Understanding the Ergonomics Issues in Sawmill Industries: Why It Becomes a Concern?

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Abstract This study aims to highlight the ergonomic issues in sawmill industries. Thus, the importance of ergonomics risk factors is sought to be dug out. Sawmill workers are exposed to many occupational safety and health hazards, including ergonomics. Previous studies showed that, with ergonomic principles, the workplace could become safer and indirectly will help in increasing workers' productivity, improve physical and mental wellbeing and job satisfaction among workers. To achieve the study objective, a field observation was conducted, and reviews of published literature were collated to support the findings. In the beginning, a total of 213 articles was identified. However, after undergoing the screening process, only 28 articles are included in this study. Many ergonomics risks are scientifically proven to exist in the sawmill industries. Therefore, the knowledge and understanding of ergonomic risk will help the researchers to plan the next step to improve workers' wellbeing.

Keywords Ergonomic · Sawmill · WMSD

1 Introduction

Successful implementation of ergonomics in the work environment design may balance worker preferences and job requirements. Doing so will increase productivity for the worker and provide workplace health, mental and physical health, and job satisfaction. Previous studies have shown beneficial effects by applying the concepts of ergonomics in workplaces, occupational safety, and health, environment,

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job, machine, and facilities design [1]. In a study conducted by Ali et al. [2] small-scale and unorganised sawmills that provide wide-ranging services with thousands of employees are inadequate in ergonomic procedures, planning, and procedures.

Wood product manufacturing is often labour-intensive and production-oriented, with employees typically work at a rapid pace [3]. Musculoskeletal Disorders (MSDs) among sawmill workers can be devastating and significantly influence daily production, depending on the sort of work they conduct. Heavyweights, uncomfortable postures, and repetitive actions are all substantial risk factors for developing musculoskeletal disorders in these industries. In general, the heavy workload is more vulnerable to load-carrying than the body limit of the workers [4]. The dimensions of the wood, the load, the distance of loading the wood, the number of tasks, and the overall length of tasks are the vital occupational dangers in the sawmill sector. Qutubuddin [5] analysed that most sawmill workers are exposed to several occupational hazards, especially ergonomic problems during sorting, cutting, and processing raw logs.

The previous study showed that sawmill workers are exposed to many occupational safety and health hazards, including ergonomics. Potential problems are the fingers or limbs of the operator's contact with the saw blade or band [6]. Moreover, Queenslan [7] reviewed the hazards of crushing, trapping, bullets, noise, and vibration due to the log debarking process. In sawmill, work activity of manual handling is common. Starting from intake and rough sorting of the woods, debarking, sorting and stacking, adjusting and sorting, wrapping and packaging, and finally loading cleaned wood or logs for delivery, fully mechanising machinery is difficult to be implemented [8].

Potential issues such as inappropriate procedures or repetitive injury associated with bending, gripping, cutting, and awkwardly elevating limbs become the norm when involving human strength and contact. The operation of manually moving and locating logs, such as sorting and stacking where parameters of size and species sort the logs, can lead to overexertion, muscle strain, uncomfortable. Static posture and repetitive work are also common contributing factors to MSDs [9].

According to Poisson et al. [10] most sawmill workers are exposed to hazardous machines like chain conveyors, circular saws, and vertical saws while interacting on equipment at all stages of their life cycle such as in maintenance, adjustment, set-up, troubleshooting, repairs and cleaning, and dismantling. Adjustment and sorting involve cutting off small sections from the log's edges by the band saw. Thus, potential problems are material from the saw blade or band flying towards the operator.

Ergonomic risks have been the subject of numerous studies. However, occupational disease issues continue to rise and have become a matter of concern in the workplace [11]. Therefore, this review needs to be conducted to explore the occupational ergonomics risk factors based on the published articles. The goals of this research are to (1) identified concerns in the sawmill sector, (2) highlight activities and issues from a site visit and (3) based on the issues, suggest workplace control measures that should be implemented. Authors believe that knowledge of the arising issue in the sawmill industry will ease planning to improve workers' wellbeing in the sawmill industry.

2 Methodology

A site visit was conducted to identify the issues in sawmill, particularly in terms of ergonomics. The importance of site visits is to observe the facilities, communicate with workers, and verify the accuracy of previous statements. This phase is crucial in identifying the ergonomic issues in this industry. The sawmill workers that comprised of mill workers and machine operators were observed. The authors also reviewed the published articles regarding ergonomics issues from 1992 to 2019 to further understand the consequences of the exposure. For the reviewing process, the inclusion criteria for the paper selection include; English articles, exposure to any ergonomic risk factor, and ergonomic issues in the sawmill industry. The exclusion criteria were, for example, non-SME Multinational corporations, sectors of government, or sectors that have over 200 employees and ergonomic concerns at other sectors apart from the timber sector. Besides that, duplicate articles in the database are removed.

3 Result and Discussion

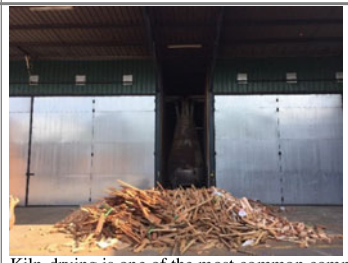
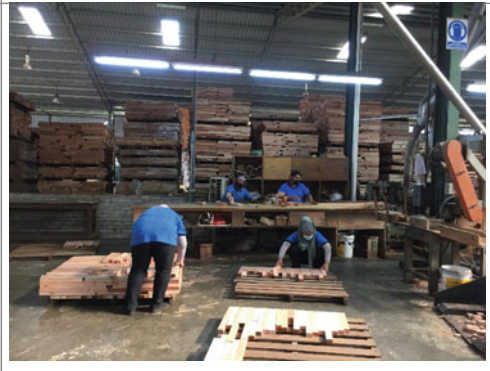
3.1 Sawmill Activities

The sawmill runs four areas of operations, namely, kiln-drying, moulding, regrading and surfacing, and transport. The activities of sawmill are depicted in Table 1. Kiln-drying is the process to ensure the wood dry in a chamber with controlled air circulation, humidity, and temperature so that the wood is in moisture content. Moulding is the process of concealing or decorating transitions between surfaces by using four methods: finger-jointed, surfaced four sides, edge-joint laminated board, and surfaced two sides. Besides, regrading and surfacing are required on any defects that may have occurred during the drying. Finally, the wood products will be transported to customers following safe lifting and stacking processes. In Table 1, the safety and health issues that may exist during each operation are also explained.

3.2 Article Searching and Selection

Table 2 shows the results of each phase of retrieving published articles as mentioned in the methodology. Based on the designed search criteria, at the beginning total of 213 articles were identified. However, after undergoing the screening process, only 28 articles are included in this study.

Table 1 The sawmill activities

Operations	Description	Issues
Kiln-Drying	 Kiln-drying is one of the most common commercial processes for seasoning wood. External energy is used to drive moisture out of the seasoning process, which speeds up the process [12]	The wood is placed horizontally with wide spaces between each piece and horizontally with strips of wood between each layer to ensure vertical separation and then placed within a chamber where the conditions can be changed to provide the optimum seasoning results. The charge (stacked lumber) is surrounded by air, and the temperature and humidity can be adjusted for optimal drying. Before entering, the kilns must be adequately ventilated and must remain open while working inside. Thus, it is important to direct-fired kilns with fan decks The timbers were left in the kiln for two days to one week. Wood chips and dust should be removed from floors, especially around the heating units, since ignition sources on timber stocks can burn. Then, all wood composites outside kilns must be sealed or stored in containers to keep the passageway clear from obstruction Gaskets around the kiln doors are frequently degraded, allowing gas to escape uncontrollably. When poorly maintained, these same gaskets might become tripping hazards. Thus, safety signage and emergency rescue plan are required in this place
Wood Moulding	 **Finger jointed** The purpose of structural finger joints is to keep a piece of wood strong throughout its whole length	A finger joint is a woodworking joint made by gluing shorter pieces of timber end-to-end that have several tapered “fingers” into long pieces. Ergonomics problems occurred, such as poor posture, repetitive motion, reaching out, and bending while arranging the wood piece Personal protective equipment (PPE) that is compulsory to use is safety glasses or safety goggles. This is because the dust from cutting wood and primed wood may irritate eyes, causing discomfort and pain Long sleeves shirts and gloves are also required as the dust from cutting wood, and primed wood may irritate the skin, causing itching and rash Workers should wear suitable respirators while cutting and machining the wood. The dust from cutting wood and primed wood may irritate the nose, throat, and lungs, particularly in respiratory and chest illness sufferers or asthma

(continued)

Table 1 (continued)

Operations	Description	Issues
	 *Surfaced four sides (S4S)* Surfacing lumber, or dressing lumber, is the act of planning the boards so that each board is smooth and uniformed in thickness	S4S is a finishing process that gives a board planer-finished faces and edges. Bending body and hands while pushing and pulling the timber into and from the machine leads to awkward posture and repetition risk factors. This action can lead to MSDs at the lower back and wrist Emergency instructions and safety signage are required in this area
	 *Edge-joint laminated board* Laminated timber is a structural wood product made from strips of wood glued	The workers gathered the laminated timber for final checking. Proper lifting technique is a must to avoid muscle injuries due to awkward posture while carrying the wooden boards. Furthermore, safety gloves should be used while lifting the laminated board to minimise workers' exposure to pricks or contact with glues or any other hazardous product Laminated boards are glued to at least four strips or sheets of sawn good. A face mask is needed because workers might be exposed to noxious substances of different nature, such as varnishes, glues, paints, or other hazardous substances like acids or solvents. Volatile Organic Compounds (VOCs) created from the use of varnishes and solvents can induce intoxication, so the company needs to make sure the ventilation is adequate

(continued)

Table 1 (continued)

Operations	Description	Issues
	 *Surfaced two sides (S2S)* S2S is a finish that allows some sections to be slightly rough or "skipped" after dressing	The use of wood planer during S2S involves pushing and pulling acts. Repetitive manual handling might contribute to musculoskeletal system disorders such as tendons, bones, joints, blood vessels, and nerves. Thus, handle height should be between the shoulder and waist to provide a good, neutral stance when pushing or pulling Most of the workers use sanding machines and panel planers in this section. Earmuff must be worn in the workplace to protect the workers from excessive noise at the workplace Workers must be provided with an appropriate face mask to protect them from infections caused by inhaling wood dust and sawdust
Regrading and surfacing	 Trimming woods on faults such as split ends, loose knots, and other flaws are managed in this section	Before stacking sawn timber for storage, it is usually inspected for any faults that may have developed during the drying process. When using the vibrating tools, the workers might be exposed to excessive hand-arm vibration. Thus, workers should be reminded to keep their hands warm and dry and not clutch a tight vibrating instrument. Moreover, safety signages are required to be displayed near the machine as a safety precaution The workers must wear earmuffs when using the machine to protect them from excessive noise Floors should be free and clear from wood chips and dust to avoid slips, trips, and falls. Airborne chips and dust generated during machining and sanding processes might cause vision impairment

(continued)

Table 1 (continued)

Operations	Description	Issues
Transport	 Sawn timber exported upon request	Manual placement of dunnage entails a lot of bending and reaching, twisting, and other awkward postures. This action may result in cuts and bruises from sharp dunnage and harm to the musculoskeletal systems from repetitive manual handling Direct exposure to ultraviolet (UV) light from the sun, as well as severe heat, is a severe risk when working outdoors. Long periods of exposure to direct sunlight can cause weariness, disorientation, and thirst. So, workers need to be informed on the symptoms of heat-related diseases, such as heat exhaustion or heat stroke, and the indicators of dehydration and allow them to take rest breaks to cool down

Table 2 The result of retrieving published related articles

Identification	Published studies identified through Universiti Malaysia Pahang database—science direct (n = 110)	Studies identified through web of science (n = 11)	Studies identified through ResearchGate (n = 5)	Additional studies identified through google scholar (n = 92)
Screening	Studies after duplicates removed (n = 213)			
	Studies screened based on titles (n = 148)	Studies excluded based on titles (n = 65) Reasons: ergonomic not the outcome (63), overlap (2)		
Eligibility	Full-text studies assessed (n = 28)	Full-text studies excluded, with reasons (n = 120) Reasons: unrelated with risk assessment (76), no association (44)		
Included	Studies included in the review (n = 28 articles)			

3.3 Review of Ergonomic Issues in Sawmill Industry

Table 3 depicts the ergonomic issue from the previous studies. The sawmill industry's hazards comprised noise, machinery-related hazards, and ergonomic hazards from lifting heavy loads, reaching for objects, repetitive work, and poor work posture. Heavy work and repetitive motions have mostly been researched for musculoskeletal problems or overexertion, as studied by Holcroft et al. [13]. Manual materials handling such as lifting, pushing, pulling, and carrying timber and logs, was found to be responsible for forty percent of all sawmill injuries [14]. Meanwhile, Bjoring [15] found that repetitive hand movements, especially when combined with force, may cause MSDs in the arm or wrist when severe postures, high external force, high speed, and high static load are present.

Ng et al. [16] revealed that musculoskeletal disorders MSDs and the global economy. MSDs result from poor work posture, frequent and repetitive movement, force exertion, stress vibrations of psychological and physiological, and physical disability in human beings, such as lower back pain (LBP) and spinal abnormalities. Furthermore, Joshi et al. [17] found that MSDs are a regular occurrence, especially low back pain. The risk identified in work activities, postural loading, vibration effect, tool use, coupling, awkward postures, frequency and duration of movements, and ergonomic workstation design to address the MSDs issues. The

Table 3 Previous studies on the ergonomics issues

Author	1	2	3	4	5	6	7	8
Ng et al. [16]	√				√	√		
Joshi et al. [17]	√							
Awosan et al. [19]	√	√	√					
Oranye et al. [18]	√					√		
Queenslan [7]	√	√						√
Poisson et al. [10]		√	√			√	√	√
Griffith [21]	√							√
Hermawati et al. [14]	√						√	√
Qutubuddin [5]	√			√			√	
Saldanha et al. [23]	√	√	√	√			√	√
Nunes et al. [25]	√				√	√		
Bello et al. [24]		√		√		√	√	
Holcroft et al. [13]	√		√		√	√	√	√
Jones et al. [14]	√			√	√			
Bjoring et al. [15]	√					√	√	√

1 = WMSD; 2 = Noise; 3 = Temperature; 4 = Lifting heavy load; 5 = Forceful Exertion; 6 = Repetitive work; 7 = Poor work posture; 8 = Manual handling

muscles, tendons, tendon sheaths, peripheral nerves, joints, bones, and ligaments are all prevalent WMSDs.

According to Oranye [18] and Awosan et al. [19] the risk of recurrent work injuries is believed to be higher in workers who are experiencing MSDs, resulting in repetitive injuries, job disability, and enormous compensation claims. In the sawmill industries, manual handling is the norm when processing timber, especially when using machinery. Manual handling is defined as the activity that requires a person to raise, lower, move, pulls, carry, throw, restrain or hold an object. Dangers involved with sawmilling, such as machine-related injuries especially when handled incorrectly or without sufficient protections, and excessive noise, can cause irreversible noise-induced hearing damage (NIHL). Other risks include irritation and other negative health effects caused by wood dust and chemicals used in finishing processes, such as allergic skin reactions, asthma, cough, and other respiratory illnesses.

On the other hand, local exhaust ventilation (LEV), which eliminates dust at or near its source, is the most common way of managing wood dust. Exhaust hoods should be placed close to the emission source, either on the woodworking machines or near it. Aside from that, the management of the organisation should take care of indoor air quality. A case reported using the band saw blades might increase silicon concentrations in interior buildings, resulting in harmful indoor air [20]. Queenslan [7] reported that almost all of the job done by sawmill workers involves manual labour. Common issues highlighted are housekeeping, noise, vibration, dust, working at height, hazardous chemicals, manual work lead to MSDs such as repetitive movements, sustained or awkward postures, repetitive or sustained forces, and lastly, psychosocial hazards. Workers are exposed to dangers because they interact with machinery at all stages of its life cycle, including installation, operation, maintenance, troubleshooting, repairs, adjustments, set-up, production disruptions, cleaning, and disassembly.

Gopalakrishnan et al. [8] mentioned that electricity use is significant to operate engines in equipment such as debarker, head saw, re-saw, edger, trimmer, chipper, planer, fans, and pumps, as well as in material handling equipment such as conveyors and belts. Machines can provide various hazards, and exposure to these risks can lead to harm or death. The hazards can be physical such as sharp edges, projections, mechanical such as entanglement, crushing, and cutting. Electrical hazards also can exist. Apart from that, noise and vibration, hot or cold temperatures, physical ergonomics hazards such as awkward working positions, manual handling, repetitive movements also can be found while performing the job in the sawmill industries [10].

Besides, Griffith [21] stated that sawmill processes including timber raising, turning or dragging, adjusting knives of the tool, removing blockages, and cleaning are handled by human strength. Thus, it is essential to walk through the work area, including the access way, and identify all hazards to avoid slips, trips and falls, and MSDS injuries. Surveys such as that conducted by Hermawati et al. [22] have shown that the most often addressed ergonomics issues were working posture and workstation or tool design, followed by material handling and MSDS. Thus, redesigning and evaluating workstations or tools to accommodate worker anthropometry and promote better working postures is crucial.

Activities that are conducted primarily by manual handling often lead to overexertion and long-term risks to health [5]. It has been shown that sawmill workers experience MSDS risks, harsh environmental conditions, strenuous tasks such as manual load handling, awkward postures, and dangerous equipment and machinery [23]. Workplace risks, poor workers' health, mechanical equipment injuries, disabilities, and MSDs caused by poor workplace design, which reduces worker productivity.

Forty percent of sawmill injuries were related to manual material handling, mainly of wood and logs. With the high degree of manual handling in sawmilling processes, employees are exposed to higher risk rates associated with handling logs and operation of machines, environmental hazards, body injury associated with work, and death, in severe cases [24]. The finding showed twenty-seven percent of all industrial back injuries are linked to some form of lifting or manual handling of material. These injuries are usually repeatable and result after months or years of work [25]. An injury is more likely to occur if the employees work in a physically demanding job and are prolonged. MSDS such as repetitive strain injuries (RSI), repetitive motion injuries (RMI), and cumulative trauma disorders (CTDs) are because of soft tissue injuries.

3.4 Review of MSDs Risk

As conjunction from the Table 3, WMSD is the most commonly reported concern in the sawmill business. Workers who are exposed to certain workplace risk factors are at a higher risk of MSDs. High job repetition exhausts a worker's body beyond its capacity to recover, resulting in MSDs. MSDs have the most frequent effect on hands, elbows, ears, eyes, and back. In these areas, they directly affect the nerves, tendons, and muscles. MSDS can also affect particular fingers, elbows, and knees, although they are less common. Table 4 illustrates the previous studies related to the risk of MSDs among sawmill workers.

Prolonged standing during sawmill activities was responsible for 65% of the number and incidence of joint discomfort at back, waist, and foot region. Also, the issue of vascular illnesses, which has grown as an occupational discomfort as a result of sawmill workers standing for long periods [26]. Meanwhile, in a study conducted by Awosan et al. [14] frequent injury reported was due to fatigue, sprains and joint discomfort, back pain, eye infuriation, stress, and exhaustion. Eighty percent of the workers do not undergo occupational health and safety training. So, if workers are uninformed of their working hazards, they are less inclined to defend themselves.

On the other hand, Queenslan [7] reviewed the cause of MSDs where contact with vibrating surfaces such as the heavy seat of machinery or vehicles caused whole-body vibration and lead to low back pain. Heavy lifting, repetitive movements, and improper posture throughout work hours were the main sources of ergonomic risks in the wood processing sectors [27]. Crushed hands, severed fingers, amputations, and blindness are common woodworking accidents, including rotating devices, cutting or shearing blades, in-running nip points, and meshing gears as examples of industrial

Table 4 Causes of musculoskeletal disorders (MSDs)

Author	Causes of musculoskeletal disorders
Sutcu et al. [26]	Loading and unloading of loggers, transportation of huge and heavy goods between machines, and machine loading factors
Awosan et al. [19]	Poor training in occupational health and safety, as well as a lack of understanding of workplace hazards such as back pain, sprains, and joint pains
Queenslan [7]	Grip, manipulate, strike, toss, carry, move (raise, lower, push, pull), hold, or constrain an object or load are all dangerous manual tasks
Mong'are et al. [27]	Hazardous woodworking, high noise levels from operating machines, dust conditions, and work-related musculoskeletal diseases caused by repetitive movements are all factors that are likely to have an impact on employees' health
Saldanha et al. [23]	The inappropriate use of equipment, systems, and tasks creates musculoskeletal system illnesses, particularly back discomfort
Ali et al. [2]	Workers are at risk of MSDs because of hard environmental conditions such as cold temperatures, slick and uneven ground; heavy work likes manual handling of loads, back flexed and twisted, and risky tools and machinery such as chainsaws
Bello et al. [24]	The high occurrence of musculoskeletal and respiratory diseases in the industry was partly due to a disregard for the usage of individual protection devices and other safety equipment
Bjoring et al. [15]	Gripping the spray gun trigger was identified as a high risk for WMSD in the wrist for some of the wood painters

injuries. Previous epidemiological research has shown that assessing the lower arms is critical to avoiding MSDs [28].

In a previous study by Saldanha et al. [23] accidents related to occupational diseases such as RSI and MSDs occur each year in the wood industry, which includes the manufacturing of lumber, veneer, plywood, crowded and pressed wood, products for construction, packaging, industrial, commercial, and domestic use. Moreover, as Ali et al. [2] stated, many employees work in poor postures; nearly 80% of the workers suffered pains in the thighs, legs, and back. As a result of the heavy manual workload, environmental conditions, and dangerous instruments, the loggers may develop MSDs.

Bello et al. [24] reported that fifty-eight percent of sawmill workers were affected with back and lower back injuries. The prevalence of joint discomfort such as back, waist, foot caused by standing in prolonged periods reached sixty-five percent. The worker disregards the use of individual protection such as hand gloves when moving and stacking logs or sawn lumbers and not wearing overalls while carrying logs that primarily serve as lumbar back support.

Bjoring et al. [15] believe that manual spray painting is still widely used in the woodworking sector despite rationalisations. When painting the horizontal surface of the workpiece, the majority of these painters abduct the right upper arm so much that they risk supraspinatus tendinitis. According to recent reports, manual spray

painting is a likable labour task. As a result, spray painters with musculoskeletal issues probably work longer than other employees with similar symptoms.

4 Conclusion

The issue of the sawmilling sector in Malaysia is revealed. Occupational safety and ergonomic issues occur among workers, especially in PPE usage and WMSDs while performing lifting, adjusting machine knives, releasing blockages, and cleaning activities. Furthermore, this industry was susceptible to a wide range of risks, including noise, environmental factors, and ergonomic issues such as awkward work posture, hand-arm, and whole-body vibration. Lifting these problems caused a hazardous workplace environment, affects the worker's health, disabilities such as body injuries while using mechanical equipment, WMSDs and thus result in low efficiency among workers if the ergonomics field is not adequately considered. So, an ergonomic risk assessment should be carried out to determine the workplace risk factors that lead to musculoskeletal disorders.

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