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Applying Risk Assessment and Hazard Analysis Techniques in Wood Manufacturing: A Case Study of a Sawmill in Warri, Delta State

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Abstract: *This study applies risk assessment and hazard analysis techniques to evaluate occupational and operational safety risks in a wood manufacturing process, using a sawmill located in Warri, Delta State, Nigeria as a case study. Despite the crucial role of sawmills in Nigeria's wood value chain, they remain prone to high-risk operations due to inadequate safety measures and obsolete machinery. The study adopted a mixed-method approach combining observation, interviews, and hazard identification checklists. Risk assessment was carried out using the Failure Mode and Effects Analysis (FMEA) and Risk Matrix models based on ISO 31000 standards. Findings revealed that mechanical hazards (40%), ergonomic hazards (25%), and noise exposure (20%) constituted the major risk categories. The overall risk priority numbers (RPN) ranged from 40 to 210, with unguarded cutting machines and poor wood handling practices ranked as "high-risk" activities. While workers demonstrated awareness of safety practices, compliance with personal protective equipment (PPE) usage was below 60%. The study recommends safety engineering controls, regular safety training, and compliance monitoring by regulatory bodies to reduce operational hazards in sawmill operations. The findings underscore the need for proactive occupational safety management in Nigeria's wood manufacturing industry.*

Keywords: Risk assessment, Hazard analysis, Sawmill, Occupational Safety, Wood Manufacturing, Nigeria

1. Introduction

Manufacturing processes are critical to industrial development and economic growth, yet they remain inherently exposed to numerous operational and occupational hazards. In Nigeria, the wood manufacturing and sawmill industry forms an important component of the country's agro-based industrial sector, contributing to employment generation, furniture production, and export earnings (Olorunnisola, 2023). However, the industry is dominated by small and medium-scale enterprises characterized by outdated equipment, informal safety practices, and limited regulatory oversight. These deficiencies increase the risk of accidents, injuries, and environmental hazards. According to Nnaji, and Udokpoh (2023), the Nigerian wood sector records some of the highest rates of workplace accidents, particularly in sawmill operations, where mechanical, physical, and ergonomic hazards are prevalent.

A sawmill represents a typical manufacturing setting where raw logs are converted into processed timber using sawing, planning, and finishing equipment. The process involves several hazardous operations such as log handling, cutting, trimming, and waste disposal, which expose workers to risks including noise-induced hearing loss, dust inhalation, cuts, electrocution, and fire outbreaks (Bello, & Mijinyawa, 2010). Despite the high-risk nature of sawmill operations, many firms in developing countries lack structured occupational risk assessment systems. The absence of preventive measures not only endangers workers' health but also affects production efficiency, machinery lifespan, and overall organizational performance.

Risk assessment and hazard analysis are therefore indispensable tools in industrial safety management. These methods provide systematic approaches for identifying, evaluating, and prioritizing risks associated with manufacturing processes, and form the foundation for developing control strategies (ISO 31000:2018). Techniques such as Hazard and Operability Study (HAZOP), Failure Mode and Effects Analysis (FMEA), and Job Safety Analysis (JSA) have been widely used to enhance decision-making in safety management (Rahim et al., 2024; Ispășoiu et al., 2024). In the wood manufacturing sector, their application helps prevent injuries and maintain compliance with occupational safety standards such as the Nigerian Factories Act (Cap F1, LFN 2004) and International Labour Organization (ILO) (ILO, 2016).

1.2 Problem Statement

Despite the proliferation of sawmill enterprises in Warri and other industrial clusters in Delta State, the majority still operate without a comprehensive safety management framework. Observations from preliminary field visits revealed poor safety culture, minimal use of protective equipment, and inadequate hazard communication among workers. These conditions often result in accidents such as hand injuries, wood splinters, or even fatalities from machine entanglement. A study by Opoku et al. (2024) reported that over 65% of sawmill workers in Sokoban Wood Village, Kumasi, Ghana had experienced at least one work-related injury within a 12-month period.

While several studies have examined occupational safety practices in Nigerian industries, limited empirical attention has been given to structured risk assessment and hazard analysis using quantitative techniques in sawmill settings. Furthermore, local research rarely integrates international risk assessment frameworks such as ISO 31000 or FMEA models with contextual realities of small-scale manufacturing enterprises. This gap necessitates an evidence-based approach to quantify and rank potential hazards, determine their causes, and propose cost-effective mitigation strategies applicable to the local industry.

1.3 Objectives of the Study

The main aim of this study is to apply risk assessment and hazard analysis techniques to evaluate occupational and process related risks in a sawmill located in Warri, Delta State. The specific objectives are to:

1. Identify and categorize the major hazards associated with wood manufacturing processes in the selected sawmill.
2. Conduct a structured risk assessment using the Failure Mode and Effects Analysis (FMEA) and Risk Matrix techniques.
3. Determine the severity, frequency, and detection levels of identified hazards.
4. Indorse appropriate control and mitigation measures to enhance safety performance.

1.4 Research Questions

The following research questions were formulated to guide the study:

1. What are the predominant hazards in sawmill manufacturing operations in Warri, Delta State?
2. How can risk assessment and hazard analysis techniques be applied to evaluate these hazards?
3. What is the risk priority level of the identified hazards based on FMEA and risk matrix results?
4. What control measures can effectively reduce these risks to acceptable levels?

1.5 Research Hypotheses

To guide the study further, the following null hypotheses were formulated in line with the stated objectives and research questions:

H_{01}: There is no significant relationship between the major types of hazards identified and the specific manufacturing operations in the sawmill process.
H_{02}: The application of risk assessment and hazard analysis techniques does not significantly influence the identification and evaluation of hazards in sawmill operations.
H_{03}: There is no significant difference in the severity, frequency, and detection ratings of identified hazards across different operational units of the sawmill.
H_{04}: The implementation of control and mitigation measures has no significant effect on overall safety performance in sawmill operations.

1.6 Significance of the Study

The study is an addition to the existing research on occupational risk management in the emerging economies. It offers a method of evaluation of hazards in small-scale manufacturing conditions based on internationally accepted approaches. In practice, the research can be of great help to managers, safety officers, and policymakers to develop preventive measures specific to the local industry requirements. It also explains the significance of incorporating safety management systems into the informal manufacturing industry in Nigeria, which is a major contributor to the economic growth, though it is usually overlooked in the study of occupational safety.

1.7 Scope of the Study

This paper looks at one sawmill company which is in the Warri Industrial Layout in Delta State, Nigeria. It deals with process like log cutting, trimming, planning and packaging. The risk evaluation is contained to the physical, mechanical, ergonomic and environmental hazards that impact on the employees directly involved in production. The non-production and administrative personnel were not included in the analysis.

2. Literature Review

2.1 Risk Assessment and Hazard Analysis Conceptual Overview.

The risk assessment and hazard analysis are considered as the primary elements of occupational safety management systems stipulated to identify, estimate, and manage risks in industrial processes in a systematic manner. The term hazard is a source or a situation that has the potential to cause a harm and the term risk is the likelihood and intensity with which such a harm may be caused (ISO 31000:2018) (Rout & Sikdar, 2017). In the manufacturing industries like sawmills, the hazards can be related to machinery, manual work, exposure to dust and the environment. Risk assessment consists of a series of steps: the identification of hazards, risk appraisal, risk prioritization, and control measures associated with ensuring workplace safety and compliance with regulations (Lele, 2012).

Hazard analysis process is supposed to focus on the identification of root causes of the potential incidents and on the definition of preventive or corrective measures. Such common methods as the Failure Mode and Effects Analysis (FMEA), Hazard and Operability Study (HAZOP)., and Job Safety Analysis (JSA) are used. Both of the techniques offer a systematic approach to measuring risk and prioritizing safety measures. Reason (2016) indicates that these proactive measures can help organizations to forecast and prevent risks before their accidents happen and respond to accidents after they happen.

2.2 Theoretical Framework

This paper will be based on Swiss Cheese Model of Accident Causation (Reason, 1997) and ISO 31000 Risk Management Framework (ISO, 2018; Comcover information sheet, 2018).

In accordance with the Swiss Cheese Model, accidents in complex systems are caused by the combination of several failures on several levels of defense, each level (such as the safety rules, training and supervision) has its possible weaknesses in the form of the so-called holes. These holes are aligned and the hazards go through them thus leading to accidents. This theory supports the importance of a combination of several and intersecting preventive initiatives instead of depending on a single control mechanism.

Instead, ISO 31000 framework offers a procedural approach to risk identification, assessment, and management in the organizational setting. It refers to risk management as an integrated effort of guiding and managing an organization in reference to risk. The framework highlights principles which include risk identification, risk analysis, evaluation, treatment, monitoring, and communication. The utilization of these frameworks allows the process of sawmills to be systematically classified and prioritized in terms of the risks and guarantee the constant service of the safety systems.

2.3 Hazard overview in the Wood Manufacturing Industry

Sawmill and the manufacturing of wood exposes the workers to various hazards. The mechanical hazards are mechanical contacts with moving blades, unguarded machinery and flying pieces of wood. Physical hazards encompass noise, vibration, and heat, whereas chemical hazards are caused by sawdust, glues, and coating (Gbadamosi, 1999). Manual lifting of heavy logs and an awkward position are the causes of ergonomic hazards and may cause musculoskeletal disorders. Oseme et al. (2020) note that mechanical tools like band saws and circular saws are the leading causes of injuries in the Nigerian sawmills (around 60%).

The International Labour Organisation (ILO, 2023) has shown that the number of occupational injuries among the wood processing workers is higher than the occupational injuries among other light manufacturing industries across the world. In developing countries, the situation is even worse in terms of safety enforcement since there is informal work and the enforcement of safety measures is weak. Research articles by Otitolaiye (2019) reveal that a large number of sawmills in Nigeria do not have safety signs, machine guard, or noise-control equipment even though the national regulations are available.

2.4 Techniques in Risk Assessment in Manufacturing.

A number of risk assessment models have been designed to facilitate decision making in the industrial safety management:

1. Failure Mode and Effects Analysis (FMEA): FMEA determines possible modes of failure in a system, causes and impacts such failures have on the operations. Ratings of each hazard are done on three aspects of Severe (S), Occurrence (O) and Detection (D). The multiplication of the values (S × O × D) results in the Risk Priority Number (RPN) that is used to prioritize risks that need to be mitigated immediately (Emily, R.S. (2025).
2. Hazard and Operability Study (HAZOP): HAZOP is a qualitative technique that finds out the deviation of the normal operations and the reasons behind them with the help of structured guide words, which include more, less, or no. It is mostly used in chemical industries, and is becoming increasingly used with mechanical and wood manufacturing systems (Yang et al., 2015).
3. Risk Matrix Approach (RMA): The risk matrix technique classifies risks based on the probability (likelihood) and severity. The risks are then classifying them as low, medium, or high, depending on their location on the matrix (Lemmens et al., 2020).

The FMEA and risk matrix approaches were also integrated in this study to produce quantitative and qualitative views on the safety of sawmills.

2.5 Empirical Research on Risk Assessment on Sawmill Operations.

The importance of structured risk analysis on enhancing safety in the workplace is supported by empirical evidence in other regions of the world. Mitchual et al. (2015) carried out a hazard assessment of 25 sawmills in Ghana and established that mechanical injuries and respiratory illnesses were the most significant occupational illnesses. Mrema et al. (2015) also found that due to the high incidence of respiratory complications among the woodworkers, sawdusts inhalation and poor ventilation were common in Tanzania.

Onowhakpor et al. (2017) conducted a safety evaluation of timber processing facilities in Benin City, Nigeria, by utilizing a modified risk matrix and discovered that 70 percent of employees worked without personal protective equipment (PPE). In a similar vein, Mayowa (2023) investigated occupational risk management in the Ibadan sawmills and found the insufficient training and inefficient services of machines as some of the most significant risk factors.

In the developed economies, the corresponding studies show the effectiveness of formal safety systems in lowering the risk exposure. As an example, Yang et al. (2018) applied the FMEA to the Canadian sawmills and halved the number of recorded accidents after the engineering controls and safety monitoring programs were implemented. These data are going to indicate that the implementation of systematic risk analysis models in Nigerian sawmills can lead to quantifiable changes in the safety of workers.

2.6 Conceptual Framework

According to the literature that was reviewed, the conceptual framework of the given study will incorporate the ISO 31000 risk management cycle and hazard evaluation using the FMEA. The following process is highlighted in the model:

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Source: Authors Sketch (2025)
Fig. 1: Risk management Triangle and hazard evaluation using the FMEA

This combined framework will make sure that both the qualitative and quantitative risk assessment aspects are applied to the case study.

2.7 Research Gap

Although more people in Nigeria are becoming more aware of occupational safety, there is still paucity of empirical implementation of risk assessment and hazard analysis most especially in the small scale industries like sawmills. Other past researchers (Mitchual et al., 2015; Mrema et al., 2015) have been mostly descriptive without involving themselves in such standardized analytical methods as FMEA or ISO 31000 models. Moreover, not many studies have placed the priorities of the risks in the context of the specific challenges of the informal manufacturing setting in Nigeria, including the limited capital, absence of formal training, and insufficient safety regulations. Thus, this paper fills the gap by imposing the internationally accepted risk assessment techniques to a local sawmill business, yielding the practical findings on enhancing safety in the wood manufacturing industry.

3. Methodology

3.1 Research Design

The research design used was a case study research with a mixed-method design that integrated the use of qualitative and quantitative data collection methods. The design was selected such that there is a comprehensive appreciation of risk and hazard dynamics in a real industrial situation. One sawmill firm in Warri, Delta State was sampled intentionally courtesy of its size of operations, accessibility as well as a representative of the common small and medium-sized wood production firms in Nigeria. This study was done through direct observation of working processes, administration of structured questionnaires and interviews with the most essential staff. Failures modes and effects Analysis (FMEA) and Risk Matrix models were used to analyze quantitative data to create risk priority levels.

3.2 Study Area

Warri is a large industrial city in the Delta State, Nigeria, which boasts of petrochemical, construction, and wood processing. The sawmill that has been chosen is more than 15 years old and has around 45 employees who work in different departments, which are the log yard, sawing, planning, finishing, and packaging. Log conversion is achieved with the help of band saws, circular saws, and planning machines thus exposing the workers to various mechanical, ergonomic and environmental hazards. The equipment layout and site plan offered an appropriate background on application of risk assessment and hazard analysis methods.

3.3 Population and Sample Size

The participants used in the study were 45 workers who were machine operators, maintenance workers, supervisors, and the helpers. A total of 30 respondents who are directly engaged in the production activities were picked through a purposive sampling process, and a thorough analysis of the respondents was to be carried out. The sample was good enough to triangulate data; observations, interviews and risk assessment ratings. The main informants that were involved were the production manager, the safety officer and the three senior machine operators.

3.4 Data Collection Methods

a. Direct Observation

The researcher made two weeks' on-site observations to determine the unsafe conditions and unsafe acts. The loading of wood, the adjustment of blades, and the log cutting were also strictly controlled based on the structured hazard checklist with references to the International Labour Organization (ILO) checklist named Checklist for Wood Processing Safety (2021).

b. Questionnaire and Interviews

The questionnaire was semi-structured to take into consideration the perceptions of the workers with regard to hazards, safety practices and history of accidents. Management personnel interviewees offered information on safety policy application, maintenance program, and adherence to the requirements of the statutory law e.g. the Nigerian Factories Act (Cap F1, LFN 2004).

c. Document Review

The safety history of the company, the first-aid record and maintenance history of the company were looked up to supplement the primary data and reinforce the incidence frequency.

3.5 Risk Assessment Procedures

The two-step assessment model that was used in the study is a combination of Failure Mode and Effects Analysis (FMEA) and a Risk Matrix approach as it is prescribed by ISO 31000, 2018.

Step 1: Hazard Identification

The possible risks that come with the sawmill operations were all established by observing the site, employee feedback, and literature standards. There were four major categories of hazards, which included:

i. Mechanical hazards (e.g., contact with blades, flying objects, etc.)
ii. Physical hazards (i.e. noise, dust, vibration)
iii. Ergonomic injuries (e.g. repetitive lifting, bad posture)
iv. Hazards in the environment (e.g., waste disposal, fire outbreak)

Step 2: FMEA Assessment

All the identified hazards were rated on the basis of:

i. The severity (S): the severity of the consequence (1 = negligible; 10 = catastrophic)
ii. Occurrence (O): The frequency of occurrence of hazards (1 = rare; 10 = frequent)
iii. Detection (D): The probability of the likely occurrence or prevention of the hazard resulting in loss (1 = very likely; 10 = undetectable)

The Risk Priority Number (RPN) was calculated as: $RPN=S\times O\times D$

While the hazards were prioritized into:

i. Low Risk (RPN < 50)
ii. Medium Risk (RPN 50-100)
iii. High Risk (RPN > 100)

Step 3: Risk Matrix Evaluation

To further support FMEA a 5 x 5 risk matrix was created by classifying risks based on both likelihood (rare to frequent) and consequence (minor to fatal). The findings gave a visual analysis of the levels of risks and influenced the choice of mitigation actions.

3.6 Data Analysis

FMEA scoring descriptive statistics and ranking methods were used to analyze quantitative data in Microsoft Excel. The average RPN of each type of hazard was calculated and interpreted to find the relative severity. Interview data and observational data that were qualitative data were assigned a thematic code to determine common safety issues and management behaviour. Findings of the two methods were triangulated in order to enhance validity of findings.

3.7 Reliability and Validity

In order to be reliable three independent raters (safety officer, production supervisor, and researcher) participated in FMEA scoring. Consent scoring was used to obtain inter-rater consistency. Expert review and pre-testing in a local sawmill in Sapele showed content validity of the instrument. Triangulation of the data technique also created a high level of robustness and credibility.

4. Results and Discussion

4.1 Hazards Identified

Field observation and interviews exposed diverse hazards that were involved in the manufacturing processes in the sawmill. These risks were grouped into four broad categories of mechanical, physical, ergonomic, and environmental analyses as expressed in Table 1.

Table 1: Categories of Identified Hazards in the Sawmill Operation

Hazard Category	Specific Hazards Identified	Frequency of Occurrence (%)
Mechanical	Blade contact, wood kickbacks, unguarded machines	40
Physical	Noise, heat, dust inhalation, vibration	25
Ergonomic	Manual lifting, repetitive bending, awkward posture	20

Environmental	Fire risk, poor waste disposal, slippery floor	15

Sources: Authors field work (2025)

Table 1 revealed categories of identified hazards in the sawmill operation. The study findings show that mechanical hazards (40%) were the most frequent and severe, followed by physical hazards (25%). Most accidents were linked to contact with high-speed blades or unguarded rotating parts. These results align with the observations of Adebayo and Oni (2020), who reported similar dominance of mechanical risks in Nigerian sawmills.

4.2 FMEA Analysis Results

By the FMEA model, all hazards were estimated in accordance with the severity (S), occurrence (O), and detection (D) values to produce Risk Priority Numbers (RPN). The list of the top ten hazards along with the RPN value is presented in Table 2.

Table 2: FMEA Ratings and Risk Priority Numbers

Hazard	Severity (S)	Occurrence (O)	Detection (D)	RPN (S×O×D)	Risk Level
Contact with unguarded saw blade	10	7	3	210	High
Wood kickback during sawing	9	7	3	189	High
Excessive noise exposure	7	6	4	168	High
Dust inhalation	6	7	4	168	High
Poor manual handling posture	6	6	4	144	Medium
Fire outbreak from wood dust accumulation	8	4	4	128	Medium
Electrical shock from faulty wiring	9	3	3	81	Medium
Vibration-induced strain	5	4	4	80	Medium
Slippery floor due to sawdust	4	4	4	64	Low
Poor waste disposal and clutter	4	3	3	36	Low

Source: Authors Field work analysis (2025)

Table 2 is on FMEA Ratings and Risk Priority Numbers. The RPN scores were between 36 and 210 with an average RPN of 127.9 indicating medium overall risk profile. The three most ranked hazards were: i. Contact to exposed saw blades (RPN, = 210), ii. Wood kickback (RPN = 189), and iii. Over-exposure to noise and dust (RPN = 168 each). The study results revealed that mechanical and physical hazards are prevailing in the sawmill operations and it needs immediate engineering and administrative control measures.

4.3 Risk Matrix Evaluation

In order to supplement the FMEA results, a 5x5 Risk Matrix was also used where the level of risk was considered as Low, Medium or High based on the probability and impact (Table 3).

Table 3: Risk Matrix

Risk Level	Description	Examples
High	Requires immediate control	Blade contact, noise, dust inhalation
Medium	Acceptable with mitigation	Manual handling, fire hazard
Low	Tolerable, monitor periodically	Slippery floor, waste disposal

Source: Authors Compilation (2025)

Table 3 reveal the aggregate outcomes of the FMEA and risk matrix analysis revealed that half of the hazards that were identified were high risk, 30% medium and 20% low. The preponderance of the high-risk hazards is associated with the lack of engineering controls and formal safety programs within the company. There is some correlation between this result and the work of Mitchual et al. (2015) who add that small-scale sawmills in Nigeria hardly invest in machine guards and ventilation systems because of the cost factor.

4.4 Safety Compliance and Behaviour of the Worker

The result of the questionnaire showed that although 73% of employees knew about safety regulations, only 58% wore protective personal equipment (PPE), including gloves, ear muffs, or nose mask every time. It was revealed in interviews that workers found PPE uncomfortable or not needed when working in short operations, which indicated the presence of an attitude-behavior gap. This is consistent with Faremi et al. (2014), who established a poor safety culture and behavioral compliance among the wood industry workers despite the level of awareness.

Furthermore, two out of five described that they had not undergone any formal safety training during the last one year (62 percent). The informal system of learning by peer observation is used by newest employees thus raising the chances of procedural errors. Maintenance was also not regular and the machine guard would be removed out of convenience. These conditions are indicative of a reactive safety management methodology where one acts upon the event of incidences happening.

4.5 Discussion of Findings

From the study so far, the findings confirm that mechanical and physical hazards are the most critical risks in sawmill operations. The high RPN scores for blade contact and wood kickbacks are consistent with international studies such as Anjalee et al. (2021), who found that machine guarding deficiencies were responsible for nearly 40% of injuries in Canadian sawmills. In the Nigerian context, limited capital investment and inadequate supervision exacerbate such risks (Faremi et al., 2014).

The high noise and dust exposure levels also highlight environmental health concerns. Continuous noise levels above 85 dB and prolonged dust inhalation can lead to hearing impairment and respiratory issues, respectively. According to the World Health Organization (WHO, 2021), long-term exposure to wood dust is associated with chronic bronchitis and nasal cancer. Despite these risks, only a few Nigerian sawmills have implemented dust extraction or noise control systems.

The ergonomic hazards such as manual lifting and awkward posture yielded medium RPN values, but they represent cumulative risks leading to musculoskeletal disorders over time. Workers often lift logs exceeding 50 kg without mechanical assistance, contravening occupational safety standards. This aligns with Mrema et al. (2015), who linked musculoskeletal disorders among Tanzanian sawmill workers to prolonged manual labor and poor workplace design.

Furthermore, the study's findings lend support to the Swiss Cheese Model (Reason, 1997), illustrating that multiple system weaknesses, such as lack of training, absence of guards, and poor housekeeping, combine to create accident conditions. Similarly, applying the ISO 31000 framework reinforces the need for structured risk management processes, from identification to mitigation and monitoring.

4.6 Implications for Safety Management

The findings underscore the urgent need for proactive safety management in Nigeria's wood manufacturing sector. For policymakers, enforcing compliance with the Factories Act (Cap F1, LFN 2004) and Federal Republic of Nigeria (2019) can drive safer operations. For management, integrating FMEA-based risk assessment into regular safety audits can help prioritize control investments effectively. From a practical perspective:

i. Engineering controls such as blade guards, noise dampening panels, and dust extraction systems should be prioritized.
ii. Administrative controls should include scheduled safety training, machine inspection checklists, and hazard reporting systems.
iii. Behavioral interventions such as safety incentives and peer monitoring could improve PPE compliance.
iv. Implementing these measures would reduce RPN values, minimize accident frequency, and improve overall operational efficiency.

5. Conclusion and Recommendations

5.1 Conclusion

This study assessed the application of Risk Assessment and Hazard Analysis Techniques in a wood manufacturing context, using a case study of a sawmills company in Warri, Delta State. The main objective was to identify, analyze, and evaluate hazards associated with the manufacturing process and to propose control measures that enhance worker safety and operational efficiency.

The findings from field observations, questionnaires, and FMEA-based analysis revealed that mechanical and physical hazards constitute the most significant safety risks in sawmill operations. These include unguarded saw blades, wood kickbacks, excessive noise, and dust exposure, all of which recorded high Risk Priority Numbers (RPN). The study also established that poor safety culture, limited use of personal protective equipment (PPE), and inadequate safety training exacerbate accident frequency and severity in the sector.

Applying the FMEA and Risk Matrix techniques proved effective in identifying high-priority hazards and quantifying their relative significance. The results showed that 50% of all hazards were high risk, requiring immediate control measures, while 30% were medium and 20% low. This highlights a generally unsafe work environment requiring urgent policy and managerial intervention. The findings reinforce the argument that structured risk assessment systems, such as FMEA, are indispensable in Nigeria's manufacturing sector, especially small- and medium-scale industries like sawmills that often lack formal safety management systems.

5.2 Recommendations

Based on the results and analysis, the following recommendations are proposed:

1. Install proper machine guards on all rotating saw blades and moving parts and introduce dust extraction systems and noise barriers to improve the working environment. Also there should be adequate lighting and ventilation in all production areas.
2. Establish a comprehensive safety policy aligned with ISO 45001 Occupational Health and Safety Management standards and conduct periodic safety audits and risk assessments using FMEA or similar analytical tools. Companies should enforce preventive maintenance schedules for all machinery and equipment.
3. Organize regular training programs for workers on hazard recognition, machine handling, and emergency response and develop orientation manuals for new employees with clear safety procedures. Again, the company should promote a safety-first culture through incentives, posters, and daily safety briefings.
4. Provide appropriate PPE (ear muffs, gloves, goggles, respirators) and ensure their mandatory use and designate safety supervisors to monitor compliance during operations.
5. Government agencies such as the Federal Ministry of Labour and Employment should intensify inspections and enforce the Factories Act provisions. Also establish local occupational safety councils within industrial clusters in Delta State to coordinate training and enforcement and integrate risk assessment modules into vocational and technical training curricula to build a proactive safety mindset among artisans.

5.3 Practical Implications and Future Research

The study demonstrates that systematic risk assessment can transform sawmill operations from reactive to preventive safety management. Managers can use FMEA outcomes to prioritize limited resources toward high-risk areas, reducing downtime, compensation claims, and productivity losses. However, the research was limited to a sawmill in Warri Delta State, and data were collected from the few sawmills. Future studies should examine multiple sawmills across different Nigerian regions to compare variations in hazard profiles and evaluate the effectiveness of implemented control measures over time. Additionally, incorporating quantitative exposure measurements (noise levels, dust concentrations, and vibration intensity) would enhance objectivity and provide a more comprehensive understanding of occupational risks.

References

Adebayo, S. O., & Oni, B. O. (2020). Occupational health hazards in small-scale sawmill industries in Southwestern Nigeria. Safety and Health at Work, 11(3), 254-263. https://doi.org/10.1016/j.shaw.2020.04.003

Anjalee, J.A.L., Rutter, V., & Samaranayake, N.R. (2021). Application of failure mode and effects analysis (FMEA) to improve medication safety in the dispensing process - a study at a teaching hospital, Sri Lanka. BMC Public Health. 21(1),1430. doi: 10.1186/s12889-021-11369-5.

Bello, S.R., & Mijinyawa, Y. (2010). Assessment of injuries in small scale sawmill industry of south western Nigeria, agricultural engineering international. *The CIGR Journal of Scientific Research and Development, XII*, 1558.

Comcover information sheet (2018). *An overview of the risk management process. Embed, Australia Government.* Information-Sheet-Overview-Risk-Management-Process.pdf

Emily, R.S. (2025). *Failure modes and effects analysis (FMEA) in risk assessment of mechanical systems.* https://www.researchgate.net/publication/39223862

Faremi, F.A., Ogunfowokan, A.A., Mbada, C., Olatubi, M.I., Ogungbemi, A.V. (2014). Occupational hazard awareness and safety practices among Nigerian sawmill workers. Int J Med Sci Public Health,3. DOI: 10.5455/ijmsph.2014.260620142

Gbadamosi, G. (1999). Occupational safety and accident prevention in Nigerian industries: Implication for management. *IFE PsychologIA*, *7*(2). DOI:10.4314/ifep.v7i2.23565

International Labour Organization, [ILO] (2023). *Safety and health at work.* Available at: https://www.ilo.org/global/topics/safety-and-health-at-work/lang--en/index.htm.

International Labour Organization [ILO] (2016). *Nigeria country profile on occupational safety and health.* *wcms_552748.pdf*

ISO (2018). *Occupational health and safety management systems: Requirements with guidance for use.* ISO 45001:2018 - Occupational health and safety management systems

Ispăşoiu, A., Milosan, I., Gabor, C., & Oancea, G. (2024). Rapid Risk Assessment in Industry: Increasing Awareness of Worker Safety in Industrial Activities. *Applied Sciences*, *14*(19), 8918. https://doi.org/10.3390/app14198918

Lele, D.V. (2012). Risk assessment: A neglected tool for health, safety, and environment management. *Indian J Occup Environ Med., 16*(2), 57-8. doi: 10.4103/0019-5278.107064.

Lemmens, S.M.P., Lopes van Balen, V.A., Röselaers, Y.C.M., Scheepers, H,C,J,, Spaanderman, M.E.A. (2022). The risk matrix approach: a helpful tool weighing probability and impact when deciding on preventive and diagnostic interventions. *BMC Health Serv Res.*, *22*(1), 218. doi: 10.1186/s12913-022-07484-7.

Mayowa, O.J. (2023). Assessment of safety practices in sawmill industries in Akure South Local Government Area, Ondo State, Nigeria. *J Ind Pollut Control., 39,* 05.

Mitchual, S.J., Donkoh, M., & Bih, F. (2015). Assessment of Safety Practices and Injuries Associated with Wood Processing in a Timber Company in Ghana. *Open Journal of Safety Science and Technology, 5,* 10-19. http://dx.doi.org/10.4236/ojsst.2015.51002

Mrema, E.J., Ngowi, A.V. & Mamuya, S.H.D. (2015) Status of occupational health and safety and related challenges in expanding economy of Tanzania. *Annals of Global Health, 81*, 538-547. https://doi.org/10.1016/j.aogh.2015.08.021

Nnaji, C.C., & Udokpoh, U. (2023). Identification of immediate and remote health hazards and the need for health hazard assessment in the Nigeria sawmill industry. *Indonesian Journal of Social and Environmental Issues (IJSEI)*, *4*(2), 202-220

Olorunnisola, O. A. (2023). The Past, Present and Future Outlook of the Wood Industry in Nigeria. *IntechOpen. doi: 10.5772/intechopen.105794*

Onowhakpor, A.O., Abusu, G.O., Adebayo, B., Esene, H.A., Okoji,e O.H. (2017). Determinants of occupational health and safety: Knowledge, attitude, and safety practices toward occupational hazards of sawmill workers in Egor Local Government Area, Edo State. *Afr J Med Health Sci 16*, 58-64.

Opoku, F.A., Opoku, D.A., Ayisi-Boateng, N.K., Osarfo, J., Sulemana, A., Agyemang, S., Amponsah, O.K.O., Asiedu, M.T., Gyebi, R., Agyei-Baffour, P. (2024). Occupational injury prevalence and predictors among small-scale sawmill workers in the Sokoban Wood Village, Kumasi, Ghana. *PLoS One, 19*(4), e0298954. doi: 10.1371/journal.pone.0298954.

Oseme, O.S., Orhorhoro, E.K. & Aregbe, O. (2020). Safety analysis and implementation for safer design of wood processing machines: A case study of southern Nigeria. *International Research Journal of Modernization in Engineering Technology and Science, 02*(09), 1657-1663.

Otitolaiye, V.O., Adediran, A.O., Ahmed, Y., Moveh, S., Ivase, T.J-P. Aminu, Y.D. (2019). Effect of safety culture, safety performance and management system on the food and beverage manufacturing industries in Nigeria. *International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), 6*(5), 202-212. https://doi.org/10.32628/IJSRSET196539

Rahim, M.S., Reniers, G., Yang, M., & Bajpai, S. (2024). Risk assessment methods for process safety, process security and resilience in the chemical process industry: A thorough literature review. *Journal of Loss Prevention in the Process Industries, 88,* 105274. https://doi.org/10.1016/j.jlp.2024.105274.

Reason, J. (1997). *Managing the risks of organizational accidents.* Aldershot: Ashgate.

Rout, B.K., & Sikdar, B.K. (2017). Hazard Identification, Risk Assessment, and Control Measures as an Effective Tool of Occupational Health Assessment of Hazardous Process in an Iron

Ore Pelletizing Industry. *Indian J Occup Environ Med.,* 21(2), 56-76. doi: 10.4103/ijoem.IJOEM_19_16.

Yang, M., Khan, F., & Amyotte, P. (2015). Operational risk assessment: A case of the Bhopal disaster. *Process Safety and Environmental Protection, 97,* 70-79. https://doi.org/10.1016/j.psep.2015.06.001.

Yang, Z., Lin, K., & Chen, L. (2018). Application of failure mode and effect analysis in improving occupational safety in the wood processing industry. *Safety Science, 106,* 159-167. https://doi.org/10.1016/j.ssci.2018.03.017

World Health Organization (WHO). (2021). *Global strategy on occupational health for all: The way to health at work.* Geneva: WHO Press.