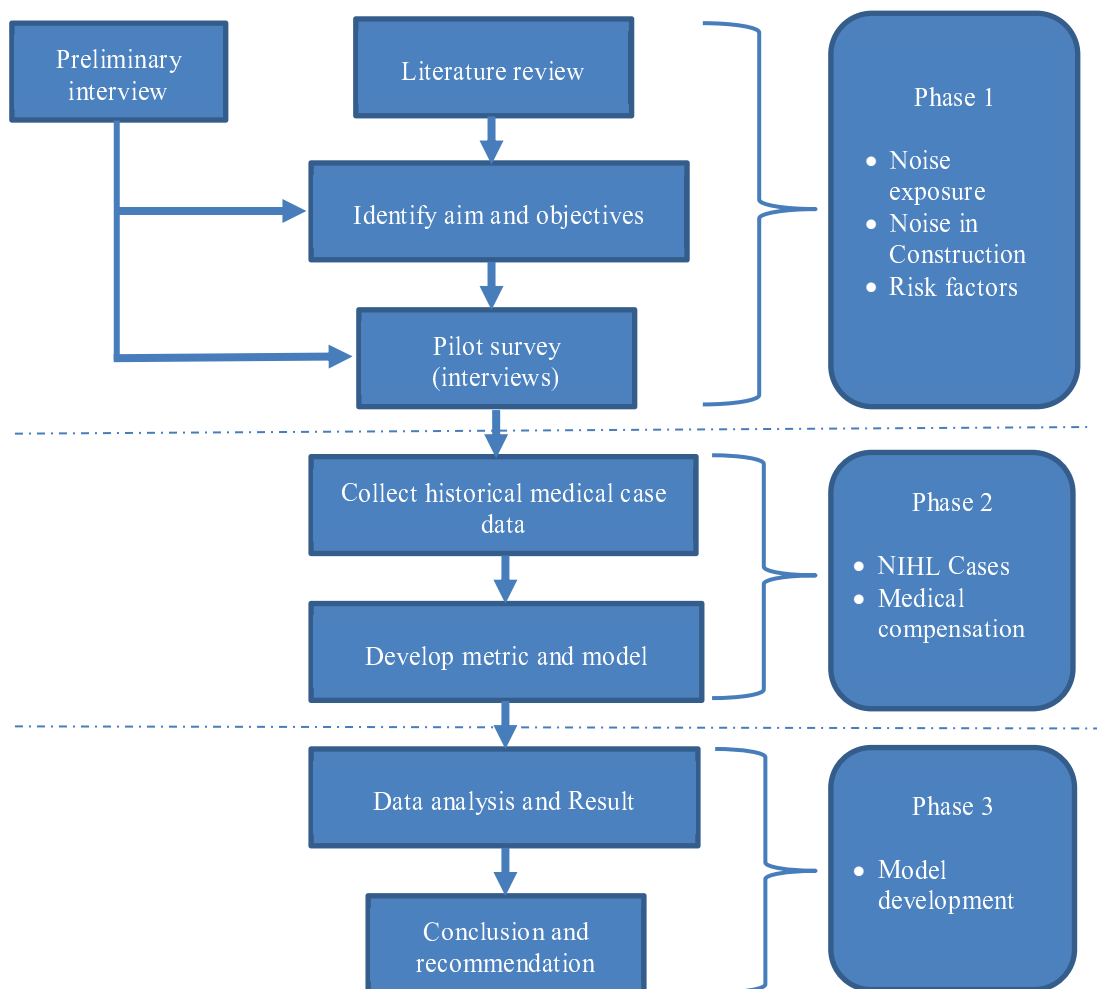
The impact of the current study is potentially for the improvement of occupational health and safety processes, particularly in the field of monetary compensation and NIHL prevention practice. The inclusion of intangible variable in terms of NIHL risk factors will increase the accuracy for calculating the complete coverage amount of NIHL compensation. While NIHL is mainly the result of exposure to high-intensity noise, the study shows that other factors can accelerate the deterioration of hearing ability as well.

Research outcomes from this study stands to positively impact the field of hearing conservation practices within Malaysia and many other countries. Prevention practice currently adopted in the Malaysian construction industry focuses on the factors that occur during the occupational hour with little regard towards the buffer time required for hearing conservation action. Findings from this study will provide evidence that the mentioned risk factors are the essential parts that need to be highlight more as prevention action towards the increasing number of NIHL cases. The potential impact for the inclusion of utilisation for the comprehensive system as an integral and required part of the process of NIHL compensation claim is that policies and legislation should be influenced and changed at the national level.

## **1.8 Methodology**

There are three distinct phases of the study; Phase 1 involves literature review and preliminary interview, Phase 2 deals with data collection and analysis using retrospective record review, and Phase 3 comprises of developing a framework and model to assess the cost of NIHL in construction workers. Detailed discussion of the

research methodology is provided in Chapter 3. Figure 1.1 outlines the methodology for this study.



**Figure 1.1** Brief Research Methodology

### Phase 1: Literature Review and Preliminary Interview

Phase 1 is aimed at reviewing information on noise in general, the parameter of noise, hearing issues in construction and the hearing loss trend among construction workers to establish the problem area. Preliminary interview with established occupational safety and health practitioners were conducted to find evidence and establish that NIHL is a common health issue in the construction industry. This preliminary interview also provides direction on what the industry demands for the

problem-based research to be conducted. It is essential as the goal of the study is to contribute for the well-being of society to a greater extent and the construction community, in particular. Subsequently, factors which influence the deterioration of hearing were also being investigated. Published academic reports were reviewed to uncover these risk factors. Risk factors considered for this study are based on those which provide significant impacts toward hearing deterioration while being measurable and appropriate for the national climate and culture considered for this study.

#### Phase 2: Retrospective Record Review

The majority of data analysis is contained within Phase 2. The medical report and health background record of construction workers suffering from NIHL were collected from Pertubuhan Keselamatan Sosial (PERKESO). These records were reviewed to find out the relationship between risk factors that have been established in Phase 1 with hearing loss.

#### Phase 3: Model Development

The result obtained from Phase 2 formed the basis for the model development phase. The relationship was later interpreted and analysed. The Hedonic Regression Model was adopted to evaluate the relationship.

### **1.9 Organisation of the Thesis**

Chapter 1 of the thesis provides the direction for the study pursued. It also serves as the introductory chapter to the current study with an overview of justification, rationale, and approach adopted for the study. This chapter also includes the scope of study that explains the boundary of the study undertaken. A

brief methodology is also discussed, which will be explained thoroughly in the methodology chapter.

Chapter 2 clarifies noise induced-hearing loss while highlighting the effect of noise exposure and global prevalence of NIHL. It focuses on the occurrence of NIHL, especially among construction workers. This chapter also explains further about risk factors that influence the severity of NIHL. The risk factors are classified into two categories which are occupational and non-occupational risk factors. The explanation will also be complemented with a description of the mentioned risk factors for a better understanding.

Chapter 3 discusses compensation. It explores the history of compensation to provide background information for the overall research. Additionally, it provides international perspective on compensation. Compensation process from all around the world is also discussed. The countries included Australia, Singapore, German, the United Kingdom and United States. This chapter also explains the process and legislation used by Malaysian entity bodies. This chapter also contains the research gap for the study.

Chapter 4 consists of the procedure applied throughout the research. In addition, the rationale for using retrospective record review is explained. It also lists the steps executed for retrospective record review and hedonic pricing method to show the systematic approach in analysing the data. As the justification for the methodology was established in the previous chapter, this chapter explains the action taken for the analysis process.

Chapter 5 provides the result of this study. Relationship between each selected risk factor with hearing impairment is explained for better understanding. The calculation for noise exposure in monetary values is tabulated for future referral.

The discussion of the results follows each result to facilitate and clarify the findings. The frameworks for NIHL models are also developed.

Finally, chapter 6 concludes the discussion of significant findings during this study and implication towards the calculation of compensation value. Recommendations for further research are also included to encourage more comprehensive meaning towards the quantification of compensation cost, especially in the construction industry.

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