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RESEARCH ARTICLE

Subjective Hearing Complaints as Early Indicators of Hearing Health Risk Among Indonesian Plywood Workers

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ABSTRACT

Introduction: Occupational noise is an important environmental risk factor that may cause hearing disorders among industrial workers. Subjective hearing complaints as an early detection method of hearing health risk have not been well explored in Indonesia, particularly among plywood industry workers exposed to continuous occupational noise. This study aimed to identify subjective hearing complaints as early indicators of hearing health risks among plywood workers.

Methods: This descriptive observational study employed a cross-sectional approach among 54 production workers from PT Kayu Lapis Indonesia using a total population sampling method. Questionnaire data and audiometric records involving workers were collected in 2025, while environmental noise was measured in 2024 using a sound level meter. Descriptive statistical analysis and Fisher's exact test were performed to compare differences among machine operator groups.

Results: Clinic records classified all 54 workers as having normal hearing, although available frequency-specific thresholds ranged from 5 to 35 dB. Workers reported emotional disturbance (70.37%), tinnitus (55.56%), difficulty concentrating (31.48%), and difficulty understanding speech (16.67%); these are complaint-specific proportions and do not imply that every worker reported a complaint. Fisher's exact test detected no statistically significant difference among machine groups for any of the four complaints (all $p > 0.05$).

Conclusion: Auditory and non-auditory complaints were reported despite normal clinic-assigned hearing classifications. These cross-sectional findings do not establish that noise caused the complaints or that complaints predict hearing loss. Structured symptom documentation may complement audiometry; the preventive and health-promotion approaches discussed are literature-informed options that were not evaluated in this study.

Keywords: Hearing Complaints; Noise Exposure; Occupational Health; Plywood Industry; Workers

INTRODUCTION

Occupational noise is one of the most prevalent environmental risk factors in the industrial sector (1). Noise-induced hearing loss (NIHL) may develop when workers are exposed to noise levels exceeding the Threshold Limit Value (TLV) of 85 A-weighted decibels (dBA) for eight hours per working day. Without appropriate intervention, this condition may progress to permanent hearing loss (2,3). Noise exposure has also been associated with non-auditory effects, including sleep disturbance, psychological stress, impaired concentration, and an increased risk of hypertension and cardiovascular disease (4,5).

The World Health Organization (WHO) estimates that more than 1.5 billion people worldwide experience some degree of hearing loss, a substantial proportion of which is attributable to noise exposure (6). In the early stages, workers frequently report subjective auditory complaints, including tinnitus, difficulty understanding conversation, and a sensation of aural fullness (7).

Hearing complaints typically develop gradually and progress over time, and are therefore frequently unnoticed by workers (8-11). Initial symptoms include difficulty perceiving high-frequency sounds or discriminating speech in noisy environments, which may progress to more substantial impairment. The process is painless and is often misinterpreted as a normal consequence of ageing (12). Workers exposed to occupational noise have been reported to perform more poorly on cognitive tests than unexposed workers (13). Exposure to noise levels exceeding 85 dBA has been linked to memory impairment, slower reaction times, mental health issues, and impaired decision-making ability (8,14).

Occupational noise remains relevant in industrial production settings because sustained exposure can adversely affect hearing health (1).

PT Kayu Lapis Indonesia, located in Kendal, Central Java, is a plywood manufacturer (15), making it a relevant setting in which to examine health risks associated with occupational noise exposure.

Although previous studies have shown that subjective hearing complaints can occur despite normal audiometric thresholds, to our knowledge no prior study in Indonesia, particularly within the plywood industry, has concurrently examined environmental noise levels, audiometric findings, and workers' subjective hearing complaints within a single occupational cohort. This gap limits the ability of occupational health surveillance in this sector to capture early auditory and health-related symptoms that audiometry alone may not detect. Addressing this gap, the present study provides preliminary descriptive evidence that may inform the development of more comprehensive hearing-health surveillance approaches in the plywood industry.

This study was conducted as a preliminary investigation to describe subjective auditory complaints among workers exposed to occupational noise at PT Kayu Lapis Indonesia. The findings are expected to provide preliminary insight into hearing health risks within the plywood industry and to establish a basis for subsequent research on health promotion initiatives and broader intervention strategies.

METHODS

Study Design and Sample Characteristics

This study was a quantitative, descriptive observational investigation employing a cross-sectional design. Data collection at PT Kayu Lapis Indonesia in Central Java, Indonesia, took place in two stages: environmental noise was measured in 2024, while questionnaire data and audiometric records involving workers were collected in 2025. The study population comprised 54 production workers operating the re-saw, break-down, and pony machines, all of whom were consistently exposed to elevated levels of occupational noise during their work shifts. The worker-level data were collected after ethical approval was issued by the Health Research Ethics Committee of the Faculty of Public Health, Diponegoro University, on 30 January 2025 (No. 26/EA/KEPK-FKM/2025; valid through 30 January 2026). The approval names the broader protocol "Noise Absorber Using Waste Materials to Reduce Noise Intensity, Hearing Complaints, and Blood Pressure Among Workers in a Plywood Company"; this manuscript reports its noise and hearing-complaint components.

A total of 54 workers participated as respondents. They were recruited using a total population sampling method, in which all workers meeting the inclusion criteria were included. The inclusion criteria were: (1) assignment to the production area; (2) exposure to machine noise for at least eight hours per shift; and (3) a minimum of one year of service. Workers with a history of chronic ear disease, previous ear surgery, or hearing aid use were excluded. Demographic data, including age and years of service, were collected to characterize the sample.

Sample Size

The sample comprised all 54 eligible workers from production units in which noise levels exceeded the national TLV of 85 dBA. This sample size was considered sufficient to provide a comprehensive descriptive analysis of subjective hearing complaints among workers exposed to occupational noise at PT Kayu Lapis Indonesia.

Data Collection Methods and Instruments

Self-reported complaints were assessed using the original questionnaire, supplied as Supplementary Appendix 1. Section II, item 7 lists seven possible complaints: ringing in the ears (tinnitus), vertigo, muscle tension, dizziness, increased emotional reactivity, difficulty concentrating, and a need to speak loudly. Three outcomes analysed in Table 4 (tinnitus, emotional disturbance, and difficulty concentrating) correspond to options a, e, and f of item 7. Difficulty understanding speech was

derived from separate communication questions in Section II, especially item 5 about not clearly understanding a coworker, with related items 3 and 4; it is not one of the seven options in item 7. Item 8 asks whether complaints began before or after starting employment. The analysis was restricted to the four complaint variables retained in the dataset. The exact coding rule used to derive the difficulty-understanding-speech variable from these communication questions was not documented. Respondents completed the questionnaires independently under the supervision of the research team. Objective hearing data were obtained from Clinic Cito Indraprasta Semarang medical records, which contained the results of routine audiometric examinations conducted by a certified audiometrist as part of the occupational health surveillance programme. Pure-tone audiometry was performed binaurally using both air conduction (250, 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz) and bone conduction testing (250, 500, 1000, 2000, 3000, and 4000 Hz). Available frequency-specific thresholds ranged from 5 to 35 dB across both ears (mean approximately 17 dB), with the highest mean thresholds observed at 3000–4000 Hz. The clinic recorded a final normal hearing classification for all 54 workers. The clinic's exact algorithm for assigning this worker-level classification, including the frequency set, ear rule, and summary measure, was not documented in the records available for this study; the category is therefore reported as clinic-assigned rather than inferred from the highest individual frequency-specific threshold. The timing of audiometry relative to questionnaire administration was also unavailable. Environmental noise was measured using a Sound Level Meter (SEW Digital Noise Level Meter 2310SL). Measurement points were selected at the location on each machine producing the highest noise intensity, namely, the re-saw, pony, and break-down machines, with the instrument positioned 1 m from the identified noise source and its position held constant across all measurements. At each point, noise level was recorded continuously for 10 minutes with readings logged every 5 seconds (120 data points per location), and the equivalent continuous sound level (Leq) was calculated and used as the reported value. Measurements were taken during normal working hours, beginning at 09:00 Western Indonesian Time (WIB), and were compared with the national TLV of 85 dBA stipulated in Regulation of the Minister of Manpower of the Republic of Indonesia No. 5 of 2018 concerning Occupational Safety and Health in the Work Environment.

Research Variables

The variables investigated in this study were defined as follows. Tinnitus was defined as the perception of ringing or buzzing sounds, representing an early symptom of sensorineural hearing disorders (17). In this study, the four subjective complaints were classified into two categories. Tinnitus and difficulty understanding speech were classified as auditory complaints, directly related to hearing function. Emotional disturbance and difficulty concentrating were classified as non-auditory effects of noise exposure, reflecting psychological and cognitive responses rather than auditory symptoms per se; emotional disturbance was defined as increased irritability or anger, previously associated with elevated blood pressure (18), while difficulty concentrating was defined as difficulty in maintaining concentration. This distinction is maintained throughout the Results and Discussion to avoid combining auditory, cognitive, and psychosocial symptoms under a single undifferentiated construct. Difficulty understanding speech was defined as the inability to comprehend speech clearly when it is delivered within the same environment (20).

Statistical Analysis

All collected data were checked for completeness before entry. A double-entry system was applied to minimise entry errors, and the database was password-protected to maintain data security. Coded identifiers were used to protect the confidentiality of participants. Descriptive statistics were computed using the Statistical Package for the Social Sciences (SPSS) version 30 to obtain the frequency and percentage distributions of age, years of service, noise exposure levels, and audiometric results; continuous variables are presented as mean ± standard deviation (SD). Because subjective hearing complaints were recorded as dichotomous (present/absent) outcomes, Fisher's exact test was used to compare the distribution of each complaint among operators of the re-saw, break-down, and pony machines simultaneously across all three groups. Fisher's exact test was applied to each of the four outcomes given the categorical nature of the data and the relatively small sample size within each machine group (n = 18), which limits the reliability of the chi-square approximation. No correction for multiple comparisons was applied given the exploratory nature of this analysis. The level of statistical significance was set at $\alpha = 0.05$; a p value < 0.05 indicated a statistically significant difference between machine-operator groups, whereas a p value ≥ 0.05 meant that no statistically significant difference was detected; it did not establish equivalent or uniform complaint distributions or an association with individual noise exposure.

RESULTS

Environmental noise measurements conducted in 2024 at the three primary production machines showed noise intensity levels (Leq) of 87.1 dBA at the re-saw machine, 90.2 dBA at the break-down machine, and 95.8 dBA at the pony machine, with an oversall mean of 91.03 dBA. All three values exceeded the national Threshold Limit Value of 85 dBA. Calibration procedures for the sound level meter prior to measurement were not documented in the available field records.

Table 1. Age Distribution of Workers

Age Range (Years)	Number of Workers (n)	Percentage (%)
28 – 32	9	16.67
33 – 37	13	24.07

Age Range (Years)	Number of Workers (n)	Percentage (%)
38 – 42	25	46.30
43 – 47	7	12.96
Total	54	100

As shown in Table 1, most workers were aged 38–42 years (25 workers; 46.30%), followed by those aged 33–37 years (13 workers; 24.07%) and 28–32 years (9 workers; 16.67%). The smallest proportion was found in the 43–47 year age group (7 workers; 12.96%). The mean age of respondents was 37.78 ± 4.62 years.

Table 2. Distribution of Workers by Length of Service

Years of Service	Number of Workers (n)	Percentage (%)
1 – 2	17	31.48
3 – 4	29	53.70
5	8	14.81
Total	54	100

As shown in Table 2, most respondents had 3–4 years of service (29 workers; 53.70%), followed by those with 1–2 years of service (17 workers; 31.48%). The smallest group comprised workers with ≥ 5 years of service (8 workers; 14.81%). The mean length of service was 3.09 ± 1.21 years.

Table 3. Clinic-Assigned Audiometric Classification of Workers

Audiometric record	Clinic-assigned hearing category	Number of Workers (n)	Percentage (%)
Final clinic classification	Normal	54	100
Final clinic classification	Abnormal	0	0
Total		54	100

Note: Routine clinic audiometry covered 250–8000 Hz for air conduction and 250–4000 Hz for bone conduction, assessed binaurally. Available frequency-specific thresholds ranged from 5 to 35 dB. Table 3 reports the clinic-assigned final hearing category. The exact frequency set, ear rule, and summary measure used to derive this category, and the examination date relative to questionnaire administration, were unavailable in the study records.

Table 3 shows that the clinic assigned a normal final hearing category to all 54 workers. This worker-level classification does not imply that all frequency-specific thresholds were ≤25 dB: available measurements ranged up to 35 dB, and the clinic's classification algorithm was unavailable. The table reports the recorded clinic category rather than a category reconstructed from individual thresholds.

Table 4. Distribution of Subjective Hearing Complaints by Machine Type

Machine Type	Number of Workers (n)	Emotional Disturbance, n (%)	Tinnitus, n (%)	Difficulty Concentrating, n (%)	Difficulty Understanding Speech, n (%)
Re-saw Machine	18	11 (61.11%)	8 (44.44%)	5 (27.78%)	2 (11.11%)
Break-down Machine	18	13 (72.22%)	10 (55.56%)	4 (22.22%)	2 (11.11%)
Pony Machine	18	14 (77.78%)	12 (66.67%)	8 (44.44%)	5 (27.78%)
Total	54	38 (70.37%)	30 (55.56%)	17 (31.48%)	9 (16.67%)

Table 4 presents the distribution of subjective hearing complaints among workers operating the re-saw, break-down, and pony machines. Because each worker could report more than one complaint simultaneously, the total number of complaints exceeded the total number of workers. Among re-saw machine operators, the most frequently reported complaint was emotional disturbance (11 workers; 61.11%), followed by tinnitus (8 workers; 44.44%), difficulty concentrating (5 workers; 27.78%), and difficulty understanding speech in noisy environments (2 workers; 11.11%).

Among break-down machine operators, emotional disturbance was reported by 13 workers (72.22%), followed by tinnitus (10 workers; 55.56%), difficulty concentrating (4 workers; 22.22%), and difficulty understanding speech in noisy environments (2 workers; 11.11%). Among pony machine operators, emotional disturbance was reported by 14 workers (77.78%), followed by tinnitus (12 workers; 66.67%), difficulty concentrating (8 workers; 44.44%), and difficulty understanding speech in noisy environments (5 workers; 27.78%).

Overall, emotional disturbance was reported by 38 of 54 workers (70.37%), followed by tinnitus (30 workers; 55.56%), difficulty concentrating (17 workers; 31.48%), and difficulty understanding speech in noisy environments (9 workers; 16.67%).

Table 5. Fisher's Exact Test of Subjective Hearing Complaints Between Machine Groups

Subjective Complaint	p-value	Interpretation
Tinnitus	0.462	Not significant
Emotional disturbance	0.657	Not significant
Difficulty concentrating	0.436	Not significant
Difficulty understanding speech	0.466	Not significant

Table 5 shows that Fisher's exact test identified no statistically significant differences in subjective hearing complaints between operators of the re-saw, break-down, and pony machines (all $p > 0.05$). Although tinnitus, emotional disturbance, difficulty concentrating, and difficulty understanding speech in noisy environments were reported slightly more frequently in certain machine groups, these differences did not reach statistical significance.
Fisher's exact test detected no statistically significant difference in the proportion reporting each complaint among the three machine-operator groups. These results do not establish equivalent complaint distributions across groups or an association between personal noise exposure and the complaints, because individual full-shift noise dose was not measured.

DISCUSSION

The clinic assigned a normal final hearing classification to all 54 workers, while workers reported the individual complaints shown in Table 4. The most frequently reported symptom was emotional disturbance, affecting 38 respondents (70.37%), followed by tinnitus in 30 respondents (55.56%), difficulty concentrating in 17 respondents (31.48%), and difficulty understanding speech in 9 respondents (16.67%). The coexistence of reported complaints and normal clinic-assigned classifications warrants further investigation; this cross-sectional study cannot determine whether complaints precede hearing loss or are caused by occupational noise (21). It is also possible that complaints such as emotional disturbance and difficulty concentrating were influenced by unmeasured factors, including occupational stress, workload, sleep quality, or general psychological health, rather than noise exposure alone.
One possible mechanism discussed in the literature is cochlear synaptopathy, which may not be detected by conventional pure-tone audiometry (22,23). The present study did not include tests for cochlear synaptopathy or auditory-processing impairment; it therefore cannot verify "hidden hearing loss" in these workers. Reported complaints alongside normal clinic-assigned classifications warrant further documentation and study, without implying a specific diagnosis or predicting subsequent impairment.
Fisher's exact test detected no statistically significant difference in the proportion reporting any of the four complaints among re-saw, break-down, and pony operators (all $p > 0.05$). This finding does not demonstrate uniformity of complaints across groups or establish that exposure was shared equally across the production environment. Short-duration area measurements cannot characterize individual full-shift noise exposure.
Independent of this study's descriptive findings, ecological approaches to workplace hearing-health promotion and hearing-awareness campaigns have been described in prior literature (29,30). Education, support from colleagues and supervisors, and organisational policies may be considered when designing a local programme; this study did not evaluate whether these approaches change worker behaviour or hearing outcomes.
Further workplace assessment could combine noise measurements with workers' descriptions of their sound environment, an approach used in soundscape research in other settings (33). The current measurements and complaint comparisons cannot establish the effects of engineering controls or identify a machine group for targeted intervention.

Health Promotion Implications

The following health-promotion approaches are literature-informed options for future consideration, not interventions evaluated in this study. The observed data comprise complaint-specific proportions, clinic-assigned hearing classifications, and short-duration area noise measurements; worker knowledge, hearing-protection practices, organisational support, psychosocial stress, and intervention effectiveness were not assessed. Prior literature discusses education about hearing hazards and participatory occupational health and safety training (34–37). Any programme in this workplace would require local assessment and evaluation.
Occupational hearing-health literature provides context for considering structured documentation of workers' complaints alongside audiometry (38). The questionnaire results here describe reported symptoms; this study did not validate a symptom screening tool or test whether symptom monitoring identifies future hearing loss. Hearing conservation literature provides a basis for assessing engineering noise controls, machine maintenance, and work organisation as possible local measures (26,29,38). Reports from other worker populations describe hearing complaints alongside other health concerns (41,42). The effectiveness and suitability of these options for this facility were not tested here.
Hearing conservation literature discusses management commitment, worker participation, and locally adapted training as possible elements of a programme (26,29). Fisher's exact test in the present study detected no statistically significant difference in complaint proportions among machine groups; it cannot determine whether these interventions are needed or effective at any particular machine.
The reported emotional disturbance may justify studying psychosocial conditions alongside auditory complaints in future work. The present questionnaire and analyses do not establish that noise caused distress, hypertension, or other health outcomes, and no psychosocial intervention was evaluated. Relevant occupational health literature can inform the design of such future evaluations (43–46).

Access to quieter rest spaces could be explored as a workplace option. The current study neither measured the effect of rest spaces on hearing or well-being nor compared workers with different access to such areas.
Broader occupational health frameworks support assessing working conditions alongside individual health (47–50). Whether a rest space or other environmental change benefits workers in this facility remains a question for prospective evaluation.

Strengths and Limitations

This study has several strengths. First, the entire production workforce was surveyed, which ensured an accurate representation of on-site conditions and minimised selection bias. Second, the study combined subjective and objective data, namely hearing complaints together with audiometric and environmental noise measurements, to obtain a more complete picture of hearing health hazards. Third, the study was conducted in one of the largest plywood industries in Central Java, and the findings may therefore reflect conditions encountered in comparable industrial settings.
This study also has several limitations. First, it was conducted in a single company, which limits the generalisability of the findings to the Indonesian plywood industry as a whole. Second, other health-related factors, such as occupational stress, lifestyle, general health status, and non-noise exposures, were not examined despite their potential influence on workers' complaints. Third, the precise coding rule used to derive the difficulty-understanding-speech outcome from the separate communication questions could not be reconstructed from the supplied questionnaire alone. Fourth, because of its cross-sectional and exploratory design, the study cannot establish a causal relationship between noise exposure and auditory complaints. Finally, noise levels at the re-saw, break-down, and pony machines were measured on a single occasion, so daily fluctuations in noise exposure could not be characterised. These limitations should be addressed in future research.

Implications and Future Directions

The findings may support further study of structured symptom documentation alongside clinic audiometry and more complete personal noise assessment. Education, engineering controls, psychosocial support, and quiet rest areas are literature-informed options for local assessment and evaluation; the present study did not assess their feasibility or effects. Broader occupational health frameworks provide context for designing future programmes (39,50).
Future studies should include additional plywood companies and other industrial sectors in order to improve the generalisability of the findings. Subsequent research should also examine factors such as occupational stress, lifestyle, general health status, and other non-noise exposures that may modify the health effects of noise. In addition, technological aspects such as the design and evaluation of noise barriers should be prioritised in order to assess their effectiveness in reducing noise levels and subjective hearing complaints among workers. Further research could evaluate whether these proposed approaches are suitable and effective for plywood workers in this setting.

CONCLUSION

The clinic assigned normal final hearing classifications to all 54 workers, while workers reported emotional disturbance (70.37%), tinnitus (55.56%), difficulty concentrating (31.48%), and difficulty understanding speech (16.67%). These complaint-specific proportions do not imply that all workers reported a complaint. Fisher's exact test detected no statistically significant difference among machine groups for any complaint. With the cross-sectional design, incomplete documentation of the speech-outcome coding, and short-duration area noise measurements, the study cannot establish that noise caused the complaints or that symptoms predict later hearing loss. Structured documentation of complaints may complement routine audiometry. Education, technical noise controls, psychosocial support, and quieter rest areas are literature-informed options that were not evaluated in this study.

DECLARATIONS

Author contributions: Conceptualization and study design: Elmerilia Tandilangi, Hanifa M. Denny. Data collection: Onny Setiani. Data analysis and interpretation: Elmerilia Tandilangi, Hanifa M. Denny. Drafting of the manuscript: Elmerilia Tandilangi. Critical revision of the manuscript for important intellectual content: all authors. All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

Conflicts of interest: The authors declare that they have no conflicts of interest related to this study.

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