UNIVERSITI PUTRA MALAYSIA

PREVALENCE OF MUSCULOSKELETAL DISORDER AND ITS ASSOCIATION WITH RISK FACTORS AMONG VEHICLE SERVICE TECHNICIANS IN KLANG VALLEY, MALAYSIA

AHMAD FAISAL BIN AHMAD NASARUDDIN

FPSK(m) 2016 51

PREVALENCE OF MUSCULOSKELETAL DISORDER AND ITS ASSOCIATION WITH RISK FACTORS AMONG VEHICLE SERVICE TECHNICIANS IN KLANG VALLEY, MALAYSIA

By

AHMAD FAISAL BIN AHMAD NASARUDDIN

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

November 2016

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

PREVALENCE OF MUSCULOSKELETAL DISORDER AND ITS ASSOCIATION WITH RISK FACTORS AMONG VEHICLE SERVICE TECHNICIANS IN KLANG VALLEY, MALAYSIA

By

AHMAD FAISAL BIN AHMAD NASARUDDIN

November 2016

Chair: Assoc. Prof. Shamsul Bahri bin Hj. Mohd Tamrin, PhD
Faculty: Medicine and Health Science

Introduction: The primary objective of this study is to determine the association between risk factors and the prevalence of Musculoskeletal Disorder (MSD) among vehicle technicians in Klang Valley, Malaysia. **Methodology:** This cross-sectional study was conducted at eight vehicle service centers in Klang Valley, Malaysia. One hundred and ninety one technicians were recruited. A modified version of the general Standardised Nordic Questionnaire was used for analyses of perceived MSD in nine different parts of the body (neck, shoulder, elbow, arms, upper back, lower back, thigh, knee and legs). Rapid Upper Limb Assessment (RULA) test had been done to determine the work posture of the respondent and hand vibration had been measured. Independent Chi-square test was used to determine the significant association between MSD prevalence and the risk factors. Binary logistic regression was performed to assess the association between risk factors on the MSD prevalence. The probability limits for evaluating statistical significance was $p < 0.05$. **Results:** The prevalence of MSD among vehicle service technicians is 82.7% and suffered from MSD especially on body parts which are shoulder 62.3%, legs 61.8%, neck 59.2% and lower back 56 %. The logistic regression shows significant association between MSDs and job demand OR=3.713 (95% C.I.=1.121-12.290, p=0.012). BMI and monthly income also show significant association with OR=4.661 (95% C.I.=1.204-18.030, p=0.025) and OR=4.770 (95% C.I.=1.393-16.330, p=0.012) respectively. **Conclusion:** Service technicians at vehicle service centers in Klang Valley are likely to be exposed to a variety of ergonomic hazards and risk factors. Therefore, ergonomics awareness among employer and employee with training and information sharing shall be increase to reduce the prevalence of MSDs.

Keywords: Musculoskeletal disorder, automotive, job demand

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

KELAZIMAN GANGGUAN MSD DAN KAITANNYA DENGAN FAKTOR-FAKTOR RISIKO DI KALANGAN JURUTEKNIK MENYELENGGARA KENDERAAN DI LEMBAH KLANG MALAYSIA

Oleh

AHMAD FAISAL BIN AHMAD NASARUDDIN

November 2016

Pengerusi: Assoc. Prof. Shamsul Bahri bin Hj. Mohd Tamrin, PhD
Faculty: Fakulti Perubatan dan Sains Kesihatan

Pengenalan: Objektif utama penyelidikan ini adalah untuk mengenal pasti hubungan antara factor-faktor risiko dan kelaziman gangguan MSD di kalangan juruteknik menyelenggara kenderaaan di Lembah Klang, Malaysia. **Metodologi:** Kajian keratan rentas ini telah dijalankan di lapan cawangan pusat servis di Lembah Klang, Malaysia. Satu ratus dan sembilan puluh satu telah mengambil bahagian. Soalan kajian Standardised Nordic Questionnaire telah diterjemahkan kepada Bahasa Melayu bagi menganalisa masalah gangguan MSD pada 9 bahagian badan (leher, bahu, siku, lengan, atas belakang, bawah belakang, paha, lutut dan kaki). Penilaian postur dengan menggunakan Rapid Upper Limb Assessment (RULA) bagi mengenalpasti postur kerja dan ujian tangan getaran telah diambil daripada juruteknik. Ujian Chi-square telah digunakan bagi mengenal pasti hubungan antara kelaziman gangguan MSD dan faktor-faktor risiko. Binari regresi logistik telah dijalankan bagi menilai hubungkait antara faktor-faktor risiko dan kelaziman sakit otot rangka. Had kebarangkalian untuk menilai kepentingan statistik adalah $p < 0.05$. **Keputusan:** Kelaziman gangguan MSD di kalangan juruteknik adalah sebanyak 82.7% dan peratusan pada anggota badan tertentu iaitu pada bahu 62.3%, kaki 61.8%, leher 59.2% dan bawah belakang 56 %. Keputusan binari regresi logistik menunjukkan hubungan yang ketara antara gangguan MSD dan permintaan pekerjaan dengan (OR=3.713 95% C.I.=1.121-12.290, p=0.012). BMI dan jumlah pendapatan bulanan juga menunjukkan hubungan yang ketara dengan (OR=4.661 95% C.I.=1.204-18.030, p=0.025) and (OR=4.770 95% C.I.=1.393-16.330, p=0.012). **Kesimpulan:** Juruteknik di pusat servis di Lembah Klang mungkin akan terdedah kepada pelbagai bahaya dan faktor-faktor risiko ergonomik. Oleh itu, kesedaran ergonomik di kalangan majikan dan pekerja perlu dipertingkatkan dengan latihan dan perkongsian maklumat tentang gangguan MSD.

Katakunci: Gangguan MSD , otomotif, permintaan pekerjaan

ACKNOWLEDGEMENTS

Alhamdulillah. Thank you, Allah the almighty. Firstly, I would like to take this opportunity to extend my outmost gratitude to Assoc. Prof. Dr. Shamsul Bahri Hj. Mohd Tamrin, my supervisor for his continuous guidance, supervision encouragement and support throughout the completion of this project. Very special thanks to him for his countless ideas and advises which very helpful in answering many uncertainties that arise during the progress of this study.

Special acknowledgement is also extended to Dr Karmegam as a co-supervisor for support encouragement and guidance.

My heartiest gratitude to all the respondents for their cooperation because willingly to spend their time almost to hours as a respondent in this study.

Finally, to all individuals who helped me in making this study come true by lending a hand directly or indirectly, my sincere gratitude and appreciation to all of them.

Thank you.

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

Shamsul Bahri bin Hj. Mohd Tamrin, PhD
Associate Professor
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Chairman)

Karmegam a/l Karuppiah, PhD
Senior Lecturer
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Member)

_____

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

Date:

Declaration by graduate student

I hereby confirm that:

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

Signature: _____ Date: _____

Name and Matric No.: _____

Declaration by Members of Supervisory Committee

This is to confirm that:

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

Signature: _____
Name of Chairman of Supervisory Committee: _____

Signature: _____
Name of Member of Supervisory Committee: _____

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Background

Musculoskeletal disorders (MSDs) have accounted countless compensation days and disability in numerous countries. In United States, the direct cost of MSDs was $1.5 billion in the year 2007. The indirect costs were $1.1 billion for MSDs for the same year (Bhattacharya, 2014).

Musculoskeletal symptoms are prevailing and their influence is extensive. MSDs are the most frequent cause of serious lifelong illness and physical disability. MSDs influence hundreds of millions people globally too. MSD greatly impact psychosocial level of those who experience it, their family and caretaker (Woolf & Pfleger, 2003). Musculoskeletal syndromes are a various category that links to path of physiology but are connected to pain and weakened bodily system. The conditions of MSDs include a critical occurrence that could last for short duration or are permanent like rheumatoid arthritis, osteoporosis, osteoarthritis and lower back pain.

Musculoskeletal pain is a common issue among those who working in vehicle servicing industries. Researchers have investigated the occurrence of musculoskeletal pain and possible risk factors for such pain among vehicle service technicians (Nasrull et al., 2010; Torp et al., 2001; Vyas et al. 2011). A vehicle body shape is not adjustable hence it requires employees to adapt physically during the servicing process that included working inside, underneath or around the vehicle. Vehicle services are mostly dominated by men and they are usually young in age (Åström et al., 2006). Vehicle service industries have developed from using traditional manual hand tools to using hand power pneumatic tools, vehicle lifts and electronic diagnosis to check for any engine default. Despite these improvements, the service process is still challenging for employees and this might be linked to MSDs.

Working in a comfortable environment at a workplace can reduce injuries, avoid risk factor and also reduce the working time. People have become aware that occupational psychosocial aspects could influence musculoskeletal disorders. These risk factors consist of repetition, forceful exertions, false postures, contact stress, and segmental vibration. In addition, ergonomic hazards are identified in the work of automotive service technicians. This is caused by several factors such as physical exposures which include forceful exertion at upper and lower extremities as well as segmented vibration. Even though ergonomics assessment is considered for the vehicle designs for those who work in automotive manufacturing, vehicle designs for automotive maintenance appear to be neglected. Therefore, this study is conducted with the objective: to determine the prevalence of MSDs and the association with risk factors among vehicle service technicians. Hence, improvements can be

made to limit or eliminate the risk factors of MSDs at the workplace.

1.2 Problem statement

Among all factors of disabilities, MSDs make the second place and this is as identified by the global years lived with disability. MSDs influence hundreds of millions people globally. Presently, the estimation of people experiencing MSDs are 632 million for back pain, 332 million for neck strain, 250 million for osteoarthritis (OA) knee and 560million for other musculoskeletal conditions (Bone and Joint Decade, 2012).

It had been reported by Social Security Organization (SOCSO) (2012, 2013 & 2014), there is an increasing on the number of occupational diseases and benefit paid according to causal of occupational musculoskeletal disorders as shown in Figure 1.1.

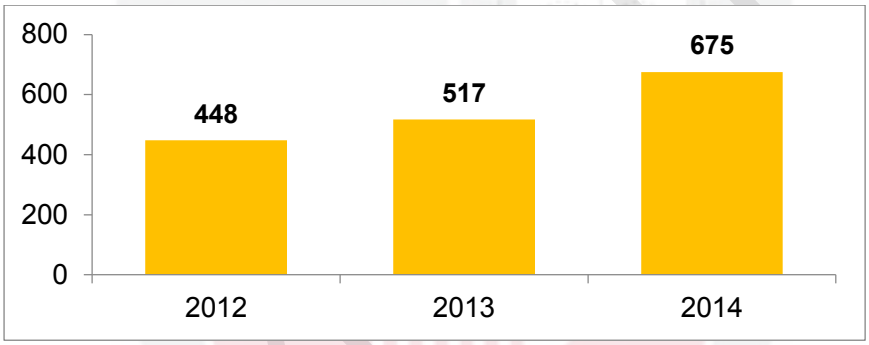

Figure 1.1: Number of occupational diseases and benefit paid according to causal of occupational musculoskeletal disorders
(Source: Social Security Organization, 2012, 2013 & 2014)

In 2014, a total of 1169 number cases of invalidity caused by disease of the musculoskeletal system have been reported to the Social Security Organization, and reported as the highest numbers of invalidity compared to other causal of disease as shown in Figure 1.2. The total benefit payment for invalidity pension and grant for 2014 is 496.82 million ringgit Social Security Organization (SOCSO) (2014).

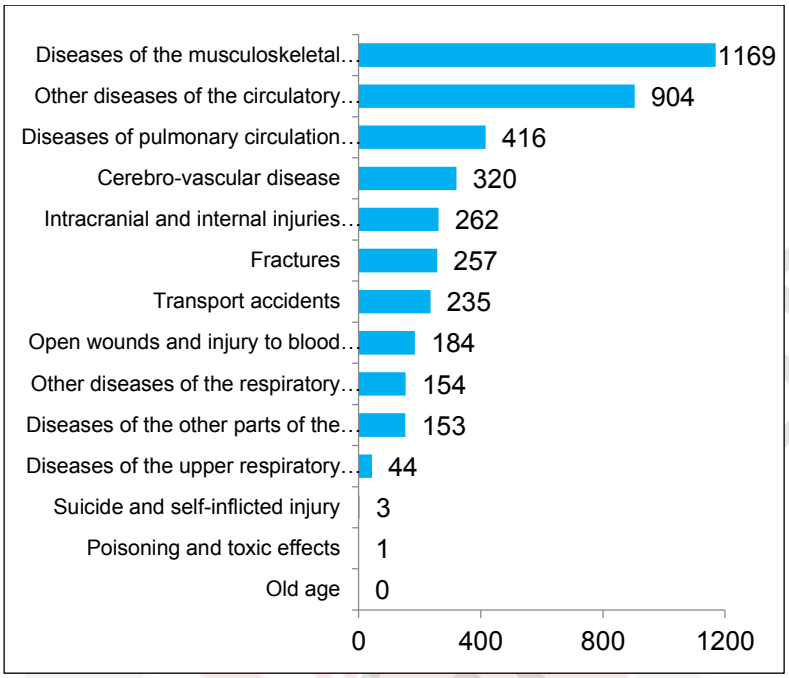

Figure 1.2: Number of invalidity cases reported
(Source: Social Security Organization, 2014)

According to Malaysian Development Investment Authority (MIDA), Malaysia is one of the countries in the South East Asia (ASEAN) with high volume of vehicles due to economic stability and high purchasing power. Based on statistic from Malaysian Investment Development Authority (2014), Malaysia showed the third highest total vehicle sales in the ASEAN (Figure 1.3).

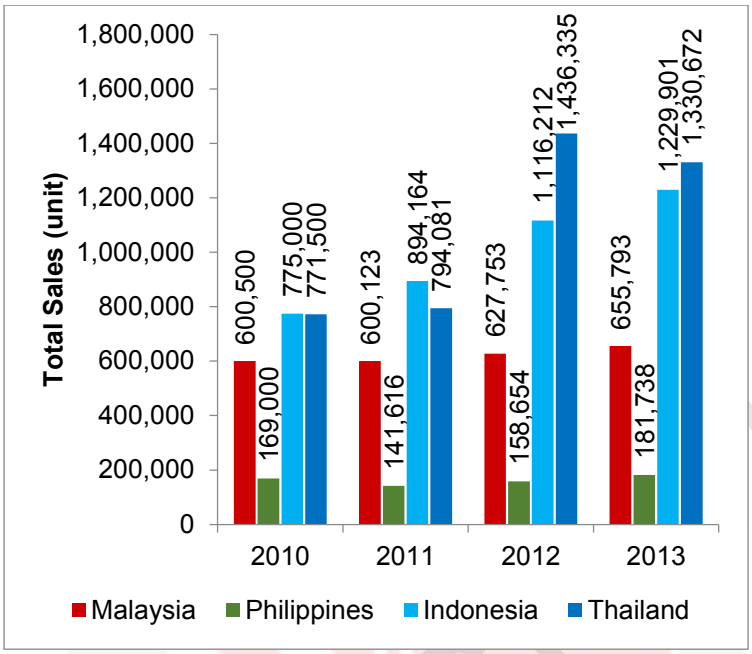

Figure 1.3: Vehicle sales in four major ASEAN countries from 2010 to 2013

(Source: Malaysian Investment Development Authority, 2014)

Due to the increasing demands of vehicles, hence, the necessity for services and maintenance of vehicles which are equally on the rise. According to Department of Statistics Malaysia, (2008) there are approximately 18, 000 service outlets for vehicle services and maintenance in Malaysia with total of 209,835 employees.

According to the study conducted by Nasrull (2010) on the MSDs study in vehicle servicing industries, it was found that the prevalence of MSDs prevalence in vehicle servicing industries is 91.7%. According to Department of Statistics Malaysia, the total vehicle service employees in Malaysia are 209,835 employees. Therefore, the number of possible employees to get the MSDs is 192,419 employees.

In Malaysia, there is no study conducted to determine the prevalence of MSDs among those who working in vehicle servicing industries. Therefore, this study will be an inaugural study in Malaysia to determine the prevalence of MSDs among vehicle service technicians.

1.3 Study justification

This study will provide the data based on the current prevalence of MSDs among those who working in vehicle servicing industries in Malaysia. It is acknowledged that although there are many vehicle services outlet in Malaysia,

the effects of the workplace risk factors to MSDs among vehicle service technician has not been highlighted. In Malaysia there is no research on the MSDs association with workplace risk factors among vehicle service technician.

Even though no cases specifically reported on the MSDs among vehicle service technician in Malaysia, it is suspected that several number of patient suffered MSDs cause by exposure to the workplace risk factors. Therefore, this study was conducted to determine relationship between MSDs and workplace risk factors among vehicle service technicians in Klang Valley.

Due to the lack of studies conducted in this area in Malaysia, the information and results from this study will be used as baseline data for further study. The data can also be used by enforcement bodies such as the Department of Occupational Safety and Health (DOSH) in facilitating them in focusing the enforcement to the correct target group. The study may improve the safety and health of the workers, as it will allow the problem to be detected at early stages.

1.4 Conceptual framework

This study is to determine the association between risk factors and the prevalence of MSD among vehicle technicians in Klang Valley.

The vehicle service technician exposed to the various type of MSDs risk factors during perform their daily task such as ergonomics occupational factors, psychosocial work factors, workplace environment factors, lifestyle factors, psychological factors and demography factors.

There are four common ergonomics risks present among vehicle service technician namely awkward posture, forceful exertion, vibration and repetition. Among all the risk factors, only three ergonomics risk factors is considered may give an effect to the MSDs namely awkward posture, forceful exertion and hand arm vibration. Repetition risk factor was neglected from this study since the operation of the technician is a various process which depended on the type of vehicle and type of service work process. The postures performed by vehicle service technicians were analysed using Rapid Upper Limb Assessment (RULA) that will be discussed in Methodology section. The postures performed by vehicle service technicians when the height of the work area is inconvenient led to an awkward posture; especially in a bending position. It was apparent that the workers practiced a limited number of positions with the vehicle. Each of this position was associated with a specific set of awkward posture and contact stress risk factors but was not dependent on the task being executed. These risk factors were influenced by the size of the vehicle and to a lesser extent by the size of the service technician. A study done by Vyas, (2011) among automobile repair technician found that awkward postures, challenging occupational requirements and manual handling would cause strain, muscle fatigue, lethargy. Moreover, strenuous work postures practiced by technicians increase the symptoms of MSDs (OR 1.8, 95%CI 1.5–22.2) (Vyas et al., 2011). Another ergonomic factor that may influence the

occurrence of MSD is the force of exertion. Vehicle maintenance technicians must carry heavy pneumatic wrenches and heavy tires in addition to suffering stress from tire handling operations. This is called over-exertion and it can result in musculoskeletal damage (Denis et al., 2008). A study conducted in automotive plant identified that physical exertion was associated with the MSDs (neck: OR 5.6, 95%CI 1.8-21.2, shoulder: OR 4.9, 95%CI 1.4-20.4, lower back: OR 6.4, 95%CI 2.0-24.4) (Fredriksson et al., 2001). Technicians endure overexertion to achieve a shorter time of servicing process. In order to achieve that, they usually work while bending their neck and backs together with repetitious hand and finger gestures.

The last risk factor that will be focused on in this study is hand-arm vibration (HAV). HAV is transmitted from the hand power tool to technicians' necks which leads to muscle and joint strains (Åström et al., 2006). However, HAV might indirectly impact neck and shoulders when a static posture is regularly practiced hence muscular burden is raised. It is well-known that people will likely escalate their grip force when they handle HAV tools(Åström et al., 2006).

The second factor for MSD is psychosocial work factors such as unrewarding work, lack of control from management and job demand. The prevalence of work-related MSDs is said to be linked to excessive physical occupational requirement. For instance, it is analysed that a minimum of one-third employees who face more physical occupational requirement are likely to be affected with MSDs than those who do not face it which is only 10%. Additionally, occupational MSDs are likely to affect those who face administrative and psychosocial job stresses (e.g. job strain, effort-reward inequality, emotionally challenging task, tense circumstances, and psychological and sexual harassment). The occurrence of occupational MSDs also increases up to 40% among employees who face all of the four physical occupational requirements and administrative job stress. This is also linked to psychological affliction and depressing symptoms among male and female employees (Vezina et al.,2010). The third factor for MSDs is workplace factors such as income, overtime and incentive rate that may lead to job dissatisfaction. A study by Da Costa and Vieira, 2010, showed that the increased level of job dissatisfaction affects the OR for musculoskeletal symptoms to be high as well. The fourth factor is psychosocial factors that were analysed using general health questionnaire 12 (GHQ-12) that will be discussed in Methodology section. The final factor is social demographic factor like age, body mass index and smoking habit had been reported as a cofounding risk factors influencing MSD. A study by Veira et al., (2008) reported that smoking and overweight associated with MSD with OR=2 and OR 1.38 respectively (Vieira et al., 2008).

Therefore, it is very important to determine the association between risk factors and the prevalence of MSD among vehicle technicians at the early stage. Figure 1.4 shows the summary of all the factors and the study variables.

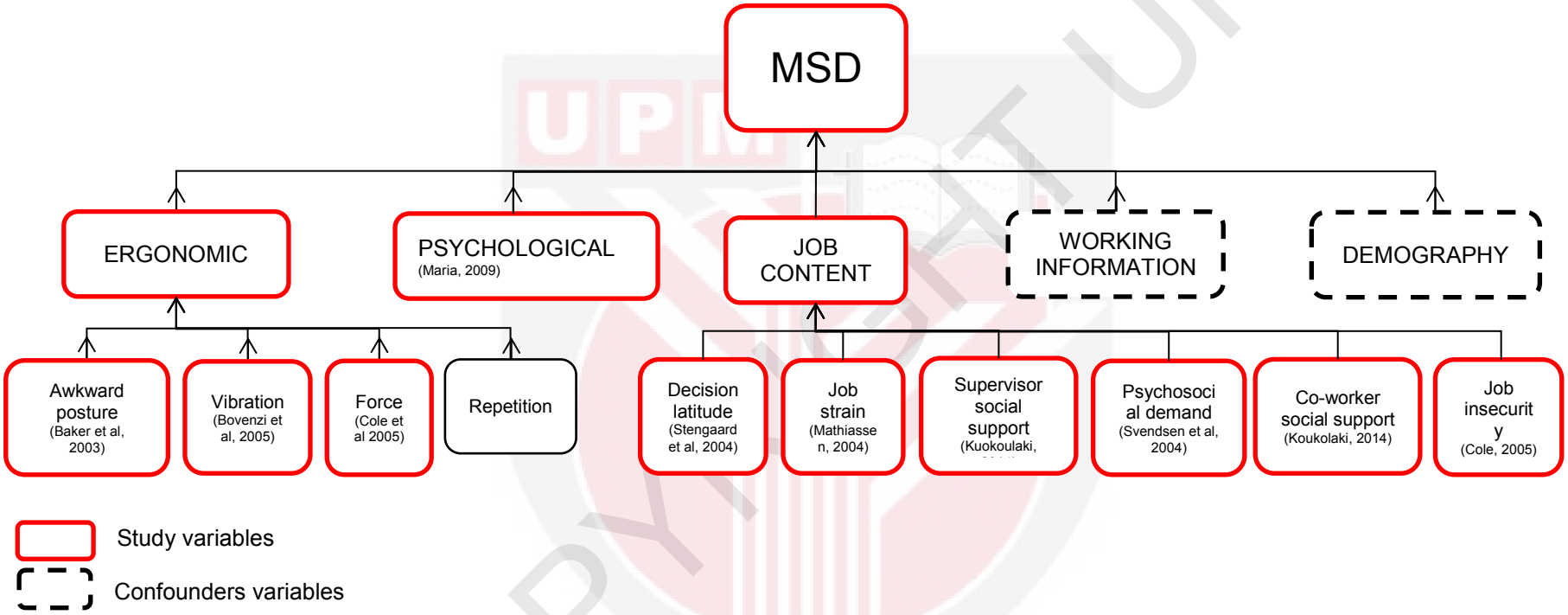

Figure 1.4: Conceptual frameworks of factors contributing to musculoskeletal disorder among vehicle technicians in Klang Valley.

1.5 Research objective

1.5.1 General objective

To identify the association between risk factors and the prevalence of MSD among vehicle technicians in Klang Valley.

1.5.2 Specific objectives

1) To identify the prevalence of MSD among technicians.
2) To identify the working posture adapted and the association with MSD among vehicle service technicians.
3) To determine the accurate magnitude of vibration and the association with MSD among vehicle service technicians.
4) To determine the work forceful exertion and the association with MSD among vehicle service technicians.
5) To determine the work psychosocial factors and the association with MSD among vehicle service technicians.
6) To determine the psychological factors and the association with MSD among vehicle service technicians.
7) To determine the association of multivariate factors from working posture adapted, magnitude vibration, forceful exertion, work psychosocial and psychological factors and MSD among vehicle service technicians.

1.6 Hypothesis

1) There is significant association between poor working posture and MSD among vehicle service technicians.

2) There is significant association between exposure of hand above permissible level of vibration and MSD among vehicle service technicians.

3) There is significant association between high level of forceful exertion and MSD among vehicle service technicians.

4) There is significant association between high level of work psychosocial and MSD among vehicle service technicians.

5) There is significant association between high level of psychological depression and MSD among vehicle service technicians.

6) Poor working posture, exposure of hand arm vibration above the permissible level, high level of forceful exertion, high level of work psychosocial and high level psychological depression are the most influences factors to the MSD among vehicle service technicians.

1.7 Definition of variables

Dependent variable: Prevalence of MSD
Independent variable: Poor working posture, exposure of hand on above permissible level of vibration, great amount of forceful exertion, great amount of job psychosocial factors and high level of psychological depression.

Confounders variable: Age, body mass index, smoking habit, working overtime, and working incentives.

1.8 Terminology

1.8.1 Musculoskeletal disorders (MSDs)

Conceptual Definition

Musculoskeletal disorders (MSDs) are injuries and disorders that affect the human body's movement or musculoskeletal system (i.e. muscles, tendons, ligaments, nerves, discs, blood vessels, etc.).

Operational Definition

MSDs symptoms were identified using Standardized Nordic Questionnaire (Kourinka et al., 1987) by answering either 'Yes' or 'No'. Prevalence of musculoskeletal symptoms were identified at 9 body parts area which area neck, shoulder, elbow, arms, upper back, lower back, thigh, knees and legs.

1.8.2 Awkward posture

Conceptual Definition

Awkward or false posture concerns with how a body is positioned during an occupational activity. Awkward posture is linked to a greater consequence of injury. It is believed that when a joint is stretched beyond the recommended limit, it will increase the risk of injury (Michael, 2002).

Operational Definition

Awkward posture is obtained from the posture assessment: Rapid Upper Limb Assessment (RULA) or Rapid Entire Body Assessment (REBA) that will be discussed in Methodology.

1.8.3 Hand arm vibration

Conceptual Definition

Hand-arm vibration (HAV) is an extensive threat in numerous organizations and professions which includes the handling of hand-held tools (like grinders or hammer drills), hand-control machines (like lawnmowers and plate compactors) or hand-fed machines (like pedestal grinders). Constant and customary contact vibration might influence employees' health which might result with pain or dysfunction the nerves, blood supply, joints, and hand as well as arm muscles (Health & Safety Executive (HSE) UK, 2005).

Operational Definition

Hand arm vibration (HAV) is measured to get a value in m/s^2A (8) units. HSE UK introduced Vibration regulation 2005 on the Exposure Action Value and Exposure Limit Value for HAV (Health & Safety Executive (HSE) UK, 2005).

Exposure Action Value : 2.5 m/s^2 A(8)

Exposure Limit Value : 5 m/s^2 A(8)

1.8.4 Forceful exertion

Conceptual Definition

Forceful exertions occur when a lot of physical efforts are needed to do a task. For example, manual tasks that require human to pick up, push, pull, transport and operate a tool or machine.

Operational Definition

Borg rating perceives exertion category ratio (CR) scale is used to determine the rating of force exertion. CR scale positions verbal expressions on a ratio scale based on quantitative nature (Borg, 1990). Numbers from 0 to 10 are used to with regard of the regular form of the scale. Perceptual responses that are really strong are implied by the number 10. Examples of activities that fall under this category are running in a fast speed or lifting and carrying particularly heavy weights. Number 10 is the highest degree of strain that one may experience.

1.8.5 Job demands

Conceptual Definition

Job demand or occupational requirement is defined as pressure that arise from anxiety in completing certain assignments, doing unanticipated duties and facing occupational personal problem (Karasek, 1985).

Operational Definition

Job demands may be derived from the measurement of five questions in the core Job Content Questionnaire (JCQ) version. To eliminate neutral answer during JCQ measurement scale 4 points Likert-type scale, ranging from 1= strongly disagree to 4= strongly agree has been used in the study.

1.8.6 Job strain

Conceptual Definition

Job strain is known as increased psychological demand during lack of judgement circumstances (decision latitude).(Job Strain and the Prevalence and Outcome of Coronary Artery Disease, 1995)

Operational Definition

Job strain may be obtained from the method of Karasek, (1985). Responses to job statements with 4-points scale: 4, strongly agree; 3, agree; 2, disagree; and 1, strongly disagree. Items are categorized into two scales (decision latitude and psychological demands), with the formula below (Karasek, 1985).

$$Job\ strain\ index = \frac{(32 - Decision\ latitude)}{32 - 8}$$

1.8.7 Body Mass Index (BMI)

Conceptual Definition

The BMI is defined as the body mass divided by the square of the body height, and is universally expressed in units of kg/m^2, resulting from mass in kilograms and height in metres.

Operational Definition

Calculation of body weight and the height of a person is done using the formula below:

$$BMI = \frac{Weight\ (kg)}{[Height\ (m)]^2}$$

REFERENCES

Abledu, J. K. & Abledu, G. K. (2012). Multiple logistic regression analysis of predictors of musculoskeletal disorders and disability among bank workers in Kumasi, Ghana. *J Ergonomics*, 2: 111

Abou-ElWafa, H. S., El-Bestar, S. F., El-Gilany, a.-H., & Awad, E. E.-S. (2012). Musculoskeletal disorders among municipal solid waste collectors in Mansoura, Egypt: a cross-sectional study. *BMJ Open*, *2*(5): 1338.

Abousleiman, R. I., & Sikavitsas, V. I. (2006). Bioreactors for tissues of the musculoskeletal system. *Advances in Experimental Medicine and Biology*, 585: 243–259.

Andersen, J. H., Haahr, J. P., & Frost, P. (2007). Risk factors for more severe regional musculoskeletal symptoms: A two-year prospective study of a general working population. *Arthritis and Rheumatism*, 56(4): 1355–1364.

Anita, A. R., Yazdani, A., Hayati, K. S., & Adon, M. Y. (2014). Association between Awkward Posture and Musculoskeletal Disorders (MSD) among Assembly Line Workers in an Automotive Industry. *Malaysian Journal of Medicine and Health Sciences,* 10(10): 23-28

Antonopoulou, M. D., Alegakis, A. K., Hadjipavlou, A. G., & Lionis, C. D. (2009). Studying the association between musculoskeletal disorders, quality of life and mental health. A primary care pilot study in rural Crete, Greece. *BMC Musculoskeletal Disorders*, 10:143.

Armstrong, T. J., Fine, L. J., Radwin, R. G., & Silverstein, B. S. (1987). Ergonomics and the effects of vibration in hand-intensive work. *Scandinavian Journal of Work, Environment and Health*, *13*(4): 286–289.

Armstrong, T. J., Marshall, M. M., Martin, B. J., Foulke, J. a., Grieshaber, D. C., & Malone, G. (2002). Exposure to forceful exertions and vibration in a foundry. *International Journal of Industrial Ergonomics*, 30(3): 163–179.

Åström, C., Rehn, B., Lundström, R., Nilsson, T., Burström, L., & Sundelin, G. (2006). Hand-arm vibration syndrome (HAVS) and musculoskeletal symptoms in the neck and the upper limbs in professional drivers of terrain vehicles-A cross sectional study. *Applied Ergonomics*, 37: 793–799.

ASEAN Automotive Federation. (2014). *ASEAN Automotive Statistic as at January 2014*. Retrieved from http://www.asean-autofed.com/statistics.html.

Deros, B.M., Dian Darina Indah Daruis, Ahmad Rasdan Ismail, Nurfarhana Abdul Sawal, & Jaharah A. Ghani. (2010). Work-Related Musculoskeletal Disorders among Workers ' Performing Manual Material Handling Work in an Automotive Manufacturing Company Baba Md . Deros , Dian Darina Indah Daruis , Ahmad Rasdan Ismail , Nurfarhana Abdullah Sawal and Jaharah A . Ghani Depar. *American Journal of Applied Sciences*, *7*(8): 1087–1092.

Baker, P., Reading, I., Cooper, C., & Coggon, D. (2003). Knee disorders in the general population and their relation to occupation. *Occupational and Environmental Medicine*, 60: 794–797.

Barregard, L., Ehrenström, L., & Marcus, K. (2003). Hand-arm vibration syndrome in Swedish car mechanics. *Occupational and Environmental Medicine*, 60: 287–294.

Bhattacharya, A. (2014). Costs of occupational musculoskeletal disorders (MSDs) in the United States. *International Journal of Industrial Ergonomics*, 44(3): 448–454.

Bernard, B.P. (1997). Musculoskeletal disorders and workplace factors: A critical review of epidemiologic evidence of work-related musculoskeletal disorders of the neck, upper extremity, and lower back. *National Institute for Occupational Safety and Health,* 97-141

Choong P., Brooks P. (2012). Achievements during the Bone and Joint Decade 2000-2010. *Best Practical Research Clinical Rheumatol,* 26(2):173-81.

Borg, G. (1990). Psychophysical scaling with applications in physical work and the perception of exertion. *Scandinavian Journal of Work, Environment and Health*, *16*(c): 55–58.

Bovenzi, M., Della Vedova, A., Nataletti, P., Alessandrini, B., & Poian, T. (2005). Work-related disorders of the upper limb in female workers using orbital sanders. *International Archives of Occupational and Environmental Health*, *78*(4): 303–310.

Burt, S. E., & Fine, L. J. (1997). Musculoskeletal Disorders and Workplace Factors. *National Institute for Occupational Safety and Health*, (July 1997).

Bylund, S. H., Burstrom, L., & Knutsson, A. (2002). A descriptive study of women injured by hand-arm vibration. *The Annals of Occupational Hygiene*, 46(3): 299–307.

Callaghan, J. P., & McGill, S. M. (2001). Intervertebral disc herniation: studies on a porcine model exposed to highly repetitive flexion/extension motion with compressive force. *Clinical Biomechanics*, 16(1): 28–37.

Carmona, L., Ballina, J., Gabriel, R., & Laffon, a. (2001). The burden of musculoskeletal diseases in the general population of Spain: results from a national survey. *Annals of the Rheumatic Diseases*, 60(11): 1040–1045.

Carton, R. L., & Rhodes, E. C. (1985). A critical review of the literature on ratings scales for perceived exertion. *Sports Medicine (Auckland, N.Z.)*, 2(3): 198–222.

Chan, A., Chen, Y. P., Xie, Y., Wei, Z., & Walker, C. (2014). Disposable Bodies and Labor Rights : Workers in China ' s Automotive Industry, *Working USA: The Journal of Labor and Society* 17: 509–529.

Choobineh, A., & Movahed, M., Tabatabaie S.H., Kumashiro M. (2010). Perceived demands and musculoskeletal disorders in operating room nurses of Shiraz city hospitals, *Industrial Health*, 48(1):74-84.

Coggon, D., Ntani, G., Palmer, K. T., Felli, V. E., Harari, R., Barrero, L. H., Gray, A. (2013). Disabling musculoskeletal pain in working populations: Is it the job, the person, or the culture? *Pain*, 154(6):856-63.

Cole, D. C., Ibrahim, S. a, Shannon, H. S., Scott, F., & Eyles, J. (2001). Work correlates of back problems and activity restriction due to musculoskeletal disorders in the Canadian national population health survey (NPHS) 1994-5 data. *Occupational and Environmental Medicine*, 58(11): 728–734.

Cole, D. C., Ibrahim, S., & Shannon, H. S. (2005). Predictors of work-related repetitive strain injuries in a population cohort. *American Journal of Public Health*, 95(7), 1233–1237.

d'Errico, A., Gore, R., Gold, J. E., Park, J. S., & Punnett, L. (2007). Medium- and long-term reproducibility of self-reported exposure to physical ergonomics factors at work. *Applied Ergonomics*, 38: 167–175.

Denis, D., St-Vincent, M., Imbeau, D., Jetté, C., & Nastasia, I. (2008). Intervention practices in musculoskeletal disorder prevention: A critical literature review. *Applied Ergonomics*, 39: 1–14.

Department of Statistics Malaysia. (2008). Retrieved from http://www.statistics.gov.my

Department of Occupational Safety and Health's Guidelines for Hazard Identification, Risk Assessment and Risk Control (HIRARC). (2008). Retrieved from http://www.dosh.gov.my.

Department of Occupational Safety and Health's Annual Report. (2008 & 2009). Retrieved from http://www.dosh.gov.my.

Department of Occupational Safety and Health's Statistic. (2014). Retrieved from http://www.dosh.gov.my.

Deros, B.M., Daruis, D. D. I., Ismail, A. R., & Rahim, A. R. A. (2010). Work posture and back pain evaluation in a Malaysian food manufacturing company. *American Journal of Applied Sciences*, 7(4): 473–479.

Feveile, H., Jensen, C., & Burr, H. (2002). Risk factors for neck-shoulder and wrist-hand symptoms in a 5-year follow-up study of 3,990 employees in Denmark. *International Archives of Occupational and Environmental Health*, 75(4): 243–251.

Fredriksson, K., Alfredsson, L., Thorbjornsson, C. B., Punnett, L., Toomingas, A., Torgen, M., & Kilbom, A. (2000). Risk factors for neck and shoulder disorders: a nested case-control study covering a 24-year period. *American Journal of Industrial Medicine*, 38(5): 516–528.

Fredriksson, K., Bildt, C., Hägg, G., & Kilbom, Å.˚. (2001). The impact on musculoskeletal disorders of changing physical and psychosocial work environment conditions in the automobile industry. *International Journal of Industrial Ergonomics*, 28: 31–45.

Gangopadhyay, S., Ghosh, T., Das, T., Ghoshal, G., & Das, B. B. (2007). Prevalence of upper limb musculo skeletal disorders among brass metal workers in West Bengal, India. *Industrial Health*, 45: 365–370.

Gili, M., Ferrer, V., Roca, M., & Bernardo, M. (2000). Psychiatric disorders and medical comorbidity in a community epidemiological study. *Psichotema,* 12: 131-135.

Gironimo, G. Di, Martino, C. Di, Lanzotti, A., Marzano, A., Russo, G., Tecchio, P., & Arco, P. D. (2010). A Virtual Ergonomics approach to predetermine after-sales services times in automotive industry. *Evaluation*, 1–6.

Goldberg, D. P., Gater, R., Satorius, N., Ustun, T. B., Piccinelli, M., Gureje, O., & Rutter, M. (1997). The validity of two versions of the GHQ in the WHO study of mental illness in general health care. *Psychological Medicine*, 27: 191-197

Goldberg, D. P., & Hillier, V. F. (1979). A scaled version of the General Health Questionnaire. *Psychological Medicine,* 9: 139-145

Hansson, J. E., Eklund, L., Kihlberg, S., & Ostergren, C. E. (1987). Vibration in car repair work. *Applied Ergonomics*, 18(1): 57–63.

Health and Safety (The control of Vibration at Work) Regulations 2005, United Kingdom Health and Safety Regulations

Hincapié-Ramos, J., & Guo, X. (2014). Consumed Endurance: A metric to quantify arm fatigue of mid-air interactions. *In Proceedings of the 32nd annual ACM conference on Human factors in computing systems* 1063–1072.

Houtman, I., Jettinghof, K., & Cedillo, L. *Raising awareness of stress at work in developing countires : a modern hazard in a traditional working environment : advice to employers and worker representatives*. World Health Organization, Geneva 2007.

Hussain, T. (2004). Musculoskeletal symptoms among truck assembly workers. *Occupational Medicine*, 54: 506–512.

IJzelenberg, W., & Burdorf, A. (2005). Risk factors for musculoskeletal symptoms and ensuing health care use and sick leave. *Spine*, 30(13): 1550–1556.

International Organization for Standardization. *Mechanical vibration-Guidelines for the measurement and the assessment of human exposure to hand-transmitted vibration.* Geneva: ISO, 1986:5349

International Organization for Standardization. *Mechanical vibration-measurement and evaluation of human exposure to hand-transmitted vibration-Part 1: General requirements.* Geneva: ISO, 2001:5349-1

International Organization for Standardization. *Mechanical vibration-measurement and evaluation of human exposure to hand-transmitted vibration-Part 2: Practical guidance for measurement at the workplace*. Geneva: ISO, 2002:5349-2

Jordan, K. P., Jöud, A., Bergknut, C., Croft, P., Edwards, J. J., Peat, G., Englund, M. (2014). International comparisons of the consultation prevalence of musculoskeletal conditions using population-based healthcare data from England and Sweden. *Annals of the Rheumatic Diseases*, 73: 212–8.

Jung, W., Banholzer, B., Brameshuber, W. (2005). Analytical simulation of pull-out tests-the direct problem. *Cement and Concrete Composites,* 27: 931-101.

K Abledu, J. (2012). Multiple Logistic Regression Analysis of Predictors of Musculoskeletal Disorders and Disability among Bank Workers in Kumasi, Ghana. *Journal of Ergonomics*, 02(04): 10–13.

Karasek, Robert; Brisson, Chantal; Kawakami, Norito; Houtman, Irene; Bongers, Paulien; Amick, Benjamin (1998). The Job Content Questionnaire (JCQ): An instrument for internationally comparative assessments of psychosocial job characteristics. *Journal of Occupational Health Psychology,* 3(4): 322-355

Kee, D., & Lee, I. (2012). Relationships between subjective and objective measures in assessing postural stresses. *Applied Ergonomics*, 43(2): 277–282.

Koukoulaki, T. (2014). The impact of lean production on musculoskeletal and psychosocial risks: An examination of sociotechnical trends over 20 years. *Applied Ergonomics*, 45: 198–212.

Kourinka, Jonsson, B., Kilbom, A., Vinterberg, H., Biering-Sorensen, Andersson, G., Jorgensen, K. (1987). Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Applied Ergonomics,* 18(3): 233-237.

Liker, J. (2003). *The Toyota Way: 14 Management Principles From the World's Greatest Manufacturer* (pp. 25-26). McGraw-Hill Education.

Linton, S. J. (2000). A review of psychological risk factors in back and neck pain. *Spine*, *25*(9): 1148–1156.

Malchaire, J., Piette, A., & Cock, N. (2001). Associations between hand-wrist musculoskeletal and sensorineural complaints and biomechanical and vibration work constraints. *The Annals of Occupational Hygiene*, 45(6): 479–491.

Malaysia Investment Development Authority. (2014). *Business Opportunities: Malaysia's Automotive Industry*. Retrieved from http://www.mida.gov.my.

Malaysia Automotive Association. (2014). Retrieved from http://www.maa.org.my.

Malcolm, H. P., Khengn, L. G., Marianne, L. M. (2002), Spine Ergonomics. *Annu. Rev. Biomed. Eng.*4: 49-68.

Malik, N. (2011). A study on occupational stress experienced by private and public banks employees in Quetta City. *African Journal of Business Management*, 5:3063–3070.

Mark, A., Hlatky, Lai C. L., Kerry, L. L., Nancy, E., Clapp-Channing, Redford, B. W., David, B. P., Robert, M. C., & Daniel, B. M. (1995). Job strain and the prevalence and outcome of coronary artery disease. *American Heart Association,*92: 327-333.

McAtamney, L. & Nigel, C. E. (1993). RULA: A survey method for the investigation of work-related upper limb disorders. *Appl Ergon,* 24(2): 1-9

McGorry, R. W., Lin, J.-H., Dempsey, P. G., & Casey, J. S. (2010). Accuracy of the Borg CR10 scale for estimating grip forces associated with hand tool tasks. *Journal of Occupational and Environmental Hygiene*, 7(5): 298–306.

Mh, J., Ks, K., Sw, L., Tg, K., Hw, R., My, L., & Yl, W. (2014). The Relationship between Job Stress and Musculoskeletal Symptoms in Migrant Workers .,*Korean Journal of Occupational and Environmental Medicine*, 21(4):378-387.

Miranda, H., Viikari-Juntura, E., Heistaro, S., Heliovaara, M., & Riihimaki, H. (2005). A population study on differences in the determinants of a specific shoulder disorder versus nonspecific shoulder pain without clinical findings. *American Journal of Epidemiology*, 161(9): 847–855.

Ministry of Transport Malaysia. (2012). *Transport Statistic*. Retrieved from http://www.mot.gov.my.

Murata, K., Kawakami, N., & Amari, N. (2000). Does job stress affect injury due to labor accident in Japanese male and female blue-collar workers? *Industrial Health*, 38: 246–251.

Murrell, K. F. H. (1971). Applied Ergonomics Handbook part 1a first introduction chapter 14 work organisation. *Applied Ergonomics,* 2(2): 79-91.

Musculoskeletal Disorders and Workpalce Factors (1997). Department of Health and Human Services, US

Nasrull, M. A. R., Aziz, F. A., & Yusuff, R.M. (2010). Survey of body part symptoms among worker in a car tyre service centre. *Journal of Human Ergology,* 39(1): 53-56.

New York Committee for Occupational Safety & Health (2012). "Hierarchy of Hazard Controls." Retrieved from http:// http://nycosh.org/

Ohlsson, K., Attewell, R. G., Johnsson, B., Ahlm, A., & Skerfving, S. (1994). An assessment of neck and upper extremity disorders by questionnaire and clinical examination. *Ergonomics*, 37(5): 891–897.

Palmer, K. T. (2000). Prevalence and pattern of occupational exposure to hand transmitted vibration in Great Britain: findings from a national survey. *Occupational and Environmental Medicine*, 57(4): 218–228.

Palmer, K. T., Griffin, M. J., Syddall, H. E., Pannett, B., Cooper, C., & Coggon, D. (2001). Exposure to hand-transmitted vibration and pain in the neck and upper limbs. *Occupational Medicine (Oxford, England)*, 51(7): 464–467.

Peate, W. F., Gerry, B., Karen, L., Smitha, F., & Kristen, B. (2007). Core strength: A new model for injury prediction and prevention. *Journal of Occupational Medicine and Toxicology ,2*: 3

Punnett, L., and Wegman, D. H. (2004). Work-related musculoskeletal disorders. The epidemiologic evidence and the debate. *Journal of Electromyography and Kinesiology*, 14: 13-23.

Silverstein, B. A., Bao, S. S., Fan, Z. J., Howard, N., Smith, C., Spielholz, P., Viikari-Juntura, E. (2008). Rotator cuff syndrome: personal, work-related psychosocial and physical load factors. *Journal of Occupational and Environmental Medicine / American College of Occupational and Environmental Medicine*, 50(9): 1062–1076.

Smith, D. R., Kondo, N., Tanaka, E., Tanaka, H., Hirasawa, K., & Yamagata, Z. (2003). Musculoskeletal disorders among hospital nurses in rural Japan. *Rural and Remote Health*, 3(3): 241.

Smith, D. R., Mihashi, M., Adachi, Y., Koga, H., & Ishitake, T. (2006). A detailed analysis of musculoskeletal disorder risk factors among Japanese nurses. *Journal of Safety Research*, 37(2): 195–200.

Snook, S. H. (1978). The design of manual handling tasks. *Ergonomics,* 21(12): 63-85

Social Security Organization's Annual Report. (2012, 2013, 2014 & 2015). Retrieved from www.perkeso.gov.my

Spallek, M., Kuhn, W., Uibel, S., van Mark, A., & Quarcoo, D. (2010). Work-related musculoskeletal disorders in the automotive industry due to repetitive work - implications for rehabilitation. *Journal of Occupational Medicine and Toxicology (London, England)*, 5: 6.

Svendsen, S. W., Bonde, J. P., Mathiassen, S. E., Stengaard-Pedersen, K., & Frich, L. H. (2004). Work related shoulder disorders: quantitative exposure-response relations with reference to arm posture. *Occupational and Environmental Medicine*, 61: 844–853.

Svendsen, S. W., Gelineck, J., Mathiassen, S. E., Bonde, J. P., Frich, L. H., Stengaard-Pedersen, K., & Egund, N. (2004). Work above shoulder level and degenerative alterations of the rotator cuff tendons: a magnetic resonance imaging study. *Arthritis and Rheumatism*, 50(10): 3314–3322.

Torp, S., Riise, T., & Moen, B. E. (1996). Work-related musculoskeletal symptoms among car mechanics: a descriptive study. *Occupational Medicine (Oxford, England)*, 46: 407–413.

Torp, S., Riise, T., & Moen, B. E. (2001). The impact of psychosocial work factors on musculoskeletal pain: a prospective study. *Journal of Occupational and Environmental Medicine / American College of Occupational and Environmental Medicine*, 43: 120–126.

Ülgen, O., & Upendram, S. (1997). Productivity simulation in the automotive industry. *Simulation Series*. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.114.8646&rep=rep1&type=pdf

Veerapen, K., Wigley, R. D., & Valkenburg, H. (2007). Musculoskeletal pain in Malaysia: A COPCORD survey. *Journal of Rheumatology*, 34: 207–213.

Vezina, M., Bourbonnais, R., Marchand, A., & Arcand, R. (2010). The association between psychosocial work demands and mental health problems in Quebec: a gender-based analysis. *Canadian journal of public health*, 101(2): 3–8.

Vieira, E. R., Kumar, S., & Narayan, Y. (2008). Smoking, no-exercise, overweight and low back disorder in welders and nurses. *International Journal of Industrial Ergonomics*, 38(2): 143–149.

Vivek, D. (2011) Ergonomics Concepts, Issues, and Methods in Vehicle Design, *In Ergonomics in the Automotive Design Process* (pp. 1–2). CRC Press.

Vuille-Lessard, E., Boudreault, D., Girard, F., Ruel, M., Chagnon, M., & Hardy, J.-F. (2012). Postoperative anemia does not impede functional outcome and quality of life early after hip and knee arthroplasties. *Transfusion*, *52*(2): 261–270.

Vyas, H., Das, S., & Mehta, S. (2011). Occupational Injuries in Automobile Repair Workers. *Industrial Health*, 49: 642–651.

Wahlstrom, J., Burstrom, L., Hagberg, M., Lundstrom, R., & Nilsson, T. (2008). Musculoskeletal symptoms among young male workers and associations with exposure to hand-arm vibration and ergonomic stressors. *International Archives of Occupational and Environmental Health*, 81(5): 595–602.

Waters, T. R., Dick, R. B., Davis-Barkley, J., & Krieg, E. F. (2007). A cross-sectional study of risk factors for musculoskeletal symptoms in the workplace using data from the General Social Survey (GSS). *Journal of Occupational and Environmental Medicine / American College of Occupational and Environmental Medicine*, 49(2): 172–184.

Weir, E. and Lander, L. (2005). Hand-arm vibration syndrome. *Canadian Medical Association Journal,* 172(8)

Westling, G., & Johansson, R. S. (1984). Factors influencing the force control during precision grip. *Experimental Brain Research*, 53(2): 277–284.

Wind, A. E., Takken, T., Helders, P. J., & Engelbert, R. H. (2010). Is grip strength a predictor for total muscle strength in healty children, adolescents, and young adults? *Europe Journal Pediatric,* 169(3): 1-7

Woolf, A. D., & Pfleger, B. (2003). Burden of major musculoskeletal conditions. *Bulletin of the World Health Organization*, 81(03): 646–656.

A Guide to Automative Workshop Safety (2004). WorkSafeVictoria, Australia

Ye, Z., Abe, Y., Kusano, Y., Takamura, N., Eida, K., Takemoto, T., & Aoyagi, K. (2007). The influence of visual display terminal use on the physical and mental conditions of administrative staff in Japan. *Journal of Physiological Anthropology*, 26(2): 69–73.

Yu, S. (2012). Musculoskeletal Symptoms and Associated Risk Factors in a Large Sample of Chinese Workers in Henan Province of China, 293: 281–293.

Yu, W., Yu, I. T. S., Li, Z., Wang, X., Sun, T., Lin, H., Xie, S. (2012). Work-related injuries and musculoskeletal disorders among factory workers in a major city of China. *Accident Analysis and Prevention*, 48: 457–463.

Yusoff, M. S. B. (2010). The sensitivity, specificity and reliability of the Malay version 30-item General Health Questionnaire (GHQ) in detecting distressed medical students. *Education in Medicine Journal*, 2(1).