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Determining the Risk Factors Affecting Work-Related Musculoskeletal Disorders Among Provincial Air-Conditioned Bus Drivers in Metro Manila Bus Hubs

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Abstract

Bus drivers are exposed to Work-Related Musculoskeletal Disorders (WMSDs), which have become a significant occupational health concern. Numerous risk factors contribute to the occurrence of WMSD. This study identified significant risk factors among 11 variables contributing to the prevalence of WMSD among provincial air-conditioned bus drivers in Metro Manila bus hubs. A total of 124 bus drivers participated in the study. Data was collected using various data instruments, and multiple linear regression was used to determine the correlation between the prevalence of WMSD and the independent variables. IBM SPSS Software and WarpPLS were utilized for analysis. The results found that age, BMI, work tenure, repetitive movements, work duration, vehicle ergonomics, and work posture significantly affect WMSD. The Rapid Entire Body Assessment also indicated that the average risk level for bus drivers falls under the medium risk category. WMSD among bus drivers was found to be the most common in the feet (45.97%), lower back (38.71%), and shoulders (28.23%).

Keywords
Work-related Musculoskeletal Disorders, Provincial Bus Drivers, Ergonomics, Risk Factors, Occupational Health

1. Introduction
Bus drivers play a crucial role in ensuring the safe and efficient transportation of passengers, especially those on provincial routes that cover long distances. Their responsibilities go beyond driving, as they must adhere to traffic regulations, perform pre-trip inspections, and ensure both passenger safety and vehicle reliability (TalentLyft 2024). Despite the importance of their work, the health and well-being of bus drivers are often overlooked. The Department of Labor and Employment (DOLE) in the Philippines mandates written contracts between bus operators and drivers that outline wages, working hours, and benefits; however, these contracts often overlook the physical strain and health risks associated with the job. Given the limited local ergonomic standards for professional bus drivers, this study aims

to address the research gap by identifying the primary risk factors contributing to WMSDs among provincial bus drivers in Metro Manila.

Musculoskeletal disorders (MSDs) often result in pain and reduced mobility (Greggi et al. 2024), which can impair people's ability to work and participate socially. These disorders are caused or exacerbated by the employee's work environment (CDC 2020). According to the 2021/2022 Integrated Survey on Labor and Employment released by the Philippine Statistics Authority (2024), work-related musculoskeletal disorders are among the top diseases affecting Filipino workers, with a total of 132,710 reported cases, yet no program has been designed to address them. Most bus drivers in the Philippines are exposed to hazardous working conditions and unhealthy routines (Pandarinath et al. 2023). Prolonged sitting during their long working hours, combined with awkward postures, repetitive movements, forceful exertions, and vibration, increases their risk of musculoskeletal disorders (MSDs) (Tang 2022). Given their typically limited income, severe musculoskeletal disorders could jeopardize the driver's health and financial stability, and such conditions may lead to termination due to their inability to fulfill job requirements.

1.1 Objectives

This study aims to (1) identify the significant demographic, individual-related, and environmental risk factors that contribute to WMSDs among provincial bus drivers in Metro Manila, (2) determine the prevalence and severity of WMSDs by identifying key risk factors from existing literature, (3) analyze the data gathered using multiple linear regression, and (4) propose ergonomic and policy interventions to mitigate these risks.

2. Literature Review

According to Burton et al. (2022), bus drivers are among the occupations with the highest prevalence of work-related musculoskeletal disorders. WMSDs can have both short-term and long-term effects, including chronic pain, reduced mobility, and diminished work performance (Oakman et al., 2016; Popova et al., 2025). Sekkay et al. (2020) found that long working hours and overexertion lead to physical fatigue and persistent musculoskeletal pain in truck drivers. Alexander, Chen, and Hu (2022) also observed that 78.3% of drivers experienced discomfort, particularly in the neck and shoulders. Furthermore, severe WMSDs may lead to job insecurity, financial strain, and psychological distress (Pandarinath et al. 2023; Hanumegowda and Gnanasekaran 2022).

Several studies have investigated the factors that influence WMSDs among professional drivers. Demographic factors such as age and work tenure were seen to significantly influence the risk of developing work-related musculoskeletal disorders (WMSDs). As individuals age, bone density, muscle strength, and joint flexibility naturally decline, making older drivers more susceptible to musculoskeletal strain (World Health Organization 2022; Villa-Forte 2022). Several studies have also demonstrated that longer work experience increases the risk of WMSDs due to prolonged exposure to repetitive movements, static postures, and vibration (Krishnan et al., 2021; Zulkarnain et al., 2021). Individual-related factors such as total work duration, work posture, and lifestyle also play a role in the development of WMSDs. Extended driving hours caused by traffic congestion in Metro Manila have increased the daily exposure of professional drivers to physical strain and fatigue (Suzara et al. 2021), while prolonged sitting and awkward postures exert mechanical stress on muscles and joints, particularly in the back, neck, and shoulders (Pickard et al. 2022; Joseph et al. 2020). Moreover, lifestyle habits such as smoking, alcohol consumption, and poor body mass index have been associated with higher WMSD prevalence, highlighting how both occupational and behavioral factors influence drivers' musculoskeletal health (Tabriz et al. 2023). Environmental conditions such as vibration exposure and vehicle ergonomics are also contributors to WMSD. Constant vibration from bus engines and uneven roads increases spinal loading and fatigue, accelerating degenerative changes in the lower back (Rahmani et al. 2022; Kasemsan et al. 2021), while poor vehicle ergonomics, such as uncomfortable seats, limited cabin space, and poorly positioned controls, aggravate muscle tension and restrict movement (Pickard et al. 2022; Gnanasekaran and Hanumegowda 2022).

There have been only two studies conducted in the Philippines regarding work-related musculoskeletal disorders among bus drivers, both specifically targeting suburban bus drivers (Santos and Lu 2016; Mendoza et al. 2014). Other studies on occupational drivers in the Philippines focus on taxi, jeepney, and tricycle drivers. Alexander, Chen, and Hu (2022) stated that the prevalence of symptoms and detailed risk factors varies by country and region, and studies of Joseph et al. (2020) have also shown that drivers of heavy vehicles are more prone to lower body pain compared to light vehicle drivers, which presents the researchers with the opportunity to conduct this study. The significant variables identified by Pickard et al. (2022) and Zulkarnain et al. (2021) are adapted. Instruments used to gather data include the Musculoskeletal Disorders Severity and Frequency Questionnaire (MSFQ) and the instruments used by Mendoza et al. (2014), which comprise a self-administered questionnaire for obtaining the demographic profile and the physical ergonomic risk factors, as well as a camera for documenting static sitting postures. The reviewed studies form the basis for this study's framework.

3. Methods

The study uses a quantitative, non-experimental approach and utilizes purposive sampling. Eligible respondents were required to have at least one year of experience as provincial bus drivers and to have been actively employed within the past three months. This ensures that the data collected accurately reflects recent exposure to the occupational environment and that the driver's work is a possible contributing factor to musculoskeletal disorders. The bus drivers must also have reported WMSD. Screener questions were used to filter out potential respondents.

3.1 Sampling Plan and Sample Size

G*Power software was used in determining the appropriate sample size for the study. The analysis involved 11 predictors, with parameters set for the computation as follows: an alpha level of 0.05, an effect size of 0.15, and a power of 0.8. This ensures that the risk of Type I errors is reduced to 5% and a 95% confidence level is maintained. Based on these parameters, the recommended sample size was 123.

3.2 Analysis Software

The IBM SPSS software was used to verify if the data met the assumptions of linearity, homoscedasticity, independence of errors, independence of independent variables, and normality, prior to conducting the multiple regression analysis. WarpPLS was then utilized for conducting multiple linear regression, as most independent variables do not show a linear relationship with the dependent variable (WMSD). WarpPLS was chosen for its ability to capture non-linear relationships while accurately identifying significant predictors. Kinovea was also utilized for a more accurate REBA Working Posture Assessment.

4. Data Collection

Data was collected through surveys and face-to-face interviews with provincial bus drivers who drive air-conditioned buses in Quezon City and Manila, where many bus hubs of Metro Manila are located. A total of 124 drivers participated. Ethical considerations and compliance with the Data Privacy Act (RA 10173) were strictly observed to ensure respondents' rights and well-being are protected during data collection.

4.1 Data Gathering Procedure

The data was gathered through self-administered questionnaires and ergonomic assessment methods. The Work-related Musculoskeletal Disorders Questionnaire (WMSDsQ) served as the screener questionnaire for this study. Once the screener questionnaire confirms that the discomfort they are experiencing is possibly due to WMSD and not other health-related concerns, they proceed to answer the self-administered questionnaire, which is divided into three sections: demographic, individual-related, and work-related factors. Multiple-choice and five-point Likert scale questions were used to obtain relevant responses, with researchers assisting participants during distribution. Researchers also took photos of the respondents' usual driving position for the evaluation of ergonomic risks. Data were screened for completeness and consistency prior to statistical analysis to remove invalid or incomplete responses.

4.2 Data Analysis

Data were analyzed using multiple linear regression (MLR) to determine the relationship between WMSD prevalence and the 11 independent variables, using WarpPLS and SPSS software for statistical analysis. The Rapid Entire Body Assessment (REBA) was used to assess physical strain and posture of the participants, evaluating the biomechanical load across body regions, while the Musculoskeletal Disorder Severity and Frequency Questionnaire (MSFQ) was used to measure the dependent variable by categorizing WMSD severity levels based on computed scores derived from self-reported frequency and intensity of discomfort, as seen in Figure 1 (Chailklieng and Poochada, 2022). Perception levels are as follows: no MSDs (0 points), mild MSDs (1-2 points), moderate MSDs (3-4 points), severe MSDs (5-8 points), and very severe MSDs (9-16 points).

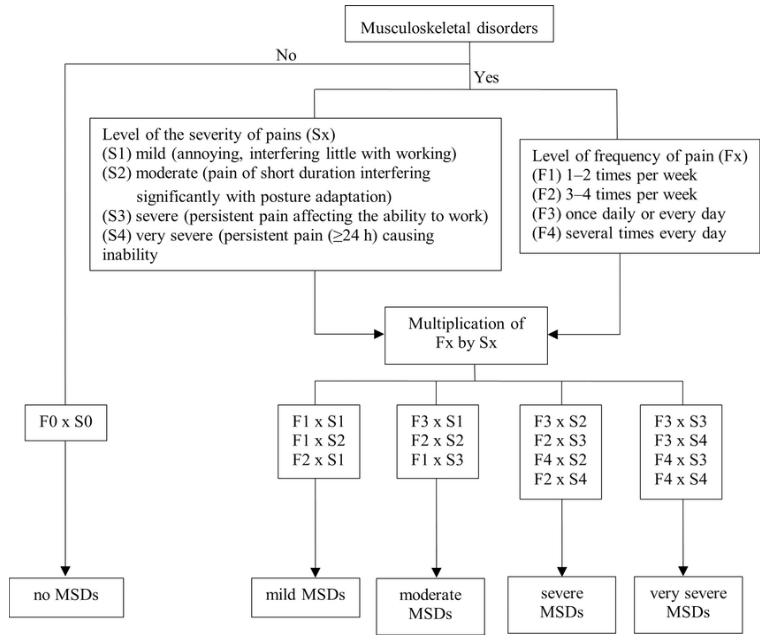

Figure 1. Framework for Computing Musculoskeletal Disorder Severity and Frequency based on the MSFQ (Chailklieng & Poochada, 2022).

5. Results and Discussion

Based on the validated dataset, the following results summarize the prevalence and statistical significance of each risk factor. The study was conducted systematically, starting with the verification of assumptions for multiple linear regression, followed by the analysis of regression coefficients, interpretation of the model summary, analysis of descriptive statistics, and finally, analysis of correlations through bivariate correlation analysis. The resulting individual effect and contribution of each predictor variable to WMSD are examined and summarized in Table 1, highlighting significant predictors with p-values below 0.05. The regression coefficients indicate the direction and magnitude of the relationship between each independent variable and WMSD. At the same time, the significance values (p-values) help determine which predictors are statistically significant in explaining variations in WMSD. The most significant factors affecting the presence of WMSDs were identified as work tenure, age, total daily work duration, BMI, work posture, repetitive movements, and vehicle ergonomics.

Table 1. Summary of Regression Results Showing the Significance and Direction of Relationship Between Predictor Variables and WMSDs

Variable	**p-value**	**Statistical Significance**	**Value of Coefficient**	**Relationship**
Work Tenure	0.024	Significant	0.172	Positive
Age	0.004	Significant	0.226	Positive
Drinking Habits	0.150	Not Significant	-0.092	Negative
Smoking Habits	0.204	Not Significant	0.073	Positive
Total Work Duration per Day	<0.001	Significant	0.530	Positive
Vibration	0.324	Not Significant	0.041	Positive
Driving Frequency	0.466	Not Significant	-0.008	Negative
BMI	0.046	Significant	-0.147	Negative
Work Posture	0.001	Significant	0.259	Positive
Repetitive Movements	0.026	Significant	0.169	Positive
Vehicle Ergonomics	0.028	Significant	-0.167	Negative

5.1 Proposed Improvements

The following recommendations are proposed to address the seven risk factors that significantly contribute to WMSDs. Various studies, including those by NIOSH (n.d.), Vernekar and Shah (2021), Jayakumar and Vinodkumar (2024), and Biswas et al. (2022), recommend that drivers undergo regular or periodic general medical check-ups. These annual check-ups can help monitor and manage health risks. It is recommended that bus companies offer regular medical examinations to ensure the health and safety of their drivers. They should also plan and assign wellness breaks for their drivers by alternating work and rest period duration to allow drivers to recover from physical strain. The organization can also conduct ergonomic assessments across all its bus models to identify and prioritize those with favorable designs and provide the appropriate ergonomic interventions to other bus models as deemed necessary. Adjustable seating systems with dynamic lumbar support pillows are essential. Seat height, backrest angle, seat depth, and lumbar pad thickness must be adjustable to accommodate drivers of various body sizes and reduce the degree of spinal flexion during driving (Horina et al., 2025). Ergonomic redesign can also be standardized by government agencies. The Land Transportation Franchising and Regulatory Board (LTFRB) and the Department of Transportation (DOTr) could develop and implement detailed, objective ergonomic standards that adhere to ISO standards. Such changes in policy should require all buses to have driver workstations that meet certain standards.

Government agencies have also recognized the need to address the risks associated with prolonged driving hours. In 2017, the Land Transportation Franchising and Regulatory Board (LTFRB) recommended limiting driving to only six hours (GMA News, 2017) and more recently, the Philippine Department of Transportation (DOTr) further proposed reducing the driving hours of public utility vehicles to four hours, requiring a reliever driver on board for trips exceeding this limit (ABS-CBN News, 2025). Bus companies should follow these recommendations. Bus drivers themselves are also encouraged to perform simple stretching exercises during breaks or at stoplights to reduce muscle stiffness and improve circulation (Gasibat et al., 2023).

A potential technological intervention includes active suspension seat technologies, which feature built-in sensors, electromagnetic motors, and microcomputers that can detect and adjust seat motion to counteract unwanted movements. These systems improve comfort and can reduce lower back pain by up to 25% (Oregon Health & Science University, 2022). Together with the introduction of active and semi-active seats, drivers should also adjust their seats accordingly to achieve optimal support and comfort. Lastly, as drivers age, they are encouraged to adopt lifestyle changes such as maintaining a balanced diet and engaging in regular physical activity.

5.2 Validation

Before conducting the multiple linear regression test, the researchers examined the five (5) assumptions of multiple linear regression to ensure the quality of the data and its accuracy for application.

Table 2. Regression Model Summary with Durbin-Watson Test

					Change Statistics					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.383[a]	.147	.054	11.04489	.147	1.589	12	111	.105	1.999

a. Predictors: (Constant), Vehicle_Ergonomics, Work_Posture, Vibration, Work_Tenure, Days_of_smoking, Days_of_drinking, Driving_Frequency, BMI, Work_Duration, Repetitive_Movements, Age, Cigarettes_per_day

b. Dependent Variable: WMSD

Table 2 shows the Durbin-Watson Test having a statistic value of 1.99, indicating that the residuals are not autocorrelated, as it falls within the acceptable range of 1.5 to 2.5. This confirms that the residuals are independent from one another, satisfying the assumption of independence.

Table 3. Variance Inflation Factor (VIF) Test Results

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-20.856	14.498		-1.439	.155	-49.765	8.053					
	Work_Tenure	-.384	.181	-.248	-2.122	.037	-.745	-.023	.063	-.244	-.179	.520	1.924
	Age	.504	.181	.337	2.781	.007	.143	.865	.323	.313	.234	.483	2.069
	Alcohol_Habits	-.264	.235	-.101	-1.124	.265	-.733	.205	.005	-.132	-.095	.877	1.140
	Smoking_Habits	.109	.147	.110	.742	.461	-.184	.402	.190	.088	.063	.322	3.110
	Cigarettes_per_day	.054	.364	.023	.148	.883	-.673	.780	.143	.018	.012	.299	3.345
	Work_Duration	1.463	.282	.494	5.192	.000	.901	2.025	.595	.525	.438	.785	1.274
	Vibration	.152	1.211	.012	.125	.901	-2.263	2.567	-.025	.015	.011	.818	1.223
	Driving_Frequency	-1.473	1.142	-.121	-1.290	.201	-3.751	.804	-.183	-.151	-.109	.809	1.236
	BMI	-.129	1.406	-.009	-.091	.927	-2.932	2.675	-.165	-.011	-.008	.803	1.245
	Work_Posture	.882	1.048	.076	.841	.403	-1.208	2.971	.084	.099	.071	.872	1.146
	Repetitive_Movements	2.181	1.069	.205	2.039	.045	.049	4.313	.294	.235	.172	.701	1.428
	Vehicle_Ergonomics_	-.744	1.858	-.041	-.401	.690	-4.450	2.961	.126	-.047	-.034	.687	1.455

a. Dependent Variable: WMSD

Table 3 presents results indicating that all predictor variables have VIF values below 10, found in the last column, suggesting no significant multicollinearity. Therefore, independent variables are not highly correlated with each other.

Table 4. Cook's Distance Test Results

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-6.06	37.52	14.52	8.353	84
Residual	-19.023	31.475	.000	8.428	84
Std. Predicted Value	-2.464	2.754	.000	1.000	84
Std. Residual	-2.088	3.454	.000	.925	84

a. Dependent Variable: WMSD

Table 4 presents the Cook's Distance test; all values were below 1, indicating that there were no influential data points or outliers that could distort the regression model. Tables 2-4 collectively ensure the validity of the regression model.

Table 5. Model Summary and Fit

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.704[a]	.496	.410	9.113	.496	5.812	12	71	.000	2.039

a. Predictors: (Constant), Vehicle_Ergonomics_, Smoking_Habits, Work_Posture, Work_Tenure, Vibration, BMI, Alcohol_Habits, Driving_Frequency, Work_Duration, Repetitive_Movements, Age, Cigarettes_per_day

b. Dependent Variable: WMSD

Table 5 provides the Model Summary. The results showed that the model explained 5.4% of the variance in WMSDs ($R^2 = 0.147$, Adjusted $R^2 = 0.054$, $F(12, 111) = 1.589$, $p = 0.105$). According to a study by Field (2018), the interpretation of R^2 values varies across disciplines. It is possible that the R^2 in this study is low due to the non-linear relationship between the independent variables and WMSD, and that there are other relevant independent variables not included in the study but still affect WMSD (Fernando, 2025). It is recommended that additional variables be included for future studies.

Table 6. Descriptive Statistics

Descriptive Statistics

	Mean	Std. Deviation	N
WMSD	14.52	11.866	84
Work_Tenure	11.24	7.664	84
Age	41.99	7.940	84
Alcohol_Habits	2.88	4.540	84
Smoking_Habits	7.95	12.004	84
Cigarettes_per_day	3.24	5.021	84
Work_Duration	10.87	4.006	84
Vibration	2.24	.913	84
Driving_Frequency	6.44	.974	84
BMI	2.68	.794	84
Work_Posture	6.94	1.022	84
Repetitive_Movements	4.17	1.118	84
Vehicle_Ergonomics_	4.51	.649	84

Table 6 presents the basic statistical profile of the study's sample, consisting of 124 male bus drivers aged 28 to 59 years (M = 41.99, SD = 7.940). The average work duration per trip was 10.87 hours (SD = 4.006), ranging from 2 to 16.5 hours. Drivers typically completed 1 to 6 trips per day and worked 3 to 7 days per week. The REBA analysis scores ranged from 6 to 10 (M = 6.94, SD = 1.022), indicating a medium risk level due to leg extension posture while driving, which may cause muscle strain (Pickard et al., 2022). The mean WMSD score was 14.52 (SD = 11.866), suggesting very severe discomfort with notable variability among participants. Despite this, most drivers perceived their work environment as comfortable. The most common areas of discomfort among respondents were the feet (45.97%), followed by the lower back (38.71%), and the shoulders (28.23%).

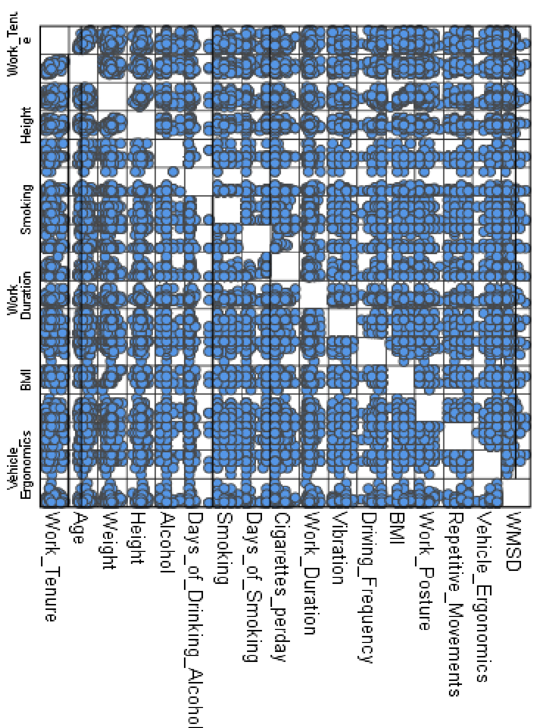

Figure 2. Scatter Plot Matrix shows the relationship between WMSD and Predictor Variables.

Figure 2 reveals that only the variable 'age' exhibits a positive linear relationship with Work-Related Musculoskeletal Disorders (WMSDs), as it follows a straight-line trending upward to the upper right corner. This means that as age increases, WMSDs also tend to increase. Other variables did not exhibit a linear relationship with WMSDs.

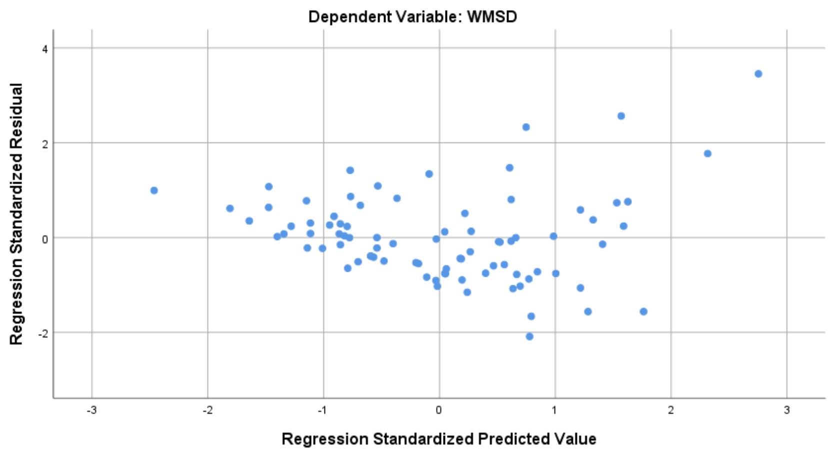

Figure 3. Homoscedasticity Residual Plot.

Figure 3 shows that the residuals are evenly distributed across predicted values, with no observable patterns or funnel shapes. This indicates constant variance of residuals, satisfying the assumption of homoscedasticity.

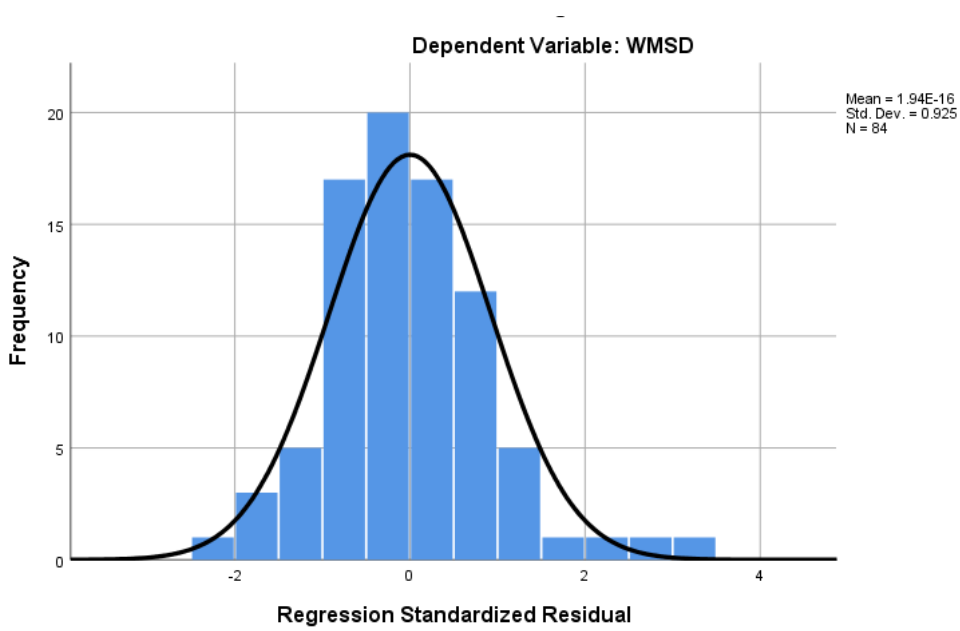

Figure 4. Histogram of Standardized Residuals.

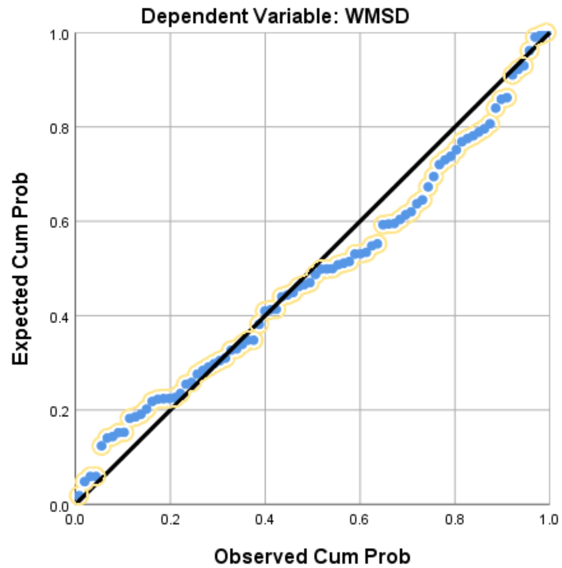

Figure 5. Normal P-P Plot of Standardized Residuals.

Figure 4 displayed a bell-shaped curve, and Figure 5 showed points closely aligned with the diagonal line. These findings indicate that the residuals follow a normal distribution, satisfying the assumption of normality.

6. Conclusion

All study objectives were achieved. Out of eleven risk factors examined, 7 factors significantly contributed to WMSDs, including work tenure, age, work duration, BMI, work posture, repetitive movements, and vehicle ergonomics. All seven factors, excluding BMI and vehicle ergonomics, demonstrate a positive correlation with WMSDs, indicating that as work tenure, age, total work duration per day, repetitive movements, and REBA scores (which assess work posture) increase, the likelihood of WMSD also increases. Meanwhile, BMI and vehicle ergonomics demonstrate a negative correlation with WMSD. As BMI moves further from the range considered healthy, the level of pain associated with WMSD increases. Similarly, as vehicle ergonomics worsens (low score), the pain level due to WMSD also increases. The descriptive statistics also show that despite having a mean of a medium-risk REBA analysis score (6.88), most drivers perceive their work environment as comfortable, which minimizes the prevalence of musculoskeletal disorders. Furthermore, repetitive movements were not perceived as a major concern by the bus drivers, as their ability to shift positions and adjust their posture reduces discomfort. The descriptive statistics also showed that WMSD among bus drivers was most common in the feet (45.97%), lower back (38.71%), and shoulders (28.23%).

The findings of this study can serve as a foundation for developing interventions aimed at reducing the discomfort experienced by bus drivers. By identifying risk factors that contribute to WMSD, this research contributes to a deeper understanding of the challenges faced by bus drivers in their work. These insights benefit the workers themselves, bus transportation companies, occupational health practitioners, and policymakers by allowing them to propose interventions that can lead to more sustainable working conditions within the transportation industry. This paper contributes to the limited literature on the musculoskeletal health of provincial bus drivers in the Philippines.

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Aaron Remata is a student of the Bachelor of Science in Industrial Engineering program at the University of Santo Tomas, España, Manila, Philippines. He is mechanically inclined and regularly works on DIY projects. Skilled in practical tasks, he applies engineering concepts to projects with attention to detail and quality. Aaron is currently an intern at the Department of the Building Official of the Quezon City Government, where he applies his knowledge about process improvement, organizational management, and human resource concepts. A balance of determination and openness to continuous improvement inspires him to perform well.

Andrea Tamba is a senior Industrial Engineering student at the University of Santo Tomas. Throughout her academic journey, she has applied her knowledge and skills through three research studies focusing on marketing, product development, and ergonomics. Currently, she is further enhancing her technical and analytical capabilities through her internship at Globe Telecom, where she gains valuable industry experience. Andrea holds a strong fascination for systems and simulation, which she continues to develop using tools such as Arena Simulation, AnyLogic, and Python. Beyond academics, she has been an active member of both a faculty-based organization and a university-wide organization, demonstrating her commitment to leadership, collaboration, and professional growth.