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Herlina J. EL-Matory

Institut Kesehatan Deli Husada Deli Tua, Deli Serdang, herlinajelmatory.hjem@gmail.com

Nabila Syahlan

Universitas Indonesia, Depok, nabilasyahlan@ui.ac.id

Mohd Rafee B. Baharuddin

Universiti Putra Malaysia, Selangor Darul Ehsan, mohdrafee@upm.edu.my

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Determinants of Musculoskeletal Disorder in Formal and Informal Workers in Indonesia

Herlina J. EL-Matiry^{1*}, Nabila Syahlan^{2,3}, Mohd Rafee B. Baharuddin⁴

¹Faculty of Public Health, Institut Kesehatan Deli Husada Deli Tua, Deli Serdang, Indonesia

²Master Program of Occupational Safety and Health, Faculty of Public Health, Universitas Indonesia, Depok, Indonesia

³Undergraduate Program of Law Science, Faculty of Law, Social, and Political Science, Universitas Terbuka, Indonesia

⁴Department of Community Health, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, Selangor Darul Ehsan, Malaysia

Abstract

Musculoskeletal disorders (MSDs) are a leading cause of disability globally and are strongly influenced by occupational conditions. Evidence comparing MSD risk between formal and informal workers remains limited, particularly in developing countries. This study examined the association between individual and job-related factors with MSD symptoms among formal and informal workers in Indonesia. A cross-sectional study was conducted among 1,089 workers in North Sumatra Province, Indonesia, from August 2024 to December 2025. Participants were recruited using stratified convenience sampling from both the formal (office and health workers) and informal (drivers, traders, and farmers) sectors. MSD symptoms were assessed using the Nordic Body Map questionnaire and categorized into low, moderate, and high-risk levels. Independent variables included age, sex, work experience, and job type. Data were analyzed using Chi-square tests and multivariate logistic regression. Overall, 31.6% of workers reported moderate-to-high MSD symptoms. Informal workers had significantly higher odds of MSD symptoms (OR = 1.607; 95% CI: 1.20–2.10; p-value <0.001). Male workers were more likely to report MSD symptoms (OR = 3.65; 95% CI: 2.7–4.9; p-value <0.001). Longer work experience (>5 years) was associated with lower MSD risk (OR = 0.46; 95% CI: 0.34–0.63; p-value <0.001), while age was not a significant predictor. MSDs remain a substantial occupational health problem among Indonesian workers, particularly in the informal sector. Targeted ergonomic interventions and occupational health programs are needed to reduce disparities and improve workers' health in developing-country settings.

Keywords: ergonomics risk, informal workers, musculoskeletal disorders, Nordic Body Map, occupational health

Correspondence*:

Herlina J. EL- Matiry

Faculty of Public
Health, Institut
Kesehatan Deli Husada
Deli Tua, Deli Serdang,
Indonesia
herlinaelmatiry.hjem@gmail.com

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Introduction

Musculoskeletal disorders (MSDs) constitute a significant global occupational health problem and are significantly related to ergonomic hazards in the workplace.¹ Work-related cumulative trauma due to poor work posture, repetitive work, and prolonged physical effort results in MSDs in various jobs, which reduces productivity and results in an elevated disability burden.¹ Recent studies in West Java Province, Indonesia, show that MSDs are prevalent in multiple sectors, such as office environments, physical labor, and informal work, with rates exceeding 50% in many populations when assessed using standardized instruments like the Nordic Body Map (NBM).^{2,3}

Ergonomic evaluations with NBM have become more popular in cross-sectional research to assess MSD complaints and pinpoint high-risk body areas among employees. For example, ergonomic assessments of garment and artisan employees showed significant MSD issues in

the back, neck, and lower limb areas.^{4,5} Likewise, studies of construction workers and teachers showed the significant impact of posture and work requirements on MSD risk.^{6,7} Another study involving market porters revealed that understanding ergonomics greatly influences the risk of MSD, indicating that educational initiatives might lessen symptom occurrence.⁸

In Indonesia, studies on workplace MSDs similarly show consistent links among ergonomic factors and symptoms of MSDs. A cross-sectional study of office employees revealed a nearly universal occurrence of ergonomic risk when assessed using NBM, indicating systemic exposure to risk factors.² Another study indicates important correlations between non-ergonomic work behaviors, extended work hours, and heightened MSD complaints.⁹

Data from conventional craft industries, such as woodworkers and weaving artisans, also points to repetitive activities and prolonged awkward positions as indicators of MSDs.^{10,11}

Although there is an increasing amount of research, extensive studies involving diverse worker populations from both formal and informal sectors are scarce. Additionally, limited research has examined personal and work-related factors (age, sex, experience, and work) associated with MSD complaints using logistic regression models, hindering comprehensive risk assessment. The recognition of ergonomic hazards and their contribution to MSDs is a main topic of investigation in occupational health, particularly in developing suitable interventions to minimize the impact of MSDs across various workforces.

Demographics such as age, sex, and job experience have been found to affect the risk of MSD. Recent studies indicate that male employees have a higher prevalence of MSD (>50%) due to increased exposure to physically strenuous tasks.^{4,9} Reduced work experience has also been linked to an increased risk of MSD, as workers with less experience might not have developed adaptive strategies and ergonomic understanding.¹¹ Outcome concerning age is inconsistent, as certain studies show greater MSD prevalence in younger workers attributed to heavier workloads and increased task intensity.^{5,7,8}

The type of job significantly influences ergonomic exposure. Informal workers frequently face greater MSD risk due to ergonomic problems in the work environment, long working hours, and limited access to occupational health facilities.¹⁰ Comparison between formal and informal sectors reveals that informal sector workers have the highest prevalence (>50%) of MSD symptoms (especially low back, shoulder, and neck).^{2,5} These outcomes highlight the significance of work-related elements in the development of MSDs.

While many studies have examined MSDs in specific occupations, recent studies have increasingly analyzed multiple individual and occupational factors across industries using multivariate methods.^{2,7,12,13} Further, some studies used multivariate analyses such as logistic regression to examine the relationship between MSD risk and age, sex, work experience, or occupation.^{2,7,12,13} This gap is important to develop targeted ergonomic interventions and evidence-based workplace health regulations. This study aimed to estimate the prevalence of MSDs and examine the associations between age, sex, work experience, job type, and MSDs in relation to different sectors of workers using NBMs. The following hypotheses would be tested: sex, work experience, and job type significantly relate to MSDs; informal workers face a greater risk of MSDs compared to formal workers; and

increased work experience correlates with a reduced risk of MSDs.

Despite extensive evidence on MSDs, existing research remains largely fragmented and occupation-specific, limiting the ability to understand how broader labor structures shape risk. In particular, comparative evidence between formal and informal sectors is scarce, and few studies have applied multivariate approaches to disentangle the independent effects of individual and work-related determinants across heterogeneous worker populations. This study addressed these gaps by providing a cross-sectoral, multivariate analysis of MSD determinants within a unified framework. It explicitly positions employment type, formal versus informal, as a central analytical variable, rather than a contextual background factor. By doing so, this study advanced the premise that MSD risk is not solely driven by ergonomic exposures, but is structurally embedded within labor conditions and regulatory environments.

Focusing on a developing country context, this study further contributed by generating policy-relevant evidence on occupational health inequalities, where informal workers remain underrepresented in occupational safety and health (OSH) systems. The study therefore offers a more comprehensive and generalizable model of MSD risk, bridging individual-level epidemiological factors with systemic labor dynamics, and providing a stronger foundation for equity-oriented occupational health interventions.

Method

This study employed a quantitative cross-sectional design across multiple occupational settings in North Sumatra Province between August 2024 and December 2025. A stratified convenience sampling approach was used to recruit 1,089 workers from both formal (office and health workers) and informal sectors (drivers, traders, and farmers), ensuring representation of heterogeneous occupational groups. Participants were eligible if they were actively working at the time of data collection and provided informed consent. Data were collected using a structured, self-administered questionnaire, with guidance from trained researchers to ensure consistency and minimize misinterpretation.

The primary outcome variable was MSD symptoms, assessed using the NBM, a validated instrument widely used in occupational health research. The NBM evaluates discomfort across 28 anatomical regions, including the neck, shoulders, upper and lower back, and upper and lower extremities

(arms, wrists, fingers, thighs, calves, knees, and ankles). Each region was rated using a four-point ordinal scale: 0 (no discomfort), 1 (mild discomfort without interference), 2 (moderate discomfort with some activity limitation), and 3 (severe discomfort requiring rest or limiting work activities).

Individual scores were summed to produce a total MSD score that represents the overall musculoskeletal burden. Scores were categorized into low (0–10), moderate (11–20), and high (>20) MSD levels based on established cut-off values. For inferential analysis, the total score was dichotomized into low (0–10) and moderate-to-high (>10) categories. For regression analysis, moderate and high MSD categories were combined into a single “moderate-to-high” category to generate a binary outcome variable appropriate for logistic regression and to improve analytical stability.

The independent variables included demographic and occupational factors. Age was categorized into ≤30 years and >30 years. Sex was categorized as male and female. Work experience: categorized into ≤5 years and >5 years. Job type classified as formal (office and health workers) and informal (drivers, traders, and farmers). Formal employment referred to institution-based occupations with structured employment arrangements and occupational safety oversight, whereas informal employment referred to occupations characterized by irregular work conditions, limited social protection, and lower regulatory coverage.

All statistical analyses were performed using IBM SPSS Statistics V.25 (licensed, 1989, 2023). Descriptive statistics were used to summarize participant characteristics and the distribution of MSD symptoms. Bivariate analysis was conducted using Chi-square tests to assess associations between independent variables and MSD categories. Variables with a p-value <0.25 were included in the multivariate logistic regression model to identify independent predictors of MSD symptoms. Results were reported as odds ratios (ORs) with 95% confidence intervals (CIs), and statistical

significance was set at p-value <0.05. Model adequacy was evaluated using the Hosmer–Lemeshow goodness-of-fit test, with a p-value >0.05 indicating acceptable model fit. Multicollinearity was assessed using the Variance Inflation Factor (VIF) values, and all predictors demonstrated VIF values <10, indicating no significant multicollinearity.

Results

The outcomes section details the distribution of respondent traits and the incidence of MSD symptoms among workers, along with analyses of the relationships among demographic and occupational factors and MSD outcomes. Descriptive outcomes were initially presented to provide an overview of age, sex, work experience, and job type, followed by bivariate and multivariate analyses to identify factors influencing MSD risk. These outcomes provided a foundation for comprehending differences in MSD symptoms among formal and informal employment sectors.

As shown in Table 1, a total of 1,089 workers participated in the study. Most participants were aged ≤30 years (65%), male (64.8%), and had ≤5 years of work experience (81.4%). The distribution between formal (51.3%) and informal workers (48.7%) was relatively balanced. Overall, 31.6% of participants reported moderate-to-high MSD symptoms.

Table 2 demonstrated that sex, work experience, and job type were significantly associated with MSD symptoms (p-value <0.001), while age was not statistically significant (p-value = 0.062). Male workers were more likely to experience moderate-to-high MSD symptoms compared to females (OR = 2.731; 95% CI: 2.116–3.527). Workers with ≤5 years of experience had a higher risk compared to those with >5 years (OR = 2.159; 95% CI: 1.560–2.988). Informal workers also had a higher risk than formal workers (OR = 2.235; 95% CI: 1.720–2.904). Reference categories were ≤30 years, male, ≤5 years of work experience, and formal workers.

Table 1. Frequency of Age, Sex, Work Experience, Job Type, and Musculoskeletal Disorder

Factor	Categories	Frequency (%)
Age	>30 years	381 (35%)
	≤30 years	708 (65%)
Sex	Male	706 (64.8%)
	Female	383 (35.2%)
Work Experience	≤5 years	886 (81.4%)
	>5 years	203 (18.6%)
Job Type	Formal (office and health workers)	559 (51.3%)
	Informal (drivers, traders, farmers)	530 (48.7%)
Musculoskeletal Disorder	Low	745 (68.4%)
	Moderate-High	344 (31.6%)

Table 2. Demographic and Occupational Factors and Musculoskeletal Disorders

Factor	Categories	Musculoskeletal Disorder		χ^2 / p-value	OR (95% CI)
		Low	Mod-high		
Age	>30 years	247 (64.8%)	134 (35.2%)	3.479 / 0.062	0.777 (0.596–1.013)
	≤30 years	498 (70.3%)	210 (29.7%)		
Sex	Male	419 (59.3%)	287 (40.7%)	76.298 / <0.001	2.731 (2.116–3.527)
	Female	326 (85.1%)	57 (14.9%)		
Work Experience	≤5 years	575 (64.9%)	311 (35.1%)	27.143 / <0.001	2.159 (1.560–2.988)
	>5 years	170 (83.7%)	33 (16.3%)		
Job Type	Formal (office and health workers)	429 (76.7%)	130 (23.3%)	36.905 / <0.001	2.235 (1.720–2.904)
	Informal (drivers, traders, farmers)	316 (59.6%)	214 (40.4%)		

Note: Reference categories were ≤30 years, male, ≤5 years of work experience, and formal workers

Table 3. Logistic Regression Summary: Risk Factors for Musculoskeletal Disorder

Factor	Categories	Reference	Exp(B)	Sig.	MSDs Risk
Age	>30 years	≤30 years	0.712	0.027	28.8% lower risk than ≤30 years
Sex	Female	Male	0.274	<0.001	72.6% lower risk than males
Work Experience	>5 years	≤5 years	0.464	<0.001	53.6% lower risk than ≤5 years
Job Type	Informal	Formal	1.607	<0.001	60.7% higher risk than formal

Note: Reference categories were ≤30 years, male, ≤5 years of work experience, and formal workers.

Table 3 shows the logistic regression analysis of the main determinants in relation to the risk of MSD signs among workers. After adjustment, workers aged >30 years had lower odds of MSD symptoms than those aged ≤30 years (OR = 0.712; 95% CI: 0.525–0.965; p-value = 0.027). Female workers had significantly lower odds compared to males (OR = 0.274; 95% CI: 0.198–0.379; p-value <0.001). Workers with >5 years of experience had reduced risk (OR = 0.464; 95% CI: 0.317–0.679; p-value <0.001). Informal workers had higher odds of MSD symptoms compared to formal workers (OR = 1.607; 95% CI: 1.230–2.099; p-value <0.001). Reference categories were ≤30 years, male, ≤5 years of work experience, and formal workers.

Discussion

This study identified sex, work experience, and job type as significant determinants of MSD symptoms, with informal workers exhibiting a consistently higher risk. This finding aligned with global evidence indicating that workers in informal and precarious employment experience greater ergonomic exposure, weaker regulatory protection, and limited access to occupational health services, resulting in a higher MSD burden.^{1,14} The Global Burden of Disease Study 2019 confirms that musculoskeletal conditions remain a leading cause of disability worldwide, particularly among working-age populations exposed to suboptimal work environments.^{1,14} In Indonesia, similar patterns have been reported among informal workers, such as farmers, drivers, and market laborers, in which repetitive physical tasks and limited ergonomic awareness contribute to higher MSD prevalence.^{15,16} These findings reinforced that labor informality operates as a structural determinant of occupational

health, rather than merely a contextual characteristic.

Several findings diverge from conventional patterns, particularly the protective effects of longer work experience and the non-significant role of age. While cumulative exposure is often associated with increased MSD risk, this study suggested a healthy worker effect, whereby individuals who remain in physically demanding jobs are those who have adapted or are less susceptible to musculoskeletal strain.^{17,18} In addition, experienced workers may develop adaptive strategies, improved body mechanics, and greater awareness of safe working practices, reducing biomechanical load over time. Conversely, workers with shorter experience may be more vulnerable due to limited familiarity with ergonomic principles. The absence of a significant age effect further indicates that ergonomic exposure and work organization may be more influential than chronological aging, particularly in relatively young and active working populations. Comparable findings in Indonesian studies suggest that work technique and exposure patterns are stronger predictors of MSD symptoms than age alone.^{18–20}

This study's findings state that female workers had lower MSD risk, contrasted with studies suggesting higher vulnerability among women. However, this difference was likely explained by gender-based task allocation rather than biological susceptibility, as male workers in this context are more frequently engaged in physically demanding occupations with higher biomechanical loads, particularly in informal sectors.^{17,18} Collectively, these findings indicated that modifiable workplace exposures and labor structures are more influential than demographic characteristics, supporting a shift toward context-specific, exposure-based risk assessment.

From a policy perspective, this study's results highlighted the need to extend OSH strategies beyond the formal sector, particularly in developing countries. Given the heterogeneity and limited regulatory oversight in informal settings, interventions should prioritize feasible, low-cost, and scalable approaches, including ergonomic training, task redesign, and scheduled rest breaks. Community-based programs and integration of occupational health services into primary healthcare systems offer practical entry points for reaching underserved workers.^{16,21} In Indonesia, initiatives such as the Occupational Health Effort Post to demonstrate the potential for delivering basic occupational health interventions at the community level.^{20,22} These approaches are more realistic than enforcement-based models and align with global recommendations for improving worker health equity.

However, several limitations should be considered. The cross-sectional design precludes causal inference between risk factors and MSD outcomes. Potential selection bias may arise from the use of stratified convenience sampling, particularly in the informal sector, where worker accessibility varies, potentially limiting representativeness. In addition, MSD symptoms were self-reported, introducing the possibility of recall bias and reporting heterogeneity. Although the NBM focused on recent work-related discomfort to reduce long-term recall error, self-reported symptoms remain subject to recall and reporting bias. Informal workers may underreport symptoms or interpret them differently due to variations in health literacy or the normalization of discomfort, raising the possibility of differential misclassification between groups. Furthermore, the study did not include detailed assessments of specific ergonomic exposures, physical workload, or psychosocial factors, which may confound the observed relationships. These limitations also restricted the generalizability of findings to similar occupational contexts in developing countries.

Despite these limitations, the study provided robust evidence that MSD symptoms were strongly influenced by occupational conditions, particularly job type and work experience, and that informal workers remain disproportionately affected. Overall, the findings supported a shift toward inclusive, system-oriented occupational health strategies that address structural inequalities and prioritize high-risk worker populations.

Conclusion

This study showed that MSD risk is strongly associated with employment type, sex, and work experience, with informal workers and males having higher odds of symptoms. The findings highlight the importance of targeted ergonomic interventions, particularly those focusing on workload reduction, posture improvement, and occupational health access for informal workers. In heterogeneous informal work settings, low-cost and adaptable strategies such as community-based ergonomic education and integration of basic occupational health services are likely to be more feasible. Overall, the results emphasize the need for context-specific occupational health policies and preventive ergonomic programs in developing countries.

Abbreviations

MSD: musculoskeletal disorder; NBM: Nordic Body Map; OHS: occupational safety and health; OR: odds ratio; CI: confidence interval; VIF: Variance Inflation Factor.

Ethics Approval and Consent to Participate

The research was conducted based on the research ethics guidelines and has been approved under approval letter Nomor: 458/KEP-IKDH/V/2024 from the Ethics Committee of Institut Kesehatan Deli Husada Deli Tua. Informed consent was obtained from the study participants.

Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Availability of Data and Materials

It is to clarify the data sources or information used as research materials, including the Supplementary File, which the public can access for additional information on the datasets used in the research or the research findings.

Authors' Contribution

HJEM: Conceptualization; Methodology; Investigation; Data curation; Formal analysis; Writing original draft; Writing review & editing. NS: Investigation; Data curation; Project administration; Writing review & editing. MRBB: Supervision; Conceptualization; Methodology; Writing review & editing.

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Declaration on the Use of Artificial Intelligence

ChatGPT 4 (chat.openai.com) was used to assist in developing the initial structure of the discussion on the potential impacts of populism on the evidence-informed health policy process. QuillBot AI (<https://quillbot.com/>) was used to assist with editing and rephrasing the manuscript's initial drafts, as the author is a non-native English speaker.

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