

Relationship between potential ergonomic hazard factors and musculoskeletal disorders in Nipah leaf crafters in Terjun Village, Indonesia

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ABSTRACT

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Date of submission: 30.04.2025
Date of acceptance: 29.07.2025
Date of publication: 01.10.2025

Conflicts of interest: None
Supporting agencies: Universitas
Sumatera Utara No
620/UN5.2.1/KPM/2023
DOI: <https://doi.org/10.3126/ijosh.v15i3.78138>



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Introduction: Nipah leaf crafters regularly perform tasks involving awkward postures—such as sitting on the floor without back support—repetitive hand movements, manual handling of Nipah leaves and sticks, and working in physically uncomfortable environment. These factors present potential ergonomic hazards that can lead to musculoskeletal disorders (MSDs), often manifesting as pain in various body parts. This study aimed to identify potential ergonomic hazards and the presence of MSDs, as well as to analyze their relationship.

Methods: This quantitative study employed a cross-sectional design and involved 35 Nipah leaf crafters. Potential ergonomic hazards were measured using a standardized checklist, and musculoskeletal disorders were assessed using a survey based on Appendices D and B of the Indonesian National Standard (SNI) 9011:2021. The research utilized univariate and bivariate methods, and relationship between ergonomic risks and musculoskeletal outcomes was analyzed using analysis of variance (ANOVA).

Results: Common ergonomic hazards identified included awkward postures, repetitive motion, lifting, poor lighting, and exposure to solar heat. Twenty-two participants (62.90%) were classified as "requiring further observation." Reports of MSDs varied in frequency and severity across body regions, with 21 individuals (60.00%) categorized as low-risk. A statistically significant relationship ($p < 0.05$) was found between potential ergonomic hazards and incidence of MSDs.

Conclusion: This study highlights the urgent need to address occupational health risks among Nipah leaf crafters to prevent MSDs, promote worker health, and improve productivity.

Keywords: Musculoskeletal disorders, Nipah leaf crafters, potential ergonomic hazard factors

Introduction

Nipah plants are commonly found in mangrove forest environments along rivers, beaches, and coastal regions. These plants offer numerous benefits, such as fuel, roofing materials, wall components, and raw material for handicrafts. The midrib of the Nipah leaf is widely used in

crafting, where the stick serves for plaiting and broom-making, and the leaf is often used for wrapping cigarettes.

Indonesia's informal sector has been expanding rapidly, providing employment opportunities for a substantial portion of the workforce. Nipah leaf

crafting is one such activity within the informal economy that can serve as a primary or supplementary income source. It requires relatively low capital investment and can be performed from home. In Medan City, Nipah leaf crafters are predominantly located in Terjun Village, within the Medan Marelan Sub-district, where this work constitutes the main or additional livelihood for many residents. Products include woven plates, broomsticks, and cigarette wrappers.

Most of the workers in this sector are women (homemakers), with 30 out of the 35 surveyed being female. Their ages range from 15 to 71 years, and their work experience spans between 3 and 58 years. The work is typically conducted indoors or outdoors (e.g., on terraces or in yards) and follows irregular hours, often beginning between 9:00 a.m. and 12:00 p.m. and continuing from 2:00 p.m. to 4:00 p.m. or from 2:00 p.m. to 8:00 p.m. after completing household duties. The average working duration ranges from 5 to 9 hours per day. Crafters are paid based on output—IDR 3,000 per kilogram—processing between 25 and 50 kilograms of Nipah leaves daily.

A preliminary survey conducted among 10 Nipah leaf crafters in Terjun Village, using interviews and observations, identified several potential ergonomic hazards. All crafters work in seated posture without proper backrests, or with makeshift supports such as small benches or walls), often for extended durations, as shown in Figure 1. Their tasks involve repetitive and intensive upper limb movements, exposure to direct sunlight, inadequate indoor lighting, and the manual handling of Nipah leaves and sticks.



Figure 1. Work posture with a sitting position on the floor

Awkward working postures, such as prolonged neck flexion during leaf shredding, contribute to musculoskeletal complaints, including pain in the neck, shoulders, elbows, and arms. Discomfort in the spine, back, hips, buttocks, thighs, and knees are also prevalent, primarily due to sustained poor posture while sitting (on the hips). Prolonged exposure to these ergonomic risk factors may lead to significant occupational health issues, particularly musculoskeletal disorders, which can reduce productivity. Musculoskeletal disorders affect muscles, tendons, joints, nerves, and the circulatory system, commonly involving regions such as the neck, upper limbs, and back.^{1,2}

This study aimed to identify potential ergonomic hazards, assess the prevalence of musculoskeletal disorders, and analyze the relationship between ergonomic risk factors and musculoskeletal disorders among Nipah leaf crafters in Terjun Village, Medan City.

Methods

This study utilized a quantitative, cross-sectional design and was conducted from November 2023 to January 2024. The target population consisted of all Nipah leaf crafters in Terjun Village, situated in the Marelan Sub-district of Medan City, Indonesia. A census method was employed, resulting in a sample size of 35 participants.

Potential ergonomic hazards were assessed using a standardized ergonomic factor checklist. Musculoskeletal disorders were evaluated using a survey instrument adapted from SNI 9011:2021, which concerns the Measurement and Evaluation of Potential Ergonomic Hazards in the Workplace. Each participant's potential ergonomic hazard score was calculated by summing the checklist items. Scores were then categorized into three ergonomic risk levels: safe workplace conditions (score < 2), requiring further observation (score 3–6), and hazardous (score > 7).

The musculoskeletal disorders assessment evaluated pain presence or absence across various body regions, including the neck, shoulders (left and right), elbows (left and right), upper and

lower back, arms (left and right), hands (left and right), hips, thighs (left and right), knees (left and right), calves (left and right), and feet (left and right). Both the frequency and severity of reported symptoms were taken into consideration. Risk levels for musculoskeletal disorders were classified as low (scores 1–4), moderate (score 6), and high (scores 8–16), in accordance with the scoring criteria from SNI 9011:2021.

Data analysis consisted of univariate and bivariate approaches. Univariate analysis described the

frequency distribution of ergonomic risk levels and musculoskeletal complaints. Bivariate analysis was conducted using ANOVA with SPSS version 21 to examine the relationship between potential ergonomic hazards and musculoskeletal disorders. Ethical approval was granted by the Health Research Ethics Committee of Universitas Sumatera Utara (Approval No. 02/KEPK/USU/2024). All participants provided informed consent, and their confidentiality and right to withdraw were fully respected throughout the research process.

Results

Table 1: Potential Hazards of Ergonomic Factors for Nipah Leaf Crafters

| No | Description | n (%) |
|----------------------------|---|------------|
| 1. The Upper Body | Awkward postures: | |
| | a. Neck flexion > 20° | 23 (75.71) |
| | b. Unsupported arms or elbows | 35 (100) |
| | c. Rapid and repetitive forearm rotation | 23 (65.71) |
| | d. Wrist bending | 35 (100) |
| | Intensive arm movements | 35 (100) |
| | The working environment: | |
| 2. The Back and Lower Body | a. Inadequate lighting | 6 (17.14) |
| | b. Exposed to solar heat during indoor work | 20 (57.14) |
| | | |
| 3. Manual Lifting | Awkward postures: | |
| | a. 20-45° trunk flexion | 21 (60) |
| | b. > 45° extreme trunk flexion | 18 (51.42) |
| | c. Kneeling or squatting | 16 (45.71) |
| | d. Sitting posture for 3 to 9 hours per day | 35 (100) |
| | Distances ≥ 3-9 m | 24 (68.57) |

Based on the collected data, potential ergonomic hazards were categorized into three main body regions: the upper body, the back, and the lower body. In the upper body, several awkward postures were observed, including neck flexion greater than 20° in 23 participants (75.71%), unsupported arms or elbows in all 35 participants (100%), rapid and repetitive forearm rotation in 23 participants (65.71%), and wrist bending in all 35 participants (100%) during Nipah leaf shaving. These conditions were recognized as potential ergonomic hazards contributing to musculoskeletal disorders in the neck, shoulders, elbows, and arms. Additionally, all 35 participants

(100%) demonstrated intensive arm movements during leaf shredding, a repetitive and rapid activity maintained throughout working hours, further increasing risk to the shoulders, elbows, and arms. Proper working posture has been shown to reduce such musculoskeletal problems.³

Intensive arm movements were observed in all 35 individuals (100%) during leaf shredding. Intensive arm movements with the fastest work rhythm when shredding Nipah leaves and lasting throughout the working time produce an increasing number of sticks. Therefore, intensive arm movements are a potential ergonomic hazard factor that can cause musculoskeletal disorders in

the right and left arms, right and left elbows, and right and left shoulders. Inhibited movement of body parts (biomechanics) has a high risk of musculoskeletal disorders in various joints and upper limbs in carpet weavers.⁴

Workplace environmental conditions also posed hazards: six participants (17.14%) reported inadequate lighting, and 20 participants (57.14%) experienced solar heat during indoor work. Indoor lighting relied solely on sunlight, leading to potential eyestrain. Adequate lighting, tailored to task demands, is crucial to protect worker health. Therefore, the lighting intensity level must be determined by the needs of the workers to avoid any adverse effects on their health.⁵ The workplace must have sufficient lighting to avoid eye strain.³ Exposure to solar radiation heat contributed to discomfort, thirst, and sweating, with implications for productivity and health. Heat exposure can affect worker productivity and health.⁶

In the back and lower body regions, 21 participants (60%) exhibited awkward postures involving 20–45° trunk flexion while lifting Nipah leaves weighing between <7 kg and 23 kg from storage or delivery areas to the shredding zone. Lifting heavier Nipah leaves with 20–45° bending position of trunk flexion presents a significant ergonomic risk factor, potentially contributing to musculoskeletal disorders in both the upper and lower back. Furthermore, 18 individuals (51.42%) exhibited more extreme trunk flexion (>45°) when lifting lighter Nipah leaf sticks (<7 kg) from the floor to the collection point. The greater the weight lifted in such stooped positions, the higher the risk of developing musculoskeletal disorders affecting not only the upper and lower back but also the hips and thighs bilaterally.

An awkward posture involving kneeling or squatting was observed in 16 individuals (45.71%) as they moved Nipah leaves into closer positions to facilitate the shaving process. Frequent repetition of these kneeling or squatting postures significantly increases the risk of ergonomic hazards, particularly musculoskeletal disorders in the knees. Additionally, all 35 individuals (100%)

reported adopting a prolonged sitting posture for 3 to 9 hours per day. Sitting on the floor without backrests or adequate lumbar support for extended periods poses a serious ergonomic risk, potentially leading to musculoskeletal disorders in the upper and lower back, hips, knees (especially when bent), and thighs. Prolonged exposure to physically demanding tasks and awkward work postures contributes to a higher incidence of musculoskeletal disorders.⁷ Furthermore, such postures can impair worker concentration and increase the likelihood of occupational accidents.⁸ To mitigate these risks, workstations should be adjusted to match the anthropometric measurements of each worker.⁹

Manual lifting over distances of 3 to 9 meters or more was reported by 24 individuals (68.57%), often involving body twisting, one-handed lifting, handling unexpected loads, lifting at a frequency of 1 to 5 times per minute or more, and moving objects positioned at or below shoulder level. Some individuals also lifted loads while resting them on the knee. These actions occurred while transporting Nipah leaves from vehicles or storage to the shaving area, as well as while moving bundled Nipah leaf sticks to the collection point. Such lifting practices significantly increase the risk of musculoskeletal disorders in the hands, arms, upper and lower back, and hips. The primary contributing factors to these musculoskeletal issues include insufficient ergonomic knowledge, limited work experience, inattentiveness, and improper lifting postures. Workers are particularly vulnerable to such disorders during manual tasks such as lifting, lowering, pushing, pulling, and activities involving vibration exposure.¹⁰

Among Nipah leaf crafters, potential ergonomic hazards were predominantly categorized as requiring further observation, with 22 individuals (62.90%) falling into this group. Ten individuals (28.60%) were classified under the safe workplace condition category, while three individuals (8.60%) were identified as being in the dangerous category. Notably, the higher the ergonomic hazard score, the more severe the associated risk category.

Based on the results of a survey on musculoskeletal disorders among Nipah leaf crafters, several complaints were identified across different body parts. The most frequently reported issues were in the neck, right shoulder, and left shoulder, with 18 individuals (51.43%), 12 individuals (34.30%), and 12 individuals (34.30%), respectively, reporting symptoms that occurred often, although the severity was classified as "no problem." Complaints in the right elbow, left elbow, upper back, lower back, and right arm were reported with a frequency level of "sometimes" and a severity level of "discomfort," with nine individuals (25.71%), 11 individuals (31.43%), 13 individuals (37.14%), 12 individuals (34.28%), and 10 individuals (28.57%), respectively.

Additionally, the left arm, right hand, and left hand were noted with a severity level of "discomfort" by 14 individuals (40.00%), 13 individuals (37.14%), and 12 individuals (34.29%), although the frequency level was not clearly stated. The right and left hips were also commonly affected, reported as occurring "sometimes" and causing "discomfort" by 13 individuals (37.14%) and 12 individuals (34.28%), respectively.

Furthermore, discomfort was reported in the right thigh, left thigh, right knee, and left knee with a frequency of "often," though the severity level remained "no problem," as indicated by 16 individuals (45.71%) for both thighs, 13 individuals (37.14%) for the right knee, and 15 individuals (42.82%) for the left knee. In contrast, complaints involving the right and left calves, as well as the right and left feet, were mostly non-existent, with a frequency level of "never" and a severity level of "no problem," reported by 15

individuals (42.85%) for both calves, and 17 individuals (48.57%) and 17 individuals (48.85%) for the right and left feet, respectively.

Those mentioned above musculoskeletal disorders are primarily caused by occupational factors such as lifting Nipah leaves, bending the neck over the leaves, repetitive movements of the arms and hands, prolonged sitting without a backrest, extending the legs forward while dragging Nipah leaves, and the collection and lifting of sticks. Among handicraft workers, musculoskeletal disorders affecting the shoulders, back, and knees are more prominent than in other body parts.¹¹ Musculoskeletal disorders can lead to symptoms including pain, numbness, tingling, reduced work productivity, absenteeism, and even temporary or permanent disability.¹² Researchers have identified both physical and psychosocial workplace risk factors contributing to the development of these conditions. These include repetitive tasks, prolonged static sitting, fatigue, occupational stress, and the use of inappropriate tools or poorly designed work environments.¹³ Such risk factors contribute to discomfort and pain in various body regions, particularly the lower back, neck, shoulders, wrists, and lower limbs. The manifestation of symptoms varies among individuals. In India, most handicraft workers report a high prevalence of musculoskeletal disorders, especially in the neck, lower back, and knees.¹⁴ Among weavers, the annual prevalence was reported at 85% across all body parts, with 71% in the lower back, 41% in the shoulders, and 37% in the knees.¹⁵

Table 2 below shows the musculoskeletal disorders depending on the type of occupation.

Table 2: Musculoskeletal Disorders Vary Depending on The Type of Occupation

| No | Description | n (%) |
|--|---------------|-------------|
| 1. Hydroelectric Power Plant Workers ¹⁶ | a. Lower back | 103 (48) |
| | b. Wrists | 88 (41) |
| | c. Knees | 77 (36) |
| | d. Shoulders | 61 (28.30) |
| 2. Car Repair Shops ¹⁷ | a. Shoulders | 83 (84) |
| | b. Thighs | 56 (57) |
| 3. ICU Nurses ¹⁸ | a. Lower Back | 544 (80.10) |
| | b. Neck | 534 (78.60) |

| No | Description | n (%) |
|---|---------------|-------------|
| 4. Rice Farmers ¹⁹ | c. Shoulders | 478 (70.40) |
| | a. Lower Back | 135 (86.50) |
| | b. Neck | 134 (85.90) |
| | c. Shoulders | 126 (80.70) |
| 5. Clay Brick Makers ²⁰ | a. Shoulders | 157 (47.87) |
| | b. Wrists | 169 (51.52) |
| | c. Lower Back | 164 (50) |
| 6. Mango-Harvesting Farmers ²³ | a. Lower Back | 10 (71.43) |
| | b. Shoulders | 14 (100) |
| | c. Neck | 8 (57.14) |

Brick kiln workers commonly report discomfort in the wrists, lower back, shoulders, fingers, upper arms, and knees, primarily due to repetitive tasks, prolonged physical exertion, and awkward postures such as twisting, bending, stooping, lateral body movements, kneeling, and squatting.²⁰ Pottery workers most often report back pain, neck pain, shoulder and hand-arm pain, as well as foot discomfort.¹¹ Handicraft workers most commonly report issues in the neck and shoulder regions.²¹ Among e-waste workers, the back is the most affected area, followed by the shoulders, knees, lower legs, upper arms, and neck.²²

Based on the results of the ANOVA test, a significant relationship was identified (p-value < 0.05) between the potential hazards of ergonomic

Discussion

The findings of this study demonstrate that Nipah leaf crafters are exposed to significant potential ergonomic hazards, particularly affecting the upper body—such as awkward neck postures and repetitive arm movements—the back, and the lower body, which is subjected to bending, squatting, kneeling, and prolonged sitting for 5 to 9 hours per day. These physical stressors, when combined with demanding tasks like lifting and transporting Nipah leaves and sticks, contribute to the development of musculoskeletal disorders. These disorders manifest as pain in multiple regions of the body, including the neck, both shoulders, both elbows, upper and lower back, both arms, both hands, both hips, both thighs, and both knees.

factors and the occurrence of musculoskeletal disorders. A statistically significant difference was found in the mean score of potential ergonomic hazards between the category of safe workplace conditions and the category requiring further observation (p-value < 0.05). Likewise, a significant difference was observed between the mean score of potential ergonomic hazards in the safe workplace conditions category and that in the hazardous category (p-value < 0.05). However, the mean score of potential ergonomic hazards in the category requiring further observation did not differ significantly from the mean score in the hazardous category (p-value > 0.05).

There is a difference in the average score of potential ergonomic hazards, with the category of safe workplace conditions having a lower mean score than both the category requiring further observation and the category labeled as dangerous. This indicates that a lower average score of potential ergonomic hazards corresponds to safer workplace conditions and, consequently, a reduced risk of musculoskeletal disorders. Conversely, a higher average score reflects more hazardous workplace conditions and a greater risk of musculoskeletal disorders. This means there is a greater risk of musculoskeletal disorders. While there is no significant difference between the average scores of the "requiring further observation" and "dangerous" categories, both are higher than the average score in the safe category.

This suggests that workplaces classified under the "requiring further observation" and "dangerous" categories present similarly high risks of musculoskeletal disorders due to elevated ergonomic hazard levels.

Musculoskeletal disorders are serious injuries or impairments affecting muscles, bones, nerves, tendons, soft tissues, joints, cartilage, and spinal discs that develop during occupational tasks. These conditions arise from the interaction of multiple ergonomic risk factors encountered in various work environments.^{12,24} Work-related musculoskeletal disorders are primarily linked to occupational factors such as physical overload, repetitive movements, and poor posture. Common symptoms include localized or radiating pain, discomfort, fatigue, a sense of heaviness, paresthesia (numbness and/or tingling), and decreased muscular strength.²⁵ These disorders often result from prolonged exposure to high-risk ergonomic conditions, including heavy lifting, awkward or sustained postures, and repetitive or monotonous tasks.²⁶

Musculoskeletal disorders can develop gradually over time or manifest suddenly, and they are influenced by several contributing factors such as awkward postures, repetitive tasks, heavy lifting, exposure to vibration, fatigue, and extended working hours without sufficient rest.²⁷ These disorders are often chronic in nature and are primarily caused by repetitive movement patterns, physical overexertion, sustained awkward postures, and prolonged periods of sitting or standing.²⁸

Globally, musculoskeletal disorders represent a major occupational health concern. Both industrialized and developing countries acknowledge work-related musculoskeletal disorders as significant public health issues. Epidemiological studies have established strong correlations between various workplace risk factors—such as repetitive tasks, awkward postures, physical exertion, prolonged exposure, environmental conditions, psychosocial stressors,

and individual characteristics—and the development of musculoskeletal disorders.²⁹

The challenges experienced by Nipah leaf crafters mirror those encountered by other handicraft workers. The handicraft industry typically involves minimal mechanization and is marked by exposure to numerous occupational risk factors, such as prolonged static sitting, high physical exertion, and repetitive upper limb movements, all of which significantly contribute to the prevalence of musculoskeletal disorders.¹³ Similar observations have been reported among female workers in wool textile factories, where musculoskeletal complaints were associated with poor working posture, inadequate seating, and extended working hours.¹¹

Although musculoskeletal disorders are not typically fatal, their long-term consequences can be severe. They often result in short-term and long-term work absences, decreased functional capacity, reduced productivity, a decline in quality of life, and increased healthcare costs.^{18,30} Injuries resulting from work-related musculoskeletal disorders contribute to direct costs such as medical treatment, physician consultations, rehabilitation services, insurance claims, and compensation payments. Indirect costs include the training and replacement of workers, the loss of experienced labor, and increased administrative demands.²¹

Preventing work-related musculoskeletal disorders is a national priority in many countries, particularly within the informal sector and small-scale industries.³¹ The prevention of these disorders is essential for workers, employers, and policymakers, given their significant impact on worker health and productivity.² Prevention strategies are generally categorized into three levels: primary prevention, aimed at averting the onset of work-related musculoskeletal disorders; secondary prevention, which focuses on the early detection of symptoms and the prevention of further progression; and tertiary prevention, intended to reduce the impact of already existing disorders.³² Jobs with high ergonomic risks can be

identified through medical records, self-reported discomfort from workers, interviews, and expert assessments. Following identification, ergonomic interventions may include engineering controls (such as workstation redesign), administrative controls (including job rotation and scheduled rest periods), medical management (such as early diagnosis and treatment), and ergonomic modifications (e.g., the provision of armrests, footrests, lumbar support, and ergonomically designed hand tools).³²

Conclusion

The potential ergonomic hazards factors among Nipah leaf crafters primarily affect the upper body and include awkward postures such as neck flexion, unsupported arms or elbows, repetitive forearm rotation, and intensive arm movements. These risks are further compounded by adverse environment conditions, such as inadequate lighting and heat exposure. In the back and lower body, ergonomic hazards are associated with prolonged sitting and awkward postures like bending and squatting. Moreover, the manual lifting and transportation of Nipah leaves and leaf sticks contribute additional ergonomic risks. The majority of these identified hazards were categorized as requiring further observation, involving 22 individuals (62.86%).

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Musculoskeletal disorders were reported in nearly every body region, including the neck, shoulders, elbows, back, arms, hands, hips, thighs, knees, calves, and feet. The severity and frequency of complaints varied, with most classified as low-risk, affecting 21 individuals (60.00%). A statistically significant relationship ($p < 0.05$) was found between potential ergonomic hazards and the occurrence of musculoskeletal disorders.

To reduce the risk of musculoskeletal disorders, it is recommended to improve work methods and body mechanics by promoting neutral postures and minimizing repetitive movements and prolonged postures. Scheduled breaks should align with workers' physical conditions and capabilities. Furthermore, mechanical aids, such as wheelbarrows, should be used to transport Nipah leaves and leaf sticks to reduce physical strain, reducing the risk of musculoskeletal disorders, and enhance worker safety.

Acknowledgment

The authors express their deepest gratitude to the Universitas Sumatera Utara for supporting this research through pioneering research funds for the fiscal year 2023, No 620/UN5.2.1/KPM/2023, dated 03 August 2023.

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