



**UNIVERSITI PUTRA MALAYSIA**

***PREVALENCE OF HAND ARM VIBRATION SYNDROME (HAVS) AND  
IT'S ASSOCIATION WITH RISK FACTOR AMONG ELECTRONIC'S  
MANUFACTURING WORKERS AT KLANG, SELANGOR***

**NURUL AFIQAH BINTI MD SAIRONI**

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ITS ASSOCIATION WITH RISK FACTOR AMONG ELECTRONIC'S  
MANUFACTURING WORKERS AT KLANG SELANGOR**



**BY**

**NURUL AFIQAH BINTI MD SAIRONI**

**Thesis submitted in fulfilment of the requirement for the degree of Bachelor  
Science (Environmental and Occupational Health) from the Faculty of Medicine  
and Health Sciences, Universiti Putra Malaysia.**



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## **ABSTRACT**

### **PREVALENCE OF HAND ARM VIBRATION SYNDROME (HAVS) AND IT'S ASSOCIATION WITH RISK FACTOR AMONG ELECTRONIC MANUFACTURING WORKERS AT KLANG, SELANGOR**

**NURUL AFIQAH BINTI MD SAIRONI<sup>1</sup>, PROF. DR SHAMSUL BAHRI BIN  
HJ MD TAMRIN<sup>1</sup>**

<sup>1</sup>Department of Environmental and Occupational Health, Faculty of Medicine and  
Health Sciences, Universiti Putra Malaysia, Selangor, Malaysia

**Introduction:** Hand-arm vibration (HAV) is a condition in which worker is in constant use of tools and vibrating machineries. (Ng, 2012). Hand-arm vibration syndrome (HAVS) was the main concern which it is a recognize occupational disease manifesting as vascular, neurological and/or musculoskeletal symptoms in the upper limb arising after exposure to hand-transmitted vibration (Jang et al., 2002). Increasing used of power tools in manufacturing industry due to increasing production because of market demand increasing. **Objectives:** Aim of this study was to determine the prevalence of HAVS among manufacturing workers and it's association with risk factor. **Methodology:** Cross sectional study to group of 100 workers of electronic manufacturing factory located at Port Klang, Selangor were conducted. Structured questionnaires were distributed to collect data on socio-demographic background, occupational information, health and lifestyle information and symptoms related to HAV. Monofilament test conducted to test the level of vibrotactile perception. **Results and Discussion:** 44% of respondent were exposed to vibration while 56% others not exposed to vibration. Overall prevalence of HAVS based on reported symptom through questionnaire was 27.5%. None of the respondent reported any whiteness at their fingers. Prevalence of exposed workers with numbness were 37.5% (n=36) while tingling were 27.0%. 26.0% out of the workers were having monofilament test 3.61 (0.4g) or above which more than normal value the significant risk factor to HAVS which  $P < 0.05$  was: often exposed to vibration ( $P=0.38$ ), Work related dealing with vibration tool (0.02) and using vehicle to work, either motorcycle or car (0.023). **Conclusion:** This study were found that no prevalence among exposed worker with vibration and abnormal reading of monofilament test which is 3.61 (0.4g) and above. In conclusions, this study found that there is risk factor to those manufacturing workers dealing with vibration tools or machine. Exposure to vibration is one of risk factor of HAVS. Especially those were exposed for in prolonged time.

**Keywords:** Hand arm vibration syndrome (HAVS), power tool, prevalence, manufacturing workers, monofilament test, risk factor, vibrotactile perception



## ABSTRAK

### KAJIAN KELAZIMAN SINDROM GETARAN TANGAN LENGAN DAN PERHUBUNGANNYA DENGAN FAKTOR RISIKO ANTARA PEKERJA KILANG PEMBUATAN ELEKTRONIK DI KLANG, SELANGOR, MALAYSIA

NURUL AFIQAH BINTI MD SAIRONI<sup>1</sup>, PROF. DR SHAMSUL BAHRI BIN HJ MD TAMRIN<sup>1</sup>

<sup>1</sup>Jabatan Kesihatan Persekitaran dan Pekerjaan, Fakulti Perubatan dan Sains Kesihatan, Universiti Putra Malaysia, Selangor, Malaysia

**Pengenalan:** Getaran lengan tangan (HAV) adalah keadaan di mana pekerja sentiasa menggunakan alatan tangan atau jentera bergetar. (Ng, 2012). Sindrom getaran tangan (HAVS) adalah kebimbangan utama yang juga dikenali sebagai penyakit pekerjaan yang menunjukkan gejala motorik, neurologi dan/atau sensorial di bahagian pergelangan tangan yang timbul selepas pendedahan kepada getaran yang dihantar oleh alatan tangan atau jentera bergetar (Jang et al., 2002). Peningkatan penggunaan alatan kuasa dalam motorik perkilangan disebabkan oleh peningkatan permintaan pasaran dalam pengeluaran produk. **Objektif:** Tujuan kajian ini adalah untuk menentukan kelaziman sindrom getaran tangan (HAVS) dalam kalangan pekerja perkilangan dan perhubungannya dengan motorik risiko. **Metodologi:** Kajian motorik rentas kepada sekumpulan 100 pekerja kilang pembuatan elektronik yang terletak di Pelabuhan Klang, Selangor telah dijalankan. Soal selidik diedarkan untuk mengumpulkan data mengenai latar belakang sosio-demografi, maklumat pekerjaan, maklumat kesihatan dan gaya hidup yang berkaitan dengan HAV. Ujian Monofilament dilakukan untuk menguji tahap persepsi vibrotactile. **Keputusan dan Perbincangan:** 44% daripada responden terdedah kepada getaran manakala 56% yang lain tidak terdedah kepada getaran. Keseluruhan kelaziman getaran lengan tangan (HAVS) berdasarkan gejala yang dilaporkan dan melalui soal selidik ialah 27.5%. Tiada responden yang dilaporkan sebarang keputihan pada jari mereka. Kekerapan pekerja terdedah dengan kebas kelamin adalah 37.5% (n = 36) manakala kesemutan adalah 27.0%. 26.0% daripada pekerja yang mempunyai ujian monofilament 3.61 (0.4g) atau lebih tinggi daripada nilai normal motorik risiko yang signifikan kepada HAVS yang  $P < 0.05$  adalah: sering terdedah kepada getaran ( $P = 0.38$ ), Kerja berkaitan dengan alat getaran (0.02) dan menggunakan kenderaan untuk bekerja sama ada motosikal atau kereta (0.023). **Kesimpulan:** Kajian ini mendapati ada kelaziman sindrom getaran lengan tangan di kalangan pekerja yang terdedah dengan getaran dengan bacaan sensorial yang tidak normal iaitu 3.61 (0.4g) motorik atas. Sebagai kesimpulan, kajian ini mendapati bahawa terdapat motorik risiko kepada pekerja-pekerja perkilangan yang berurusan dengan alat getaran atau mesin. Getaran merupakan salah satu factor risiko HAVS. Terutama mereka yang terdedah dalam masa yang lama.

**Kata kunci:** Sindrom getaran lengan tangan (HAVS), alat kuasa, kelaziman, pekerja pembuatan, ujian sensorial, motorik risiko, persepsi vibrotactile

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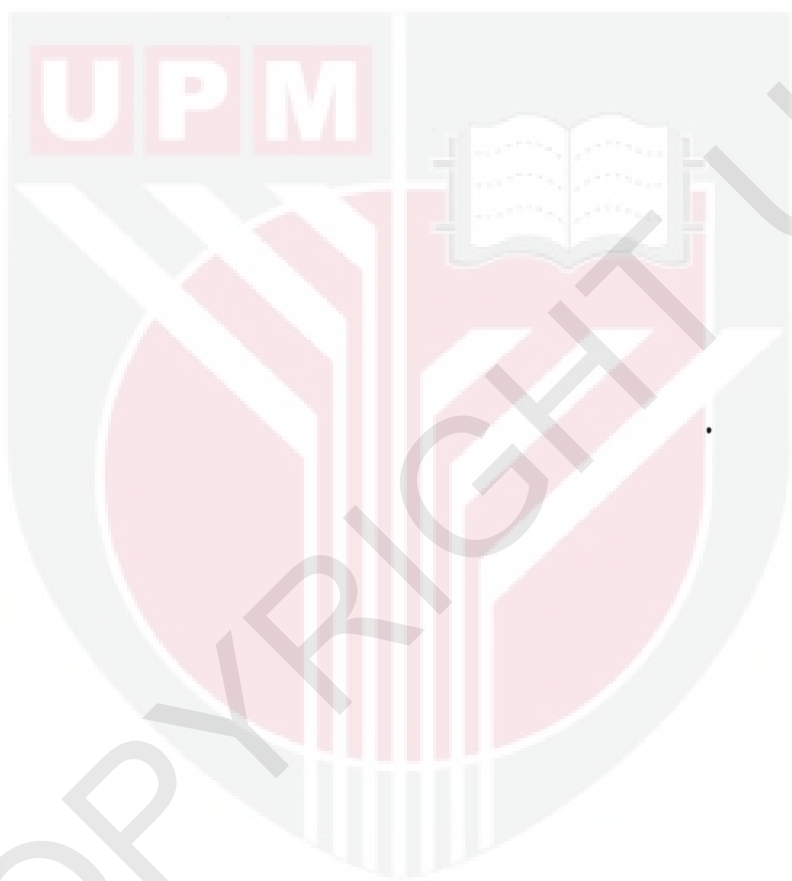
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**LIST OF ABBREVIATIONS**

|             |                                          |
|-------------|------------------------------------------|
| <b>HAV</b>  | <b>Hand Arm Vibration</b>                |
| <b>HAVS</b> | <b>Hand Arm Vibration Syndrome</b>       |
| <b>SWM</b>  | <b>Semmes Weinstein Monofilament</b>     |
| <b>EMS</b>  | <b>Electronic Manufacturing Services</b> |
| <b>HTV</b>  | <b>Hand Trasmitted Vibration</b>         |

# **CHAPTER 1**

## **INTRODUCTION**

### **1.1 Background of the study**

Hand-arm vibration syndrome (HAVS) is a recognize occupational disease manifesting as vascular, neurological and/or musculoskeletal symptoms in the upper limb arising after exposure to hand-transmitted vibration (Jang et al., 2002). Prolonged exposure to hand-transmitted vibration is associated with an increased occurrence of symptoms and signs of disorders in the vascular, neurological and osteoarticular systems of the upper limbs (Ilker Ilhanli, Kivanc Cengiz, Yunus Durmaz, 2016). The first symptomatic stage was finger numbness with or without tingling. Second stage, involves sensory perception and the most severe stage focused on reduced tactile discrimination and/or dexterity changes. Hand –arm vibration syndrome categorized according to the Stockholm Workshop scales (Palmer et al., 2000). Stockholm Workshop scales comprises rating system for vascular (circulatory system) and sensorineural (touch and pain sensation) symptoms, which sufferers of this disease can experience.

Malaysia is projected to grow at a rate of 3.3% between 2016 and 2021, on the back of growth within the global electronic industry. Malaysian electronic market is expected to grow to RM3bil in 2021, riding on a compounded annual growth rate



of 3.3% (Tan,2018). The usage of vibrating hand tools can give an adverse health effect to the hands and arms. The vibration is transmitted to the body through hand and arm when a person is using vibrating hand tools. Prolong exposure to vibrating hand held tools can lead to development of Hand Arm Vibration Syndrome (HAVS) and health effect

## **1.2 Research Justification**

Semmes Weinstein method have been used widely as a screening test in peripheral neurological investigation like diabetes and recently it also currently be use in hand-arm vibration surveillance. Semmes Weinstein method were cheap easy to be used and more mobile make more affordable and chosen to be method on this research on screening hand-arm vibration. This study will validate the prevalence of hand-arm vibration among manufacturing workers in Malaysia which . Besides, this research also explaining the risk factor of hand-arm vibration among manufacturing workers.

## **1.3 Problem Statement**

From this study, research found that high vibration exposure can give big harmful impact to human. Especially on hand-arm tool user which their hand exposed to high level of vibration. Electronic manufacturing services market (EMS) market will be driven by the electronic manufacturing, which is expected to exceed

55% of the revenue share due to the continuous demand for electronic components in various industry (Inc, 2018). Rapid rise in demand for consumer and smart electronic device across the globe were driving electronics manufacturing services growth. Increasing of the demand for efficient & safe smart devices caused increased production and manufacturing factory provided to complete the demand. This industry, vibrating hand tools or power tools were common been used, From previous study, exposed to excess vibration on hand caused some disease and effect like numbness, tingling, most of the significant findings of prevalence of HAVS due to exposed to vibration was mostly among the forestry worker, construction workers and shipyard workers which the workers exposed to high level of vibration tool for a long period or continuously . Prolong exposure to vibrating hand held tools can lead to development of Hand Arm Vibration Syndrome (HAVS) (Bahri et al., 2016). There are several type of manufacturing industry, clothing and textiles, petroleum, chemicals and plastics, electronics, computers and transportation, food production, metal manufacturing and wood, leather, papers manufacture. Most of the manufacturing industry, they used hand-arm tool that released vibration during production work. Aim for this study was to determine the prevalence of HAVS and its association with risk factor among electronic's manufacturing workers.

Statistics of occupational accidents by sector, which caused death, permanent disability and non-permanent disability, have been widely investigated and represented a significant problem to the Malaysian industries. According to the Department of Occupational Safety and Health (DOSH) report on occupational



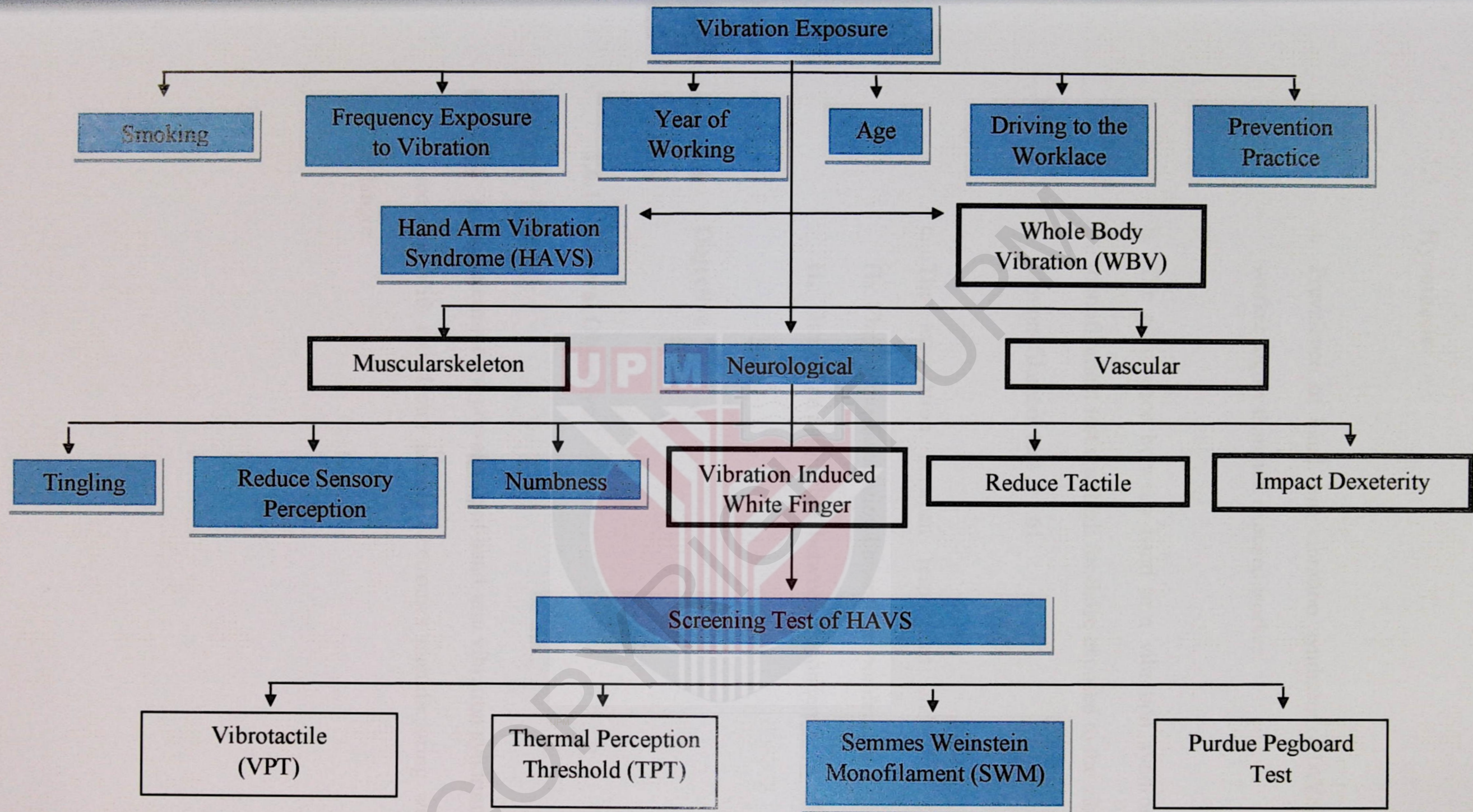
accidents for the non-permanent disabilities category until December 2013, about 1496 cases of non-permanent disability were reported by the manufacturing industries which show the highest cases. The agriculture, forestry, logging and fishing industry was the second highest of 488 cases of non-permanent disability reported, followed by utility industry (100 cases of casualties) and the transportation, storage and communication industry (84 cases of casualties) [14]. There were 161 compensation claims under musculoskeletal disorder. The increasing number of occupational diseases showed about 110 workers applied to the Social Security Organization (SOCSO) for compensation claims under the item diseases caused by vibration (disorders of muscles, tendons, bones, joints, peripheral blood vessels or peripheral nerves) (Ali, Azmir, & Yahya, 2018). Because of the lack of study on vibration impact to manufacturing workers, references towards this study were restricted. Hence, this study purpose was to find out the prevalence and risk factor of hand-arm vibration among electronic's manufacturing workers.

#### **1.4 Conceptual Framework**

Vibration is a physical hazard that can effect human that exposed to it in prolong time. In occupational, vibration can be one of hazard to the workers that being exposed to it. Vibration to human were divided into two type, which is whole-body vibration and hand-arm vibration. This study will more focus on hand-arm vibration. Hand-arm vibration defined as transfer of vibration from tools to a worker's hand and arm. Hand arm vibration may including both occupational and

non-occupational job task. Hence, the presence of several factor of HAVS caused the probability generating HAVS were high. Hand-arm vibration syndrome (HAVS) consists of vascular, neurological and musculoskeletal components. Workers with the neurological component of HAVS usually complain of numbness and tingling in the fingers and hands. These symptoms, along with the presence of sensory abnormalities on physical examination, have been used as the basis for the classification system referred to as the Stockholm sensorineural scale. In this study, researcher more focused on impact of HAVS towards neurological of hand (House, Krajnak, Manno, & Lander, 2009).





Variables that be  
studied in this research

Figure 1.4: Conceptual Framework



## **1.5 Hypothesis**

- a. Prevalence of hand arm vibration syndrome (HAVS) among exposed worker higher than non exposed worker.
- b. The prevalence between hand arm vibration syndrome (HAVS) with monofilament test was high for those exposed to the vibration with rading of monofilament test  $\geq 3.61$ .
- c. The association between respondent and risk factor of HAVS  
 $H_0$ : There is no association between respondent with risk factor of HAVS  
 $H_a$ : There is an association between respondent with risk factor of HAVS

## **1.6 Objective**

### **1.6.1 General Objective**

To determine the prevalence of hand-arm vibration syndrome (HAVS) and its association with risk factor among electronics manufacturing workers at Klang , Selangor.

### **1.6.2 Specific Objective**

- To determine the socio demographic background of the manufacturing workers.
- To determine the prevalence of exposed and non exposed workers with HAVS
- To determine the association of manufacturing workers with risk factor of HAVS

### **1.7 Variable**

#### **1.7.1 Independent Variable**

##### **a. Risk Factor:**

- Smoking
- Frequency exposure to vibration
- Experience year of working
- Age of the workers
- Driving to the workplace
- Prevention practice

##### **b. Symptom of hand arm vibration syndrome (HAVS):**

- Tingling
- Numbness
- Reduced sensory perception



1.7.1 Dependent Variable

-Reading of *semmes weinstein monofilament* test

| Value | Gram(g) | Value | Gram(g) | Value | Gram(g) |
|-------|---------|-------|---------|-------|---------|
| 1.65  | 0.008g  | 3.84  | 0.60g   | 4.93  | 8.00g   |
| 2.36  | 0.02g   | 4.08  | 1.00g   | 5.07  | 10.00g  |
| 2.44  | 0,04g   | 4.17  | 1.40g   | 5.18  | 15.00g  |
| 2.83  | 0.07g   | 4.31  | 2.00g   | 5.46  | 26.00g  |
| 3.22  | 0.16g   | 4.56  | 4.00g   | 5.88  | 60.00g  |
| 3.61  | 0.40g   | 4.74  | 6.00g   | 6.10  | 10.00g  |
|       |         |       |         | 6.45  | 180g    |
|       |         |       |         | 6.65  | 300g    |

Normal

Normal, Diminished Light Touch

Diminished Light Touch & Protective Sensation

Loss of Protective Sensation

Figure 1.7.1: Value of Monofilament Test



## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Sensory Receptor of Fingertips

Human have specific differences in sensory nerve endings, or the cortical areas dedicated to the representation of the fingers. Rapidly-adapting nerve receptors deliver information on changes that occur at skin, such as prolonged touch like grasping tools in extended period of time, the receptors slowly adapting and deliver the information. (Napier, 1965). Sensory nerve endings in the fingers include Meissner's corpuscles, Pacinian corpuscles, free nerve endings, Merkel discs and Rufini endings. Combined all the receptors allow sense of touch, heat, pain and give information on where the hand and finger relation on body (Napier, 1965)

Hand-arm vibration syndrome (HAVS), caused by hand-arm vibration (HAV) comprises both vascular and sensorineural symptoms with occurrence and progress seemingly independent of each other (Maria, 2014). Hand-arm vibration syndrome (HAVS) is an occupational disease consisting of vascular, neurological and musculoskeletal pathology in the upper limbs due to exposure to hand transmitted vibration (Dr Aaron, 2011). Hand-arm vibration mainly caused by hand-transmitted vibration from the use of hand held vibrating tools or hand-contact with hand-guided or hand-fed vibrating machine. Hand-arm vibration now were being common and many worker at risk of developing it. NIOSH estimated about 50% of exposed worker in U.S have or will develop HAVS. Combination of United Kingdom and

United States, they estimated there are between 72 000 and 144 000 prevalent cases in Canada over beginning of 2003 to end of 2008 (Dr Aaron, 2011).

## **2.2 Vibration effect**

Vibration induced health conditions health conditions progress slowly. As the vibration exposure continues, the pain may develop into an injury or disease. Vibration can caused changes in tendons, muscles, bones and joints, and can affect the nervous system. Vibration exposure can cause two effect which is whole-body vibration or hand-arm vibration. Vibration affects the bodies of people in many different methods. The human body response to vibrations depends on the amplitude, frequency, the duration of exposure, vibration input direction, type and sensitivity of the tissues. As the vibration exposure continues, the pain may develop into an injury or disease. Pain is the first health condition that is noticed and should be addressed in order to stop the injury (2015).

Vibration-induced white finger (VWF) is the most common condition among the operators of hand-held vibrating tools. Vibration can cause changes in tendons, muscles, bones and joints, and can affect the nervous system. Collectively, these effects are known as Hand-Arm Vibration Syndrome (HAVS). The symptoms of VWF are aggravated when the hands are exposed to cold (2015). About 2.5 million workers, in the U. S. A. alone, are exposed daily to hand-arm vibration (HAV) from the power tools they use on their jobs. Approximately, 24% of Australian workers are exposed to vibration in their workplace, 43% of whom are specifically exposed to



only HAV. The effects of vibration appear as mechanical and psychological disorders. As a mechanical damage and with regards to the vibration input area, vibration resonance may happen to various tissues, and the body tissues are damaged directly. From the viewpoint of psychology, the syndrome may be appeared as stress reactions, and cognitive or movement disorders. Concentration and paying attention to duties may be influenced, too. A cross-sectional study was performed on 652 active workers in 39 jobs located at United States, the study were involve in selected. Exposure to hand transmitted vibration (HTV) has been linked with several health the best known being Raynaud's phenomenon. Vibration induced white finger (VWF). Sensorineural impairment in the fingers and carpal tunnel syndrome are other reported hazards from use of vibratory tools, and osteoarthritis of the wrist and elbow have also been associated with HTV in some studies.

### **2.2.1 Whole-body Vibration (WBV)**

Whole-body vibration (WBV) is transmitted through the seat or feet of employees who drive mobile machines, or other work vehicles, over rough and uneven surfaces as a main part of their job. Large shocks and jolts may cause health risks including back-pain. At first glance, whole-body vibration may not appear to be so serious. According to the Bureau of Labor Statistics, the number of occupational injuries or illnesses involving days away from work caused by "rubbed, abraded, or jarred by vibration" was 1,750 in 2007. However, these numbers may not accurately reflect the damage vibrations can do for various reasons. In the United States, an estimated 6 million American workers are "regularly exposed" to whole-body



vibration – meaning for more than two hours a day, according to Kristine Krajnak, a research biologist with NIOSH. This can lead to an array of health problems – most notably lower back pain, which is second only to colds and flu for reasons why Americans see a doctor, according to the National Institutes of Health.

### **2.2.2 Hand Arm Vibration Syndrome**

Hand-arm vibration syndrome (HAVS) is caused by occupational exposure to vibrating hand tools. Hand arm vibration injuries begins with the workers exposing vibration transmitted energy to hand palm hence experiencing discomfort or pain after operating hand-held vibrating equipment at a workplace (Ali et al., 2018). HAVS has three main components: Peripheral neuropathy of the hands that produces numbness, tingling, or both in a glove distribution. Loss of dexterity may occur. Secondary Raynaud's phenomenon of the hands, sometimes re-ferred to as vibration white finger (VWF). This is the most dramatic manifestation, characteristically producing intermittent well-demarcated blanching of the fingers starting at the distal tip of one or more digits, and as the disease progresses, the pallor extends more proximally to involve the length of the fingers, sometimes extending into the palm. The thumbs are typically the least affected. During these episodes, concurrent paresthesia of the in-volved digits is typical. Musculoskeletal problems. These are the least specific manifestations and may include complaints of weakness, discomfort, and pain of the hands, wrists, forearms, and elbows. Peripheral neuropathy and Raynaud's phenomenon may occur independently but usually occur together. Symptoms tend to be bilateral and it is unusual for more advanced symptoms to

affect a single digit only. In such cases, other diagnoses such as thenar or hypothenar hammer syndrome, as well as more localized vascular injury of the palmar arches or digital arteries, should be considered.

A short exposure to vibration of a certain magnitude can lead to temporary discomfort which can cause reduced work output and reduced work efficiency (Health and Safety Laboratory, 2008). Prolonged exposure to HAV is associated with increased in occurrence of hand-arm vibration syndrome (HAVS) (Hagberg et al., 1995). The prevalence of HAVS ranged from 5% to more than 80% globally depending on the types of tools, extent of vibration exposure and climatic factors. An overview of epidemiological studies shows that sensorineural disorders tend to appear earlier than vascular disorders and that these disorders develop independently of each other at different rates. Neurological and musculoskeletal signs of HAVS are more common than vascular symptoms in tropical countries because the critical ambient temperature for the provocation of VWF is around 15°C. The low rate of VWF could explain the low disease prevalence in tropical countries since the classical diagnosis of HAVS includes VWF. The number of reported cases in Malaysia increased from 34 in 2010 to 160 in 2015 (Social Security Organisation, 2016). Social Security Organisation reports that HAVS is the second highest cause of disability resulting from a physical agent after noise-induced hearing loss. It is most likely the actual number of HAVS cases are higher due to under-reporting.



## **2.3 Effect of Hand Arm Vibration**

### **2.3.1 Neurological Effect of HAVS**

Hand-arm vibration can result in the development of damage to the sensory nerve fibres and skin mechanoreceptors in the fingers, producing digital sensory neuropathy. A recent meta-analysis has indicated approximately a fold increased risk of digital sensory neuropathy due to hand-arm vibration exposure (meta-odds ratio: 7.37; 95% CI: 4.28 – 14.15). The digital sensory neuropathy is manifested by numbness and tingling in the fingers that is present even when not exposed to the cold. Cold exposure may lead to digital vasospasm and transient reduction in blood supply to peripheral nerves with resultant transient numbness and tingling but these transient abnormalities do not constitute evidence of the sensorineural component of HAVS. The Stockholm Workshop Scale for the sensorineural component of HAVS is based on digital sensory neuropathy and it does not include carpal tunnel syndrome (CTS). However CTS due to median nerve compression at the wrist is common in workers with HAVS. For example, reported that, in 162 patients assessed for HAVS, 33% had CTS and 11% had ulnar neuropathy. CTS and digital sensory neuropathy due to HAVS present with similar symptoms, therefore creating a diagnostic challenge. The main established risk factor for CTS is exposure to ergonomic stressors, in particular repeated, forceful wrist movements and/or awkward wrist postures, but there is also recent epidemiological evidence that hand-arm vibration exposure is an independent risk factor for CTS. In particular, recent meta-analyses have found a statistically significant risk of CTS due to hand-arm vibration exposure. (Safety & Tribunal, 2018).



### **2.3.2 Vascular effect**

Raynaud's phenomenon is the clinical outcome most clearly associated with hand-arm vibration exposure. Raynaud's phenomenon may be primary or secondary. Primary Raynaud's phenomenon is not due to any identifiable underlying cause or disease. It often becomes manifest by the early 20s and affects about 3- 5% of adults, with the condition being more prevalent in women than men. Secondary Raynaud's phenomenon is due to other factors such as crushing or penetrating hand trauma or some diseases such as connective tissue diseases like scleroderma. The Raynaud's phenomenon of HAVS is a type of secondary Raynaud's phenomenon due to exposure to hand-arm vibration. There is strong evidence of a causal association between exposure to hand arm vibration and the development of Raynaud's phenomenon. A recent meta-analysis indicated that there is almost a fold increase in the risk of Raynaud's phenomenon due to exposure to hand-arm vibration (meta-odds ratio: 6.85; 95% CI: 4.17-11.25). The Raynaud's phenomenon is manifested by the development of cold induced blanching of the fingers. The blanching may also sometimes be triggered by using a vibrating tool. The blanching begins in the tips of one or more exposed fingers and, as the condition worsens, the blanching may extend down the entire finger and all fingers and thumbs may be affected. Cold exposure may also be associated with cyanosis due to reduced local supply of oxygenated haemoglobin and, during re-warming there may be reactive hyperaemia due to vasodilatation. In very severe cases there may be trophic changes in the fingers due to decreased blood supply and the trophic areas may become gangrenous resulting in loss of digits. Raynaud's phenomenon may also develop in the feet in workers exposed to hand-arm vibration. The risk of Raynaud's phenomenon in the feet

appears to be increased in workers who first develop Raynaud's phenomenon in the hands due to vibration. Workers using vibrating tools may also develop thrombi in the arteries in the hands, in particular in the ulnar artery at the wrist, which lies just below the hypothenar eminence. The evidence for these thrombotic lesions being due to vibration is mainly from case reports and, based on the small number of reports, it appears to come to clinical attention infrequently. It is at present unclear if these reported cases are due to work practices (e.g. forceful striking with the hypothenar eminence of the hand) or some aspect of the vibration such as the dominant frequency or impulsivity of the vibration.

### **2.3.3 Musculoskeleton Effect**

Decreased grip strength was reported by Farkkila 28 in workers with exposure to hand-arm vibration and this was confirmed in subsequent studies. Necking et al, using biopsies of the abductor pollicis longus muscle in 20 patients with HAVS and four controls, found that vibration exposure was associated with evidence of direct damage to muscle such as muscle necrosis, fibrosis and structural disorganization. Other pathological findings described by Necking et al suggested motor nerve injury with secondary muscle denervation/re-innervation. Therefore the decreased grip strength may be related to a combination of direct muscle injury and nerve injury due to vibration. Liss and Stock 31 investigated the association between Dupuytren's contracture and hand-arm vibration. Dupuytren's contracture is an abnormality of the palmar fascia that results in thickening and band formation of the palmar surface with secondary finger contractures. In a literature review they found only three published studies of good quality addressing this topic. All three reported



statistically significant odds ratios ranging from 2.1 (95% CI: 1.1-3.9) to 2.6 (95% CI: 1.2-5.5) for this association and two of the studies indicated evidence of a dose-response relationship. A recent meta-analysis by Descatha et al 32 reported an increased risk of Dupuytren's contracture due to exposure to hand-arm vibration (Meta-odds ratio: 2.14; 95% CI: 1.59 – 2.88); they also reported an independent increased risk of this outcome due to manual work (meta-odds ratio: 2.01; 95% CI: 1.51 – 2.66). A number of other musculoskeletal outcomes have been associated with hand-arm vibration including bone cysts and osteoporosis in the hands and wrists, osteoarthritis of the wrist, elbow and shoulder, epicondylitis and non-specific muscle and joint pain and stiffness. Hagberg carried out a comprehensive review of these musculoskeletal outcomes and concluded that the evidence that vibration per se is a risk factor was weak although there was strong evidence that work with vibrating tools was associated with these musculoskeletal disorders. Ergonomic factors and/or work practices were potential confounders of an effect specifically due to hand-arm vibration for all of these musculoskeletal outcomes.

## **2.4 Hand Transmitted Vibration**

Mechanical vibration arising from powered processes or tools and entering the body at the fingers or the palm of the hands is called hand-transmitted vibration (HTV). Occupational exposure to hand-transmitted vibration arises from hand-held powered tools used in manufacturing (e.g., percussive metal-working tools, grinders and other rotary tools, impact wrenches), quarrying, mining and construction (e.g., rock-drills, stone-hammers, pick-hammers, vibrocompactors), agriculture and



forestry (e.g., chain saws, brush saws, barking machines) and public utilities (e.g., road and concrete breakers, drill-hammers, hand-held grinders). Excessive exposure to hand-transmitted vibration can cause disorders in the blood vessels, nerves, muscles, and bones and joints of the upper limbs. It has been estimated that 1.7 to 3.6% of the workers in European countries and the United States are exposed to potentially harmful hand-transmitted vibration (ISSA International Section for Research 1989) (Manager, "Hand-Transmitted Vibration").

The prevalence of HAVS in workers regularly exposed to vibration has been reported to vary from 6% to 100% with an average of 50%<sup>14</sup>. The reported latencies between first exposure and the development of HAVS range from 6 weeks to 14 years,<sup>15</sup> and latency can be quite short with HAVS developing in less than two years if the exposure levels are high. Miyashita et al<sup>16</sup> reported that, in forestry workers, symptoms of HAVS did not typically appear until after 2000 hours of exposure but symptoms were present in more than 50% of workers after 8000 hours of exposure.

#### **2.4.1 Health Effect of Hand-transmitted Vibration**

Most of the interest with hand-transmitted vibration is due to the disorders that are often observed in populations who use vibrating tools. Disorders can be broadly divided into vascular and nonvascular categories (Griffin, 1990). Nonvascular disorders can be further subdivided into neurological and musculoskeletal disorders. Collectively, both types of symptoms are referred to as HAVS. The HAVS is a disease that implies circulatory disorders (i.e. vibration white

fingers), motor and sensory disorders and musculoskeletal disorders, which may occur in workers who use vibrating hand-held tools such as jackhammers, electric drills and saws, grinders and pneumatic drills (Weir & Lander, 2005). The relevance of studying hand arm vibration in power tools for industry is emphasized by a statistical revelation that the prevalence of HAVS ranges from 2.5% to more than 82.8% globally depending on the duration and magnitude of vibration as well as climatic factors (Lin et al., 2005). However, this percentage will increase as the working environment temperature decreases, thus the vibration induced white fingers renowned by low ambient temperature countries compared to warm environment countries. Its prevalence in warm environment such as Malaysia is not well established compared to European Union (EU) countries since there is no regulation concern about occupational hand arm vibration hazard (Su et al., 2011). In line with the occupational vibration epidemiological study at temperature climate countries, structure review done by Su et al., (2011) revealed that the applicability of ISO 5349-1 dose response for a 10% prevalence of vibration induce white fingers prediction model in tropical countries as the disease of HAVS could be overestimated. The hand-transmitted vibration exposures were different between industry or work specification. Hence, the prevalence of neurological symptoms (finger tingling and numbness) were higher which range from 13.0% to 67.6% than vascular symptoms (Table 2.1) and was investigated in countries such as Indonesia, Vietnam, South Africa and Malaysia.

There is established standard operating procedure to monitor the diagnosis of HTV exposure health cause-effect at workplace such as vibration magnitude and duration, observation, questionnaires interview and vibrotactile perception threshold,

a need to improve the risk control measure either by engineering or administrative of HTV exposure and to investigate the interactions between variables especially in Malaysia industry is still required. Most of the investigations related to HAVS diseases are merely different from each country due to different climatic environment condition and work activities. Thus, the occupational health surveillance in which „early detection“ and „prevention“ for determining the health cause-effect due to HTV in the workplace acquire attention to improve occupational health among workers (Ali et al., 2018). Furthermore, most of the established hand-transmitted assessments are not deeply revealing the health cause-effect due to complicated exposure dose response relationship during the data analysis process either by linear or neural network methods

#### **2.4.2 Symptoms of Hand Arm Vibration Syndrome**

Symptoms of HAVS include finger blanching and coldness, paraesthesia, pain in the hands, loss of manual dexterity and weakness of hand muscles (Mason et al., 2004). A few symptom of HAVS was:-

- Tingling and Numbness
- Not being able to feel things with fingers.
- Loss of strength in hands
- In the cold and wet, the tips of fingers going white then red and being painful on recovery

Continued use high-vibration tools these symptoms will probably get worse, for example:



- The numbness in hands could become permanent and caused won't be able to feel things at all;
- Difficulty picking up small objects such as screws or nails;
- The vibration white finger could happen more frequently and affect more fingers

### **2.4.3 Numbness and Tingling**

Numbness or tingling in the hand is a common symptom. Often it is thought to result from impingement of one or more nerve roots in the neck as a consequence of cervical spondylosis. However, it can also arise from peripheral neuropathies, including nerve entrapment at various sites in the arm. In particular, sensory symptoms in the hand are an important feature of carpal tunnel syndrome, which is caused by compression of the median nerve in the carpal tunnel at the wrist. In theory, the anatomic distribution of numbness and tingling in the hand should provide a useful pointer to the underlying pathology. For example, symptoms associated with carpal tunnel syndrome would be expected to occur in the sensory distribution of the median nerve (i.e., on the palmar surfaces of the thumb, index finger, middle finger and medial part of the ring finger, and in the medial palm). In practice, however, the distinction may not be clear-cut. Thus, sensory disturbance that is limited to the palmar surface of the index finger might be attributable to either carpal tunnel syndrome or impingement of the C7 nerve root. Moreover, recall of the exact distribution of symptoms may not always be reliable. (Karen, et al., 2003).

#### **2.4.4 Industries And Tools Affecting HAVS**

Industries that can affected HAVS was jobs requiring regular and frequent use of vibrating tools and equipment and handling of vibrating materials are found in a wide range of industries, for example:

- Building and maintenance of roads and railways;
- Construction;
- Estate management (eg maintenance of grounds, parks, water courses, road and railside verges);
- Forestry;
- Foundries;
- Heavy engineering;
- Manufacturing concrete products;
- Mines and quarries;
- Motor vehicle manufacture and repair;
- Public utilities (eg water, gas, electricity, telecommunications);
- Shipbuilding and repair.

While, there are hundreds of different types of hand-held power tools and equipment, which can cause ill health from vibration. Some of the more common ones are:

- Chainsaws
- Concrete breakers/road breakers
- Cut-off saws (for stone etc)
- Hammer drills
- Hand-held grinders

- Impact wrenches
- Jigsaws
- Needle scalers
- Pedestal grinders
- Polishers
- Power hammers and chisels
- Powered lawn mowers
- Powered sanders
- Scabblers
- Trimmers/brush cutters

Retrieved from <http://www.hse.gov.uk/vibration/hav/yourhands.htm>

## **2.5 Pathophysiology and Histopathology of HAVS**

The mechanisms by which vibration leads to tissue damage and the vascular, sensorineural and musculoskeletal outcomes of HAVS are incompletely understood although, as summarized by (Stoyneva et al, 2017) considerable research has been done in this area. Absorption of vibration may be associated with tissue shear and bending stresses that may increase the risk of tissue damage through increases in oxidative stress and inflammation. Finger biopsies of patients with HAVS have shown thickening of the smooth muscle of digital arteries due to muscle cell hypertrophy. As well vascular endothelial cell damage leads to release of the potent vasoconstrictor endothelin and an imbalance between endothelin – 1 and calcitonin-gene-related peptide (CGRP), a powerful vasodilator. Vibration damage may also be



associated with changes in sensitivity to vasodilating and vasoconstricting factors. Finger biopsies have also shown demyelination of nerve fibres, axonal degeneration and nerve fibre loss. The loss of digital cutaneous perivascular nerve fibres, which secrete CGRP, also leads to an increased tendency to vasoconstriction, showing an inter-relationship between the pathophysiology of vascular and sensorineural effects. It has been reported that biopsies of the abductor pollicis longus muscle of patients with HAVS have shown evidence of damage to muscle fibres, which correlate with the duration of vibration exposure (Neckling et al 2019).

## **2.6 Method in Hand-Arm Vibration Syndrome (HAVS) Evaluation**

UK developed guidelines under the Control of Vibration at Work Regulations in 2005 using the 2002 EU Physical Agents (Vibration) Directive. This regulation established and introduced vibration exposure action and limit values. In these regulations, the action value was set at a vibration magnitude of  $2.5 \text{ m/s}^2$  and the limit value to  $5 \text{ m/s}^2$ . Both values are A(8) values, meaning they are average vibration magnitude values over the course of a 8-hour workday. This regulation serves as a good guide to evaluate HAV exposure, and also offers suggestions with respect to reducing associated risks. (Middlesworth .M, Hand-Arm Vibration (HAV), A Step by Step Guide to Evaluate & Control Risk, 2018).

## **2.7 Risk Factor HAVS**

Age and metabolic disease are the primary potential confounders for HAVS. It is important that epidemiologic studies examine non-occupational factors, and control for them. Most of the studies were able address “age” by stratification in their analyses, or through use of multiple logistic regression (Bovenzi et al., 1995; Mirbod et al., 1995). This is important because of the effect that some disorders have on peripheral circulation which may have symptoms similar to HAVS, non occupational Raynaud’s phenomena is a rare disorder which mimics HAVS has been known to occur in individuals with metabolic disorder, peripheral neuropathy, alcohol-related illness, as well as other condition. Neurosensory injuries in the form of sensory impairment, reduced motor function and trouble from neurosensory symptoms in relation to vibration exposure, over a long period

From the previous study, The prevalence of HAVS among the 110 participants was 13.6% (vibration white finger 0.9%,neurosensory symptoms 3.6%, and 9.1% musculoskeletal symptoms). Cases of HAVS increased significantly with age, increasing exposure categories and total years vibration exposure. Workers who are exposed to HAV have an increased risk of vascular and neurological diseases compared to non-vibration exposed groups (Nilsson, Wahlström, & Burström). HAVS also complicated by smoking, Garner et al recently carried out a systematic review of the literature and meta-analysis of risk factors for primary Raynaud’s phenomenon.<sup>56</sup> They found that risk factors for primary Raynaud’s phenomenon included smoking ( meta odds ratio: 1.27; 95% CI: 1.06- 1.53), female gender (meta odds ratio: 1.65; 95% CI: 1.42-1.91), family history (meta odds ratio: 16.6; 95% CI:

7.44-36.8), manual occupation (meta odds ratio: 2.66; 95% CI: 1.73-4.08), migraine headaches (meta odds ratio: 4.02; 95% CI: 2.62-6.17), cardiovascular disease (meta odds ratio: 1.69; 95% CI: 1.22-2.34) and unmarried marital (meta odds ratio: 1.67; 95% CI: 1.20-2.33). Therefore, smoking is a risk factor for the development of primary Raynaud's phenomenon. However the literature is unclear about whether smoking modifies the risk of development of secondary Raynaud's phenomenon due to hand-arm vibration exposure. After development of the vascular component of HAVS, plethysmographic improvement in cold-induced vasospasm following removal from vibration exposure appears to be delayed in smokers compared to non-smokers.

## **2.8 Semmes Weinstein Monofilament (SWM)**

Semmes-Weinstein monofilament testing for perception of light touch-deep pressure sensation, the small-object shape identification test, and moving two-point discrimination testing for functional sensibility provided the most indications of pathologic outcomes. SWM are cheap and easy to use and have been used widely as a screening test in peripheral neurological investigation, such as diabetes and recently they have been used more in HAVS health surveillance. The Touch Test Sensory Evaluators (Semmes-Weinstein's Monofilament) provides a non-invasive evaluation of cutaneous sensation levels with results that are valid and repeatable. Touch thresholds were assessed at the pulp of digits II and V, bilaterally. The filament was pressed at 90° angle against the skin until it bowed. It was held in place for 1.5 seconds and then removed. For monofilaments with a force in grams from



0.07 g (normal sensation) to 0.4 g (diminished light touch) the stimulus was applied in the same location up to three times to elicit a response. For filaments from 2.0 g (diminished protective sensation) through 300 g (deep pressure sensation only), the stimulus was applied once only. For each finger pulp the testing started with monofilament 0.07 g. If the subject was unable to feel this monofilament, the test continued with 0.2 g, and then if necessary with 2.0 g.

## **CHAPTER 3**

### **METHODOLOGY**

#### **3.1 Study Design**

The study is a cross-sectional study with the objective of determining the socio-demographic of the manufacturing workers, prevalence of hand-arm vibration syndrome (HAVS) among manufacturing workers that exposed to vibration and non-exposed to vibration and its association with risk factor of HAVS. The demographic, prevalence and association are determining using questionnaire and monofilament test of the workers

## **3.2 Sampling Technique**

### **3.2.1 Sampling Frame**

The sampling frame has referred on name list of all employees working at the production area of factory. The name list was taken from the Human Resource Department of factory.

### **3.2.2 Sampling Location**

**SAMSUNG ELECTRONICS (M) Sdn Bhd**

**Lot 2, Lebu 2, North Klang Straits,**

**Area 21, Industrial Park, 42000**

**Port Klang, Selangor**



**Figure 3.2.2: Research location**

### 3.3 Sample Size

#### 3.3.1 Sample Size Calculation

P= 18% having HAVS (Su TA, Hoe VCW, Masilamani R, *et al*, 2011)

$$n = \frac{P(100-P)}{5^2}$$

$$n = \frac{18(100-18)}{5^2}$$

n = 59.04 ~ 59 respondent ~ 100 respondent

Exposed group: 44 respondent, Non-exposed group: 56 respondent

Sample size increases to increase power of population and to overcome non-responsive respondent.

#### 3.3.2 Sampling Population

The study population has involved workers in the production area of the factory which were exposed to hand-tool vibration as exposed group and those workers from other work units without using hand-tool vibration as non exposed group. All respondent are from SAMSUNG ELECTRONICS (M) Sdn Bhd. The respondent also including inclusion and exclusion criteria of this research.



### **3.3.3 Selection Criteria**

#### **Inclusion Criteria**

- Electronics manufacturing workers
- Minimum one year work experiences
- Age above 18 years old
- Using vibration hand-tool (for exposed group)
- Not using vibration hand-tool (non-exposed group)

#### **Exclusion Criteria**

- Current hand-arm injury

### **3.4 Sampling Method**

This study has applied random sampling method. By using this method, selection of respondents has begun from the previous percentage of prevalence of HAV. The respondents also needed to comply with all the inclusion criteria. Thus, a new total number of populations that complied with all criteria was obtained. From that, the true sample population for this study has been randomly selected as calculated in sampling calculation.

**3.5 Data Collection**

**3.5.1 Instrumentations**

**1. Questionnaires**

An adapted questionnaire from previous studies (Su, A. T., Maeda, S., Fukumoto, J. at.el, 2014) were used in this study which consisted of five parts:

- a) Part A: Socio-Demographic
- b) Part B: Occupational Information
- c) Part C: Health and Lifestyle Information
- d) Part D: Symptoms Related to Hand-Arm Vibration

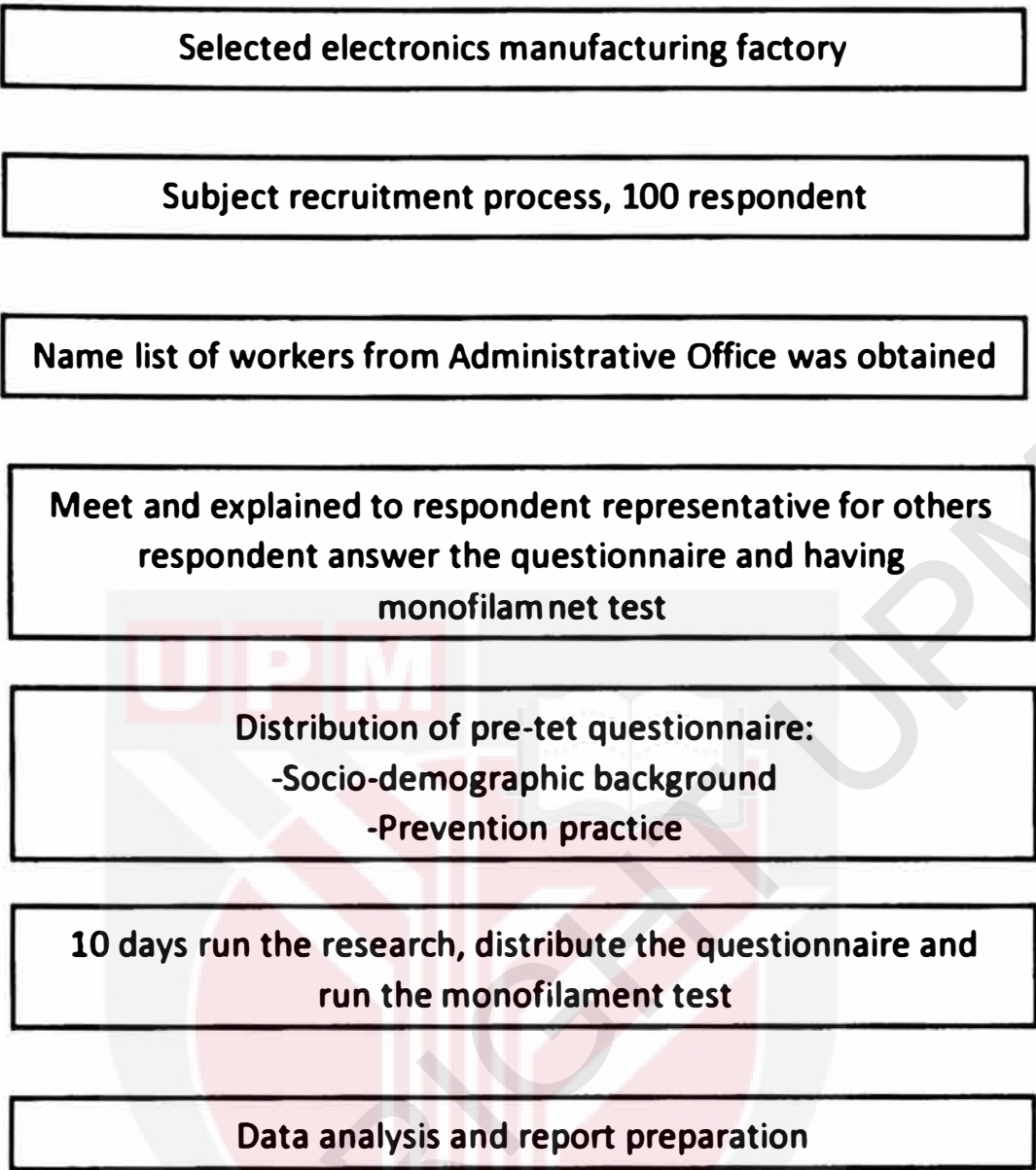
**2. Instrument**

**Monofilament Test Tools:**



**Figure 3.5.1: Touch Test Sensory Evaluator Monofilament Test**

**3.6 Data Collection Workflow**



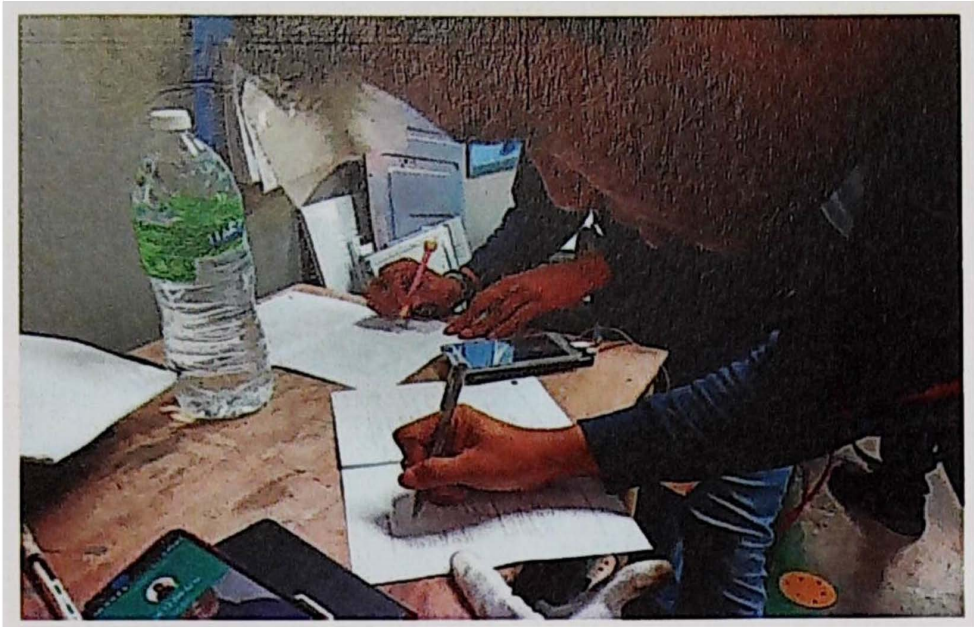
**3.6.1 Procedure of data collection**

**Screening on how the workers make work activity**

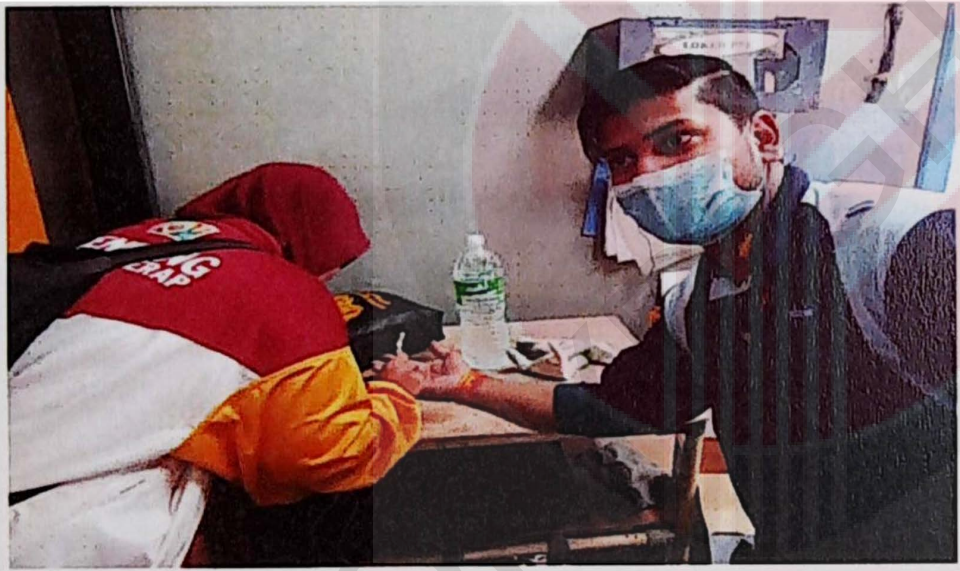




**Respondent answering the questionnaire:**



**Monofilament test for the workers**



**3.7 Data Analysis**

| Variable                                                                                    | Type of Analysis                                 |
|---------------------------------------------------------------------------------------------|--------------------------------------------------|
| 1. To determine socio-demographic data of respondents                                       | Descriptive analysis                             |
| 2. To determine the prevalence of HAVS of exposed and non exposed workers                   | Crosstabulation analysis +<br>Prevalence Formula |
| 3. To determine risk factor of HAVS to exposed and non exposed group to hand-tool vibration | Chi-square analysis                              |

## **CHAPTER 4**

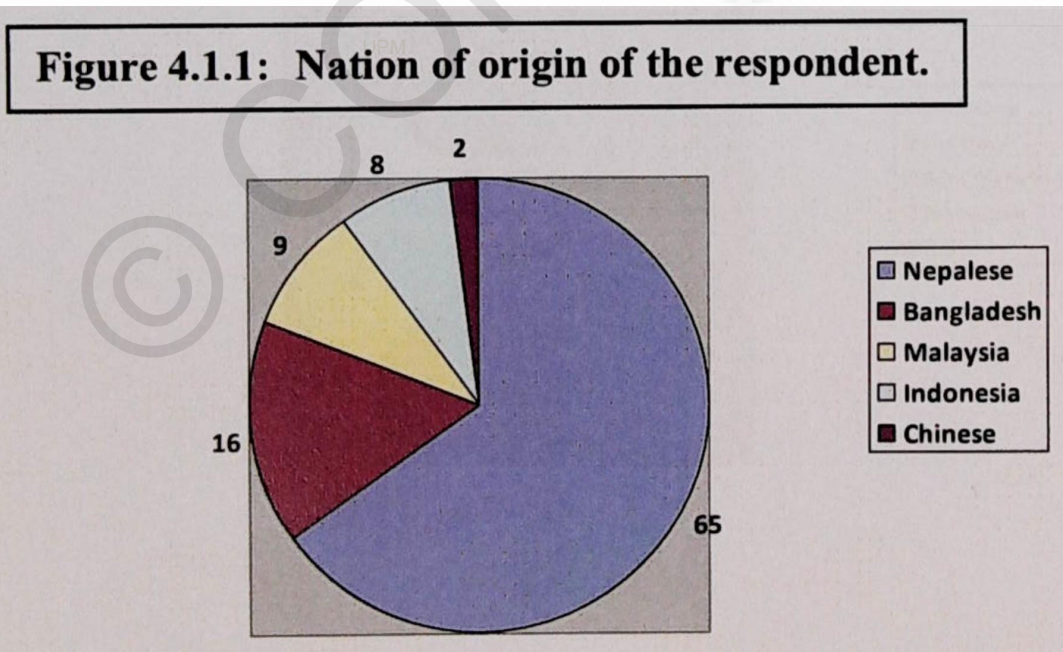
### **RESULTS**

#### **4.1 Characteristics of the respondents**

The characteristics of the respondent were tabulated on Table 4.1. All 100 study subject are from mix country which is Bangladesh, Nepal and also Malaysian people. With mean age of the respondent were 31.25 , majority of them are Nepalese which are 65.0%, while Bangladesh are 16.0%, Malaysian with 9%, Indonesia are 8% and the least one was Chinese with 2%. 73.0% of the respondent received education up to secondary level, while others are 15.0% of them were only received education up to primary level, and the least one are for those received education level up until university level. All 100 respondent were selected randomly and there is worker working with power tool which mean they were categorize as exposed workers and those not exposed or dealing with power tool. 56.0% are exposed workers and 44.0% are non-exposed workers.

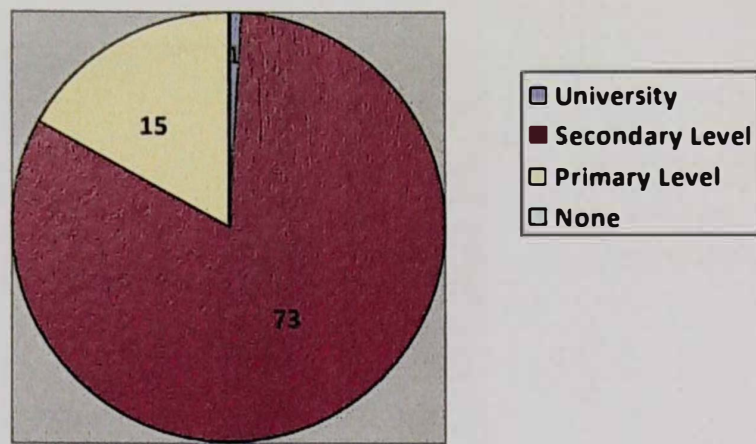


Among the respondent, 36.0% are work under workshop unit, 8% production, 16.0% administration unit, 27.0% loading unit and 13.0% are office part. Work related and using power tools are workshop and production workers. There are some of the respondent were work more and below than 6 years, also some of them were working below than 3 years. From questionnaire findings, 33.0% respondent had below 3 year working experience, the most is 55.0% were more than 3 year but below 6 year working experience and the least were only 12.0% of the respondent were 6 year and more working experience. Only 23% of the respondent were exposed to chemical during working activities. 98.0% of the workers are smoking and 2% only does not smoking. For previous health problem, 38.0% respondent reported they had history muscle ache 38.0% of the respondent 61.0% others were not have any previous health problem and only 1% had broken hand

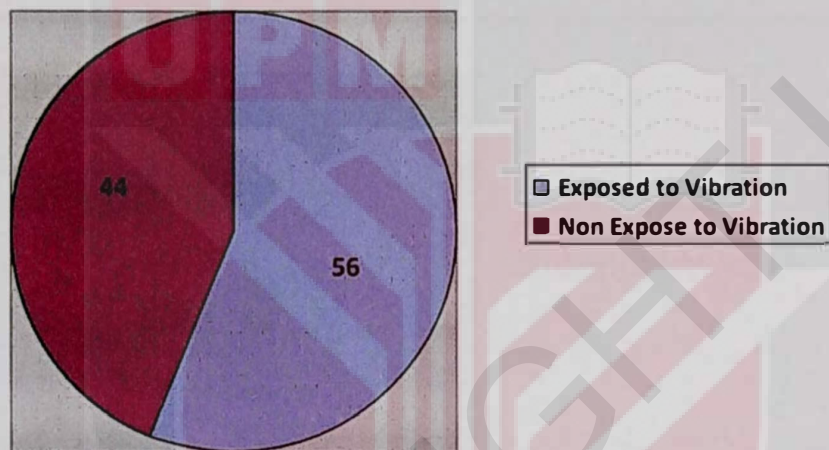




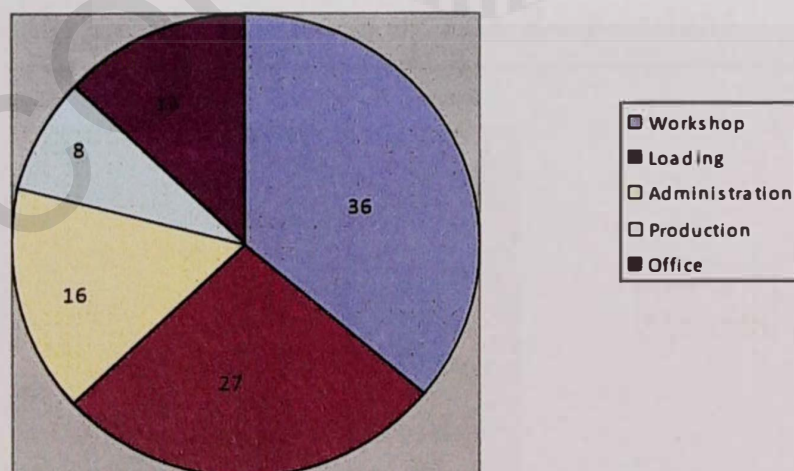
**Figure 4.1.2: Level of education of the respondent.**



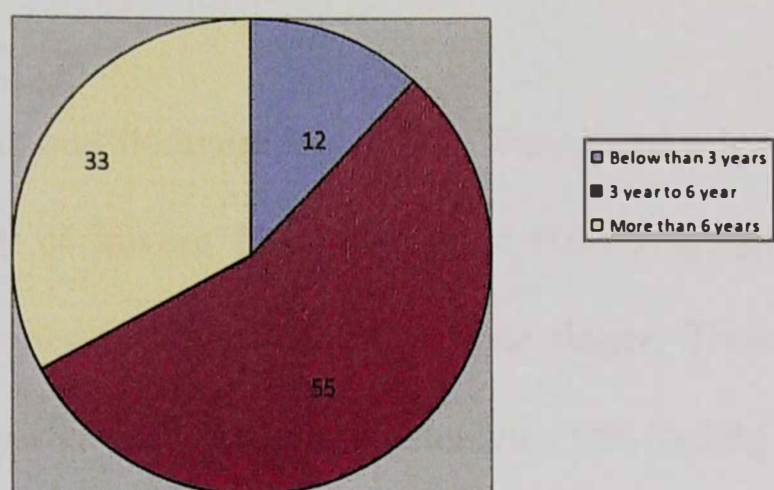
**Figure 4.1.3: Exposed and non exposed repondent to vibration**



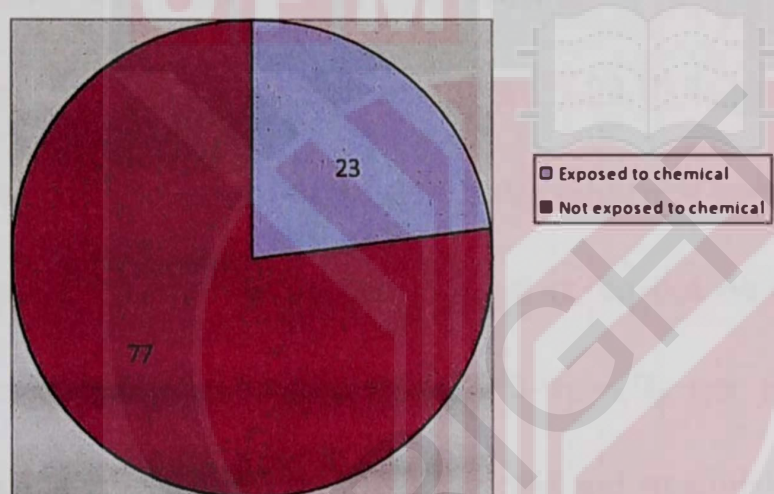
**Figure 4.1.4: Working unit of the respondent**



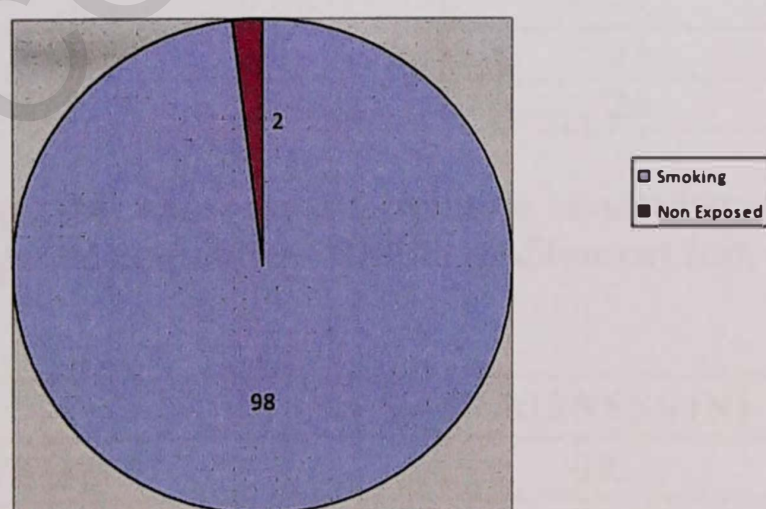
**Figure 4.1.5: Working experience of the respondent**



**Figure 4.1.6: Exposed and non exposed respondent to chemical**



**Figure 4.1.7: Smoking Status of The Respondent**



**4.2 Respondent having HAVS characteristics.**

From the questionnaire, researcher were listed a few symptom of HAVS that be an indicator of having HAVS. List of HAVS symptom, numbness, tingling, reduce sensory perception and induce white finger. Those choose score of 3 and below were reported having the characteristic. The finding show, 71.0% respondent reported they had numbness while 41.0% reported they had tingling. No induce white finger reported among the workers. For monofilament test, referred to previous study for moderate sensitivity for normal were 2.83 (0.07g) Massy-Westropp (2002) and for moderate sensitivity for exposed were 3.22 (0.16g) . From the questionnaire, 59.1% (n=26) of exposed respondent get monofilament value 3.61 (0.4g) and above, while 40.9% (n=18) respondent reported get monofilament value 3.22 (0.16g) and below. For non-exposed respondent, 17.9% (n=10) get monofilament value 3.61 (0.4g) and above, while 82.1% (n=46) reported get monofilament value 3.22 (0.16g) and below.

| YES SCORE   | NUMBNESS (N) | TINGLING (T) | MONOFILAMENT<br>≥3.61 |
|-------------|--------------|--------------|-----------------------|
| EXPOSED     | 36           | 33           | 26                    |
| NON EXPOSED | 35           | 26           | 10                    |

**Table 4.2.1: The table show cross tabulation results between exposed and non-exposed respondent with monofilament test, numbness and tingling.**

| YES SCORE         | NUMBNESS (N) | TINGLING (T) |
|-------------------|--------------|--------------|
| HAVING HAVS ≥3.61 | 39           | 26           |
| NO HAVS ≤3.22     | 32           | 33           |

**Table 4.2.2: The table show cross tabulation results between having HAVS and non having HAVS with respondent with numbness and tingling.**



### 4.3 Prevalence of exposed and non exposed respondent with HAVS

For this objective, crosstabulation analysis are used to examining the relationship between two categorical variables. Then, this analysis is used to examined the relationship between exposed and non-exposed group with each of possibly HAVS symptoms which is numbness and tingling and monofilament test as one of HAVS test. From the analysis, we found that for exposed and non-exposed respondent with monofilament value, numbness and tingling had different percent realted with each other. We found that out of 46 of exposed respondent, 26 of them get the value of monofilament  $\geq 3.61$  ( $\geq 0.4g$ ) which higher than moderate value for esposed worker, 36 from them reported getting numbness and 33 from them reported getting tingling with frequency of “Score: 3, sometimes” . While for 56 non-exposed respondent, 10 of them getting value  $\leq 3.22$  ( $\leq 0.16$ ) which is also higher than moderate value of monofilament were 2.44 (0.04g), 35 of them reported having numbness and 26 of them having tingling. By using formula of prevalence (refer the Diagram 4.3), prevalence for exposed respondent for monofilament value  $\geq 3.61$  ( $\geq 0.4g$ ) are 26.0%, for numbness 36.0% and for tingling 33.0%. While for non-exposed respondent, monofilament value  $\leq 3.22$  ( $\leq 0.16$ ) are 10.0%, for numbness 35% and for tingling 26.0%.

#### 4.4. To determine the association between manufacturing workers with risk factor of HAVS

For this objective, chi-square were used to used for testing relationships between categorical variables. The null hypothesis of the Chi-Square test is that no relationship exists on the categorical variables in the population; they are independent. From the analysis, we found that 3 risk factor that show significant difference of  $P < 0.05$ , which are frequency exposed to vibration during working activities  $P = 0.038$ , drive to work were  $P = 0.023$  and using power tool during working activities  $P = 0.002$ . This 3 variable show significant difference with exposed respondent. While others variable that does not show significant difference was, years of working, exposed to chemical during work, smoking, age and having previous health.

| Risk Factor           | df | Asymp. Sig. (2-sided) | Expected count      | Minimum expected count |
|-----------------------|----|-----------------------|---------------------|------------------------|
| Age                   | 2  | 0.099                 | (16.7) less than 5  | 3.96                   |
| Smoking               | 2  | 0.677                 | (50.0%) less than 5 | 0.72                   |
| Exposure to vibration | 1  | 0.001                 | (0.0%) less than 5  | 7.20                   |
| Experience of working | 1  | 0.013                 | (16.7%) less than 4 | 4.32                   |
| Driving to workplace  | 1  | 0.086                 | (0.0%) less than 5  | 11.88                  |
| Prevention practice   | 1  | 0.003                 | (0.0%) less than 5  | 7.92                   |

**Table 4.4: The table show the association of respondent with risk factor of HAVS**

## **CHAPTER 5**

### **DISCUSSION**

#### **5.1 Demographic of the respondent**

From the demographic results, overall respondent or the workers of the factory were at moderate age, which below than 50 years old. Which the potential or ability of the worker assumed still in high level. But, most of the workers were smoking, smoking will harms nearly body of the smoker to more likely attack by any diseases and reduce health of the smokers in general. From the previos study, they found those working, exposed to vibration and smoking had higher possibility to having HAVS symptom was high (Aj et al., 1987). Hence, smoking being one of concern item to be taken in this study. From this study, most of the worker were having below than 6 years experience of working. From previous study, time to HAVS develop to person that exposed with vibration are 6 month to 6 years (Trotto, 2018). This show that HAVS can be develop earlier, below than 1 year based on how extreme of vibration exposure the workers get and how far the surrounding of the worker support on developing of HAVS, referred to amount of risk factor they exposed to. Based on the questionnaire, respondent included were mostly from nepalese then followed with bangladesh. However, we had no found study of HAVS related with country of origin.

This study were discover about 100 respondent that work with different type of working task and unit. Type of working unit related was workshop unit,



production unit, administrative unit, loading unit and office unit. However, not all of the working unit will exposed with vibration. Out of 100 respondent, 56 of them were working with vibration effect which is using power tool, thier working unit were production unit and workshop unit. While remaining was from administrative, loading and office unit.

## **5.2 Prevalence of exposed and non exposed to HAVS**

The exact prevalence of HAVS in this study is undetermined. If we restrict our definition of HAVS to the occurrence of symptoms in all three components of the hand (vascular, neurological and musculoskeletal). In this objective, monofilament test were choose to be used to measure the potential HAVS that can developed among the workers. The results show, an exposed workers had higher value of monofilament category than non exposed workers, 26 out of 44 exposed workers get value of monofilament 3.61 and higher, from here we can see the effect to the workers that starting to induce their tactile perception due to prolonged exposure to the vibration. The Semmes-Weinstein monofilaments were used to assess perception of touch/pressure and were used in the standardize way, Bell-Krotoski (1995). Monofilament had 20 set kit with different gram and value of its filament, the lowest filament was 1.56 with mass 0.008g but for nomal tactile perception based on the references at kit box, was the filament with 2.44 (0.04g) or 2.83 (0.07), while for those had been exposed to the vibration, the best filament should they get in way or normal tactile perception was maximum to 3.22 in mass 0.16g. Hence when this filament were tested to the exposure person and they were

get higher than 3.22 (0.16g) this show their hand were started with induce the sensory perception that were one of the symptom of HAVS. Other than that, HAVS symptom also can be screen through the effect of their hand in which from the results some of the exposed group experience numbness and tingling, with potential percentage 36% and 33%. This prevalence percentage can increased if no prevention action be taken and the worst case can induced whitening finger which results to very least sensory perception of the finger.

### **5.3 Association of respondent with risk factor of HAVS**

From the table results below, we found that exposure to vibration, experience of working and prevention practice were show that null hypothesis were rejected. Which the  $H_0$  are there is no association with risk factor while  $H_a$  are the is association with risk factor, however only 3 of those risk factor results were shown P value were below than 0.05 proved that null hypothesis rejected. Hence, we found that the most significance to get HAVS with high value of monofilament were vibration, experience of working and prevention practice. This study found that with exposed to the vibration, will having high possibility to get the HAVS. From previous study, they also found that those subject that exposed to the vibration, will had abiity on reducing sensoneurial effect to the hand and reduce perception lower than normal perception of human hand (Forouharmajd, Yadegari, Ahmadvand, Forouharmajd, & Pourabdian, 2017). Hand transmitted vibration most often occurred from use of grinders that was used for grinding, polishing, and cutting. Respondent that exposed to vibration in this study were also used and working with the grinders.



This also support this study which hand exposed with vibration will had high association to get HAVS. From previous study also found that prolonged working with vibration and frequently having high risk to developed numbness and tingling which one of the symptom of HAVS. From previous study, Risk factors which could effect the prevalence of HAVS symptoms in this study were smoking, tobacco chewing, alcohol consumption, chemical exposure at work, non-work exposure to hand transmitted vibration, past medical and surgical history involving the upper limbs, vascular and neurological disease with residual organ dysfunction, and medication with neurotoxic side effect (Su, Hoe, Masilamani, & Mahmud, 2011). Hence, this study were conclude that, manufacturing workers also have high possibility on developing HAVS with including exposure with vibration. High amount and frequent exposure may caused high risk to developed this symptoms of HAVS.

| <b>Risk Factor</b>    | <b>df</b> | <b>Asymp. Sig. (2-sided)</b> | <b>Expected count</b> | <b>Minimum expected count</b> |
|-----------------------|-----------|------------------------------|-----------------------|-------------------------------|
| Age                   | 2         | 0.099                        | (16.7) less than 5    | 3.96                          |
| Smoking               | 2         | 0.677                        | (50.0%) less than 5   | 0.72                          |
| Exposure to vibration | 1         | 0.001                        | (0.0%) less than 5    | 7.20                          |
| Experience of working | 1         | 0.013                        | (16.7%) less than 4   | 4.32                          |
| Driving to workplace  | 1         | 0.086                        | (0.0%) less than 5    | 11.88                         |
| Prevention practice   | 1         | 0.003                        | (0.0%) less than 5    | 7.92                          |

**Table 4.4: The table show the association of respondent with risk factor of HAVS**



## **5.4 Recommendation**

The prediction model of having HAVS among the manufacturing workers formulated in this study is recommended as baseline to compare exposed and non-exposed workers. It recommended also to get very detailed of respondent previous study and measure how long they exposed to the vibration. Some management of lagging time should given to the exposed workers so at that time they will not exposed to the vibration and reduce the risk of HAVS.

It recommended also to having briefing and expansion of working activities frequently by the management. This will help to control the amount of exposure of vibration to the workers and prevention taken to avoid the prolonged exposure.

## **5.5 Study Limitation**

There are some limitations in this study due to its design itself, which is cross-sectional study design. This design may reflect only the current conditions study. As this study determine the specific objectives at one point of time, the variable may change as the time pass. Further uncertainties involving outcomes and exposure variables that vary over time may be affected by feedback bias. Although sample of this study include comparative group which is exposed and non-exposed group to vibration. Some potential bias cannot be excluded.

Uncertainty in estimation frequency of time on exposed to vibration exposure may arise because only small portion power tool had been used during working. Limitation time during questionnaire explained to the respondent and monofilament tested to the respondent. This cause the respondent rushing answering the questionnaire for right and accurate answer.

## **5.6 Conclusion**

In conclusions, this study found that manufacturing workers also may high possibility having and develop hand arm vibration syndrome with present of support risk factor which is exposed to vibration and with prolonged time. This study support others study on prolonged exposed to vibration had high risk developed HAVS.

## REFERENCES

- Azmir, N. A., Ghazali, M. I., Yahya, M. N., Ali, M. H., & Song, J. I. (2015). Effect of Hand Arm Vibration on the Development of Vibration Induce Disorder Among Grass Cutter Workers. *Procedia Manufacturing*, 2(February), 87–91. <https://doi.org/10.1016/j.promfg.2015.07.015>
- Bahri, S., Tamrin, M., Maizurayusoff, N., Rahman, A. A., Mansour, A., Sciences, H., ... Arabia, S. (2016). Original Article the Prevalence of Hand Arm Automobile Assembly Workers Vibration Syndrome. *Malaysian Journal of Public Health Medicine*, 16, 128–136
- Su, T. A., Hoe, V. C. W., Masilamani, R., & Mahmud, A. B. A. (2011). Hand-arm vibration syndrome among a group of construction workers in Malaysia. *Occupational and Environmental Medicine*, 68(1), 58–63. <https://doi.org/10.1136/oem.2009.052373>
- Wilasrusmee, C., Suthakorn, J., Guerineau, C., Itsarachaiyot, Y., Sa-Ing, V., Proprom, N., ... Kittur, D. (2010). A novel robotic monofilament test for diabetic neuropathy. *Asian Journal of Surgery*, 33(4), 193–198. [https://doi.org/10.1016/S1015-9584\(11\)60006-7](https://doi.org/10.1016/S1015-9584(11)60006-7)



Monarca, D., Biondi, P., Cecchini, M., Santi, M., Guerrieri, M., Colantoni, A., & Colopardi, F. (2008). Transmission of vibrations from portable agricultural machinery to the Hand-Arm System ( HAV ): risk assessment and definition of exposure time for daily action and exposure limits.

Poole, K., Mason, H., & Hill, H. (2009). The value of the WEST monofilaments in detecting neurosensory deficit caused by hand-arm vibration exposure RR712  
The value of the WEST monofilaments in detecting neurosensory deficit caused by hand-arm vibration exposure.

Walbruch & Kalliainen, 2015)Walbruch, B., & Kalliainen, L. (2015). The optimization of peripheral nerve recovery using cortical reorganization techniques: A retrospective study of wrist level nerve repairs. *Journal of Hand Therapy*, 28(4), 341–346. <https://doi.org/10.1016/j.jht.2015.04.001>

(Aiello et al., 2010; Canadian Centre for Occupational Health & Safety, 2019; Cederlund, Isacson, & Lundborg, 1999; Vihlborg, Bryngelsson, Lindgren, Gunnarsson, & Graff, 2017)Aiello, G., Catania, P., G, L. S., Piraino, S., Salvia, M., & Vallone, M. (2010). Risk Assessment of Hand-Arm Vibration in Different Types of Portable Shakers for Olives Harvesting. 328–335.

Canadian Centre for Occupational Health & Safety. (2019). Vibration - Health Effects. 1–5. Retrieved from [https://www.ccohs.ca/oshanswers/phys\\_agents/vibration/vibration\\_effects.html](https://www.ccohs.ca/oshanswers/phys_agents/vibration/vibration_effects.html)

- Cederlund, R., Isacson, Å., & Lundborg, G. (1999). Hand function in workers with hand-arm vibration syndrome. *Journal of Hand Therapy*, 12(1), 16–24. [https://doi.org/10.1016/S0894-1130\(99\)80029-5](https://doi.org/10.1016/S0894-1130(99)80029-5)
- Vihlborg, P., Bryngelsson, I. L., Lindgren, B., Gunnarsson, L. G., & Graff, P. (2017). Association between vibration exposure and hand-arm vibration symptoms in a Swedish mechanical industry. *International Journal of Industrial Ergonomics*, 62, 77–81. <https://doi.org/10.1016/j.ergon.2017.02.010>
- Middlesworth, M., & Middlesworth, M. M. (2014, January 15). Hand-Arm Vibration (HAV) - A Step by Step Guide to Evaluate & Control Risk. Retrieved from <https://ergo-plus.com/hand-arm-vibration-hav/>
- Health Effects of Cigarette Smoking | CDC. (n.d.). Retrieved from [https://www.cdc.gov/tobacco/data\\_statistics/fact\\_sheets/health\\_effects/effects\\_cig\\_smoking/index.htm](https://www.cdc.gov/tobacco/data_statistics/fact_sheets/health_effects/effects_cig_smoking/index.htm)
- Trotto, S., & Trotto, S. (2018, April 24). Hand-arm vibration syndrome. Retrieved from <https://www.safetyandhealthmagazine.com/articles/13117-hand-arm-vibration>
- Su, T. A., Hoe, V. C. W., Masilamani, R., & Mahmud, A. B. A. (2011). Hand-arm vibration syndrome among a group of construction workers in Malaysia. *Occupational and Environmental Medicine*, 68(1), 58–63. <https://doi.org/10.1136/oem.2009.052373>

Su, T. A., Hoe, V. C. W., Masilamani, R., & Mahmud, A. B. A. (2011). Hand-arm vibration syndrome among a group of construction workers in Malaysia. *Occupational and Environmental Medicine*, 68(1), 58–63. <https://doi.org/10.1136/oem.2009.052373>

Forouharmajd, F., Yadegari, M., Ahmadvand, M., Forouharmajd, F., & Pourabdian, S. (2017). Hand-arm Vibration Effects on Performance, Tactile Acuity, and Temperature of Hand. Retrieved from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5691565/>

Karen, Palmer, T., K., Cooper, Cyrus, & David. (2003, March 15). Anatomic Distribution of Sensory Symptoms in the Hand and Their Relation to Neck Pain, Psychosocial Variables, and Occupational Activities. Retrieved from <https://doi.org/10.1093/aje/kwf225>

Ronnie Lundström, Baloch, A., Mats Hagberg, Tohr Nilsson, & Lars Gerhardsson. (2018, June 22). Long-term effect of hand-arm vibration on thermotactile perception thresholds. Retrieved from <https://occup-med.biomedcentral.com/articles/10.1186/s12995-018-0201-1>

What are the health effects of hand-arm vibration? (2015, May 01). Retrieved from <https://www.ishn.com/articles/101336-what-are-the-health-effects-of-hand-arm-vibration>



Su, T. A., Hoe, V. C. W., Masilamani, R., & Mahmud, A. B. A. (2011). Hand-arm vibration syndrome among a group of construction workers in Malaysia. *Occupational and Environmental Medicine*, 68(1), 58–63. <https://doi.org/10.1136/oem.2009.052373>

Whole body vibration at work. (n.d.). Retrieved from <http://www.hse.gov.uk/vibration/wbv/index.htm>

Nilsson, T., Wahlström, J., & Burström, L. (n.d.). Hand-arm vibration and the risk of vascular and neurological diseases-A systematic review and meta-analysis. Retrieved from <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0180795>

Safety, T. W., & Tribunal, I. A. (2018). Hand-Arm Vibration Syndrome. 2080(2080).

Palmer K, Crane G, Inskip H. Symptoms of hand-arm vibration syndrome in gas distribution operatives. *Occup Environ Med*. 1998;55(10):716–21. <http://dx.doi.org/10.1136/oem.55.10.716>. 16.

Edlund M, Gerhardsson L, Hagberg M. Physical capacity and psychological mood in association with self-reported work ability in vibration-exposed patients with hand symptoms. *J Occup Med Toxicol*. 2012;7(1):22. <http://dx.doi.org/10.1186/1745-6673-7-22>. 17.

Atroshi I, Englund M, Turkiewicz A, Tagil M, Petersson IF. Incidence of physician-diagnosed carpal tunnel syndrome in the general population. *Arch Intern Med*. 2011; 171(10):943–4. <http://dx.doi.org/10.1001/archinternmed.2011.203>. 18.

Dieleman JP, Kerklaan J, Huygen FJ, Bouma PA, Sturkenboom MC. Incidence rates and treatment of neuropathic pain conditions in the general population. *Pain*. 2008;137(3):681–8. <http://dx.doi.org/10.1016/j.pain.2008.03.002>.

Futatsuka M, Shono M, Sakakibara H, Quan PQ (2005) Hand Arm Vibration Syndrome among Quarry Workers in Vietnam. *J Occup Health* 47, 165–70.

Futatsuka M, Inaoka T, Ohtsuka R, Moji K, Sakurai T (1991) A preliminary study on the function tests of the vibration syndrome in tropical rain forest workers. *J Human Ergol (Tokyo)* 20, 95–9.

Futatsuka M, Inaoka T, Ohtsuka R, Sakurai T, Moji K, Igarashi T (1995) Hand-arm vibration in tropical rain forestry workers. *Cen Eur J Public Health* 3, 90–2

Z. Mallick, “Optimization of the operating parameters of a grass trimming machine,” *Appl. Ergon.*, vol. 41, no. 2, pp. 260–5, Mar. 2010.

M. J. Griffin, “Negligent exposures to hand-transmitted vibration.,” *Int. Arch. Occup. Environ. Health*, vol. 81, no. 5, pp. 645–59, Apr. 2008.

T. J. Armstrong, L. J. Fine, R. G. Radwin, and B. S. Silverstein, "Ergonomics and the effects of vibration in hand-intensive work," *Scand. J. Work. Environ. Health*, pp. 286–289, 1987.

A. Burdorf and A. Monster, "Exposure to vibration and self-reported health complaints of riveters in the aircraft industry," *Ann. Occup. Hyg.*, vol. 35, no. 3, pp. 287–298, 1991.

Malchaire J, Rodriguez Diaz LS, Piette A, Gonçalves Amaral F, Schaetzen D (1998). Neurological and Functional Effects of Short-Term Exposure to Hand-Arm Vibration. *Int Arch Occup Environ Health*, 71 (4): 270-6.

Sato T, Kishi R, Gong Y, Katakura Y, Kawai T (2009). Effect of Styrene Exposure on Vibration Perception Threshold. *Neurotoxicol*, 30 (1): 97-102.

Zali NA. The Relationship between Vibrotactile Perception and Chemical Exposure among Vehicle Service Technician in Klang Valley [Master thesis], Faculty of Medicine and Health Sciences, University Putra Malaysia, Malaysia; 2014

Chuang H, Schwartz J, Tsai S, Lee M, Wang J, Hu H (2000). Vibration Perception Threshold in Workers with Long Term Exposure to Lead. *Occup Environ Med*, 57 (9): 588-594.



Hooisma J, Hanninen H, Emmen HH, Kulig BM (1994). Symptoms Indicative of the Effects of Organic Solvent Exposure in Dutch Painters. *Neurotoxicol Teratol*, 16 (6): 613-22.

Aotola S, Farkkila M, Pyykko I, Korhonen O, Starck J (1990). Measuring Method for Vibration Perception Threshold of Fingers and its Application to Vibration Exposed Workers. *Int Arch Occup Environ Health*, 62 (3) :239-42.

Griffin MJ (2008). Measurement, Evaluation and Assessment of Peripheral Neurological Disorders Caused by Hand-Transmitted Vibration. *Int Arch Occup Environ Health*, 81 (5): 559-73.

Bovenzi M. Hand-arm vibration syndrome and dose-response relation for vibration induced white finger among quarry drillers and stonecarvers. Italian Study Group on Physical Hazards in the Stone Industry. *Occup Environ Med* 1994;51:603e11.

Bovenzi M, Franzinelli A, Mancini R, et al. Dose-response relation for vascular disorders induced by vibration in the fingers of forestry workers. *Occup Environ Med* 1995;52:722e30.

Department of Statistics Malaysia. Yearbook of Statistics, 2006. Putrajaya: Department of Statistics Malaysia, 2006.

**Social Security Organization Malaysia. SOCSO statistics: schedule 10 number of occupational diseases by causing agent year 2006. 2008.**

**<http://www.perkeso.gov.my/Jadual10.pdf> (accessed 16 Sep 2008).**

**Su TA, Hoe VCW. Reliability of a Malay-translated questionnaire for use in a hand-arm vibration syndrome study in Malaysia. Singapore Med J 2008;49:1038e45.**

**A.J. Brammer, W. Taylor, and G. Lundborg, “Sensorineural stages of the hand-arm vibration syndrome,” Scand. J. Work. Environ. Health, pp. 279–283, 1987.**

**Stewart AL, Greenfield S, Hays RD, et al. Functional status and well-being of patients with chronic conditions. Results from the Medical Outcomes Study. JAMA 1989;262:907–13. 2.**

**Bongers PM, De Winter CR, Kompier MAJ, et al. Psychosocial factors at work and musculoskeletal disease. Scand J Work Environ Health 1993;19:297–312. 3.**

**Leino PI, Hanninen V. Psychosocial factors at work in relation to back and upper limb disorders. Scand J Work Environ Health 1995;21:134–42. 4.**

**Macfarlane GJ, Hunt IM, Silman AJ. Role of mechanical and psychosocial factors in the onset of forearm pain: prospective population based study. BMJ 2000;321:676–9.**

## APPENDIX A: QUESTIONNAIRE



**PROJEK PENYELIDIKAN TAHUN AKHIR  
B.S. KESIHATAN PERSEKITARAN DAN PEKERJAAN  
FAKULTI PERUBATAN DAN SAINS KESIHATAN  
UNIVERSITI PUTRA MALAYSIA  
SERDANG, SELANGOR**

***"BORANG SOAL SELIDIK BAGI KAJIAN KELAZIMAN SINDROM GETARAN  
TANGAN LENGAN DAN PERHUBUNGANNYA DENGAN FAKTOR RISIKO ANTARA  
PEKERJA KILANG PEMBUATAN ELEKTRONIK DI KILANG SAMSUNG, MALAYSIA,  
KLANG, SELANGOR."***

### ARAHAN SOALAN:

1. Borang soal selidik ini mengandungi empat (5) bahagian iaitu:

**BAHAGIAN A: MAKLUMAT DIRI**

**BAHAGIAN B: MAKLUMAT PEKERJAAN**

**BAHAGIAN C: MAKLUMAT KESIHATAN DAN MAKLUMAT GAYA HIDUP**

**BAHAGIAN D: MAKLUMAT SIMTOM PENDEDAHAN GETARAN**

2. Untuk menjawab, sila tandakan jawapan di bahagian jawapan yang telah disediakan
3. Borang soal selidik hendaklah dikembalikan kepada pengkaji setelah selesai menjawab semua soalan
4. Semua maklumat yang diperolehi di dalam kajian ini adalah rahsia dan hanya digunakan untuk tujuan pembelajaran semata-mata.

Sekian, terima kasih.



1.0 BAHAGIAN A: MAKLUMAT DIRI

1.1 Nama : \_\_\_\_\_  
Name

1.2 Umur : \_\_\_\_\_ Tarikh Lahir:  
Umēra Janma miti

1.3 Alamat : \_\_\_\_\_  
Thēgānā

1.4 No. Telefon : \_\_\_\_\_  
Phōna nambara

1.5 Bangsa : \_\_\_\_\_  
Rāṣṭra

1.6 Tahap Pendidikan : ☐ Tidak Bersekolah / Skūlamā upasthita hunuhunna  
Śikṣā stara ☐ Rendah / Prāthamika vidyālaya  
☐ Menengah / Ucca vidyālaya  
☐ Universiti / Viśvavidyālaya

2.0 BAHAGIAN B: MAKLUMAT PEKERJAAN

2.1 Pekerjaan Sekarang : \_\_\_\_\_  
Ahilē kāma garnuhōs

2.2 Grinders Yang Digunakan (Jika Ada) :  
Prayukta grinḍara (yadi upalabdha cha)

7032 ☐ BOSCH GWS 900-100 ☐ MAKITA GP 0630 ☐ YAMA AT

2.3 Tempoh Kerja : ☐ / ☐☐  
Kārya avadhi  
Bulan Tahun  
Mahinā Varṣa

2.4 Sila Jawab Soalan Berikut Jika Anda Menggunakan Alatan Tangan

| Bil   | Perkara                                                                                                                                                                                                                             | 1     | 2                | 3                           |
|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------------------|-----------------------------|
|       |                                                                                                                                                                                                                                     | YA/Hō | TIDAK/<br>hō'ina | TIDAK TAHU/<br>Thāhā chaina |
| 2.4.1 | Adakah anda kerap terdedah dengan getaran pada setiap hari?<br>Tapā'īm aksara dainika ādhāra mā kampana kō ujāgara gardai hunuhuncha?                                                                                               |       |                  |                             |
| 2.4.2 | Adakah anda terdedah denga bahan kimia ketika bekerja?<br>Kē tapā'īm kāma garnē bēlā rasāyanaharūlā'ī ujāgara gardai hunuhuncha?                                                                                                    |       |                  |                             |
| 2.4.3 | Adakah terdedah dengan getaran pada pekerjaan terdahulu?<br>Kē yō aghillō kāmamā kampana kampana bha'ēkō cha?                                                                                                                       |       |                  |                             |
| 2.4.4 | Adakah anda terdedah dengan bahan kimia pada pekerjaan anda terdahulu?<br>Kē tapā'īm āphnō aghillō kāmamā rasāyanaharūlā'ī ujāgara garnubhayō?                                                                                      |       |                  |                             |
| 2.4.5 | Adakah anda menggunakan sarung tangan semasa menggunakan alatan tangan yang bergetar pada pekerjaan terdahulu?<br>Kē tapā'īm dastakaharū prayōga garnuhuncha jaba pachillō kāryamā kampana garnē hāta upakaraṇaharū prayōga gardai? |       |                  |                             |

BAHAGIAN C: MAKLUMAT KESIHATAN DAN GAYA HIDUP

- a. Adakah Anda Merokok?  
Kē tapā'ī dhumrapāna garnuhuncha?
- Ya/Tidak  
Hō/ hō'ina
- b. Berapa Batang Anda Merokok Dalam Sehari?  
Ēka dina tapā'īm kati salākhaharū dhumrapāna garnuhuncha?
- \_\_\_\_\_ Batang / Bāṇṭāṇa

c. Adakah Anda Ambil Alkohol?  
Kē tapā'īm raksī pā'unubhayō?

Ya/Tidak  
Hō/ hō'ina

d. Berapa Jumlah Alkohol Anda Ambil Dalam Sehari?  
Tapā'īm ēka dina kati dhērai alkōhala garnuhuncha?

\_\_\_\_\_ Tin/Botol/MI (Ṭina/ bōtala)

e. Adakah Anda Pernah Alami Kecelakaan Berikut Pada Tenguk/Leher/Bahu/Lengan Atau Tangan?

Kē tapā'īnlē kahilyai cōṭa lagā'unubha'ēkō thiyō nipa/ gyāṁsa/ kandhē/ āstīna vā hātamā?

- |                                                                         |                                                                                        |                                                                |
|-------------------------------------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------------|
| <input type="checkbox"/> Patah<br>Ṭūṭēkō cha                            | <input type="checkbox"/> Kekejangan Sendi (Tangan)<br>Jōḍaharū (hyāṇḍa)                | <input type="checkbox"/> Keradangan Kulit<br>Chālā insulēsana  |
| <input type="checkbox"/> Ketumbuhan<br>Vikāsa                           | <input type="checkbox"/> Sakit Otot Atau Tendon<br>Mānsapēśiyōm kō darda<br>yā tēṇḍana | <input type="checkbox"/> Masalah Saraf<br>Tantrikā samasyāharū |
| <input type="checkbox"/> Lain-Lain, Nyatakan:<br>Arū, nirdiṣṭa garnuhōs |                                                                                        | <input type="checkbox"/> Tiada<br>Kunai pani chaina            |

f. Jika Ada Kecelakaan Di Atas, Adakah Kecelakaan Tersebut Telah Sembuh?  
Yadi kunai cōṭa lāgēna bhanē, kē thiyō cōṭa nikō thiyō?

Ya/Tidak  
Hō/ hō'ina

g. Adakah Anda Membawa Kendaraan Untuk Ke Tempat Kerja? (Jika tidak terus ke muka surat seterusnya)

Kē tapā'īm kāravāhī garna kāma gardai hunuhuncha? (Yadi arkō pṛṣṭhamā sīdhā nagarnuhōs)

Ya/Tidak  
Hō/ hō'ina

h. Jika Ya, Sila Nyatakan Kendaraan Yang Anda Bawa

\_\_\_\_\_



i. Berapakah Jarak Tempat Tinggal Anda Dengan Tempat Kerja?

\_\_\_\_\_ m/km/

BAHAGIAN D: MAKLUMAT SIMTOM PENDEDAHAN GETARAN

Soalan ini adalah untuk mengenal pasti tahap kondisi tangan untuk menjalankan aktiviti atau pekerjaan anda. Soalan ini juga merujuk kepada fungsi tangan (s) / pergelangan tangan anda pada minggu yang lalu. (Sila pilih satu jawapan untuk setiap soalan). Sila jawab SEMUA soalan, walaupun anda tidak mengalami sebarang masalah tangan dan / atau pergelangan tangan.

Yō praśna tapā'īṅkō gatividhi vā pēśākō lāgī hāta hālnē starakō pahicāna garna hō. Yō praśnalē pani tapā'īṅkō haptā/ kalā'ī prakāryalā'ī pachillō haptāmā bujhā'um̐cha. (Pratyēka praśnakō lāgi ēka javāpha cayana garnuhōs). Sabai praśnahrūkō javāpha dinuhōs, bhadau bhanē tapā'īnsaṁga āphnō hāta ra/ vā kalā'ī saṅga kunai samasyā chaina.

Tangan Kanan / Pergelangan Kanan

Dāhinē hāta/ dāyāṁ kalā'ī

| No | Soalan                                                                                                      | Sangat Bagus / Dhērai rāmrō | Bagus / Rāmrō kāma | Sederhana / Sarala | Lemah / Kamajōra | Sangat Lemah / Dhērai kamajōra |
|----|-------------------------------------------------------------------------------------------------------------|-----------------------------|--------------------|--------------------|------------------|--------------------------------|
|    |                                                                                                             | 1                           | 2                  | 3                  | 4                | 5                              |
| 1  | Bagaimanakan keadaan jari kanan anda?<br>Tapā'īṅkō dāhinē auṁlā kasarī sahī cha?                            |                             |                    |                    |                  |                                |
|    | Bagaimanakah keadaan pergelangan tangan kanan anda?<br>Tapā'īṅkō sahī kalā'ī rājya kasarī cha?              |                             |                    |                    |                  |                                |
| 3  | Bagaimanakah keadaan deria rasa tangan kanan anda?<br>Tapā'īṅkō dāhinē hāta kasarī bhāvanā mahasusa garcha? |                             |                    |                    |                  |                                |

|    |                                                                                                                                                                                                                         |                                       |                   |                                    |                                          |                                         |
|----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|-------------------|------------------------------------|------------------------------------------|-----------------------------------------|
| 4  | <p>Bagaimanakah keseluruhan tangan kanan anda berfungsi?</p> <p>Tapā'īnkō sampūrṇa bāyāṁ hāta kasarī kāma gardacha?</p>                                                                                                 |                                       |                   |                                    |                                          |                                         |
| 5  | <p>Bagaimanakah tahap kekuatan tangan kanan anda?</p> <p>Tapā'īnkō bāyāṁ hāta kasarī baliyō huncha?</p>                                                                                                                 |                                       |                   |                                    |                                          |                                         |
| 6  | <p>Bagaimanakah tahap pergerakan tangan jari kanan anda?</p> <p>Tapā'īnkō dāhinē hātakō cāla kasarī cāliyō?</p>                                                                                                         |                                       |                   |                                    |                                          |                                         |
|    |                                                                                                                                                                                                                         | Sangat<br>Kerap /<br>Dhērai<br>paṭaka | Kerap /<br>Aksara | Kadang-<br>Kadang /<br>Kahilēkāhīm | Sangat<br>Jarang /<br>Dhērai<br>durlabha | Tidak<br>pernah /<br>Kahilyai<br>hō'ina |
| 7  | <p>Pernahkah anda alami keadaan jari kanan merasa kebas?</p> <p>Kē tapā'im̐saṁga kahilyai aṁdhyārō phōhōra lagā'unubha'ēkō cha?</p>                                                                                     |                                       |                   |                                    |                                          |                                         |
| 8  | <p>Pernahkah anda mengalami keadaan jari kanan berdenyut-denyut kesemutan serupa cucukan pin/jarum?</p> <p>Kē tapā'ilē kahilyai sahī jāṅgha dāmyā jhanjhaṭamā samāna ṭiṅgiṇa pina/ suṭkō anubhava garnubha'ēkō cha?</p> |                                       |                   |                                    |                                          |                                         |
| 9  | <p>Pernahkah anda mengalami apa-apa perubahan warna pada jari?</p> <p>Kē tapā'inlē āphnō aunlāmā kunai pani nis'sandēha anubhava garnubha'ēkō cha?</p>                                                                  |                                       |                   |                                    |                                          |                                         |
| 10 | <p>Adakah tangan kanan anda berasa sakit jika terdedah dengan getaran?</p> <p>Kē tapā'īnkō dāyāṁ hāta bhā'ibrēsanamā pardā birāmī bha'ēkō cha?</p>                                                                      |                                       |                   |                                    |                                          |                                         |
| 11 | <p>Adakah jari anda berasa sakit ketika terdedah dengan getaran?</p> <p>Tapā'īnkō kampāna birāmī huṁdā birāmīkō mahasusa huncha?</p>                                                                                    |                                       |                   |                                    |                                          |                                         |

**Tangan Kiri / Pergelangan Kiri**

**Bāmyā hyāṇḍa/ bāmyā kalāṭ**

| No | Soalan                                                                                                      | Sangat Bagus / Dhērai rāmrō | Bagus / Rāmrō kāma | Sederhana / Sarala | Lemah / Kamajōra | Sangat Lemah / Dhērai kamajōra |
|----|-------------------------------------------------------------------------------------------------------------|-----------------------------|--------------------|--------------------|------------------|--------------------------------|
|    |                                                                                                             | 1                           | 2                  | 3                  | 4                | 5                              |
| 1  | Bagaimanakan keadaan jari kiri anda?<br>Tapā'imkō bāyām̐ aunlā kastō cha?                                   |                             |                    |                    |                  |                                |
| 2  | Bagaimanakah keadaan pergelangan tangan kiri anda?<br>Tapā'īnkō bāyām̐ kalāṭ rājya kasarī huncha?           |                             |                    |                    |                  |                                |
| 3  | Bagaimanakah keadaan deria rasa tangan kiri anda?<br>Tapā'īnkō bāyām̐ hātakō artha kasarī cha?              |                             |                    |                    |                  |                                |
| 4  | Bagaimanakah keseluruhan tangan kiri anda berfungsi?<br>apā'īnkō sampūrṇa bāyām̐ hāta kasarī kāma gardacha? |                             |                    |                    |                  |                                |
| 5  | Bagaimanakah tahap kekuatan tangan kiri anda?<br>Tapā'īnkō bāyām̐ hāta kasarī baliyō huncha?                |                             |                    |                    |                  |                                |
| 6  | Bagaimanakah tahap pergerakan tangan jari kiri anda?<br>Tapā'īnkō bāyām̐ auṁlā hāta kasarī cāla cha?        |                             |                    |                    |                  |                                |



|    |                                                                                                                                                                             | <b>Sangat<br/>Kerap /<br/>Dhērai<br/>paṭaka</b> | <b>Kerap /<br/>Aksara</b> | <b>Kadang-<br/>Kadang /<br/>Kahilēkāhīm</b> | <b>Sangat<br/>Jarang /<br/>Dhērai<br/>durlabha</b> | <b>Tidak<br/>pernah /<br/>Kahilyai<br/>hō'ina</b> |
|----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|---------------------------|---------------------------------------------|----------------------------------------------------|---------------------------------------------------|
| 7  | <p>Pernahkah anda alami keadaan jari kiri anda merasa kebas?</p> <p>Kē tapāṭnlē kahilyai āphnō bāyām aunlā lagā'unubha'ēkō sunnakō avasthā anubhava garēkō cha?</p>         |                                                 |                           |                                             |                                                    |                                                   |
| 8  | <p>Pernahkah Anda Mengalami Keadaan Jari Kiri Berdenyut-Denyut Kesemutan Serupa Cucukan Pin/Jarum?</p> <p>Kē tapāṭnlē suṭi pina/ suṭi kā śikharakō anubhava garnubhayō?</p> |                                                 |                           |                                             |                                                    |                                                   |
| 9  | <p>Pernahkah Anda Mengalami Apa-Apa Perubahan Warna Pada Jari Kiri?</p> <p>Tapā'im bāyām aunlāmā kastō raṇa parivartanakō anubhava garnubhayō?</p>                          |                                                 |                           |                                             |                                                    |                                                   |
| 10 | <p>Adakah tangan kanan anda berasa sakit jika terdedah dengan getaran?</p> <p>Kē tapāṭnkō dāyām hāta bhā'ibrēsanamā pardā birāmī bha'ēkō cha?</p>                           |                                                 |                           |                                             |                                                    |                                                   |
| 11 | <p>Adakah jari anda berasa sakit ketika terdedah dengan getaran?</p> <p>Tapāṭmkō kampana birāmī huṃdā birāmīkō mahasusa huncha?</p>                                         |                                                 |                           |                                             |                                                    |                                                   |

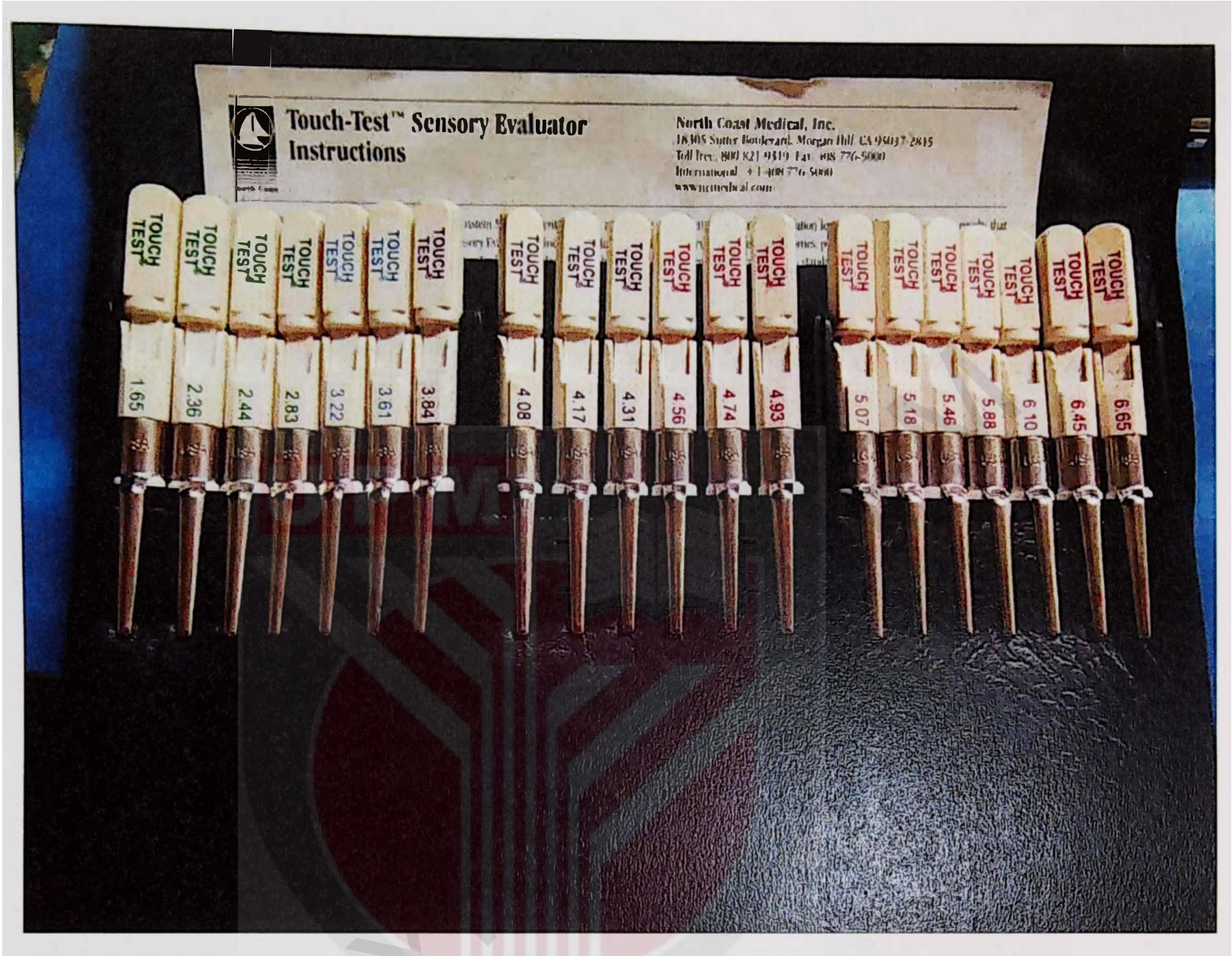
Terima Kasih Atas Kesudian Menjawab Soal Selidik Ini.

Sekian,

Yasa praśnāvalīkō javāphakō samasyākō lāgi dhan'yavāda.

Tara,

PPENDIX B: MONOFILAMENT TEST





## APPENDIX C: SENSORY EVALUATOR CHART

Figure 5—Touch-Test™ Sensory Evaluator Chart

| Product Number | Evaluator Size | Target Force* | Representation | Hand & Dorsal Foot Thresholds   | Plantar Thresholds              |
|----------------|----------------|---------------|----------------|---------------------------------|---------------------------------|
| NC12775-01     | 1.65           | 0.001         | Green          | Normal                          | Normal                          |
| NC12775-02     | 2.36           | 0.02          |                |                                 |                                 |
| NC12775-03     | 2.44           | 0.04          |                |                                 |                                 |
| NC12775-04     | 2.83           | 0.07          | Blue           | Diminished Light Touch          |                                 |
| NC12775-05     | 3.22           | 0.16          |                |                                 |                                 |
| NC12775-06     | 3.61           | 0.4           |                |                                 |                                 |
| NC12775-07     | 3.84           | 0.6           | Purple         | Diminished Protective Sensation | Diminished Light Touch          |
| NC12775-08     | 4.08           | 1             |                |                                 |                                 |
| NC12775-09     | 4.17           | 1.4           |                |                                 |                                 |
| NC12775-10     | 4.31           | 2             | Red            | Loss of Protective Sensation    | Diminished Protective Sensation |
| NC12775-11     | 4.56           | 4             |                |                                 |                                 |
| NC12775-12     | 4.74           | 6             |                |                                 |                                 |
| NC12775-13     | 4.93           | 8             |                |                                 |                                 |
| NC12775-14     | 5.07           | 10            |                |                                 |                                 |
| NC12775-15     | 5.18           | 15            |                |                                 |                                 |
| NC12775-16     | 5.46           | 26            |                |                                 |                                 |
| NC12775-17     | 5.88           | 60            |                |                                 |                                 |
| NC12775-18     | 6.10           | 100           |                |                                 |                                 |
| NC12775-19     | 6.45           | 180           |                |                                 |                                 |
| NC12775-20     | 6.65           | 300           |                | Deep Pressure Sensation Only    | Deep Pressure Sensation Only    |

\* Individually calibrated within a 5% standard deviation.

### Touch-Test™ Sensory Evaluators and Accessories:

| Product Number                                                                               | Description                                                                   |
|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| NC12775                                                                                      | Touch-Test™ 20 Piece Full Kit                                                 |
| NC12774                                                                                      | Touch-Test™ Complete Foot Kit (6 Piece Kit, Screening Forms, Colored Pencils) |
| NC12773                                                                                      | Touch-Test™ 6 Piece Foot Kit (2.83, 3.61, 4.31, 4.56, 5.07, 6.65)             |
| NC12771                                                                                      | Touch-Test™ Complete Hand Kit (5 Piece Kit, Screening Forms, Colored Pencils) |
| NC12772                                                                                      | Touch-Test™ 5 Piece Hand Kit (2.83, 3.61, 4.31, 4.56, 6.65)                   |
| NC12775-14                                                                                   | Touch-Test™ Sensory Evaluator 5.07 (10 grams of force*)                       |
| ▲ See NC12775-01 thru NC12775-20 for Individual Replacement Touch-Test™ Sensory Evaluators ▲ |                                                                               |
| NC12749                                                                                      | Foot Screening Forms (pad of 100)                                             |
| NC12750-1                                                                                    | Hand Screening Forms (pad of 100)                                             |
| NC12756                                                                                      | Colored Pencils Set                                                           |
| NC12780                                                                                      | Touch-Test™ Training Video-FREE                                               |

The following reference can be used for more detailed instructions:

*Rehabilitation of the Hand: Surgery and Therapy*, Mosby; ed. Hunter, Macken, Callahan; Vol 1, 4th Edition; Chapter 9, 1995

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