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SOCIODEMOGRAPHIC FACTORS ASSOCIATED WITH MUSCULOSKELETAL SYMPTOMS IN TRUCK DRIVERS EXPOSED TO WHOLE-BODY VIBRATION: A STUDY AT PORT KLANG, SELANGOR

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ABSTRACT

Prime mover truck operations are associated with a significant risk of musculoskeletal disorders (MSDs) among drivers due to prolonged exposure to whole-body vibration (WBV). This study aimed to explore the potential link between WBV and the prevalence of MSDs in truck drivers at a major port in Port Klang, Selangor. A cross-sectional analysis was conducted involving 205 prime mover drivers, utilizing data from the Extended Standardized Nordic Questionnaire (NMQ-E) to assess sociodemographic factors and the prevalence of MSDs. Additionally, WBV exposure was measured in a subset of 32 drivers using the Larson Davis HVM100 device. The findings indicated that WBV exposure levels were within the limits set by the European Directive 2002/44/EC, with a maximum of 1.15 m/s² over an 8-hour work period. Despite this, 25.93% of drivers reported lower back pain, 19.88% reported upper back pain, and 16.61% reported neck pain. Statistical analysis revealed significant correlations between work experience and back pain (p=0.038), work experience and hip pain (p=0.033), and body mass index (BMI) and shoulder pain (p=0.027). The study suggests that drivers should be encouraged to take regular breaks to mitigate vibration exposure and that maintaining a healthy weight could reduce the strain on musculoskeletal systems.

Keywords: Whole-Body Vibration, Musculoskeletal Disorders, Truck Drivers, Sosiodemographic Factors.

1.0 INTRODUCTION

Musculoskeletal disorders (MSDs) are a significant public health issue globally, with a substantial impact on the workforce, particularly in developed countries. According to recent studies, the economic burden of MSDs is considerable, with costs associated with treatment and absenteeism representing a significant percentage of gross domestic product (GDP) [1]. In Malaysia, the issue is compounded by occupational risk factors such as whole-body vibration (WBV), which has been identified as a key contributor to the development of lower back pain and other MSDs among professional drivers [2].

Professional drivers, particularly those operating heavy vehicles such as Prime Movers, are subject to extended periods of sitting, awkward postures, and whole-body vibration (WBV). These occupational hazards are strongly associated with an increased prevalence of lower back pain, neck pain, and other musculoskeletal disorders (MSDs) [3]. Although there have been advancements in occupational health, the regulations

governing WBV exposure in Malaysia remain insufficiently developed, highlighting the need for further investigation in this area [2].

Bauer and Hämmig (2013) noted that MSDs are among the most common health issues in developed nations, with the financial burden of these disorders estimated to account for approximately 2% of the gross domestic product [5]. In Switzerland, for example, back pain alone was responsible for direct medical costs amounting to 2.6 billion euros, which represented 6.1% of the nation's total healthcare expenditure [5]. Additionally, Osborne et al. (2007) identified that MSDs were the leading cause of outpatient visits, with orthopedic consultations accounting for 9.9% of all medical visits between 2000 and 2001. Linaker et al. (2011) highlighted that MSDs are a significant cause of work absenteeism, frequently resulting in pain and job loss. Despite their relatively low mortality rates [6], MSDs continue to pose a major public health challenge globally, significantly reducing the quality of life (Roux et al., 2005). Furthermore, it is approximately 10% of these disorders progress to chronic disabilities [8]. Long-term exposure to vibration has been linked to the onset of back pain, largely due to the strain it places on the muscles and tissues of the back. Prolonged exposure to vibration can lead to muscle tension, fatigue, and imbalances, as well as poor posture, all of which contribute to back pain. Okunribido et al. (2006) found that drivers are particularly susceptible to lower back pain, attributing this vulnerability to two primary risk factors: extended driving periods and exposure to WBV [3].

Additional factors such as prolonged static postures (Viruet et al., 2008), awkward postures, heavy lifting, and inadequate nutrition [10] can further exacerbate back pain. The National Institute for Occupational Safety and Health (NIOSH) in the United States has identified a link between WBV and lower back problems [11]. However, in Malaysia, research into the occupational risk factors for lower back pain is still in its early stages, and there are currently no established regulations for whole-body or hand-transmitted vibrations [11]. This study, focused on truck drivers operating at Port Klang, Selangor, aims to explore the sociodemographic factors associated with the prevalence of musculoskeletal symptoms in this high-risk group. The findings will not only contribute to a better understanding of the relative impact of WBV versus sociodemographic factors but also inform the development of more targeted occupational health interventions in Malaysia. By identifying these factors, the research seeks to provide valuable insights into the underlying causes of MSDs among truck drivers, thereby contributing to the formulation of more effective occupational health policies and interventions in Malaysia.

2.0 METHODOLOGY

2.1 Study Design

A cross-sectional study was conducted among 205 respondents who are prime mover truck drivers in Port Klang, Selangor. Data were collected through a structured questionnaire and whole-body vibration measurements.

2.2 Sampling Population

The study population targeted male prime mover truck drivers that dominating demographic in the industry. This criterion is important for producing consistent and reliable results by minimizing the variables associated with gender differences. Additionally, only drivers with a minimum of three months of experience were included in the study. This threshold was set to exclude beginners who might not yet be fully acclimatized to the demands of the job, thereby ensuring that the data reflected the experiences of seasoned drivers. As well, the workers were selected based on their language competency in either English or Bahasa Melayu to ensure that respondents were able to comprehend the research's instructions. This is important in reducing the possibility of misinterpretation and achieving precise data collection.

2.3 Instrumentation

The Extended Standardized Nordic Musculoskeletal Questionnaire (E-NMQ) is an adaptation of the original Nordic Musculoskeletal Questionnaire (NMQ), which was developed by Kuorinka et al. in 1987[12]. The Extended Standardized Nordic Musculoskeletal Questionnaire (E-NMQ) was utilized in this study to collect data on musculoskeletal disorders among the participants. The E-NMQ is a self-administered tool designed to evaluate musculoskeletal pain and associated disability. It is widely recognized in research for its validity and

reliability in assessing the intensity and impact of musculoskeletal discomfort across various anatomical regions and occupational settings. The questionnaire is structured into three sections: Parts A and B encompass questions related to general demographic information, physical characteristics, and smoking habits. Part C is dedicated to assessing musculoskeletal disorders, with specific emphasis on pain and discomfort experienced in seven key body regions, the presence of current back pain, and symptoms occurring within the past 12 months.

Whole-body vibration (WBV) is a significant occupational hazard, particularly in industries where workers are exposed to mechanical vibrations through prolonged contact with vibrating surfaces. The study involved the methodical evaluation of WBV exposure in two distinct types of prime mover trucks, which are Terberg and Ottawa.These trucks are specifically engineered for short-distance, repeated activities in industrial settings such as ports and distribution centre. Terberg prime movers provide a wide range of vehicles, each designed to cater to certain industrial requirements, with differences in engine size, cab arrangement, and load-borne capacity. In contrast, Ottawa prime movers are well-known for its terminal tractors, which are specifically engineered to meet demanding operational needs, encompassing both off-road and on-road applications, and available with diesel or electric power alternatives.

WBV measurements were conducted on a demographically equal population of 32 drivers, consisting of 16 drivers operating Terberg trucks and 16 drivers operating Ottawa trucks. The selected sample size was determined to provide a strong comparison study between the two truck models, therefore ensuring adequate statistical power to identify significant variations in WBV exposure and to provide valuable insights into the occupational hazards linked to each vehicle type. Figure 1 showed the measurement of WBV collected during collecting data. The measurements were conducted across three orthogonal axes (x, y, and z) using the IHVM 100 device equipped with a triaxial seat pad accelerometer. These measurements adhered to the ISO 2631 (1997) standards [13], ensuring the accuracy and reliability of the data collected. The accelerometer was strategically placed on the driver's seat, and acceleration data were captured over 15-minute intervals per route for each truck. This data facilitated the calculation of key vibration metrics, including the acceleration equivalent dose (Aeq), the vector sum of the root mean square (r.m.s) of frequency-weighted acceleration, crest factor, and vibration dose value (VDV), providing a comprehensive assessment of WBV exposure among the drivers.

Figure 1: WBV measurement

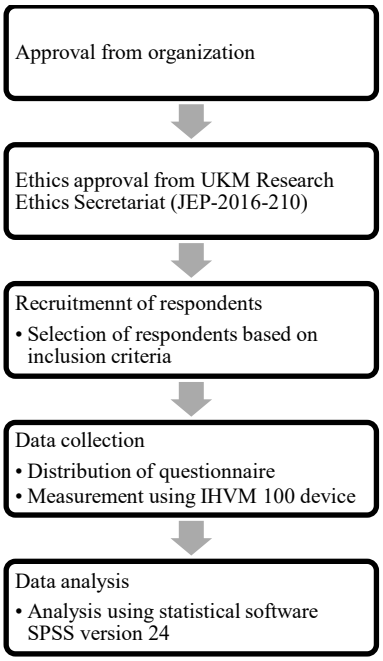
2.4 Data analysis

Data analysis was conducted using descriptive statistics and chi-square tests with the Statistical Package for the Social Sciences (SPSS) version 24.0. The frequency and proportion of sociodemographic risk factors were calculated. Chi-square analysis was employed to assess the significance of differences in the prevalence of musculoskeletal disorders (neck, upper back, lower back, hips, and knees) across various sociodemographic factors, including age, body mass index, smoking habits, and years of work experience.

2.5 Study Flowchart

Figure 2 showed the flowchart of this study. The study was carried out among Prime Mover drivers after getting the approval and cooperation from the Human Resources Division, Northport (Malaysia) Berhad. This

study has received ethical approval from the Research Ethics Committee, Universiti Kebangsaan Malaysia Medical Center (Approval Number: JEP-2016-210). The selection of respondents was based on specific inclusion criteria. Data gathering via two different approaches, specifically the questionnaire method and the vibration measurement. Analysis of the data collected in this study was completed using IBM SPSS Statistics software version 22.0.



3.0 RESULTS AND DISCUSSION

3.1 Sociodemographic Distribution

Table 1 shows the socioeconomic characteristics of all those involved in this study. The age distribution indicates that a substantial majority of the respondents (79%) are under the age of 30. The population's race breakdown is almost Malay, with 99% of respondents identifying as Malay. Regarding Body Mass Index (BMI), most participants (42.9%) have a BMI that falls within the normal weight category (18.5-24.9 kg/m²). The data on educational levels among the respondents reveals that 83.4% possess a low level of education. A substantial majority of the respondents (77.6%) indicated that they engage in smoking. Data reveals that most respondents (76.6%) had fewer than 5 years of professional experience.

The socioeconomic characteristics of the respondents in your study reveal critical insights into their health behaviors and outcomes. A significant portion of the population is young, with a high prevalence of smoking, which recent studies have linked to increased risks of hypertension, especially in individuals with a normal BMI [14]. The low educational attainment among respondents is also noteworthy, as it is often associated with unhealthy lifestyle choices and poor health literacy, which can further exacerbate health disparities [15]. The interaction between BMI, smoking, and other lifestyle factors underscores the complexity of health outcomes in this demographic, highlighting the need for targeted public health interventions [16].

Table 1. Sociodemographic Distributions among respondents

Sociodemographic Information		n(%)
Age (years)	<30	162(79)
	≥30	43 (21)
Race	Malay	203(99)
	Non-Malay	2 (1)
Body Mass Index (BMI)	Low Body Weight (<18.4 kg/m²)	14 (6.8)
	Normal (18.5-24.9kg/m²)	88 (42.9)

Sociodemographic Information		n(%)
	Overweight (25-29.5kg/m²)	61 (29.8)
	Obesity (>27.5kg/m²)	42 (20.5)
Educational Level	Low level	171 (83.4)
	High level	
Smoking habits	Yes	159 (77.6)
Years of working	<5 years	157 (76.6)
	≥ 5 years	48 (23.4)

Descriptive analysis

3.2 Prevalence of Musculoskeletal Disorders (MSDs)

As shown in Figure 1, the occurrence rate of musculoskeletal diseases (MSDs) during a period of 12 months among the respondents. The most common problem reported by the respondents was lower back pain, which affected 25.93% of them. This was followed by upper back pain, which affected 19.88% of the respondents, and neck discomfort, which affected 16.61%. The findings of lower back pain being the most prevalent musculoskeletal disorder (MSD) among forklift drivers are consistent with existing literature that identifies prolonged sitting, whole-body vibration, and repetitive movements as primary risk factors for MSDs in occupations such as forklift driving [17,18].

The high occurrence of upper back and neck pain, which were the second and third most common complaints respectively, further emphasizes the impact of poor posture, inadequate ergonomic design of seating, and the physical demands of operating forklifts on workers' musculoskeletal health [19]. These results suggest that targeted ergonomic interventions, including improved seating design, vibration reduction, and regular physical assessments, are critical in mitigating the risk of MSDs among forklift operators. Addressing these ergonomic concerns not only promotes better health outcomes but also enhances productivity and reduces absenteeism due to work-related injuries [20].

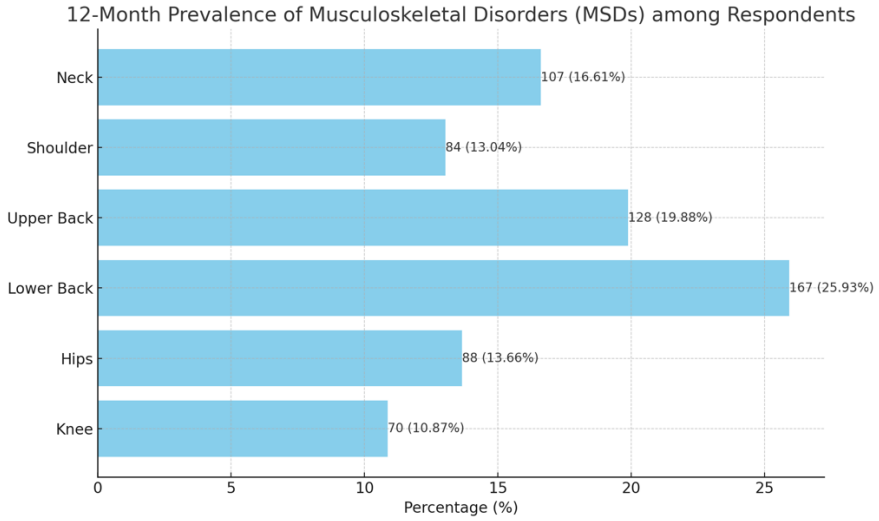


Figure 1. 12-Month Prevalence of Musculoskeletal Disorders (MSDs) among Respondents

3.3 Whole Body Vibration Exposure

Table 2 shows the average ± standard deviation of whole-body vibration exposure for the TERBERG Prime Mover vehicle across several vibration axes and parameters. The vibration exposure along the X, Y, and Z axes is shown by Aeq values of 0.703 ± 0.211, 0.737 ± 0.229, and 0.918 ± 0.258 m/s², respectively. The resultant vector sum of these axes is 1.371 ± 0.389 m/s², reflecting the total level of vibration exposure. The A (8) value, indicating the standardised vibration exposure throughout an 8-hour duration, is 0.170 ± 0.041 m/s². The crest factors, which quantify the ratio of peak vibration to the root mean square (RMS) value, exhibit significantly high values. Specifically, the crest factors for the X, Y, and Z axes are 20.438 ± 2.333, 20.406 ±

2.425, and 18.675 ± 2.362, respectively. The total of the crest factors is 17.013 ± 2.425, suggesting notable peak vibrations.

The vibration dose values (VDV), which measure the total vibration exposure, are 6.426 ± 1.542, 6.655 ± 1.524, and 7.793 ± 1.573 for the X, Y, and Z axes, respectively. The VDV has an aggregate value of 10.505 ± 2.101, indicating the combined vibration stress encountered by the drivers. The results offer a comprehensive comprehension of the whole-body vibration exposure in the TERBERG Prime Mover truck, focussing specifically on the elevated crest factors and cumulative vibration doses. These findings may have ramifications for driver comfort and long-term health.

Table 2. Mean ± Standard Deviation of whole-body vibration exposure of TURBER

Vibration axes		Mean ± Standard Deviation
Aeq	*X*	0.703 ± 0.211
	Y	0.737 ± 0.229
	Z	0.918 ± 0.258
Vector Sum		1.371 ± 0.389
A(8)		0.170 ± 0.041
Crest Factor	*X*	20.438 ± 2.333
	Y	20.406 ± 2.425
	Z	18.675 ± 2.362
Sum of Crest Factor		17.013 ± 2.425
VDV	*X*	6.426 ± 1.542
	Y	6.655 ± 1.524
	Z	7.793 ± 1.573
Sum of VDV		10.505 ± 2.101

N=16

Table 3 presents the mean and standard deviation of whole-body vibration exposure measured in three axes (x, y, z) for a sample of 16 participants using the OTTAWA model. The root mean square (RMS) vibration levels revealed higher exposure in the z-axis (0.778 ± 0.130 m/s²) compared to the x (0.312 ± 0.056 m/s²) and y (0.337 ± 0.075 m/s²) axes, with a vector sum of 0.902 ± 0.150 m/s². The 8-hour equivalent continuous acceleration (A (8)) was 0.135 ± 0.020 m/s². The crest factor, indicating the peak-to-RMS ratio, varied across the axes, with the y-axis showing the highest mean (22.444 ± 2.214). The vibration dose value (VDV) was also highest in the z-axis (7.761 ± 1.131 m/s^1.75), contributing to a sum of 8.293 ± 1.160 m/s^1.75 across all axes, emphasizing the need for measures to reduce vibration exposure, particularly along the z-axis.

Table 3. Mean ± Standard Deviation of whole-body vibration exposure of OTTAWA

Vibration axes		Mean ± Standard Deviation
Aeq	*x*	0.312 ± 0.056
	y	0.337 ± 0.075
	z	0.778 ± 0.130
Vector Sum		0.902 ± 0.150
A(8)		0.135 ± 0.020
Crest Factor	*x*	20.187 ± 1.718
	y	22.444 ± 2.214
	z	19.706 ± 1.790
Sum of Crest Factor		18.606 ± 1.814
VDV	*x*	2.942 ± 0.371
	y	3.439 ± 0.706
	z	7.761 ± 1.131
Sum of VDV		8.293 ± 1.160

N=16

Figure 2 presents a comprehensive comparison of the mean whole-body vibration exposure between two Prime Mover truck brands, Terberg and Ottawa, by analyzing four key metrics: Vector Sum, A(8), Crest Factor Sum, and Vibration Dose Value (VDV) Sum. The Vector Sum, reflecting combined vibration exposure across the X, Y, and Z axes, is higher in Terberg (1.371) compared to Ottawa (0.902). Similarly, the A(8) value, representing vibration exposure normalized over an 8-hour workday, is greater for Terberg (0.170) than

Ottawa (0.135). Both brands show crest factor sums exceeding the critical threshold of 9, with Terberg at 17.01 and Ottawa at 18.6, signaling substantial peak vibration levels.

Additionally, the VDV Sum, which accounts for cumulative vibration exposure, is higher in Terberg (10.505) than Ottawa (8.2925), suggesting greater cumulative stress on drivers. Although both brands adhere to the European Directive (2002/44/EC) exposure limit of 1.15 m/s² for an 8-hour period, the elevated crest factors indicate that drivers may still be subjected to significant peak vibrations, raising potential concerns for long-term occupational health. These findings are significant as they suggest that Terberg trucks subject drivers to higher levels of vibration across an 8-hour workday, which could contribute to an increased risk of musculoskeletal disorders (MSDs) and other health issues related to prolonged exposure to WBV [25,26]

Both truck brands have Crest Factor Sums exceeding the critical threshold of 9, with Terberg at 17.01 and Ottawa at 18.6, indicating substantial peak vibration levels. Although the VDV Sum is also higher for Terberg (10.505) than Ottawa (8.2925), both brands comply with the European Directive (2002/44/EC) exposure limit of 1.15 m/s² for an 8-hour period. However, the elevated crest factors raise concerns about the potential for long-term health impacts due to significant peak vibrations, suggesting that even when average exposure limits are met, peak vibrations can pose substantial risks to drivers [22,13].

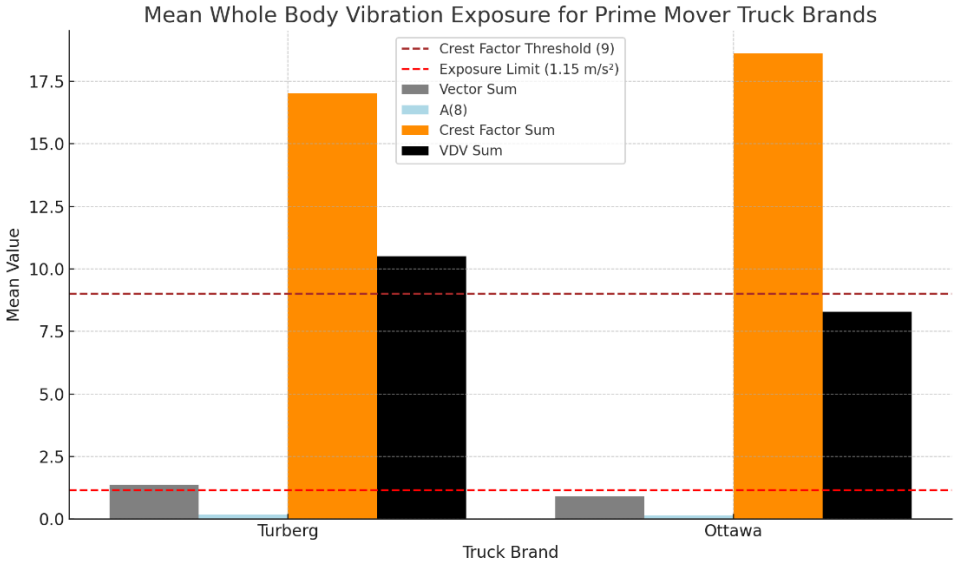


Figure 2. Mean whole body vibration exposure with Prime Mover truck brands

3.4 The Association between Socio-demographics and Prevalence of Muscukuloskeletal Disorders (MSDs)

Table 4 presents the chi-square test results analyzing the relationship between socio-demographic factors and the prevalence of musculoskeletal disorders across different body regions (Neck, Shoulder, Upper Back, Lower Back, Hips, and Knee). A significant association was observed between BMI and the prevalence of shoulder pain ($\chi 2=4.902$, $p < 0.05$). The data indicate that individuals classified as overweight (≥ Overweight) were more likely to experience shoulder pain compared to those with a normal weight. Specifically, 59.5% of the overweight group reported shoulder pain, while only 40.5% of those with normal weight experienced this condition.

Specifically, individuals classified as overweight were significantly more likely to experience shoulder pain, with 59.5% of the overweight group reporting this condition compared to 40.5% of those with normal weight. This suggests that higher BMI may be a contributing factor to increased shoulder pain risk, likely due to the added mechanical load on the musculoskeletal system [23,24]. The relationship between Body Mass Index (BMI) and the prevalence of musculoskeletal disorders (MSDs) in forklift drivers is particularly concerning given the physical demands of the job and the high exposure to whole-body vibration (WBV).

Overweight and obesity, as reflected in higher BMI, can exacerbate the strain on the musculoskeletal system during prolonged sitting and repetitive movements, which are common in forklift driving. Overweight forklift drivers are likely to experience more severe symptoms due to the combined effects of WBV and the additional load from excess body weight [25]. The interaction between high BMI and occupational hazards

like WBV not only increases the likelihood of MSDs but also contributes to the chronicity of these conditions, potentially leading to long-term disability and reduced work capacity [18,26].

There was a statistically significant relationship between the number of years working and the prevalence of lower back pain ($\chi 2=4.32$, $p < 0.05$). Workers with less than 5 years of experience reported a higher incidence of lower back pain (73.7%) compared to those with more than 5 years of working experience (26.3%). This finding highlights the potential impact of shorter work experience on the development of lower back pain, possibly due to lack of ergonomic adaptation or increased physical strain in the early years of employment [27, 28]. The association between shorter working years and the prevalence of lower back pain (LBP) among workers, particularly those in physically demanding jobs like forklift driving, can be attributed to several factors related to ergonomics, adaptation, and physical strain. Workers with less than five years of experience are often still adapting to the physical demands and ergonomic challenges of their roles. This period of adjustment is critical, as workers may not yet have developed the necessary muscle strength, endurance, or proper techniques to manage the physical stressors effectively [28, 29].

Similarly, there was a significant association between the number of years working and hip pain ($\chi^2 = 4.541$, $p < 0.05$), with those having fewer than 5 years of experience more likely to report hip pain (69.3%) compared to their more experienced counterparts (30.7%). This suggests that hip pain is more prevalent among individuals early in their careers, potentially due to physical demands or inadequate ergonomic measures in the workplace, further underscoring the need for early ergonomic interventions [30].

Table 4. Association of MSD prevalence and socio-demographics

Socio-demographics	Neck, n(%)		χ^2	Shoulder, n (%)		χ^2	Upper Back, n (%)		χ^2	Lower Back, n (%)		χ^2	Hips, n (%)		χ^2	Knee, n (%)		χ^2
	Yes	No		Yes	No		Yes	No		Yes	No		Yes	No		Yes	No	
Age (years)																		
<30	72 (67.3)	70 (71.4)	0.8	62 (73.8)	80 (66.1)	0.8	89 (69.5)	53 (68.8)	0.166	72 (67.3)	70 (71.4)	0.2	62 (73.8)	80 (66.1)	0.6	89 (69.5)	53 (68.8)	0.2
≥30	35 (32.7)	28 (28.6)		22 (26.2)	41 (33.9)		39 (30.5)	24 (31.2)		35 (32.7)	28 (28.6)		22 (26.2)	41 (33.9)		39 (30.5)	24 (31.2)	
BMI																		
≤ Normal Weight	56 (52.3)	46 (46.9)	0.60	34 (40.5)	68 (56.2)	4.9*	64 (50.0)	38 (49.4)	0.008	87 (52.1)	15 (39.5)	1.2	41 (46.6)	61 (52.1)	0.6	31 (44.3)	71 (52.6)	1.2
≥ Overweight	51 (47.7)	52 (53.1)		50 (59.5)	53 (43.8)		64 (50.0)	39 (50.6)		84 (78.5)	23 (60.5)		47 (53.4)	56 (47.9)		39 (55.2)	64 (47.4)	
Smoking																		
Yes)	84 (78.5)	75 (76.5)	0.1	66 (78.6)	93 (76.9)	0.1	104 (81.3)	55 (71.4)	2.665	84 (78.5)	75 (76.5)	0.04	66 (78.6)	93 (76.9)	0.3	104 (81.3)	55 (71.4)	0.1
No	23 (21.5)	23 (23.5)		18 (21.4)	28 (23.1)		24 (18.8)	22 (28.6)		23 (21.5)	23 (23.5)		18 (21.4)	28 (23.1)		24 (18.8)	22 (28.6)	
Working Years																		
Years of Working <5	78 (72.9)	79 (80.6)	1.7	64 (76.2)	93 (76.9)	0.01	95 (74.2)	62 (80.5)	1.1	123 (73.7)	34 (80.6)	4.3*	61 (69.3)	96 (82.1)	4.5*	53 (75.7)	104 (77.0)	0.04
Years of Working >5	26 (27.1)	19 (19.4)		20 (23.8)	28 (23.1)		33 (25.8)	15 (19.5)		44 (26.3)	4 (10.5)		27 (30.7)	21 (17.9)		17 (24.3)	31 (23.0)	

Chi-square, *significant at *p*-values (<0.05)

4.0 CONCLUSION

The study provides crucial insights into the prevalence of musculoskeletal disorders (MSDs) among prime mover truck drivers at Port Klang, Selangor, emphasizing the significant role of whole-body vibration (WBV) exposure and sociodemographic factors such as body mass index (BMI) and work experience. Despite WBV levels being within regulatory limits, a substantial proportion of drivers reported lower back pain, highlighting the need for targeted ergonomic interventions. The associations between higher BMI and shoulder pain, as

well as shorter work experience and back and hip pain, further underscore the complex interplay between occupational hazards and individual health factors. These findings suggest that enhancing workplace ergonomics by conduct regular workshops on the importance of posture, weight management, and techniques to minimize musculoskeletal strain during driving.It is critical steps towards reducing MSDs and improving the long-term health and well-being of drivers in the transportation industry.

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