Asia Pacific Environmental and Occupational Health Journal (ISSN 2462 -2214), Vol 4 (2): 29-34, 2018


# Prevalence of Hand-Arm Vibration Syndrome (HAVS) among Tyre Shop Workers in Kota Bharu, Kelantan, Malaysia

**Asraf Ahmad Qamruddin [1], Nik Rosmawati Nik Husain [1], Mohd Yusof Sidek [1], Mohd Hafiz Hanafi [2], Nizam Ali [3], Zaidi Mohd Ripin [4]**

[1]*Department of Community Medicine, Universiti Sains Malaysia*
[2]*Department of Rehabilitation, Universiti Sains Malaysia*
[3]*Department of Occupational Safety and Health, Kelantan*
[4]*Vibration Lab, Department of Mechanical Engineering, Universiti Sains Malaysia*

**Corresponding author**: Asraf Ahmad bin Qamruddin, asraf_ahmad@hotmail.com, Department of Community Medicine, Hospital Universiti Sains Malaysia, Kubang Kerian, Kelantan, 016-7123401

**ABSTRACT**

**Objective**: The objectives of this study were to determine the prevalence and severity of HAVS among tyre shop workers in Kota Bharu, Kelantan. **Method**: A cross-sectional study involving 100 tyre shop workers in Kota Bharu, Kelantan was conducted. Data was collected by interviewing the workers using Malay Translated HAVS questionnaire and measurement of hand-arm vibration using Human Vibration Meter (Larson Davis HVM 100). The next phase measurements involved a set of hand clinical examinations (Purdue pegboard, Semmes-Weinstein Monofilaments and Two-point Discrimination tests). The workers were divided into high ($\geq 5ms^{-2}$) and low/moderate ($<5ms^{-2}$) exposure group according to their 8 hr time weighted average [A(8)] of vibration exposure. **Result:** The prevalence of vascular, neurological and musculoskeletal symptoms was 16%, 47% and 51% respectively. This study has identified that the workers exposed to HAV above $5ms^{-2}$ have significantly higher risk of developing symptoms on neurological and vascular component. **Conclusion**: Therefore, there is need for better control of vibration exposure, monitoring and reporting of HAVS among workers exposed to hand-arm vibration in this tyre shop.

**Keywords:** *Hand-Arm Vibration, Hand-Arm Vibration Syndrome, Tyre Shop Workers*

## 1. Introduction

Human vibration is defined as the vibration experienced by the human body due to direct contact with vibrating surfaces (DOSH, 2003). Human vibration can be categorized into two major areas of evaluation, which are whole-body vibration and hand-arm vibration (HAV) (Health and Safety Executive). HAV are transmitted from vibrating tools, vibrating machinery or vibrating workplace to the hands, arms and shoulders of the operators. Those at risk of developing HAV are mainly in the manufacturing, mining, forestry and construction industries, whereby the work involves handling of pneumatic and electric vibrating tools (DOSH, 2003).

Based on 2010 Malaysia national labour force statistics reports, it is estimated that more than four million workers in Malaysia are at risk of developing HAV (Department of Statistics Malaysia, 2010). Currently in Malaysia, there are no national legislation to protect workers against the different types of HAV exposure, unlike for noise. Noise exposure is regulated under the Factory and Machinery (Noise Exposure) Regulation 1989. In view of the increasing number of HAVS in Malaysia, the Department of Occupational Safety and Health (DOSH) released Guidelines on Occupational Vibration that was aimed at increasing the awareness of employers and employees to the effects of vibration to the human body (DOSH, 2003).

Available local evidence for construction workers, grass cutters, foresters and traffic police riders, states that HAVS is a major occupational health problem for these workers with prevalence ranging between 15% and 30% (Azmir et al., 2016; Su et al., 2013; Diyana et al., 2017). 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). HAVS is a disorder of the vascular, neurological and musculoskeletal systems of the upper limbs (Bovenzi, 2005). 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). 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.

Due to rapid industrialization, urbanization and lack of quality public transportation in most major cities, the number of cars in Malaysia are increasing rapidly (Malaysia Automotive Info, 2017). Therefore, there is increase in demand for car maintenances including tyre services. Tyre shop workers use impact wrench which is a main exposure to HAV to tighten and loosen the nuts on tyre during their daily jobs. Currently, there is no study carried out on HAVS on tyre shop workers and the exact prevalence in this groups are unknown. This study was conducted to determine the prevalence of HAVS and to compare the severity of HAVS between high exposure and low-moderate exposure among tyre shop workers in Kota Bharu, Kelantan.

## 2. Materials and Method

This is a cross-sectional study carried out in Kota Bharu, Kelantan. The list of all the registered tyre shop workers in Kota Bharu were obtained from the local council. Thirty tyre shop workers were randomly selected. The included workers in the selected tyre shops were at least 18 years of age and were involved in tyre changing using impact wrench for at least one year. Workers with history of injury or surgery with residual complications involving muscles, vessels, nerves and bony structures of the hands, forearms and arms were excluded.

Data collection was carried out in two parts. In part one, all the subjects were interviewed using a validated Malay Translated Hand-Arm Vibration Syndrome Questionnaire produced by an International Research Group on Vibration Hazard called Vibration Injury Network (Research Network on Detection and Prevention of Injuries due to Occupational Vibration Exposures, 2001). The questionnaire consists of seven parts which included basic demographic information, occupational, social and medical histories. Detailed information on vibration exposure were obtained including duration of usage of vibratory tools, type of tools, frequency and other vibration exposure in leisure times. During the interview, information on HAVS symptoms was obtained. Following the interview, HAV was measured when the subjects were using impact wrench during their normal working conditions. The HAV was measured using a Human Vibration Meter (Larson Davis HVM 100) by a qualified operator conforming to ISO standards 5349-2:2001. The accelerometer was firmly clamped to the tool handle and measurement was carried out for 30 seconds and repeated for three times.

8 hours' time weighted average of vibration exposure [A(8)] of each subject were then calculated based on the following formula

$$A8 = \sqrt{\frac{1}{8}\sum_{i=1}^{n} a_{hvi}^2 T_i}$$

Where $a_{hvi}$ is the vibration total value for the impact wrench and $T_i$ is the daily duration of exposure to vibration. The value $a_{hvi}$ is given by the mathematical formula

$$a_{hv} = \sqrt{a_{hwx}^2 + a_{hwy}^2 + a_{hwz}^2}$$

Where $a_{hwx}$, $a_{hwy}$ and $a_{hwz}$ are the frequency weighted root mean square accelerations in the x-axis, y-axis and z-axis respectively.

Tyre shop workers were then divided into two groups according to vibration exposure limit as set by European Directive 2002/44/EC of 5 $ms^{-2}$: high exposure group and low-moderate exposure group (European Parliament and of the Council, 2002). Subjects with A(8) of hand-arm vibration of 5 $ms^{-2}$ or more were categorised into high exposure group. While those with A(8) of less than 5 $ms^{-2}$ were categorised as low-moderate exposure.

In the second part of the data collection, all subjects were invited to Hospital USM. Three specific hand function assessments were carried: Purdue Pegboard Test (hand dexterity examination), Semmes-Weinstein Monofilament (finger sensation measurement) and Two-Point Discriminator Disk (tactile discrimination measurement). For Purdue Pegboard test, the discrimination threshold for abnormal finding was 1SD below the normative population mean for male maintenance and service employee data (15.49 for right hand, 15.25 for left hand, 12.31 for both hands, 43.04 for right+left+both and 38.71 for assembly) (Lafayette

Instrument Company, 2014). Semmes-Weinstein Monofilament test was recorded as abnormal if the subject's threshold response was 3.61mm and above (Su et al., 2011). For two-point discrimination test any value at and above 6mm was recorded as abnormal (Su et al., 2011).

Written Informed consent was obtained from each subject prior to commencement of both parts of the data collection. Each subject was also provided with an Information sheet and explanation sheet which explained the details of the study. Ethic approval was obtained from Jawatankuasa Etika Penyelidikan (Manusia) of USM. Data analysis was carried out using SPSS version 22.0. Independent T-Test was used for normally distributed numerical data while Mann-Whitney U Test was used for not normally distributed data. Chi-squared analysis was used to compare between the categorical data sets. The factors associated with vascular, neurological and musculoskeletal component was analysed first using simple logistic regression analysis followed by multiple logistic regression analysis.

## 3. Results

A total of 100 workers fulfilled the study criteria and consented for participation. All the subjects were Malaysians male, except one from Bangladesh. The mean age of the subjects was 30.9 years old (SD: 10.64). Majority of the subjects (76%) undergone secondary education. Their mean BMI was 24.3 (SD: 4.53) and 87% of the subjects were right-hand dominant.

The median duration of current employment and daily usage of impact wrench was 36 months (Range: 12-92) and 40 minutes (range 10-200). Ninety-seven percent of the subjects worked 6 days per week and the remaining 3% worked 7 days per week. Median A(8) for hand transmitted vibration was 6.4ms$^{-2}$ (range 1.99-21.00). Table 1 compares the basic characteristics of the two exposure groups. The mean (SD) A(8) for hand transmitted vibration for the high exposure group compared to low-moderate exposure group were 9.1 ms$^{-2}$ (3.89) vs 3.4 ms$^{-2}$ (0.99).

The prevalence of vascular, neurological and musculoskeletal components of HAVS of the all subjects were 16%, 47% and 51% respectively. However, only 7% of all the subjects acquired all three components of HAVS. Table 2 compares the symptoms of HAVS for each component and the clinical findings for the high and low-moderate exposure group.

**Table 1**: Characteristics of the Study Subjects according to exposure status

| Variable | Frequency (%) | | p |
|---|---|---|---|
| | Low moderate[b] exposure group (n=48) | High exposure[c] group (n=52) | |
| Age (years)[a] | 28.6 (9.75) | 33.1 (11.04) | 0.032 |
| Education level | | | |
| Primary | 1 (2.08) | 0 | |
| Secondary | 34 (70.83) | 42 (80.77) | 0.354 |
| Tertiary | 13 (27.08) | 10 (19.23) | |
| Ethnicity | | | |
| Malay | 40 (83.33) | 47 (90.38) | |
| Chinese | 8 (16.67) | 4 (7.69) | 0.254 |
| Other(s) | 0 | 1 (1.92) | |
| BMI[a] | 23.9 (4.40) | 24.6 (4.66) | 0.453 |
| Smoking Status | | | |
| Current smoker | 25 (52.08) | 36 (69.23) | 0.016 |
| Previous smoker | 1 (2.08) | 3 (5.77) | |
| Non-smoker | 22 (45.83) | 13 (25.00) | |
| For current smoker | | | |
| Smoking duration (years)[a] | 10.4 (7.16) | 11.9 (7.50) | 0.963 |
| Number of cigarettes/day[d] | 10.0 (13.00) | 13.1 (11.00) | 0.828[e] |
| Alcohol consumption | | | |
| Yes | 7 (14.58) | 2 (3.85) | 0.061 |
| No | 41 (85.41) | 50 (96.15) | |
| Chemical exposure at workplace | | | |
| Yes | 10 (20.83) | 7 (13.46) | 0.327 |
| No | 38 (79.17) | 45 (86.54) | |
| Employment duration (months)[d] | 26.5 (66.00) | 46.5 (150) | 0.186[e] |
| Duration using impact wrench (minutes/day)[a] | 30.1 (15.79) | 91.5 (54.96) | <0.001 |
| Spare time activities causing hand vibration | | | |
| Yes | 4 (8.33) | 5 (9.62) | 0.823 |
| No | 44 (91.67) | 47 (90.38) | |
| Long term medical illness | | | |
| Yes | 4 (8.33) | 9 (17.31) | 0.182 |
| No | 44 (91.67) | 43 (82.69) | |
| History of injury to neck and upper limb | | | |
| Yes | 3 (6.25) | 11 (21.15) | 0.032 |
| No | 45 (93.75) | 41 (78.85) | |
| A(8)[a] | 3.4 (0.99) | 9.1 (3.89) | <0.001 |

N=100; Chi-Square analysis and Independent T-Test [a]Mean(SD) [b]A(8)<5m/s$^2$; [c]A(8)≥ 5m/s$^2$; [d] Median(IQR); [e] Mann-Whitney

**Table 2**: Comparison of symptoms, signs and clinical examination of HAVS among workers with high versus low-moderate HAV exposure (n=100)

| Variable | Vibration exposure, n (%) Low-moderate[a] exposure group N=48 | High exposure[b] group N=52 | p |
|---|---|---|---|
| Vascular component | 1 (2.08) | 15 (28.85) | <0.001 |
| Finger colour change | 1 (2.08) | 4 (7.69) | 0.199 |
| Finger coldness | 1 (2.08) | 15 (28.85) | <0.001 |
| Neurological component | 13 (27.08) | 34 (65.38) | <0.001 |
| Finger tingling | 3 (6.25) | 25 (48.08) | <0.001 |
| Finger numbness | 12 (25.00) | 25 (48.08) | 0.017 |
| Musculoskeletal component | 21 (43.75) | 30 (57.69) | 0.164 |
| Musculoskeletal problem of the upper limbs | 18 (37.50) | 26 (52.0) | 0.208 |
| Musculoskeletal problem of the neck | 6(12.50) | 11 (21.11) | 0.250 |
| Hand grip weakness | 0 (0) | 5 (9.61) | 0.028 |
| Clinical Examination | | | |
| Abnormal dexterity | 9 (18.75) | 20 (38.46) | 0.03 |
| Abnormal light touch sensation | 5 (10.42) | 25 (48.08) | <0.001 |
| Abnormal two-point discrimination | 2 (4.17) | 14 (26.92) | 0.002 |

[a]$A(8)<5m/s^2$; [b]$A(8)\geq 5m/s^2$

# 4. Discussion

Vascular component of HAVS is classically associated with blanching of fingers or occurrence of vibration white fingers (Barregard, 2001). Only 5% of this study population developed blanching of fingers which only occurred when exposed to cold conditions. Studies have shown, that clinical features of HAVS in terms of occurrence of vibration white fingers in warm countries are very low than those of the temperate countries (Su et al., 2012). Systematic review of studies conducted in temperate countries reported prevalence rates of finger blanching of vascular components to be 15% to 71% as compared to tropical countries where the prevalence of finger blanching reported tends to be less than 5% (Su et al., 2011). It seems that blanching of fingers is mostly precipitated by cold temperature. Therefore, finger coldness is often used as surrogate for vascular disorders among workers in a warm climate environment as the temperature is not cold enough to induce vibration white fingers (Ishitake & Ando, 2005). Taking into consideration both blanching of fingers and finger coldness as symptoms of the HAVS vascular component, its prevalence in this study population is 16%. This finding is congruent with systematic review of vibration white finger. In tropical countries, where the prevalence of vascular component was found to be between 10% to 30% (Su et al., 2011). Almost half (47%) of the subjects of this study had symptoms of the neurological component of HAVS. This findings is similar to the findings among quarry workers in Vietnam using rock drillers where the prevalence of neurological component was 50% (Futatsuka, 2005) despite the mean A(8) was marginally higher $26ms^{-2}$ compared vs $6.4ms^{-2}$ in this study. Of all the three components, musculoskeletal had the highest prevalence of 51%. This findings is much lower than a study looking at musculoskeletal disorder among auto repair mechanics in Klang Valley, Malaysia where the prevalence was 87% (Nasaruddin et al., 2014). The differences might be due to the study using Standardized Nordic Questionnaire (SNQ) which measures all musculoskeletal problems including lower back, knee and leg compared to the questionnaire in this study which only incorporated upper limb and neck problems.

Fifty-two percent of the subjects exposed to HTV which exceeded the recommended Threshold Limit Values. In this study, all three components (vascular, neurological, and musculoskeletal) of HAVS were higher among the high exposure group compared to the low-moderate exposure group (2% vs 29%, 27% vs 65% and 44% vs 58%). The difference between the vascular and neurological components between the 2 groups were statistically significant ($p<0.001$) However, for the musculoskeletal the differences were not statistically significant between exposed and the non-exposed group. The prevalence of vascular symptoms among the high exposure group was 29%. This finding was similar to a study carried out among construction workers in Malaysia where the prevalence of vascular symptoms among workers with 8hr TWA exposure with more than $5ms^{-2}$ was 25% (Su et al., 2011).

The prevalence of abnormal dexterity, abnormal light touch sensation and abnormal two-point discrimination was significantly higher in the highly exposed group than the low-moderate group ($p=0.03$, $p<0.001$, $p=0.002$). This findings was also similar to Su et al., (2011) and it suggested that exposures of more than $5ms^{-2}$ to HAV was associated with long term neurological and musculoskeletal damage to the hand.

Although these findings suggest that there were possible associations between the HAV level of exposure and HAVS symptoms, a causal relationship and temporality cannot be established due to the limitation of the study design. A better study design would be a cohort study, however, it would be more costly and follow up would be long as the median latency for development of HAVS is believed to be 16 years with the range of 9 months to 41 years (Health and Safety

Laboratory, 2008). Since the study population consisted of tyre shop workers in Kota Bharu, Kelantan, the result cannot be generalized to all tyre shop workers in Malaysia. The majority of the workers' population in this study were Malays (87%) which might be different in other states. This study used a validated questionnaire, and most of the information obtained especially on duration and frequency of vibration exposure required recall by the subject. Thus, the study is liable to recall bias. Recall bias was minimized as far as practical by checking with the shops on the number of tyres changed by the workers recorded in a day, therefore giving estimates of vibration exposure. As the data collection conducted by one interviewer, to minimize interviewer bias, validated standardized questionnaires were used. To reduce measurement bias, all vibration measurement was carried out by a trained technician according to ISO 5349-2:2001. The accelerometer used was calibrated annually.

This study measured the individual HAV exposure of each workers instead of using company declared values or on representative's samples as used by some other previous studies (Azmir et al., 2016; Bovenzi et al., 1995; Barregard et al., 2003; Bovenzi, 1994). Thus, a more accurate and precise exposure level and dose-response association can be established.

The findings from this study suggests, that HAVS is a significant problem even among workers in tropic countries despite the lack of vibration white finger presentation. Currently in Malaysia, there is no legislation for HAV exposure. From this study, it can be concluded that if the A(8) of HAV was kept below $5ms^{-2}$ as per European Directives if will have significant effect on both the neurological and vascular components of HAVS. Risk assessment of workplace should be carried out and workers who are exposed to high level of HAV should be placed under suitable health surveillance. Besides legislation intervention, it is important to raise awareness of the employees, employers and health professionals on HAVS. In this study, only 34% of the workers were aware that prolonged exposure to vibration can be detrimental to their hands. It is important that health professionals involved in health surveillance of workers exposed to HAV, have the necessary expertise to carry out adequate clinical assessment and avoid misdiagnosing symptoms of HAVS.

# 5. Conclusion

In conclusion, HAVS is an important but under-recognized problem among tyre shop workers in Kota Bharu. The current study has identified that the workers exposed to HAV above $5ms^{-2}$ have significantly higher risk of developing symptoms on neurological and vascular components. A further research with wider coverage is required for a better understanding the extent of HAVS among this occupational group.

# Acknowledgement

The study was funded by Research University Grant provided by Universiti Sains Malaysia. Grant No: 1001/PPSP/8012286References

**REFERENCES**

Azmir NA, Ghazali MI, Yahya MN, Ali MH. Hand-arm vibration disorder among grass-cutter workers in Malaysia. International Journal of Occupational Safety and Ergonomics. 2016;22(3):433-8.

Barregard L, Ehrenström L, Marcus K. Hand-arm vibration syndrome in Swedish car mechanics. Occupational and environmental medicine. 2003;60(4):287-94.

Barregard L. Daily exposure time to hand-arm vibrations in Swedish car mechanics. ARBETE OCH HALSA VETENSKAPLIG SKRIFTSERIE. 2001(10):293-4
.

Bovenzi M, Franzinelli A, Mancini R, Cannava M, Maiorano M, Ceccarelli F. Dose-response relation for vascular disorders induced by vibration in the fingers of forestry workers. Occupational and Environmental Medicine. 1995;52(11):722-30.

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. Occupational and Environmental Medicine. 1994;51(9):603-11.

Bovenzi M. Health effects of mechanical vibration. G Ital Med Lav Ergon. 2005;27(1):58-64.

Department of Statistics Malaysia. labour Force Survey Report, Malaysia. Labour Force Survey Report. 2010.

Diyana NA, Karuppiah K, Rasdi I, Sambasivam S, Tamrin SBM, Mani KK, et al. Vibration exposure and work- musculoskeletal disorders among traffic police riders in Malaysia: A review. Annals of Tropical Medicine and Public Health. 2017;10(2):334.

DOSH. Guidelines on Occupational Vibration. In: Ministry of Human Resources M, editor. Malaysia 2003.

European Parliament and of the Council. minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration). In: Union EPaotCoE, editor. 2002 (amended 2008).

Futatsuka M, Shono M, Sakakibara H, Quan PQ. Hand arm vibration syndrome among quarry workers in Vietnam. Journal of Occupational Health. 2005;47(2):165-70.

Griffin M, Bovenzi M, Nelson C. Dose-response patterns for vibration-induced white finger. Journal of Occupational and Environmental Medicine. 2003;60(1):16-26.

Hagberg M, Silverstein B, Wells R, Smith M, Hendrick H, Carayon P, et al. Work related musculoskeletal disorders: a reference for prevention; Kuorinka I & Forcier L. London: Taylor & Francis; 1995.

Health and Safety Executive. Vibration at Work 2017. Available from: http://www.hse.gov.uk/VIBRATION/index.htm.

Health and Safety Laboratory. Data Mining In A HAVS Referral Population. In: Executive HaS, editor. Buxton, Derbyshire: Crown; 2008

.

Ishitake T, Ando H. Significance of finger coldness in hand-arm vibration syndrome. Environmental Health And Preventive Medicine. 2005;10(6):371-5.

Lafayette Instrument Company. Grooved Pegboard Test User's Manual. 2014.

Malaysia Automotive Info. Summary of Sales & Production Data 2017 [Available from: http://www.maa.org.my/info_summary.htm.

Mason HS, Poole K. Evidence review on the clinical testing and management of individuals exposed to hand transmitted vibration: Faculty of Occupational Medicine of the Royal College of Physicians; 2004.

Nasaruddin AFA, Tamrin SBM, Karuppiah K. The Prevalence of Musculoskeletal Disorder and the Association with Risk Factors among Auto Repair Mechanics in Klang Valley, Malaysia. Iranian Journal of Public Health. 2014;43(3):34.

Research Network on Detection and Prevention of Injuries due to Occupational Vibration Exposures. Guidelines for Hand-Transmitted Vibration Health Surveillance. 2001.

Social Security Organization (2016). Annual Reports 2010-2015. Kuala Lumpur: SOCSO.

Su AT, Darus A, Bulgiba A, Maeda S, Miyashita K. The clinical features of hand-arm vibration syndrome in a warm environment—A review of the literature. Journal of Occupational Health. 2012;54(5):349-60.

Su AT, Fukumoto J, Darus A, Hoe VC, Miyai N, Isahak M, et al. A comparison of hand-arm vibration syndrome between Malaysian and Japanese workers. Journal of Occupational Health. 2013;55(6):468-78.

Su AT, Miyashita K, Maeda S, Bulgiba A, editors. A systematic review of hand-arm vibration syndrone in tropical countries. INTER-NOISE and NOISE-CON Congress and Conference Proceedings; 2011: Institute of Noise Control Engineering.

Su TA, Hoe VCW, Masilamani R, Mahmud ABA. Hand-arm vibration syndrome among a group of construction workers in Malaysia. Journal of Occupational and Environmental Medicine. 2011; 68(1):58-63.