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The Effect of Occupational Ergonomics on the Risk of Low Back Pain in Workers in Indonesia

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ABSTRACT

Background: Occupational ergonomics is directly related to all work activities (both formal and informal) and focuses on the interaction between people and their work environment to reduce musculoskeletal injuries and improve worker well-being.
Objectives: The purpose of this study was to determine the impact of occupational ergonomics on the prevalence of low back pain among Indonesian workers aged 15–49 years.
Methods: This study used secondary data from the Global Burden of Diseases (GBD) 2024, applying the Disability-Adjusted Life Years (DALYs) approach to measure the risk level of low back pain caused by occupational ergonomics.
Results: The analysis revealed a substantial disparity in the burden of Low Back Pain (LBP) attributed to occupational ergonomics across provinces. West Java, East Java, and Central Java recorded the highest disease burden (DALYs). Meanwhile, the provinces with the highest ergonomic risk exposure levels (Summary Exposure Value/SEV) were North Maluku (29.48%), Maluku (29.27%), and East Nusa Tenggara (29.21%). North Kalimantan consistently showed the lowest exposure levels and disease burden.
Conclusion: Workplace ergonomics substantially contributes to the burden of Low Back Pain (LBP) among workers. Large regional disparities (highest in Java and Maluku/NTT) underscore the need for more targeted health actions. Priority interventions should include strict regulation enforcement, workplace monitoring, and implementation of ergonomic solutions in high-risk industrial sectors to reduce DALYs.

Keywords: Ergonomics, Good Health and Well-Being, Low Back Pain, Occupational Health, Workers

INTRODUCTION

Occupational ergonomics is a discipline that aims to design safe, efficient, and effective work systems by taking into account human physical and physiological capabilities. Although it aims to create a safe working environment, work activities performed with improper posture or work habits often cause fatigue, discomfort, and ultimately lead to occupational diseases. Among various Occupational Work-related Symptoms (OWS), Low Back Pain (LBP) is the most pressing occupational health problem, characterized as the leading cause of disability globally and as having a high prevalence among workers of productive age (15–49 years) in Indonesia.

The term "work fatigue" describes a condition in which a worker's efficiency and endurance decrease, ultimately negatively impacting a company's productivity. Work fatigue is determined by various factors, such as an individual's performance level, work duration, and the ergonomics of their work position (Rahmawati and Tualeka, 2019). Individuals with excessive workloads are prone to physical fatigue. This

condition is characterized by symptoms such as headaches and digestive problems. In addition, psychological fatigue can manifest as emotional exhaustion or stress (Yudisianto, Tualeka and Widajati, 2021). The term "workload" can be defined as the interaction between job demands, work environment, skills, behavior, and perceptions of work. However, workload can also be defined operationally based on several factors, including task demands and the effort required to complete a task (Sandianto, Tualeka and Indriani, 2018).

The Global Burden of Disease, Injury, and Risk Factors (GBD) study uses a systematic methodology to calculate the burden of disease and injury based on age, sex, year, and geographic location to facilitate comparisons between different diseases. Previous Global Burden of Disease (GBD) estimates have shown that low back pain is a leading cause of disability in most countries. For most individuals experiencing low back pain, it is not possible to identify a specific cause or source of pain. The prevalence of nonspecific low back pain is influenced by several risk factors. A comprehensive review of the literature shows that the development of low back pain can be influenced by several factors, such as chronic conditions (including asthma, headaches, and diabetes), poor mental health (including psychological disorders and depression), genetic influences, uncomfortable posture, lifting, bending, heavy manual labor, and fatigue or distraction during activities. In addition, smoking, obesity, and low levels of physical activity, all of which are associated with poorer general health, have also been linked to the occurrence of episodes of low back pain (Vos *et al.*, 2020). In cases of Low Back Pain (LBP), the main influencing factor is the duration of exposure. However, in other cases, the severity of pain is the main determining factor. It should be noted that it is the combination of these factors that determines the severity of pain (Sánchez-Pérez *et al.*, 2024).

Analysis of work posture is a determining factor in identifying occupational hazards that can cause musculoskeletal disorders. This will serve as a reference for evaluators in improving work posture and work facilities, which can reduce fatigue among workers (Tarwaka, 2014). Improrer work posture is often caused by work facilities that are not suited to the anthropometry of the workforce, which can impact employee performance. Unnatural work postures, such as squatting, bending, lifting, and carrying heavy loads for long periods of time, can cause discomfort and pain in the musculoskeletal system and other parts of the body. These unnatural work postures have been proven to be among the causes of lower back pain (Suryadi and Rachmawati, 2020).

Low Back Pain (LBP) is defined as pain or discomfort felt in the lower back area. The World Health Organization (WHO) states that 90% of lower back pain cases are not caused by organic disorders but by incorrect body posture while working. The prevalence rate in Indonesia ranges from 7.6% to 37%. Lower back pain generally occurs in adulthood, with the highest prevalence observed between the ages of 25 and 60 (Santoso, Mahmud, & Syam, 2023). Low Back Pain (LBP) is a common health problem in many countries, typically affecting 50% to 80% of adults. Working-age adults are particularly susceptible to LBP. The prevalence of LBP caused by exposure to suboptimal workplace ergonomics is estimated at 2.8 million cases, consisting of 13.5 million cases in men and 8.3 million cases in women (Fatoye, Gebrye and Odeyemi, 2019). The prevalence of Low Back Pain (LBP) was significantly higher in individuals who worked more than eight hours per day compared to those who worked less than eight hours. This finding is consistent with the previously mentioned study by Sigit and Zaman (2019), which stated that working for long periods in a fixed body position, without the ability to bend, stoop, or squat, can cause muscle tension and circulation problems, thus leading to Low Back Pain (LBP) in workers.

Workers of productive age (15–49 years) are highly susceptible to LBP, especially when triggered by non-ergonomic work activities. This susceptibility is supported by contributing factors such as long working hours, incorrect posture and work habits, and worker age. Therefore, this study aims to analyze the impact of work ergonomics on the prevalence of Low Back Pain (LBP) in Indonesia. Using Global Burden of Disease (GBD) data, this study provides a comprehensive overview of the burden of disease (DALYs) due to LBP attributed to work ergonomics-related factors across all provinces in Indonesia.

METHODS

This study draws on data from the Global Burden of Disease Study (GBD) 1990-2021. The World Health Organization (WHO), the World Bank, the Bill & Melinda Gates Foundation, and various academic and research institutions and national governments collaborated on the project. This study used a quantitative method with a secondary observational study design. The data analyzed were sourced from an existing database, namely Global Burden of Disease (GBD) 2024, which is available through the Institute for Health Metrics and Evaluation (IHME). This approach specifically focuses on Disease Burden Analysis to measure and compare health impacts at the subnational level. The Global Burden of Disease (GBD) study, conducted since 1990, is a crucial part of the health policy decision-making process. Years of Life Lost due to premature death (YLL) and Years Lived with Disability (YLD) are referred to as DALYs. Data on disease prevalence and medical

causes of death, disaggregated by age and sex, are needed to calculate the disease burden. Calculating the disease burden also requires extensive data, such as disease prevalence and causes of death, as well as population structure. Calculating the disease burden at the subnational level is difficult due to a lack of accurate data. A disease is considered to have a high burden of 52.56% if it causes premature death and loss of productive time. A higher DALY loss indicates a greater disease burden in the Indonesian population. Years of life lost due to premature death and years of life lost due to disability are two factors needed to calculate this measure. Disability weights are based on individual perceptions of life events to estimate the level of disability caused by disease or injury. These perceptions may be related to environmental factors, occupational risks, and work ergonomics, or may be more specific, such as low back pain as measured by DALYs (Zhu *et al.*, 2024).

The World Health Organization (WHO) has created a standard coding system used to record bodily function impairments and disabilities related to health problems. This tool is officially known as the International Classification of Functioning, Disability, and Health (ICF). The ICF defines disability as a condition that includes limitations on performing tasks or participating in social activities. This study provides convincing evidence of the negative effects of interactions between individuals with health conditions, contextual factors related to their environment, and personal factors (ICF-WHO, 2001; Suryanti T., 2013). Based on secondary data collected from various sources in Indonesia, as well as data from the Institute of Health Metrics and Evaluation in 2024, this analysis investigates Burden of Disease (BOD) in the community. Data collection for Disability Adjusted Life Years (DALYs) in the Global Burden of Disease (GBD) uses a weighted average method, with the population taken from the GBD database for the 15 - 49 age group and further divided by gender.

The secondary data used in this study were obtained from the Global Burden of Disease (GBD) database, which is publicly available on the Institute for Health Metrics and Evaluation (IHME) platform. Data Collection and Analysis Process: Data on DALYs, YLDs, and YLLs related to Low Back Pain (LBP), particularly those caused by occupational ergonomic risk factors, were extracted for the working-age population (15–49 years) in Indonesia. The data were then filtered specifically for 34 provinces in Indonesia, covering the period 1990–2020. The main analysis focused on the calculation and comparison of two GBD metrics, namely Disability-Adjusted Life Years (DALYs) to measure the total burden of disease and Summary Exposure Value (SEV) to measure the prevalence of risk exposure at the subnational level. These calculations aim to identify and compare the burden of LBP influenced by occupational ergonomics between provinces, as well as provide a comprehensive picture of its impact on Indonesian workers. As these data are anonymous and aggregated, there is no risk of revealing personal or confidential information. Furthermore, the use of these data complies with the terms and conditions set by IHME, including compliance with requirements for citation and attribution of data sources. All analyses were conducted with consideration for the integrity, accuracy, and transparency of the research. This ensures that the results are reported responsibly and without deviation from the original data.

RESULTS AND DISCUSSION

1. Lower Back Pain (LBP) Burden Attributed to Work Ergonomic Factors

According to Global Burden of Disease (GBD) data, ergonomic factors in Indonesia affect individuals aged 15 to 49 years, both men and women. The risk of lumbar work-related injuries is one of the most important occupational factors. The risk of occupational ergonomics exposure contributing to lower back pain is estimated at197.29 per 100,000 people. This figure ranges from 139.72 to 264.96 per 100,000 people. This phenomenon indicates that lower back pain is highly prevalent among Indonesian workers. Postures that deviate from the body's natural alignment, suboptimal workstations, and workloads that exceed worker capacity are examples of these occupational ergonomic factors. The impact of occupational ergonomic factors on the prevalence of lower back pain among workers in Indonesia is illustrated in figure 1 (GBD, 2024).

The results of research conducted by the Center for Health Ecology Research and Development, Ministry of Health, on 800 people in the informal industrial sector are as follows: (1) 76.7% of brickmakers in Lampung Province experienced lower back pain; (2) 41% of fishermen in DKI Jakarta; (3) 31.6% of oil palm farmers in Riau; (4) 21% of leather puppet craftsmen in Yogyakarta; (5) 18% of onyx craftsmen in West Java; (6) 16% of gold miners in West Kalimantan; and (7) 8% of shoe craftsmen in Bogor. This study provides comprehensive and internally consistent estimates of mortality and morbidity by age, sex, and region. In addition, the study introduced the metric called Disability-Adjusted Life Year (DALYs), which is used to measure the burden of disease, injury, and risk factors (Chen *et al.*, 2022). DALYs are calculated based on the number of years of life lost due to premature death and the number of years lived with disability.

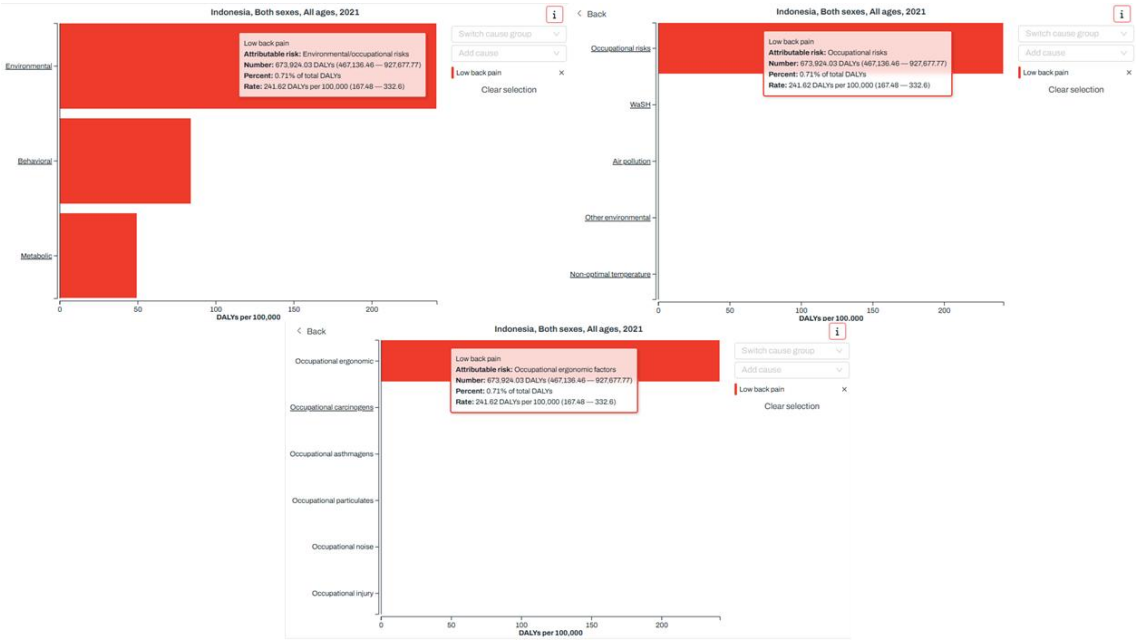

Figure 1. Relationship between Ergonomic Factors and Low Back Pain in Indonesia (Source: processed from Global Burden of Disease/GBD in 2024)

Research findings on the relationship between ergonomic factors and lower back pain in Indonesia indicate that occupational factors, such as workplace hazards, are a major concern. Occupational hazards have the potential to cause significant losses that impact the health, safety, or well-being of workers. In addition, occupational hazards can affect work ergonomics, as improper or inadequate ergonomic practices, such as poor posture, inadequate workplace design, and excessive workloads, can contribute to the development of low back pain.

Activities such as manual handling have been identified as contributing factors to low back pain. Manual handling is defined as any activity involving the manual movement of objects, including but not limited to lifting, lowering, pushing, pulling, carrying, or holding objects without the use of assistive devices. These activities are still common in various workplace in Indonesia. Factors influencing low back pain include the weight of the object, the duration of the lifting, and the frequency of lifting (Sambeko, Susanto and Alfanan, 2024). Additionally, poor posture and prolonged sitting can cause low back pain. The optimal sitting position is characterized by shoulders positioned back, a straight spine, and the buttocks pressed against the back of the chair (Hendrika, Sitompul and Petrus, 2022).

2. Summary Exposure Value (SEV) of Ergonomic Factors for Workers in Indonesia

The Summary Exposure Value (SEV) shown in Figure 2 indicates substantial differences in the prevalence of ergonomic factors between provinces in Indonesia in 2024. The age range depicted in the figure covers 15-49 years, with a particular emphasis on male and female workers in Indonesia. North Maluku Province has the highest prevalence of low back pain among individuals aged 15-49 years in Indonesia, affecting both men and women equally. The figure of 29.48% indicates that a significant proportion of workers in this region are affected by this condition. This phenomenon can be linked to conditions in the formal and informal industrial sectors, which have been identified as driving factors in the development of work-related injuries and illnesses. Maluku Province has the second highest rate of low back pain among workers in the formal and informal industrial sectors, with a rate of 29.27%. The province with the third highest rate of low back pain among workers in both the formal and informal sectors is East Nusa Tenggara, with a rate of 29.21%. The province with the lowest rate, Jakarta, recorded a value of 16.29% in the formal and informal industrial sectors (Global Burden of Disease/GBD in 2024).

The Global Burden of Disease (GBD) presents Summary Exposure Values (SEV), which are measures of exposure to risk factors that can affect population health. The data generated from this database describes the distribution of ergonomic factors across province in Indonesia. North Maluku, Maluku, and East Nusa Tenggara Provinces show the highest values. The high ergonomic factors observed in these three provinces are due to the prevalence of industrial activities, both informal and formal, in these regions. On the

other hand, the province with the lowest distribution value is Jakarta Province. Based on research conducted by (Lisma Melinda *et al.*, 2023), the prevalence of MSDs based on medical diagnosis or symptoms was highest in East Nusa Tenggara at 33.1%, followed by West Java (32.1%) and Bali (30%).

According to data from the Maluku Province Central Statistics Agency, in 2024, the micro and small industry sector, which includes the food, beverage, wood, bamboo, and rattan weaving, textile, and other industries totaled 44,564 businesses. In 2024, the food industry sector in North Maluku Province consisted of 10,973 businesses, the wood, bamboo, and rattan (weaving) craft industry sector consisted of 449 businesses, the non-metallic mineral industry sector consisted of 678 businesses, along with other sectors. The food, beverage, manufacturing (large or small), and other industries are also present in East Nusa Tenggara Province. In 2024, Jakarta Province included a large number of large and medium-sized businesses in the manufacturing sector. The informal sector is associated with ergonomic risks that can cause work-related illnesses, such as low back pain.

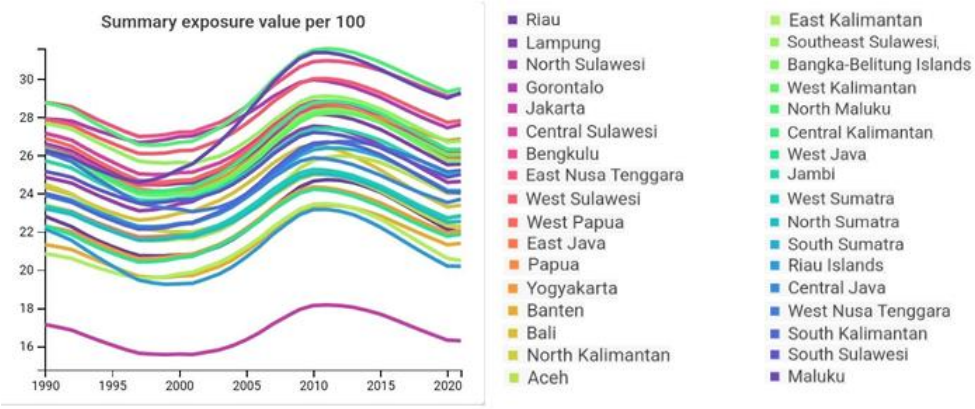

Figure 2. Ergonomic Factors in Workers in Indonesia
(Source: processed from Global Burden of Disease/GBD in 2024)

3. DALYs of Low Back Pain in Workers in Indonesia

Estimates of DALYs for low back pain in Indonesia in 2024, differentiated by age (15-49 years) and gender (female and male) among workers, are shown in Figure 3. The values for each province in Indonesia show significant variation. West Java Province has the highest value, which is 187,600.25 per 100,000. This phenomenon can be attributed to the prevalence of industrial sectors such as construction and manufacturing, which are dominant in the Province and collectively contribute to the number of workers experiencing low back pain. Next, East Java ranks second after West Java, with a value of 148,612.09 per 100,000. In addition, East Java has become a center for diverse industrial activities, covering both the formal and informal sectors. Central Java Province has the third highest value, at 136,292.59 per 100,000. This indicates that this province has experienced significant industrial development. North Kalimantan, with a value of 2,991.62/100,000, ranks lowest among the provinces (Global Burden of Disease/GBD, 2024).

In Indonesia, a comparison of DALY values based on deaths and illnesses due to low back pain shows significant differences between provinces with more advanced industrial economies and those with lower industrial activity. West Java, East Java, and Central Java have the highest DALY values, indicating a significant burden of disease and premature death in these provinces, despite their high concentration of industry. These differences may be due to variations in the scale or type of business activity (Global Burden of Disease/GBD in 2024).

Environmental factors, such as repetitive lifting and poor posture, have been identified as risk factors for occupational injuries. The same applies to workloads that exceed workers capacity, as well as physiological factors such as age, smoking, and stress. These factors can influence the onset and symptoms of low back pain, therefore it is important to take them into account. The amount and duration of exposure affect the severity of the condition. The duration of exposure has been identified as an important factor in the development of low back pain (Lataoso and Kamiluddin Saptaputra, 2024).

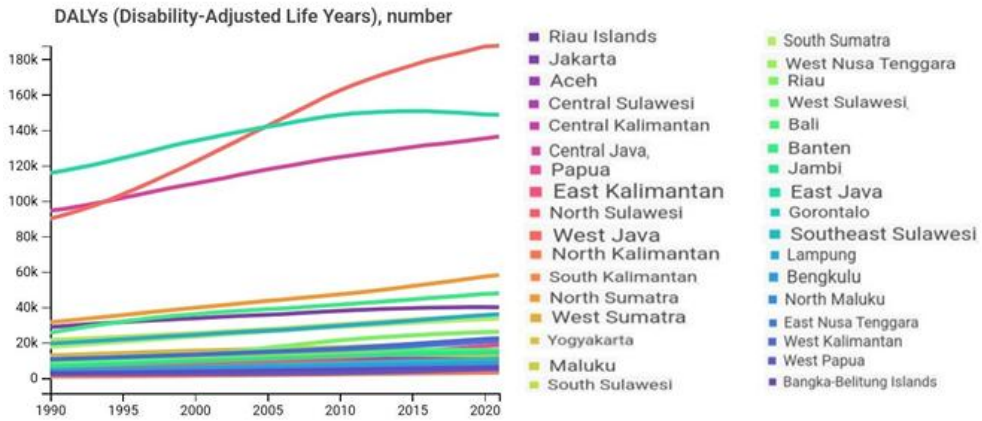

Figure 3. Low Back Pain among Workers in Indonesia
(Source: processed from Global Burden of Disease/GBD in 2024)

Most Indonesians work in the agricultural sector, as Indonesia is an agrarian country. This results in significant additional energy demands in various agricultural activities, such as plowing, hoeing, planting, and harvesting crops. Consequently, these activities can cause changes in farmers posture and body position. Numerous studies have been conducted on farmers posture and body position. The results of these studies show a high prevalence of low back pain among farmers. In fact, 87.4% of farmers show a high risk of low back pain complaints, as reported by (Arif Pristianto *et al.*, 2023). These figures are very worrying because this heavy physical burden is long-lasting and critical for agricultural productivity. These results show how important it is to conduct comprehensive research and find solutions to reduce the impact of this hazard on farmers welfare.

4. The Effect of Ergonomic Factors on Low Back Pain in Indonesia

Figure 4 shows the DALYs results for low back pain in Indonesia in 2024, covering the 15-49 age range for both genders (female and male) among Indonesian workers. The graph illustrates the variation in the distribution of the impact of ergonomic factors on low back pain based on age and gender among workers across various provinces in Indonesia. West Java Province has the highest number of DALYs per 100,000 population, with a rate of 68,683.75. This phenomenon can be attributed to the significant industrial activity in the province. East Java Province has the second highest DALYs rate, at 55,461.86 per 100,000 individuals. East Java Province is home to a number of medium and large industries. Central Java ranks third in terms of DALYs, with a value of 52,149.50 per 100,000 population, which is comparable to the two preceding provinces. In contrast, the province with the lowest DALYs rate is North Kalimantan, with a value of 1,064.60 per 100,000 population (Global Burden of Disease/GBD in 2024).

DALY values based on ergonomic factors in Indonesia, focusing on individuals aged 15-49 years and all genders, show that the three provinces with the highest values are West Java, East Java, and Central Java. North Kalimantan province shows the lowest DALY values, which may be due to a smaller workforce or lower levels of industrial activity. Further analysis of ergonomic factors shows that the highest disease burden occurs among workers aged 15-49 years, which is the productive age group. Therefore, strong interventions in the form of regulations, worker protection, and workplace monitoring are urgently needed to reduce low back pain among Indonesian workers.

Research has shown a correlation between work-related Low Back Pain (LBP) and exposure to adverse ergonomic factors in the workplace. A large number of studies have identified several factors associated with LBP. The factors mentioned above include, but are not limited to, lifting and carrying heavy objects, non-ergonomic postures, static work postures, long working hours, and length of service (Wami *et al.*, 2019). For example, prolonged involvement in work activities with incorrect or inappropriate posture can cause lower back pain. Employees with a Body Mass Index (BMI) in the overweight range show a higher tendency to complain of lower back pain compared to those with an ideal BMI. This phenomenon can be attributed to greater pressure on the spine due to higher BMI. A large number of studies show a strong correlation between an overweight BMI and a higher risk of lower back pain, with individuals in this category showing a fivefold higher prevalence compared to those with an ideal

BMI (Ones, Sahdan and Tira, 2021). A study of 133 workers in Jakarta showed that 88% of them experienced lower back pain. These findings indicate a clear relationship between work duration, work period, and work posture and complaints of lower back pain (Agustin, Puji and Andriati, 2023).

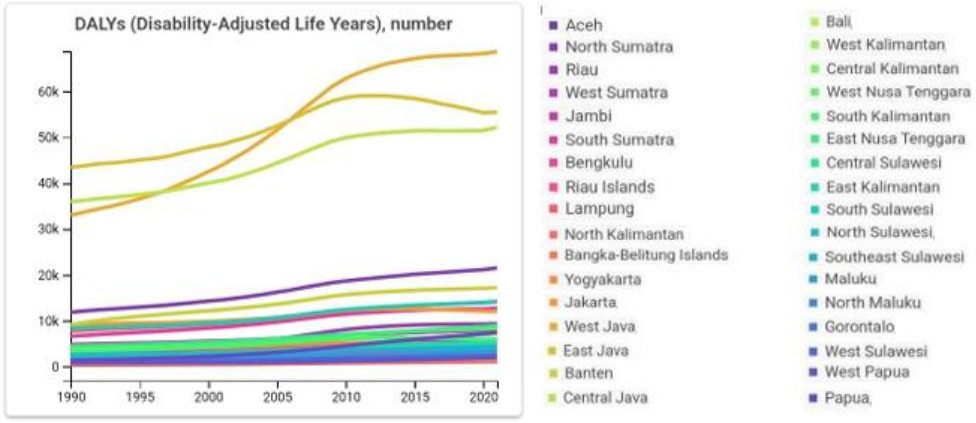

Figure 4. Effect of Ergonomic Factors on Low Back Pain in Workers in Indonesia (Source: processed from Global Burden of Disease/GBD in 2024)

This study uses secondary data from the Global Burden of Disease (GBD) to facilitate comprehensive analysis across different regions and age groups in Indonesia. The comprehensive nature of this dataset ensures that the findings are consistent with the national pattern of low back pain associated with ergonomic factors. However, a potential limitation of this study is its reliance on secondary data, which may not capture detailed individual-level risk factors or variations in specific work environments. In addition, the cross-sectional nature of the data does not allow for the establishment of causal relationships.

CONCLUSION

The results of the discussion show that there are substantial or striking disparities in the health burden associated with ergonomic factors across provinces in Indonesia. The data shows that ergonomic factors in several provinces, particularly in regions such as North Maluku, Maluku, and East Nusa Tenggara, are among the highest in the country and have a significant impact on workers health, especially lower back pain. The highest DALY values were recorded in West Java, East Java, and Central Java, indicating that ergonomic factors contribute to a substantial burden of disease. This is related to the large number of formal and informal industrial sectors that employ a substantial workforce. On the other hand, provinces with the lowest health risk levels, such as North Kalimantan, indicate that health risks can vary depending on the specific type of industry and the number of workers employed.

The uneven distribution of lower back pain attributable to ergonomic factors across provinces highlights the importance of more targeted actions in health risk management within high-risk industrial sectors. To reduce the negative impact of ergonomic factors on low back pain among Indonesian workers, it is essential to implement stricter supervision, strongr regulations, and comprehensive health protection measures, including appropriate workloads and ergonomic workstations. Further research is needed to explore intervention programs aimed at reducing ergonomic risks across various work sectors in Indonesia.

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Conflict of Interest and Funding Disclosure

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Author Contributions

NMH: conceptualization, methodology, writing–original draft; ART: data curation, validation, supervision; HAJ: formal analysis, writing–revision & editing.

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