Scientific Evaluation of Noise Pollution and Associated Health Hazards at Sawmills in Owerri Metropolis, Nigeria

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ABSTRACT: This study evaluated noise levels in selected sawmills in Owerri Metropolis, Nigeria. The study aims to measure and analyze noise intensity and frequency, assess potential health risks, and recommend mitigation strategies. A purposive sampling technique was used to select 40 respondents. A semi-structured questionnaire was used to collate information from sawmill workers using the Kobo Collect mobile application. Information gathered captured the perceptions of noise exposure and its impacts on health (symptoms of hearing loss, stress, and other related health issues) of the workers. Noise measurements were taken using sound level meters at various distances (of 1, 5 and 9 meters) within the sawmills during peak operational hours (2 – 4 pm West African Time) to ensure accuracy and representatives of typical working conditions. The study revealed that 62.5% of workers were between 30-49 years old, and 62.5% were male. Noise levels exceeded recommended safety limits, posing serious threats to workers' hearing and overall health. The Umuonyeali sawmill recorded an average of 85.4889 dB for the Circular saw machine, while the Naze sawmill recorded 94.0889 dB. The Spindle moulder machine recorded 94.2556 dB at Umuonyeali and 90.7556 dB at Naze. A significant difference in noise levels was found between the two sawmills ($p<0.1$). To mitigate these risks, the study recommends introducing work rotation schedules, conducting regular hearing tests, and installing mass-loaded vinyl or heavy materials on roofs to reduce noise levels. These measures can help protect workers' hearing and overall health, ensuring a safer working environment in the sawmills.
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INTRODUCTION

Noise hazard is the potential harm or risk to human health and well-being caused by excessive or prolonged exposure to loud or disruptive sounds. Noise hazard can have detrimental effects on both physical and mental health, contributing to issues such as hearing loss, increased stress levels, sleep disturbances, and decreased productivity (Hahad *et al.,* 2019). Workers in the mining construction, manufacturing and agricultural sectors are exposed to high noise levels which impair their hearing (Natarajan *et al.,* 2023; Tikka *et al.,* 2017). Previous studies have shown that exposure to loud noise for a longer duration can damage the hair cells of the cochlear nerve in the inner ear, leading to irreversible sensorineural hearing loss (Azizi, 2010; Basner *et al.,* 2014; Hong *et al.,* 2013). Skenberg and Ohrstrom (2002) reported that noise is one of the sources of pollution, which is a special kind due to its invisible nature. The growing rate of urbanisation has also been identified as the main cause of the continually rising levels of environmental noise worldwide (Abbaspour et al., 2014). Noise poses a common hazard in many industries, particularly in the sawmill sector.

Wood processing occurs in sawmills and exposure to noise in sawmills is perhaps the most intense and prolonged level of noise experienced daily (Ajayeoba *et al.,* 2021). The level could either be short or varied in some instances, but they are equally as damaging (Nathanson and Berg, 2024). Traditionally, the sawmill industry is known as one of the most dangerous, repetitive work settings, labour-intensive and production-oriented industries (Mong'are *et al.,* 2017). Its labour-intensive nature could result in highly physical activities which could be at variance with health and safety procedures, thereby leading to increased physical risk factors for sawmill workers (Ajayeoba *et al.,* 2021).

Sawmills are vital to the wood processing industry, playing a crucial role in meeting the demands for timber and wood products (Olorunnisola, 2023). However, the operations of sawmills generate significant levels of noise that have detrimental effects on both the health of workers within the facilities and the surrounding communities (Akinnubi, 2015). As sawmills continue to expand in urban and peri-urban areas, there is a growing concern regarding the potential noise hazards associated with these operations. This study aims to conduct a

comprehensive scientific evaluation of noise hazards in selected sawmills, to understand the sources and impact of noise pollution, assess its effects on human health and the environment, and ultimately develop effective strategies for noise mitigation. This research is imperative to ensure the well-being of those involved in the industry and to preserve a sustainable and harmonious coexistence of sawmills within their surrounding communities.

MATERIALS AND METHODS

Study area

This study was carried out in Naze Timber shed, Owerri North and Umuonyeali sawmill, Mbieri Mbaitolu both in Owerri Metropolis, Imo State. Owerri North is a Local Government Area of Imo State, Nigeria. Its headquarters are in the town of Orie Uratta. It has an area of 198 square km and a population of 175,395 at the 2006 census. Rain falls for most months of the year with a brief dry season. The harmattan affects the city in the early periods of the dry season and it is noticeably less pronounced than in other cities in Nigeria. The average temperature is 26.4 °C.

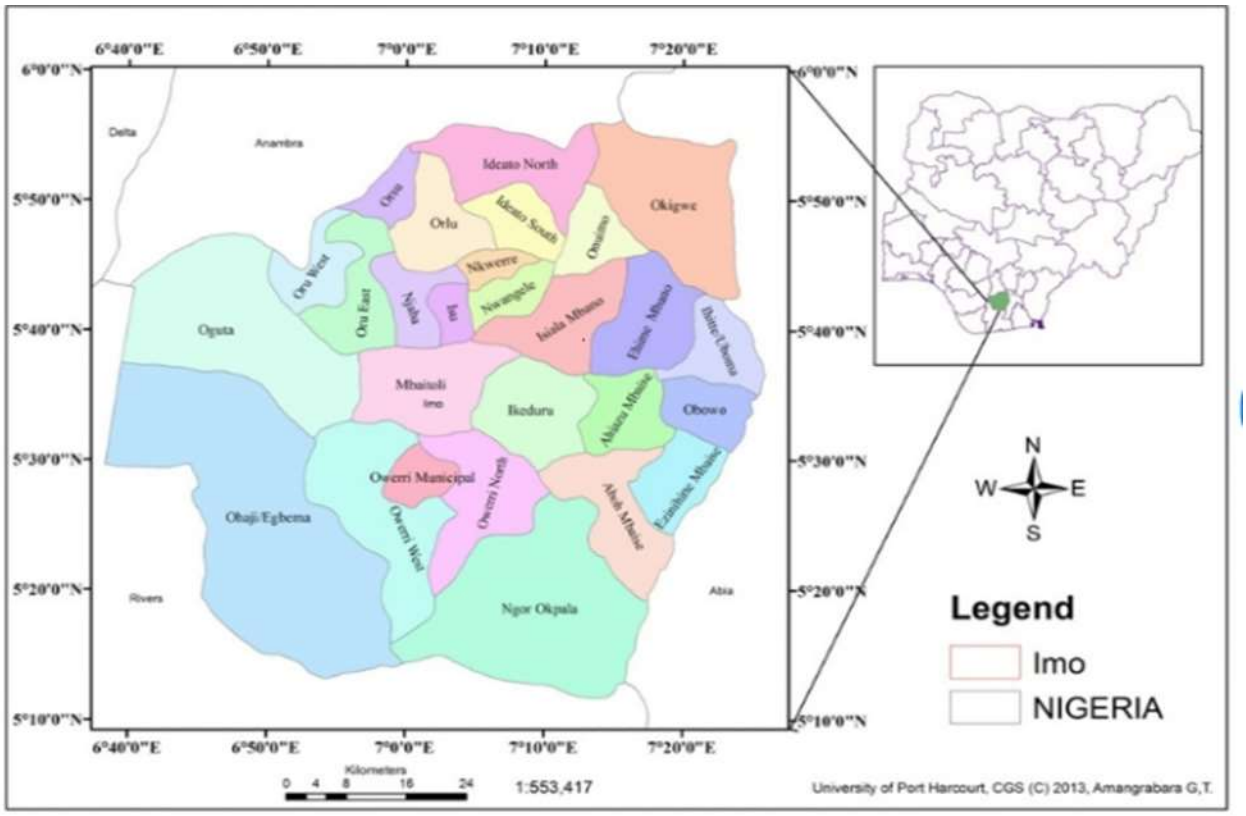

Figure 1: Map showing the study area

Data collection

Data was collected using two methods: a social survey and measuring physical noise. The social survey comprises of assessment of sawmill workers' demographic status and perceptions of working in the sawmill. A purposive sampling technique was used to select ten staff and ten non-staff in each of the two sawmills located in the study area, for a total of 40 respondents. Forty copies of semi-structured questionnaires were randomly administered to the selected staff.

The physical noise level measurement involved the use of the sound level meter. The sound level meter was set to the appropriate settings for measuring noise levels in sawmills, including the frequency weighting (e.g., A-weighting) and response time (e.g., slow or fast). Measurements were taken at different distances (1, 5 and 9 meters) within the sawmills. Other locations where sound was measured were near the sawing machines, in the workstations of sawmill workers, in areas where workers were present for extended periods, and at the perimeter of the sawmill property (to assess noise impact on surrounding communities).

The sound level meters were held at a consistent height (1.5 meters above the ground) and 1 meter away from the noise source. to ensure accurate measurements (Katinas *et al.*, 2016). Noise levels were measured for a representative period, typically 15-30 minutes, to capture the varying noise levels during different sawmill operations (Azodo *et al.*, 2019). This was done when the machine was without wood (idling stage) and active with wood, in triplicate. Also, the nature of the woods that were sawn was noted.

Statistical Analysis

Data was analyzed by coding values. The coded values were subjected to descriptive and inferential (T-test) statistics. The T-test was used to compare the mean time-weighted averages of noise exposure from sawmills at the two locations (Naze and Umuonyeali sawmills). The recorded noise level data was analyzed to determine the average noise levels at each measurement location to identify the peak noise levels and their duration.

Plate 1: Sound level meter used for the study.

Plate 2: Bandsaw machine in the study area.

RESULTS

Results from this finding show (Table 1) the respondents' age bracket, with the majority (62.5%) falling within the age bracket of 30-49 years, 25% were between 50-69 years while 12.5% represented 15- 29 years. A higher percentage (62.5%) were males, while a few (37.5%) were females. About 45% of the respondents represented those who were not married while 42.5% were married, 7.5% were widows/widowers, and 5% were divorced. Appraisal on education status revealed that 40% obtained WAEC and its equivalents, 32.5% had a first school leaving certificate (FSLC), and 27.5% attended tertiary institutions. Apart from working in the sawmill, 55% of the respondents operate as entrepreneurs, while 45% favour other sectors. 60% affirmed that they were the head of the household and 40% were not. On household size, 55% had 4-6 persons per house, 30% had 1-3 persons while 15% had more than 7 persons.

Table 1: Demographic characteristics of sawmill workers

Variables (x)			Frequency (N)		Percentage (%)
Age		15-29 years	5		12.5
		30-49 years	25		62.5
		50-69 years	10		25
		70 years >	-		-
Gender	Male		25	62.5	
		Female	15		37.5
Marital status	Single		18	45	
		Married	17	42.5	
		Divorced	2		5
		Widow/widowed	3	7.5	
Highest educational		FSLC	13		32.5
Attained		WAEC/its equivalents	16		40

	BSc/B.A/HND	11		27.5	
	Postgraduate		-		-
Employment status	public sector		-		-
	Farmer		18		45
	Entrepreneur		22		55
	Others		-		-
Head of household?	Yes		24		60
	No		16		40
Household size 1-3		12		30	
	4-6		22		55
	7+		6		15

The result (Table 2) shows 40% of the respondents worked for over 6 years in the sawmill. Thirty-five percent (35%) accounted for a 1–5-year duration while 25% had spent less than a year in the sawmill. Sixty-seven-point five per cent (67.5%) used **PPE**. Response on efficiency in using PPE emanated from those who reported that they have PPE in place while 50% reported it was efficient in using PPE while 50% had no idea about its efficiency. The frequency of sawmill machine operation varies, with the majority (57%) operating twice daily, followed by 30% operating three times a day, and a smaller percentage (12.5%) operating only once a day.

Assessment of the degree of noise disturbance revealed that 57.5% of respondents reported that noise from the sawmill was very disturbing, 40% were indifferent, while 2.5% perceived it as less disturbing. The results show that 65% of workers believed that the sawmill had a positive effect, 32.5% stated that the impact was not obvious, and 2.5% affirmed it had a negative impact. Furthermore, 40% of respondents expressed a desire for the sawmill to be further developed, 25% preferred that it be relocated to another site, while 15% emphasized the need to mitigate the impact of noise on health. A majority (65%) of respondents reported not undergoing auditory check-ups, compared to 35% who did. Among those who attended check-ups, 45% reported not going often, 22.5% stated they did not go at all, 20% attended regularly, and 12.5% visited very often.

Table 2: Sawmill Workers' Perception of the Sawmill

Variables (x)	Categories	Frequency (N)	Percentage (%)
Duration worked in the sawmill	< 1 year	10	25.0
	1–5 years	14	35.0
	6 years and above	16	40.0
Availability of Personal Protective Equipment (PPE)	Yes	13	32.5
	No	27	67.5
Efficiency in using PPE	Very efficient	–	–
	Slightly efficient	–	–
	Not efficient	20	50.0
	No idea	20	50.0
Auditory check-up attendance	Yes	14	35.0
	No	26	65.0
If yes, how often?	Very often	5	12.5
	Often	8	20.0
	Not often	18	45.0
	Not at all	9	22.5
Number of times machines are operated	Once a day	5	12.5
	Twice a day	23	57.5
	Thrice a day	12	30.0
	Continuously	–	–

The result presented in Figure 2 shows that a majority of the sawmill workers (57.5%) perceived the noise in the study area as very disturbing, while 40% reported being indifferent to the noise levels. Only a small proportion (2.5%) considered the noise to be less disturbing. This indicates varying degrees of noise tolerance among workers in the sawmill environment.

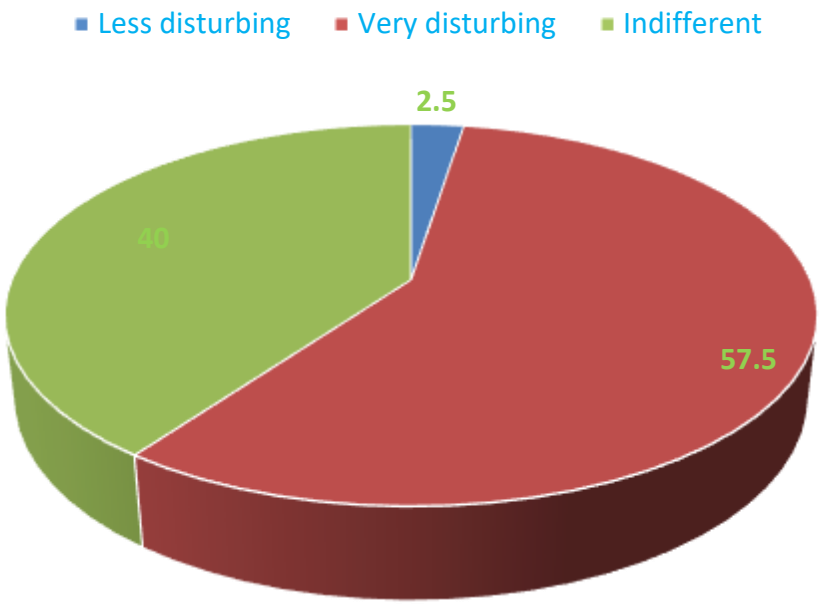

Figure 2: Sawmill workers' Perception of the Degree of Noise Tolerance in the Study Area

The result (Table 3) of noise level evaluations from three distances (1 m, 5 m, and 9 m), measured in three replicates each, under idling and active machine stages shows that at the idling stage in *Naze* sawmill, the band saw produced the highest overall mean noise level of 102.2 ± 4.4 dB, followed by the spindle moulder at 90.4 ± 2.2 dB. At the same time, the circular saw recorded the lowest noise level at 83.8 ± 2.7 dB. At the active stage in the same location, the band saw again generated the highest mean noise (105.5 ± 2.6 dB), compared to 94.1 ± 1.4 dB for the circular saw and 90.8 ± 2.1 dB for the spindle moulder. At the Umuonyeali sawmill, idle-stage measurements revealed lower noise levels than at Naze. The band saw produced a mean noise level of 93.0 ± 1.6 dB, followed by the circular saw (85.0 ± 0.6 dB) and the spindle moulder (80.9 ± 4.2 dB). Across both locations, noise levels decreased with increasing distance from the machines.

Statistical analysis indicated a highly significant difference across the measured distances ($p < 0.05$ at a 95% confidence interval), confirming that both machine type and operator proximity have a strong influence on noise exposure levels. The consistently elevated readings, especially from band saws, point to a high risk of occupational noise-induced hearing loss (NIHL) among sawmill workers.

Table 3: Noise levels derived from idling saw milling machines in the study area

Saw types	Naze sawmill factory			Umuonyeali sawmill factory		
	1m	5m	9m	1m	5m	9m
Bandsaw	106.5±1.4	101.3±4.2	98.9±3.9	91.4±0.9	93.9±0.5	93.6±0.6
Circular	83.3±1.3	85.4±2.4	82.6±1.4	85.3±0.8	85.2±0.2	84.7±1.9
Spindle moulder	89.9±5.5	91.4±0.6	89.9±0.8	83.8±2.0	82.1±0.9	76.9±5.2

Noise levels from active sawmilling machines across the study locations (Naze and Umuonyeali) (Table 4) show variations by machine type and distance from the source. The band generated the highest mean (105.5 ± 2.6 dB) noise level at the Naze sawmill, exceeding both the circular saw (94.1 ± 1.4 dB) and spindle moulder (90.8 ± 2.1 dB). At Umuonyeali sawmill, the band saw also emitted the highest noise (101.1 ± 4.5 dB), followed by the spindle moulder (94.3 ± 5.1 dB) and the circular saw (85.5 ± 1.4 dB).

A clear trend was observed where noise intensity decreased with increasing distance from the machine. For instance, the Umuonyeali band saw recorded 106.6 dB at 1 m, which reduced to 99.0 dB at 5 m and further to 97.7 dB at 9 m. A similar distance-related decline was evident across all machines, although the overall noise levels at each distance still exceeded the World Health Organization's recommended occupational exposure limit of 85 dB.

Table 4: Noise levels derived from active sawmilling machines in the study area

Saw types	Naze sawmill factory			Umuonyeali sawmill factory		
	1m	5m	9m	1m	5m	9m
Bandsaw	108.8±0.5	103.5±1.0	104.1±2.6	106.6±3.2	99±1.0	97.7±3.6
Circular	95±1.3	93.1±1.4	94.1±1.8	86.7±1.6	85.7±0.8	84.1±1.8
Spindle moulder	91.3±0.8	91.1±1.6	89.9±2.5	99.8±0.9	92.2±1.0	90.8±4.3

Table 5 compares noise levels from sawmill machines in Owerri metropolis during active and idle operations. The results show that band saws produced the highest noise levels, with mean values of 103.3 ± 4.3 dB during active use and 97.6 ± 5.7 dB when idle. Circular saws recorded the lowest noise levels, with 89.8 ± 4.8 dB during active operation and 84.4 ± 1.2 dB when idle. The spindle moulder saws showed intermediate values of 92.5 ± 3.6 dB (active) and 85.7 ± 5.7 dB (idle). Statistical analysis revealed significant differences among the machines, as indicated by the p-values (<0.001). Statistical analysis revealed significant differences in noise levels among the machines, as indicated by the superscript letters. Specifically, the band saw produced significantly higher noise levels than the circular saw, while the spindle moulder's noise levels were statistically indistinguishable from both. This finding shows that all the machines exceeded the occupational noise limit of 85 dB, with the band saw posing the greatest risk to workers' hearing health.

Results displayed in Figure 3 show that all machines assessed in the sawmill and their noise level exceeding 80 decibels. Points 1, 2 and 3, on the horizontal axis, represent machines in the Umuonyeali sawmill, while 5, 6 and 7 denote machines from the Naze sawmill.

Table 5: Comparison of Sawmill Machines in the Study Area

Saw types	Active	Idle
band saw	103.3 ± 4.3^{a}	97.6 ± 5.7^{a}
Circular saw	89.8 ± 4.8^{b}	84.4 ± 1.2^{b}
Spindle moulder saw	92.5 ± 3.6^{ab}	85.7 ± 5.7^{b}
***p*-value**	**<0.00**	**<0.001**

Note: Means with different superscripts within a column are statistical differences at the 0.05 level.

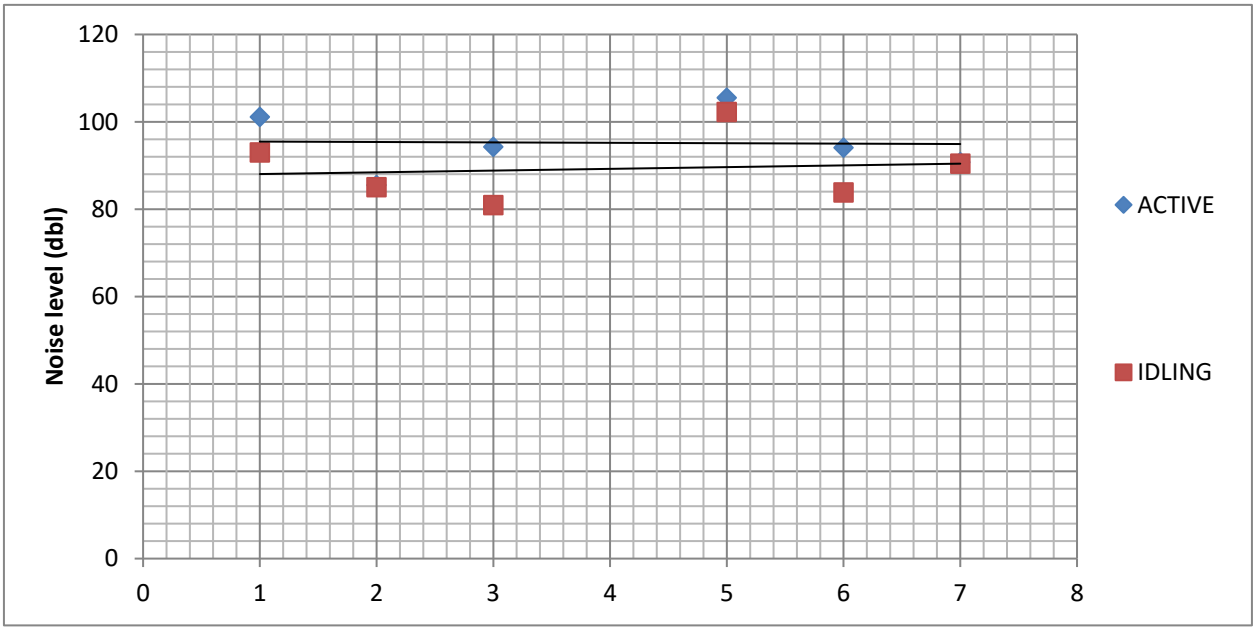

Figure 3: Graphical representation of noise levels from sawmill machines at different stages.
Where 1= bandsaw, 2= circular saw, 3= spindle moulder, all at Umuonyeali sawmill
5= band saw, 6= circular saw, 7=spindle moulder all at Naze sawmill.

Discussion

Demographic Characteristics of Sawmill Workers

The sawmill industry in the study area is dominated by middle-aged (30–49 years) individuals, a finding consistent with the report of Olagunju *et al.* (2019), who reported that middle-aged adults form the most active workforce in small-scale wood industries due to their physical strength and experience. Gender distribution showed that males accounted for most (62.5%) of the workforce, while females represented a low percentage (37.5%) of the workforce. This finding corroborates Lidestav *et al.* (2019), who reported that sawmill operations are typically male dominated due to the physically demanding nature of the job. The prevalence of males may also be linked to greater exposure to occupational hazards such as noise and dust compared to their female counterparts (Adekoya *et al*., 2020). The marital status of the respondents suggests that many sawmill workers are unmarried, likely because they are in their early adulthood and are prioritizing work and financial stability before marriage. There are generally low literacy levels among the workers, which may be attributed to socio-economic challenges such as poor access to education, financial constraints, and early exposure to manual labour (Agunbiade, 2015; Ogunsanwo *et al*., 2020).

A majority (55%) of sawmill workers reported engaging in private side jobs during their free time, which shows their need for multiple income streams. This finding aligns with Udo *et al.* (2018), who reported that workers in informal sectors often diversify income sources to mitigate economic instability. Household size distribution showed the family burden and economic pressure typical of many low-income families in Nigeria (Afolabi and Adejumo, 2018).

Perception of Sawmill Workers on Noise Emission, Noise Impact and Tolerance

Results showed that a moderate number of respondents had worked in the sawmill industry for over six years. This demonstrates prolonged exposure to occupational noise and physical stress. The absence of Personal Protective Equipment (PPE) indicates a high rate of hazards. A few respondents who used PPE often acquired it personally, while others cited discomfort or unawareness of the protective benefits. This result aligns with the report by Maisarah and Said (1993) and Idris *et al*. (2018). Those who used PPE believed it was efficient, and a moderate number of the respondents were unsure of its effectiveness. Statistical analysis ($p < 0.05$) showed no significant difference in PPE effectiveness across respondents, implying inadequate training on its use. This finding is in line with Okonkwo *et al.* (2021), who reported that poor PPE utilization in Nigerian sawmills results from a lack of awareness and enforcement. This finding on auditory check-ups aligns with Maisarah and Said's (1993) report that workers rarely prioritize hearing health since hearing loss develops gradually. Gomes *et al.* (2002) reported that wearing hearing protectors is often ignored in tropical environments due to discomfort caused by heat and humidity.

The perception of noise disturbance among sawmill workers revealed that the high level of disturbance was due to the operation of heavy-duty machinery with high frictional power and the frequent processing of hardwood species. Most workers perceived sawmill operations as having both positive and negative impacts. The perceived positive effects were attributed to job creation, plank production, and the utilization of wood residues (e.g., sawdust) for briquettes and particleboards (Awosan *et al.*, 2018; Onuegbu *et al.*, 2021). However, this finding contrasts with Rami *et al.* (2020), who reported that sawmills significantly contribute to environmental degradation, air pollution, and respiratory ailments among nearby residents. Similarly, Akachukwu *et al.* (2022) observed that emissions and waste from sawmills often contaminate the surrounding ecosystem and contribute to the prevalence of non-communicable diseases

Measurement of Noise Levels

A clear trend was observed where noise intensity decreased with increasing distance from the machine. For instance, the Umuonyeali band saw recorded 106.6 dB at 1 m, which reduced to 99.0 dB at 5 m and further to 97.7 dB at 9 m. A similar distance-related decline was evident across all machines, although the overall noise levels at each distance still exceeded the World Health Organization's recommended occupational exposure limit of 85 dB. Statistical analysis confirmed that these variations were significant ($p < 0.05$ at a 95% confidence interval), indicating that both machine type and operator proximity contribute meaningfully to workers' noise exposure risks. The consistently high readings, especially for band saws across locations, show that sawmill workers face a considerable hazard of noise-induced hearing loss (NIHL) and related health effects if protective measures are not implemented.

Noise levels recorded at the selected sawmills (Naze and Umuonyeali) exceeded the World Health Organization (WHO) permissible limit of 85 dB(A) for occupational settings (WHO, 2021). The higher noise emission from the bandsaw compared to the circular saw could be attributed to wider cutting depth, blade vibration, and mechanical friction (Miller and Wood, 2020). Overfeeding and pushing thick wood stock (over 10 cm) into the blade were observed to increase the noise level. Kerr *et al.* (2017) reported similar findings, attributing elevated sawmill noise levels to equipment vibration and lack of maintenance. The measured values indicate that most workers are consistently exposed to noise levels above the recommended limit for an 8-hour shift. Prolonged exposure of this kind can cause noise-induced hearing loss (NIHL), tinnitus, and other auditory dysfunctions (Salvi *et al.*, 2000; ACOEM, 2003; Au *et al.*, 2024). This supports the present study's observation that hearing impairment was prevalent among 89.7% of sawmill workers.

CONCLUSION

Demographic results showed that most of the workers were within the 30–49 years age bracket (62.5%), predominantly male (62.5%), and with relatively low educational attainment, as only 27.5% possessed tertiary qualifications. Most sawmill workers are significantly exposed to high noise levels that exceed the World Health Organization's recommended limit of 85 dB(A) in the study area. The measured noise intensity during active machine operation ranged from 101.1±4.52 dB(A) to 105.5±2.64 dB(A) for band saw machines, indicating hazardous exposure conditions. Prolonged exposure to these noise levels, coupled with low usage of personal protective equipment (with only 32.5% reported using PPE), implies a high risk of occupational noise-induced hearing loss among the workforce. Most (57.5%) of the workers rated noise as "very disturbing," with most (65%) of them acknowledging the positive economic impact of sawmill activities through employment and by-product, despite associated health risks. However, the observed inefficiency in PPE use and lack of regular auditory check-ups (65% never attended any hearing test) show poor occupational safety practices. Thus, there is an urgent need for the implementation of effective noise control measures, enforcing occupational safety regulations, and promoting the use of protective equipment and regular auditory monitoring among sawmill workers to mitigate the long-term effects of excessive noise exposure.

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