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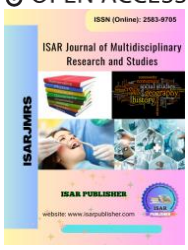

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Noise Pollution Levels and Their Impact on Workers in Wood Furniture Factories

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Abstract: The machines operated in wood furniture factories generate a high level of noise. Therefore, wood furniture workers are exposed to machine-derived noise. The noise situation and the effects of noise are worthy of attention. This study was conducted in Rajshahi City to measure the noise levels in the selected wood furniture factories and evaluate the impact of noise on workers. A digital sound level meter was used to measure the noise level, and a total of 102 furniture workers were surveyed about their perceptions of noise effects. The findings show that 70% of noise levels exceeded the 85 dBA occupational standards, and the maximum noise level was recorded at 107.6 dBA. In terms of noise effects on conversation during work time, 52% of respondents treated the workplace as moderately noisy; whereas 55.9% experienced moderate communication interference; 32.4% had moderate disturbance in recreation activities during work. 70% workers had to raise voice sometime to overcome noise; most of them (76.5%) were not aware of the adverse effects of noise. One-third (34.3%) of the workers had headaches, one-six (16.6%) had digestion problems, and a mentionable amount (13.7%) had asthma symptoms. Workers hardly wear personal protective equipment (PPE) and hearing aids while working in wood furniture factories in Rajshahi City.

Keywords: *Noise pollution, noise levels, dBA, wood furniture workers, noise effects*.

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1. Introduction

The workplace has a significant role in the environment of human. When a nation's labor receives protection from hazardous conditions, its economy is likely performing well. Modern mechanical operations have greatly reduced physical labour requirements in industrial facilities; therefore, mechanized instruments are in use in different industries, including the wood furniture sector. But the generation of noise is these procedures' mentionable side effect. A potentially major health issue at work is noise. Any unwanted sound emitting in the form of noise usually makes it difficult for workers to communicate with one another, while the high intensity of the noise may also have a negative impact on the workers' physical health as well as their psychological well-being. Exposure to high levels of sound has the potential to induce Temporary Threshold Shift (TTS), characterized by temporary alterations in auditory sensitivity that typically resolve with time, or Permanent Threshold Shift (PTS), a permanent hearing loss that does not return to baseline levels. (Ryan et al., 2016). There exist various categories of noise that have the potential to impact the efficiency of workers in the workplace, such as constant, sporadic, and variable noise. (Lee et al., 2019). Workers at sawmills had high frequency hearing loss (Boateng & Amedofu, 2004).

Modern machine-based wood furniture can also generate all this noise. Although the introduction and use of various types of machines in the wood furniture sector have reduced workers physical efforts, it has also exposed them to direct contact with noise. There are suggested levels of noise exposure at work in most nations and organizations. The European Union has set an upper exposure limit of 85 dBA and a lower limit of 80 dBA for an 8-hour workday (European Union, 2003). The health and safety of employees may therefore be negatively impacted by excessive noise. The significant degree of noise produced by machinery throughout the production process requires further study.

Rajshahi City is experiencing a rapid growth of 11.7% (Kafy et al., 2020), and the urging for wooden doors and household furniture is expanding fast to meet the demand of urbanization. In this context, further research has the potential to significantly affect an area of public health concern, reducing the risk for employees in the wood furniture sector across the nation, given the existing lack of data on noise effects in cities like Rajshahi. Mentionable work has been conducted around the world, but almost no work has been found in Rajshahi City in this field.

This study was designed to explore the effects of noise pollution in the workplace, resulting in a healthy work atmosphere to prevent occupational health hazards among workers. The objectives of the

study are to measure the noise levels in the selected wood furniture factories in Rajshahi city and compare them to international standards; and to evaluate the effects of noise on workers.

2. Materials and Methods

The study area selected for this research is Rajshahi City, which is a divisional headquarters in the northwest of Bangladesh and is a rapidly expanding metropolis. The city is situated along the renowned Padma River with 0.85 million population and 95.56 sq. km area (Islam et al., 2022). The wood furniture factories in Rajshahi City are located scattered around the city rather than concentrated in one region. Thus, 10 wood furniture factories located throughout the city Horogram, Binodpur, Uposhohor, Dewan Para, Sapura BSCIC, Vodra, Mirzapur, Chondrima, Zia Park, and Nawdapara were monitored for noise monitoring from December 2022 to June 2023. This city did not have a lot of significant factories that made doors and furniture. All the selected factories were modest businesses with up to thirty employees, and the investigation took into consideration both sawmills and furniture factories.

The working environment was hot, humid, dusty, and noisy. Usually, band saws were used in sawmills and drilling, and circular saws and computer numerical control (CNC) routers were used by carpenters. Wood doors and household furniture were the main products. Machines along with manual tasks like hammering and sanding were observed. Wood furniture factories were not agglomerated in a place in Rajshahi City; they were rather scattered in different locations. Throughout the sampling, workplace differences in terms of employees' numbers, machines used, and working environment were recorded.

2.1. Noise level monitoring

To assess the average noise level throughout the study area, noise readings were taken from the selected ten wood processing factories using a digital sound level meter SL 4023SD which meet the IEC standards. Noise descriptor like minimum noise level (Lmin) and maximum noise level (Lmax), equivalent continuous noise level (Leq) was measured from the selected workplaces. The noise percentile value L50, L90, L10 were obtained to calculate Leq. The measurement's readings were taken over a 15-minute period from a fixed position near a specific noise source. An A-weighted sound pressure level was recorded every hour for eight hours (from 09:00 to 17:00) of operation, presenting three distinct noise periods for morning, afternoon, and evening.

2.2. Noise effects data

A questionnaire was developed to assess the effects of noise on wood furniture workers, incorporating their self-reported perceptions of workplace noise, awareness, and disease symptoms. A registered wood furniture workers association reports that there were 1196 enlisted workers in Rajshahi City. Applying the Yamane technique with a 10% margin of error, the calculated minimum sample size was 92.28 (Louangrath et al., 2017), with an extra 10% added. As a result, a total of 102 respondents were interviewed from individuals employed in the wood furniture industry. These data were collected from twenty wood furniture factories including the ten mentioned factories. The population of this study consisted of all wood furniture workers of the selected factories who met the inclusion requirements, including being between the ages of 18 and 59 years old, never having worked in another noisy environment, having at least 6 months of experience in the current workplace, and being willing to participate in the study.

About noise pollution, level of annoyance due to noise at workplace; interference of conversation during work; disturbance of recreation due to noise during work; interference of concentration during work; impact on relaxation, personal protection equipment (PPE) uses patterns along with their age; work category; length of employment; exposure period to noisy environment. A five-level of descriptive rating scale were considered for assessment. The weighted value of 0,1,2,3,4 was used to indicate the response "Not at all.", Slightly", "Moderately", "Very much" and "Extremely" respectively. Using this structured questionnaire face to face interview was conducted after verbal consent from the respondents. They were told of the study's objective and how the data would be used. The analysis utilized for this study were percentage and frequency counting.

3. Results and Discussion

3.1. Noise levels at wood furniture factories

The results of the noise level of the studied wood furniture factories are given in Table 1. It contains the maximum, minimum, and continuous equivalent noise levels in accordance with different period. Different machines like table saws, circular saws, surface planers, thicknessers, sanders, power drills, and wood router machines were used in the furniture factories; on the other hand, band saws were the sole machines used in the observed sawmills. As can be observed, furniture factories create slightly less noise than sawmills. However, the findings are indicative of temporary hearing loss brought on by short exposure to noise, which returns to normal after a period of rest.

The average maximum noise level Lmax was 102.0 dBA, ranging from 96.3 to 107.6 dBA, with a narrow spread (standard deviation 4.3). The average minimum noise level Lmin was 70.1 dBA, ranging from 66.5 to 74.5 dBA with a fair distribution (Standard Deviation 2.1). The highest Lmax was found in (WF-5) a sawmill during the evening, and the minimum noise level Lmin was found in (WF-8) a furniture factory during the afternoon. The average equivalent continuous noise (Leq) was 85.6 dBA, ranging from 83.5 to 87.6 dBA with a fair distribution (Standard Deviation 1.1). The highest Leq was found in (WF-8) a furniture factory during the evening hours, and the lowest Leq was found in (WF-9) another furniture factory during the afternoon period.

However, compared to the morning (85.7 dBA) and afternoon (85.0 dBA) periods, the average noise levels in the evening (86.0 dBA) were slightly higher. When the machines were stuffed noise levels increased; Leq continued to surpass the threshold during this period. The National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA) of the United States of America (USA) generally apply their guidelines in an occupational setting, based on an 8-hour workday over a 40-year working career. The NIOSH recommends 85 dBA, while OSHA allows up to 90 dBA. (Neitzel & Fligor, 2019; Florentin et al., 2016). The data indicates that in 70% of the situations, noise levels exceeded the 85 dBA of NIOSH guidelines, even in the case of machines without loaded mode.

Table 1: Noise levels (in dBA) at selected wood furniture factories

ID	Time	Type	Lmax	Lmin	L50	L90	L10	NC	NPL	Leq
WF 1	Morning	sawmill	106.8	71.0	85.9	83.5	88.5	5.0	91.3	86.3
WF 2		sawmill	106.6	70.5	85.7	83.3	88.5	5.2	91.4	86.2
WF 3		sawmill	106.5	72.6	85.6	83.2	88.2	5.0	91.0	86.0
WF 4		sawmill	106.0	71.0	85.6	83.2	88.5	5.3	91.4	86.1
WF 5		sawmill	107.2	74.0	83.5	81.1	86.5	5.4	89.4	84.0
WF 6		Furniture	98.6	68.5	83.5	81.1	87.9	6.8	91.1	84.3
WF 7		Furniture	98.8	67.0	86.4	84.0	90.5	6.5	93.6	87.1
WF 8		Furniture	98.0	67.5	83.5	81.1	87.7	6.6	90.8	84.2
WF 9		Furniture	97.4	70.5	85.7	83.3	89.9	6.6	93.0	86.4
WF 10		Furniture	98.2	69.0	85.4	83.0	89.7	6.7	92.8	86.1
WF 1	Afternoon	sawmill	105.5	70.0	85.2	82.8	87.8	5.0	90.6	85.6
WF 2		sawmill	104.4	70.3	85.1	82.7	87.9	5.2	90.8	85.6
WF 3		sawmill	105.2	72.5	85.1	82.7	87.7	5.0	90.5	85.5
WF 4		sawmill	103.0	70.0	85.0	82.6	87.9	5.3	90.8	85.5
WF 5		sawmill	106.0	73.0	83.1	80.7	86.1	5.4	89.0	83.6
WF 6		Furniture	96.3	68.5	84.7	82.3	89.1	6.8	92.3	85.5
WF 7		Furniture	97.4	67.5	82.9	80.5	87.0	6.5	90.1	83.6
WF 8		Furniture	97.5	66.5	85.8	83.4	90.0	6.6	93.1	86.5
WF 9		Furniture	97.6	66.6	82.8	80.4	87.0	6.6	90.1	83.5
WF 10		Furniture	96.6	70.0	84.8	82.4	89.1	6.7	92.2	85.5
WF 1	Evening	sawmill	107.5	71.3	85.7	83.3	89.8	6.5	92.9	86.4
WF 2		sawmill	105.4	70.6	85.8	83.4	90.0	6.6	93.1	86.5
WF 3		sawmill	107.5	72.8	85.3	82.9	89.5	6.6	92.6	86.0
WF 4		sawmill	107.0	71.5	86.0	83.6	90.3	6.7	93.4	86.7
WF 5		sawmill	107.6	74.5	84.0	81.6	86.6	5.0	89.4	84.4
WF 6		Furniture	98.6	69.5	86.0	83.6	88.8	5.2	91.7	86.5
WF 7		Furniture	99.0	69.5	84.1	81.7	86.7	5.0	89.5	84.5
WF 8		Furniture	99.0	67.6	87.1	84.7	90.0	5.3	92.9	87.6
WF 9		Furniture	98.5	68.2	83.9	81.5	87.5	6.0	90.5	84.5
WF 10		Furniture	97.6	70.8	85.9	83.5	89.5	6.0	92.5	86.5

If a worker is 20 years old and works 30 or 40 years at a noise level of 100 dBA, there is 50% to 65% chance that they may develop hearing loss and even though the sound is loved, it is difficult to protect worker health in an environment with over 90 dBA levels, because many wood processing machines have crucial noise levels the workers may be in risk (Sahin et al., 2017). Most of the machines created high levels of noise requiring protective equipment along with proper consciousness among the concerned workers for safety purposes (Hagan et al., 2015). Another experimental study in Turkey found that type of wood, number of blades, depth, and width of cutting influenced noise emission in a wood processing spindle moulder machine, the highest noise level was observed 96.33 dBA (Durcun & Burdurulu, 2018). An investigation conducted in Greece identified noise levels ranging from 72.9 dBA to 103.2 dBA, indicating that individuals employed in the wood furniture manufacturing sector frequently experienced noise levels exceeding the permissible thresholds (Ntalos & Papadopouls, 2005). A distinct analysis carried out in the south-eastern Asian region, which encompasses Malaysia, Thailand, Indonesia, and Vietnam, demonstrated that sound levels in the rugged machinery sector peaked at 130 dBA (Ratnasingam et al., 2010). The machines used in the wood industry did not emit the same noise, the vertical band saw, and band saw exceeded the limit, but planning and slitting machines didn't (Fidan et al., 2020). It was found that in wood and textile industries in China, 84.1% workers had more than 85 dBA noise exposure level where the textile workers received higher (Zhou et al.,

2021). However, the present study reveals that the noise levels in the observed factories were above the permissible limit with loaded machines and comparatively like other studies.

The data compares three specific time of morning, afternoon, and evening at the selected wood furniture factories. An ANOVA test shows no significant difference between groups ($F = 1.59$, $p = 0.225$), as the p-value exceeds the critical value of 0.2247, indicating that the variation in different period is not statistically significant.

3.2 Noise Effects on wood furniture workers

Participants were all men; no female worker was found during the study. The average age (34.02) of the workers indicated that a young workforce was engaged in the sector, and the average work experience (13.74 years) revealed that wood furniture work required a bit of experience. The daily average work hours (8.33 hours) were just over 8 hours. This was because they were paid on a contract basis, not on a daily hour basis. The tendency to use personal protective equipment (PPE) was deplorable. No one was seen using a hearing protective device despite working in a noisy environment.

The results of noisiness showed that no respondent thought that their workplace was “not at all” noisy. 29.4% treated their workplace slightly;52.0% “moderately”; 15.7% “very much” and 2.9% “extremely noisy”. The response (mean 1.9) indicates a general lean toward “Moderately” noisy.

In terms of annoyance 52% workers were “slightly”; 25.4% “moderately”; 20.6% “very much” and only 2% “extremely” annoyed due to noise. So, every worker was annoyed by noise in the wood furniture factories. The response (mean 2.4) is positioned between “Moderately” and “Very much”.

Regarding the outcome of noise effects on communication interference 19.6% workers reported as “slightly”; 55.9% as “moderately”; 23.5% as “very much” and only 1% as “extremely” affected by noise. So, their inter-personal communication was “moderately” (mean 2.0) affected by noise during work hours.

Workers have a tradition of enjoying recreational activities such as singing, chatting, and music listening while at work. However, the noisy surroundings hindered it. When asked how much their recreational activities were disrupted by noise at work, 48% of workers said they were "slightly," 32.4 % said they were "moderately," and 19.6% said they were "very much" bothered. On average (mean 2.7) they believed that noise "moderately" hindered their recreation.

Workers communicate with others for production purpose, but due to noisy environment they require to raise their voice. Regarding voice raise 5.0% workers reported as “never”; 10.0% as “almost never”; 70.0% as “sometime” and only 15% as “very often” had to raise their usual voice to be heard in factories. The response (mean 2.0) indicates the workers used to raise voice for “sometime”. Raising one’s voice to overcome noise can strain the throat and may lead to vocal damage.

Alarmingly 76.5% of the workers said they were “not aware” of the adverse effects of noise pollution and the rest 24.5% knew to some extent. They might have learned from electronic media like TV, and textbook and other sources like posters. Therefore, it may be concluded that wood furniture workers were, not aware of noise pollution, indicating that they were unaware of its detrimental impacts on health.

Related study found that noise levels in the wood processing laboratory in the university of Ibadan, Nigeria were above the standard limits which could affect the workers hearing along with psychosomatic, physical, and mental disorders (Omoniyi & Fatoki, 2018).

Table 2. Workers Perception of the effects of noise pollution

Variables	Type of response	Respondents	%	Mean
How noisy is your workplace?	Not at all	0	0.0%	1.9
	Slightly	30	29.4%	
	Moderately	53	52.0%	
	Very much	16	15.7%	
	Extremely	3	2.9%	
Does noise annoy you?	Not at all	0	0.0%	2.5
	Slightly	53	52.0%	
	Moderately	26	25.4%	
	Very much	21	20.6%	
	Extremely	20	20.0%	
Does noise interfere your conversation or communication during work?	Not at all	0	0.0%	2.0
	Slightly	20	19.6%	

	Moderately	57	55.9%	
	Very much	24	23.5%	
	Extremely	0	0.0%	
Does noise disturb your recreation activities?	Not at all	0	0.0%	1.7
	Slightly	49	48.0%	
	Moderately	33	32.4%	
	Very much	20	19.6%	
	Extremely	0	0.0%	
	Slightly	0	0.0%	
Do you need to raise your voice during work?	Never	5	5.00%	2.0
	Almost never	10	10.00%	
	Sometimes	71	70.00%	
	Very often	15	15.00%	
	Always	0	0.00%	
Are you aware of the adverse effects of noise pollution?	Yes	78	23.5%	
	No	24	76.5%	

3.4. Health effects and symptoms

The self-reported health effects and symptoms of the wood furniture workers (Table 3) revealed that about one-third (34.3%) of the workers had headaches, 14.7% had the symptoms of dizziness, 16.6% indigestion. On the other hand, 2.9% workers had hearing problems including the symptoms of ringing-whistling in the ear, impaired hearing, blocked ears. Despite the low percentage of hearing problem, it is still a concern for safe environment of workers. This may lead to noise-induced hearing loss (NIHL). However, the most prevalent occupational disease is NIHL, which demands more extensive research (Basner et al., 2014). It may be noted that NIHL causes substantial disability and lowers quality of life but does not directly raise mortality rates (Mazlan et al., 2018). In terms of chronic diseases, a mentionable amount (13.7%) had asthma symptoms. Working in a noisy and dusty environment might be responsible for that. The rates of hypertension, diabetes, and cardiac diseases were 3.9%, 6.8%, and 3.9%, respectively.

Table 3: Self-reported symptoms and diseases of the woodworkers

Variables	**Yes**	**%**	**No**	**%**
Headaches	35	34.3%	67	65.7%
Dizziness	15	14.7%	87	85.3%
Indigestion	17	16.6%	85	83.4%
Hearing problem (Ringing, whistling in the ear, Impaired hearing)	3	2.9%	99	97.1%
Asthma (shortness of breath, Chest tightness or pain, wheezing)	14	13.7%	88	86.3%
Hypertension	4	3.9%	98	96.1%
Diabetes	7	6.8%	95	93.2%
Cardiac diseases	4	3.9%	98	96.1%

Audiometric assessment of furniture workers in west Java, Indonesia, indicated that 57% workers had noise induced hearing loss (NIHL) with tinnitus ranking highest among auditory symptoms (54%), and sleeping difficulties ranking highest among non-auditory symptoms (19%) (Nurrokhmawati et al., 2022). Similar studies in Nepal showed that the prevalence of NIHL among carpenters was 31% and sawyers 44% (Robinson et al, 2015). Another study from Shenyang, China demonstrated that the workers' psychological well-being, hearing capacity and ability to communicate on the job site had all been negatively impacted by the noise situation at construction sites (Yang et al., 2021).

From the above discussion, it is evident that the workers in wood furniture factories are exposed in slightly higher than the permissible noise limit. According to the results almost all respondents believed that noise had an impact on conversations, concentration. So, they were not seen doing important tasks at noisy workplaces. At the same time, they also believed that furniture processing noise had some sort of impact on hearing.

Disturbance of recreation was also a mentionable effect of noise, as workers in this region like to enjoy music-type recreational events during work time. They were slightly annoyed by the noise but, at the same time, tried to adapt to the increased noise environment. Due to the hot, humid environment wood furniture workers hardly ever wear PPE, and hearing aids may interfere with their ability to hear the signal from co-workers.

4. Conclusion

The study, which involved monitoring noise levels at wood furniture factories, analysing noise-related parameters, and surveying 102 workers to find out how they felt about noise, was intended to understand the effects of noise. The findings demonstrated that all readings obtained during the loaded mode of the machines exceeded the permitted NIOSH limit of 85 dBA. Majority of the workers (52.0%) treated their workplace as "moderately" noisy. More than half of respondents (55.9%) believed that noise at work "moderately" affected conversations during work hours. Almost two-third (70%) had to raise their usual voice to overcome noise. One-third (34.3%) of the workers experienced headaches. The workers' psychological well-being, hearing capacity, and ability to communicate had all been negatively impacted to varying degrees by the noisy situation at wood furniture factories. According to this study, all the observed wood furniture workers in Rajshahi City did not take any safety precautions, which may cause noise-induced hearing loss (NIHL) and other detrimental health effects. To determine the hearing issues in this sector, more studies should be conducted over time. A comprehensive hearing conservation program ought to be implemented to protect those workers from high levels of noise in the workplace.

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