RESEARCH ARTICLE **ISSN 2738-9898 (Print) ISSN 2738-9901 (Online)**

Construction Noise Pollution and Worker Perceptions in Kohalpur Municipality: Exposure Levels, Health Risks, and Control Gaps

Sushila Shahi[1], Uttam Neupane[1*], Raju Chauhan[2], Bidya Rijal[3]

[1]Central Department of Civil Engineering, Graduate School of Engineering, Mid-West University, Surkhet, Nepal
[2]Department of Environmental Science, Patan Multiple Campus, Tribhuvan University, Lalitpur, Nepal
[3]Nepal Rastriya Secondary School, Surkhet, Nepal
*Author to whom correspondence should be addressed; E-Mail: *uttam.neupane@mu.edu.np*

Received : 11 June 2025; Received in revised form : 27 June 2025; Accepted : 30 June 2025; Published: 04 July 2025

Abstract

Occupational noise exposure in construction sites is a growing concern for workers' health and safety. This case study assesses noise levels in Kohalpur Municipality, Nepal, and explores workers' awareness, perceptions, and use of protective measures. A mixed-methods approach was used, combining field measurements with the Decibel X mobile app, structured questionnaires, and secondary data analysis using SPSS and Excel. Results show that noise from construction equipment often exceeds recommended exposure limits, particularly at high frequencies. Despite the risks of hearing loss, stress, and reduced productivity, 100% of respondents reported no training, and 87.3% indicated a lack of noise control measures. Most employers do not provide hearing protection or conduct noise monitoring. The findings highlight the urgent need for awareness programs, enforcement of noise regulations, and implementation of control strategies to protect workers' health and enhance safety in the construction sector.

Keywords: Occupational Noise Exposure, Construction sites, Noise measurement, Hearing protection, Noise control strategies, Protective measures, Construction Equipment

1. Introduction

Construction-related noise is a significant source of environmental and occupational disturbance, particularly in rapidly urbanizing areas. It originates from various sources, including heavy machinery, demolition, material handling, and vehicular movement at construction sites, often resulting in elevated sound levels that can surpass 90 dB—the occupational safety limit defined by the Occupational Safety and Health Administration [1] . The intensity and frequency of such noise depend on the construction phase, equipment used, and proximity to the source. Although noise pollution does not immediately threaten human health like some other pollutants, its long-term effects are substantial. Extended exposure to high noise levels can lead to hearing loss, sleep disturbance, stress, and reduced cognitive function [2] . Moreover, the irregular and unpredictable nature of construction noise makes it difficult to monitor and regulate effectively [3] . In urban settings, this form of pollution contributes to discomfort among residents and poses health risks for construction workers and has become a significant environmental and occupational issue, especially in sites undergoing rapid development and redevelopment [2],[4]. Traditional methods of measuring construction noise rely heavily on decibel-based assessments, which are often insufficient in predicting the annoyance caused by construction noise due to the variability of sounds produced by different machinery types. As such, a more comprehensive approach has been proposed, incorporating both perceptual attributes and psychoacoustic parameters. In a recent study, the authors in [5] evaluated the perceived annoyance of 16 construction machines using audiovisual recordings and a 12-item scale. They grouped these noises into three clusters based on four key perceptual components: Incisiveness, Strength, Intermittency, and Periodicity, which were found to strongly correlate with psychoacoustic parameters such as loudness and fluctuation strength. These components were instrumental in differentiating types of construction noise that are more likely to cause annoyance.

The influence of personal characteristics on noise perception has also been studied. A significant factor identified is noise sensitivity, which plays a crucial role in how construction noise is perceived by workers and residents alike. The study in [6] found that noise annoyance varied across different stages of construction, with demolition being the most disturbing phase. They observed that noise sensitivity had the greatest impact on perceived annoyance, with individuals who were more sensitive to noise reporting greater disruption. Additionally, studies have shown that situational factors, such as job type and years of experience, also contribute to the degree of perceived annoyance, work performance degradation, and safety risks. Research into the health impacts of construction noise has expanded beyond hearing loss to consider broader physiological effects. The study in [2] conducted a study examining changes in heart rate, respiratory rate, and electrodermal activity due to construction noise exposure. The study found significant physiological changes linked to both the type and duration of noise exposure, highlighting the non-auditory health impacts of construction noise. These findings emphasize the need for updated noise regulations to protect both the auditory and non-auditory health of individuals exposed to such environments. Noise from construction sites is also a major source of complaints, particularly among nearby residents. Studies have shown that noise complaints correlate with noise levels, especially ambient sound levels, and are influenced by other construction-related nuisances [7]. Sleep disturbance, primarily affecting residents aged 45-54, is one of the most significant health impacts associated with construction noise [8]. Moreover, an active noise control (ANC) system, as developed by study in [9] demonstrated a broadband noise reduction of 8.3 dB, offering an advanced method for noise mitigation in open construction sites, outperforming traditional ANC systems. Effective noise control is often hindered by organizational and behavioral factors. The study in [10] found that construction workers' noise pollution control behaviors were influenced by their awareness of noise pollution's consequences and personal responsibility. The study emphasized that a construction company's environmental behavior and the personal norms of its employees play a significant role in influencing noise mitigation behaviors. Similarly, noise sensitivity in workers can lead to increased awareness of noise effects and a greater tendency to adopt protective behaviors. This relationship was found to be mediated by noise effect perception and positively influenced by a strong safety climate [3]. However, high levels of occupational noise exposure weakened these relationships, suggesting that protective behavior could be undermined by prolonged exposure.

In addition to personal and situational factors, environmental management of construction noise is critical. Active noise control methods, when applied during the construction phase, can help mitigate noise-related disputes and reduce negative effects on the surrounding community [11]. Moreover, a predictive model was developed using elastic net regression to estimate the proportion of buildings exposed to construction noise, outperforming general models and improving noise management even in areas lacking prior data [12].

Further research into the optimization of construction practices suggests that site layout planning during the preconstruction phase can significantly mitigate on-site worker noise exposure. The authors in [13] proposed the optimization of construction site layouts as a strategy to reduce noise while balancing safety and cost concerns. This approach could play a vital role in minimizing the impact of construction noise on both workers and the surrounding community. Complementing this a simulation-based framework was proposed in [14] using Web CYCLONE to optimize construction equipment allocation. Their framework used an exhaustive search technique to determine the most cost-effective and noise-reducing equipment allocation. This method resulted in a significant reduction in both direct construction costs and noise exposure, demonstrating the value of simulation in noise and cost management. Despite the growing global recognition of the adverse impacts of construction noise, effective management remains a significant challenge, particularly in developing countries. In Nepal, ambient noise standards have been established; however, enforcement is weak, and public awareness is limited. Moreover, existing research has predominantly focused on vehicular and urban traffic noise, often overlooking construction-specific noise sources. This oversight is particularly concerning given Nepal's rapid pace of urbanization and infrastructure development. Construction activities, especially the operation of heavy machinery generate significant levels of occupational and environmental noise, posing potential risks to the health, productivity, and well-being of construction workers. Kohalpur Municipality, a rapidly developing urban hub in western Nepal, exemplifies this trend. Despite its transformation into a major construction zone, there is little research addressing how noise pollution from construction activities affects workers. This gap in the literature underlines the need for targeted studies that examine both noise exposure levels and the subjective experiences of those most affected.

Table 1: Noise level standards of some countries and organizations [15].

Countries / Organization	**Noise level in dB(A)**							
	Silent zone		Residential Area		Commercial Area		Industrial Area	
	Day	Night	Day	Night	Day	Night	Day	Night
Nepal	50	40	55	45	65	55	75	70
India	50	40	55	45	65	55	75	70
Japan	45	35	50	40	60	50	60	50
US	45	35	55	45	60	50	70	60
WHO	45	35	55	45	55	55	65	65

1.1 Statement of the Research Problem

Noise pollution is a growing environmental and occupational concern in rapidly urbanizing regions, particularly in developing countries like Nepal. Among the various sources of environmental noise, construction activities, especially the operation of heavy equipment, generate high levels of noise that can negatively impact both the public and workers directly involved in such environments. Although Nepal has established ambient noise standards as shown in table (as shown in Table 1 and supported by various references), enforcement is limited, and awareness of occupational noise hazards remains low. Existing research on noise pollution in Nepal has largely focused on vehicular traffic in major urban centers, with minimal attention paid to construction-specific noise, despite the country's surge in infrastructure development. In this context, the situation in Kohalpur Municipality a fast-growing urban hub in western Nepal raises particular concern. The municipality has witnessed a significant increase in construction projects, yet there is a lack of empirical data on how noise from heavy construction equipment affects construction workers, who are routinely exposed to high noise levels. Little is known about these workers' perceptions of noise-related health and productivity impacts, their use of protective measures, or how demographic factors influence their experiences. This lack of focused research presents a critical gap, limiting the ability of local authorities, construction companies, and policymakers to implement effective noise control and worker safety strategies. Addressing this issue is essential to ensure safe, sustainable, and health-conscious development practices in emerging urban areas like Kohalpur.

1.2 *Research Objectives*

This study seeks to answer the central research question: What perceptions do construction workers in Kohalpur hold regarding the risks and impacts of construction-related noise pollution? To address this question, the study outlines several key objectives. First, it aims to assess the levels of noise pollution at selected construction sites within Kohalpur Municipality. Second, it examines construction workers’ perceptions of how noise impacts their physical and mental health as well as in social behaviour. Third, it analyzes demographic variations such as age, work experience, and educational background in how workers perceive these effects. Fourth, the study evaluates the extent to which construction workers use protective measures, such as earplugs and earmuffs, and whether they adhere to recommended noise safety practices. Finally, the research seeks to provide practical recommendations to promote sustainable and noise-conscious construction practices in similarly urbanizing regions.

1.3 Significance of study

The significance of this study lies in its contribution to addressing a critical gap in Nepal’s environmental and occupational health research. While much attention has been given to vehicular and urban noise pollution, the specific impact of construction noise particularly from heavy equipment has been largely overlooked. By focusing on the perceptions and experiences of construction workers in a rapidly developing municipality, this study provides valuable insights that can inform local authorities, construction firms, and policymakers. Its findings can help shape more effective enforcement of noise regulations, enhance occupational safety programs, and raise awareness among workers and stakeholders about the importance of managing construction-related noise pollution.

2. Methodology

This section outlines the comprehensive methodology adopted for the proposed research study as shown in Figure 1. A quantitative approach was adopted to assess both the measurable intensity of noise pollution and the subjective experiences of workers exposed to it. The study combined quantitative noise measurement with structured survey techniques to ensure a well-rounded analysis.

Noise Measurement: Real-time sound levels were recorded at ten active construction sites using the Decibel X mobile application. Data collection was conducted near heavy machinery and high-activity zones during peak working hours to ensure accurate representation of noise exposure conditions.

Survey Data: A structured, close-ended questionnaire was administered to 63 construction workers, selected through simple random sampling. The survey gathered quantifiable data on workers' awareness, perceptions, and use of protective measures regarding occupational noise exposure.

The study is presented in two sections: Section 1: Results of Sound Level Measurements at Construction Sites; Section 2: Results of the Respondent

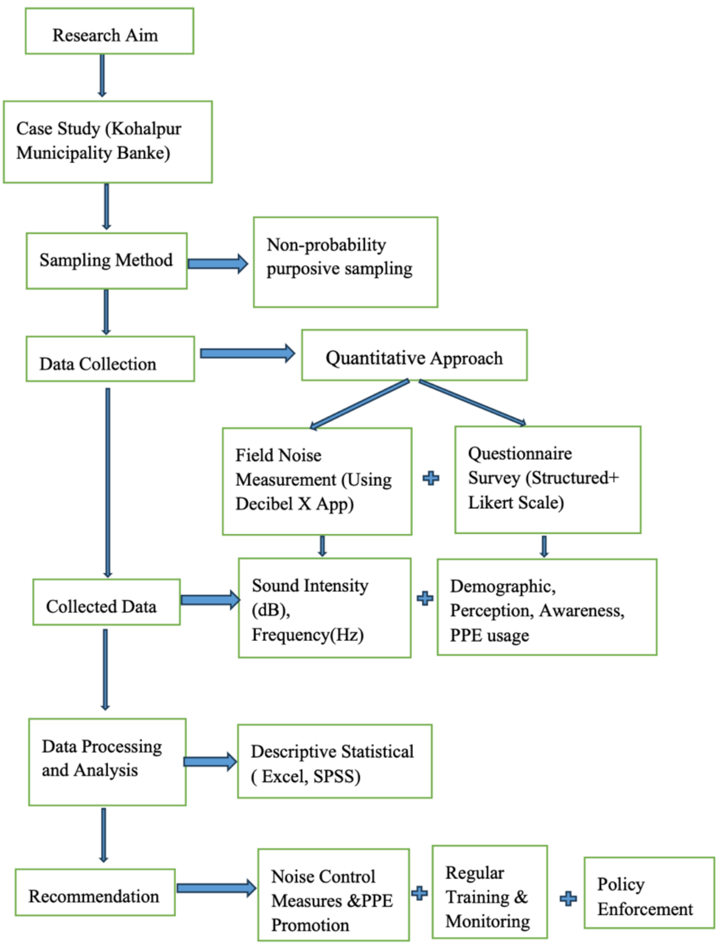

Figure 1: Methodological Flow Chart

2.1 Data Collection and Analysis

Field observations were conducted at selected construction sites to directly monitor and record noise levels produced by various construction activities and equipment, including excavators, concrete mixers, cranes, and jackhammers. A reliable mobile noise measurement application, DECIBEL X, was used for this purpose. The application was installed on an iPhone 11 Pro Max running iOS version 18.3.1 (Build 22D72). DECIBEL X provides real-time sound level readings in decibels (dB) and is commonly used for monitoring workplace noise, evaluating sound levels at public events, and offering a simple yet effective mobile-based solution. Measurements were taken near-by construction workers while they were operating equipment, at a height of 2 meters, simulating the ear level of a standing person. Standard procedures were maintained across all sites, including the use of the same device, app, time duration, and spatial orientation for consistency.

While a formal reliability test was not conducted, the use of smartphone-based noise measurement tools is supported in literature. For instance, [16] demonstrated that certain sound measurement apps for Apple smartphones and tablets may be considered accurate and reliable for assessing occupational noise exposures, particularly when measurements are taken consistently and systematically. Their results showed that some apps produced measurements within ±2 dB(A) of a Type 1 sound level meter, demonstrating acceptable accuracy.

Sound levels recorded were analyzed to determine whether they exceeded the thresholds set by the World Health Organization (WHO) and National Ambient Air Quality Standards (NAAQS) of Nepal. Survey responses were reviewed to assess the perceived impact of noise on workers' health and productivity. Descriptive statistics were used to summarize findings, and the integration of both datasets provided a more nuanced understanding of the health implications of construction noise and current safety practices.

2.2 Study Area

The study was conducted in Kohalpur Municipality located at 28° 11′ 55″ N to 81° 41′ 28″ E geographic coordinates is a second municipality in the Banke district of Lumbini province on prospective rapid urbanization after Nepalgunj. Kohalpur Municipality was selected as the study area due to its rapid urbanization, strategic location, and increasing construction activities. As a growing transportation and commercial hub in western Nepal, Kohalpur connects major highways in all directions, supporting regional trade and infrastructure development. The area has seen a surge in residential, commercial, and road construction, making it an ideal setting to study noise pollution from construction sites. Additionally, the municipality's expanding workforce and proximity to Bardiya National Park highlight the need for sustainable urban growth and informed environmental health policies. Integrated approach provides a comprehensive analysis of noise levels and evaluation and implications for workers' well-being and safety. Figure 2 shows the study area of this research.

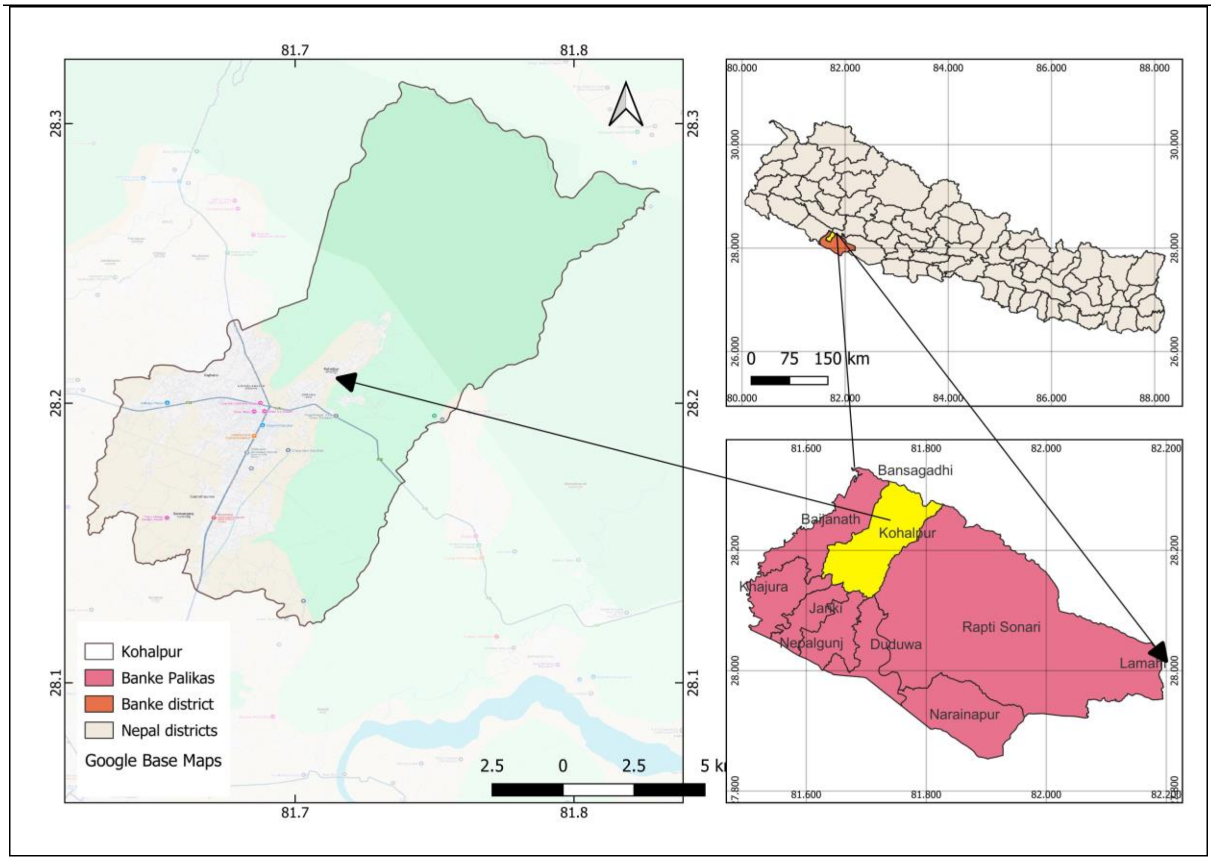

Figure 2 : Study Area

3. Results and Discussion

3.1 Reliability and Validity Test

To assess the internal consistency of the questionnaire, Cronbach's Alpha (α) was calculated for two components: the overall field survey responses and a subset of 17 Likert-scale items specifically designed to measure the perceived effects of noise pollution. The analysis yielded Cronbach's Alpha values of 0.828 for the general field survey and 0.878 for the Likert-scale items. These values indicate good to high reliability, suggesting that the items within each section are well-correlated and consistently measure their intended constructs. In general, a Cronbach's Alpha value above 0.70 is considered acceptable, while values exceeding 0.80 reflect strong internal consistency. Therefore, the results confirm that the questionnaire exhibits a high level of reliability, ensuring that the collected data are robust and suitable for further statistical analysis and interpretation. The reliability analysis affirms that the instrument effectively captures the underlying dimensions of occupational noise exposure, perception, and control behaviors among construction workers. Although no formal reliability test was conducted for the sound measurement tool, previous studies support the app's accuracy within ±2 dB(A) of professional sound meters, justifying its use for indicative assessments [16].

The validity of this study was ensured through standardized field measurements and validated survey instruments. Noise levels were recorded near active construction workers at a 2-meter height using the DECIBEL X app on an iPhone 11 Pro Max, following consistent procedures that reflect real-world exposure. The Likert-scale questionnaire was reviewed by experts and piloted to ensure content validity and contextual relevance. These steps support both the internal and external validity of the study.

3.2 Section I: Results of Sound Level Measurements at Construction Sites

Sound level measurements were conducted at multiple construction sites to assess noise emissions under two distinct conditions: (1) when equipment was in operation and (2) under normal conditions (idle or switched off). The study provides detailed insights into the noise intensity and frequency associated with various construction equipment, highlighting occupational health implications and guiding potential mitigation measures. Figure 3 shows the sound produced at construction sites.

3.2.1 Overview of Noise Levels of Construction Equipment

The measured sound levels across various construction sites reveal a consistent trend of significantly elevated noise during equipment operation compared to normal (idle) conditions. Table 2 presents detailed average (AVG) and maximum (MAX) sound levels alongside their corresponding frequency ranges.

3.2.2 Key Observations:

- The JCB Backhoe Loader exhibited the highest maximum noise level during operation at 107.3 dB, which is well above the occupational safety threshold of 85 dB
- Power Planer and Handheld Angle Grinder also recorded high operational noise levels of 96.2 dB and 95.8 dB respectively.
- Comparatively, the Sound Box had the lowest maximum noise level at 80.6 dB during operation.
- Under normal conditions (non-operational), sound levels remained mostly under the 85 dB limit, though some equipment like the Demolition Hammer (85.4 dB) still approached the upper threshold.

Figure 3: Sound Measurement at different construction sites

Table 2: Sound Level from different Sources in Construction sites.

Projects	Types of equipment	Sound level when equipment is on operation		Sound level at Normal Condition		Frequency of sound (Hz) during Equipment is on operation	Frequency of sound (Hz) at Normal Condition
		AVG	MAX	AVG	MAX		
P1	Vibrator+ Motor	76.1	82.7	68.4	82.6	652	680
P2	Hammar	70.9	92.7	68.4	82.6	474	680
P3	Cut Off Saw	85.9	90.9	55.1	72.8	699	781
P4	Concrete Mixer	75.9	82.9	61.8	79.1	844	828
P5	Concrete Mixer Truck	79.7	85.7	55.1	72.8	695	781
P6	Power Planer	88.4	96.2	62	77.5	860	643
P7	Sound Box	73.1	80.6	62.6	77.8	605	721
P8	Handheld Angle Grinder	88.9	95.8	56	63.6	5240	738
P9	Demolition Hammer	87.1	93.6	78.7	85.4	7536	773
P10	JCB Backhoe Loader	80.7	107.3	67.1	82.1	1121	791

3.2.3 Noise Frequency Characteristics

As illustrated in Figure 4, the frequency of noise emitted during equipment operation varied widely among different tools. High-frequency noise was notably prominent in:

- Handheld Angle Grinder: 5240 Hz
- Demolition Hammer: 7536 Hz
- JCB Backhoe Loader: 1121 Hz

In contrast, under idle conditions, most equipment emitted significantly lower and relatively stable frequencies (e.g., 680 Hz for Vibrator Motor and 721 Hz for Sound Box). This confirms that operational vibrations and mechanical activities are key drivers of higher frequency noise emissions, which could cause more acute auditory discomfort or damage

3.2.4 Average Sound Level Comparison

Figure 5 highlights the average noise levels across all tested equipment. During operation, almost all equipment exceeded their normal condition counterparts by a considerable margin.

Notable differences include:

- Cut Off Saw: 85.9 dB (operation) vs. 55.1 dB (normal)
- Handheld Angle Grinder: 88.9 dB (operation) vs. 56.0 dB (normal)
- Power Planer: 88.4 dB (operation) vs. 62.0 dB (normal)

This contrast emphasizes the intensity of sound generated during typical working conditions, supporting the need for real-time monitoring and the use of protective gear.

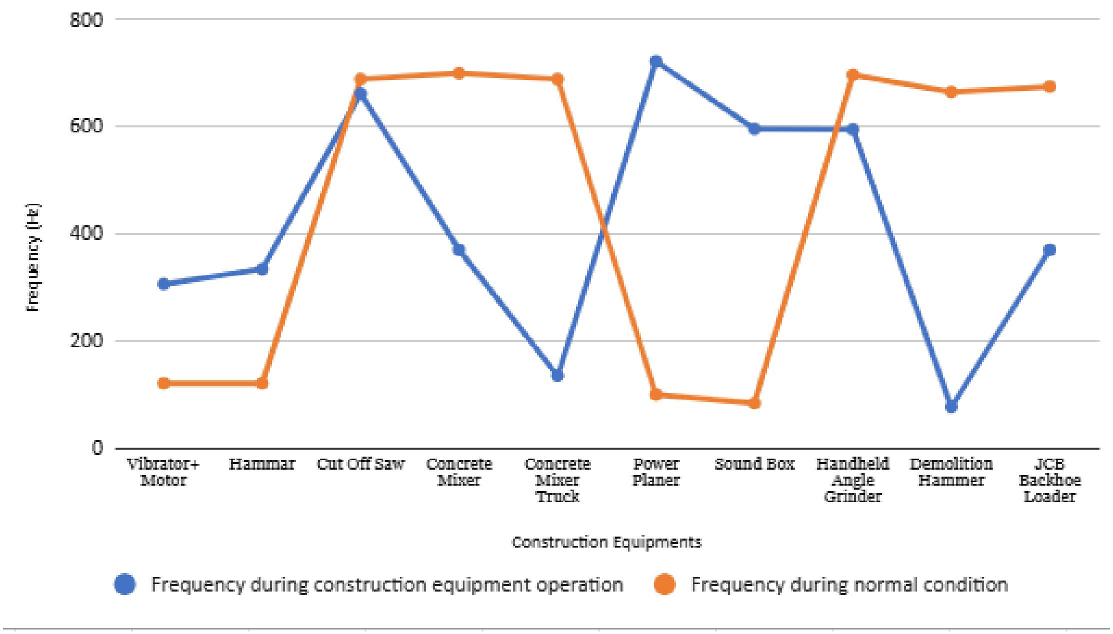

Figure 4: Frequency Ranges of Construction Equipment During Operation and Under Normal Condition

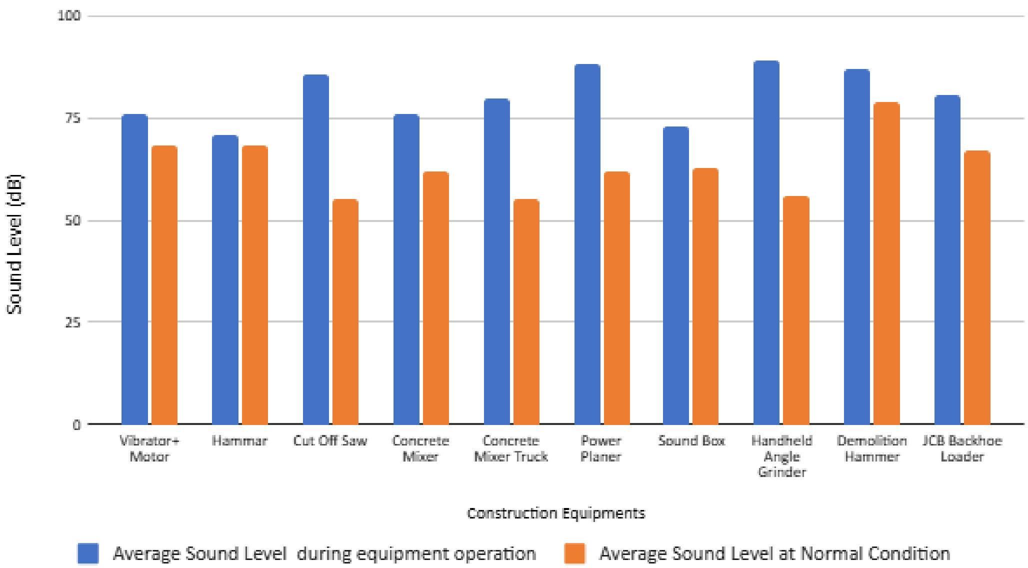

Figure 5: Comparison of Average Sound Levels During Equipment Operation and Under Normal Conditions

3.2.5 Maximum Sound Level Comparison

Figure 6 presents the maximum noise levels recorded for each equipment type in both operating and idle states. Again, a sharp rise in dB levels is evident during equipment usage. Noteworthy findings include:

- JCB Backhoe Loader: Increased from 82.1 dB (normal) to 107.3 dB (operational)
- Demolition Hammer: Increased from 85.4 dB to 93.6 dB
- Cut Off Saw: Jumped from 72.8 dB to 90.9 dB

Such peak values suggest the potential for hearing damage from even short-term exposure, underlining the urgency for engineering controls and administrative interventions.

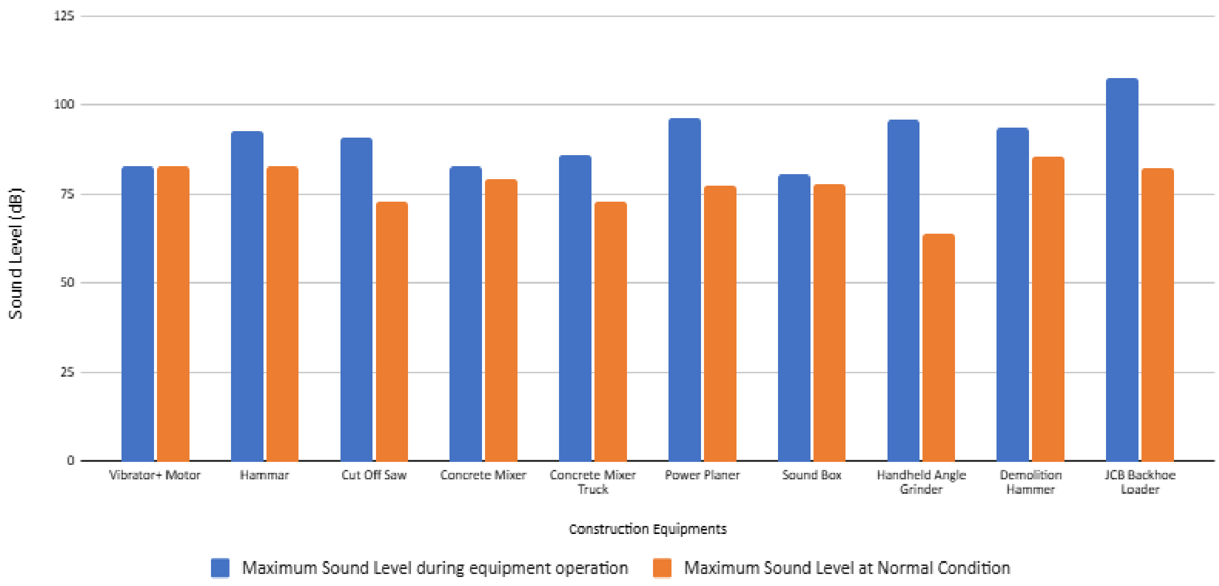

Figure 6: Comparison of Maximum Sound Levels During Equipment Operation and Under Normal Conditions

In summary, both the sound pressure levels and frequencies from construction equipment demonstrate that active operation produces noise pollution well beyond safe exposure limits in multiple instances. Equipment like the JCB Backhoe Loader, Demolition Hammer, and Power Planer pose the greatest auditory risks. These findings stress the importance of incorporating noise control measures in construction safety protocols, including regular maintenance, use of silencers, and enforcement of personal protective equipment (PPE) usage.

3.3 Section II: Results of the Respondents

3.3.1 General Characteristics of the Respondents

The demographic profile of the respondents provides essential context for interpreting their perceptions of construction site noise pollution. Respondents' ages ranged from 20–30 years to over 60 years. The majority (53.97%) were in the 20–30 age group, indicating that early-career individuals formed the bulk of the sample, which may influence their tolerance and awareness of noise impacts. The gender distribution showed a male dominance, with 76.2% males and 23.8% females. This skewed representation is likely reflective of existing occupational trends in the construction industry. Work experience varied, with 52.4% having

0–5 years of experience, 14.3% with 5–10 years, and 23.8% having 10–20 years of experience. This again emphasizes the prominence of early-career professionals in the survey. Occupational roles were distributed across various construction sectors. A significant 72.7% were involved in building construction, followed by 14.3% in highway construction. This diversity suggests varying exposure and responses to noise pollution based on the type of construction activity.

3.2 Perceptions and Awareness of Noise Pollution

Respondents' perceptions of noise revealed that 66% experienced unwanted noise that significantly disrupted their daily activities. In contrast, 34 % reported adapting to the noise over time as shown in Figure 7 .

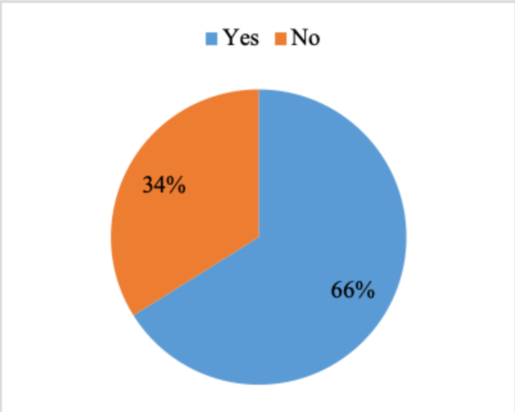

Figure **7** :Perception of Unwanted Noise

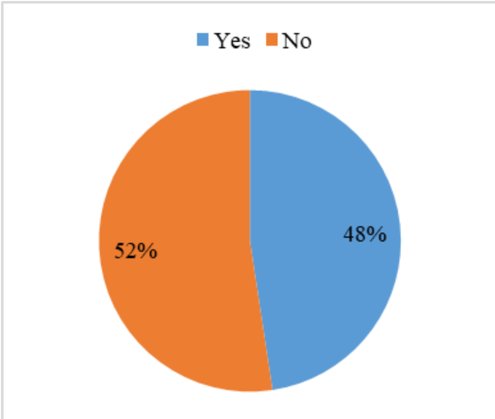

Figure 8 : Awareness of Effects of Noise Pollution

Awareness regarding the effects of noise pollution was generally low. As seen in Figure 8, 48% of respondents had limited awareness, while 52 % were entirely unaware of its health impact. This suggests a critical knowledge gap among construction workers.

3.3.3 Exposure to Noise

Exposure levels varied depending on the work environment and activity. About 33.3% reported being exposed to noise for 2–4 hours daily, especially when using machinery. Meanwhile, 31.7% indicated exposure exceeding 6 hours, particularly in urban sites and among machinery operators.

Noise pattern analysis showed that 65.1% perceived no consistent pattern of noise, reinforcing the sporadic and disruptive nature of equipment operation. 55.6% of respondents rated noise levels as moderate, 27% rated them as high, and 4.8% rated them as very high. Interestingly, some who perceived noise as moderate had become habituated, viewing it as part of their work.

3.3.4 Sources of Noise Pollution

The respondents highlighted heavy machinery (e.g., bulldozers, cranes, mixers) as the leading noise source, cited by 45.7% of participants. Power tools accounted for 27.2%, traffic for 18.5%, and human activities such as shouting for 6.2%. Other sources, like speakers and DJs, were noted by 2.5%.

Hearing assessments were rare: only 15.9% had undergone a formal hearing test. Awareness of long-term health effects was also limited, with 58.7% unaware of the associated risks like cardiovascular stress, hearing loss, and cognitive decline.

3.3.5 Noise Control and Protective Measures

Noise control practices were largely absent. 87.3% reported no measures implemented at their workplaces. Only 12.7% observed any form of control, such as scheduled breaks or PPE usage, and even these were inconsistent.

PPE usage was minimal. Only 12.7% occasionally used hearing protection (e.g., earplugs or earmuffs), while 3.2% used them in special conditions like illness. A significant 84.1% had never used or even seen PPE at work.

The main reason for non-use of PPE, reported by 58.7%, was that employers did not provide it. Other reasons included discomfort (7.9%), lack of awareness (20.6%), concern about communication interference (4.8%), and unspecified reasons (7.9%).

Noise level monitoring was virtually non-existent: 85.7% confirmed no monitoring, and 14.3% were unsure. Importantly, 100% of respondents reported never attending any training on noise exposure risks, highlighting a critical gap in workplace safety education.

3.3.6 Workplace Policy and Recommendations

19, 36.5% of respondents believed that noise levels at their sites exceeded safe limits, while 33.3% had no idea about acceptable limits.

Very few respondents (3.2%) had reported concerns to supervisors. A large majority (86.8%) had never raised any concern, citing fear of being ignored, lack of knowledge about regulations, or a belief that noise is an unavoidable aspect of construction work.

Encouragingly, 63.5% expressed willingness to participate in noise awareness programs, suggesting a readiness to learn about protective strategies and regulations.

In terms of employer support, 33% of workers requested better-quality hearing protection, 22.3% suggested noise-reduction measures, 15.5% wanted health check-ups, and 13.6% recommended regular noise assessments.

3.4 Perceptions of the Effects of Noise Pollution

The findings of this study reveal diverse levels of perception regarding the effects of noise pollution on health, mental well-being, workplace performance, communication, and psychological states as shown in Table 3 and described below.

Table 3: Perceived Effects of Noise Pollution Based on Likert-Scale Responses

Effects of noise pollution	1(%)	2(%)	3(%)	4(%)	5(%)	Mean	SD	Decision
Hearing Loss	69.8	20.6	7.9	1.6	0	1.41	0.71	Low Perception
Sleep Disturbances	52.4	12.7	33.3	1.6	0	1.84	0.954	Low Perception
Unable Focus	44.4	34.9	15.9	4.8	0	1.81	0.877	Low Perception
Miscommunication of misinterpret information	19	14.3	11.1	38.1	17.5	3.21	1.405	High Perception
Change in blood pressure and body temperature	63.5	19	15.9	1.6	0	1.56	0.819	Low Perception
Cardiovascular/ Heart Disease	81	12.7	6.3	0	0	1.25	0.567	Low Perception

Increased Stress Level	30.2	39.2	20.6	9.5	0	2.1	0.946	High Perception
Reducing working performance	47.6	30.2	15.9	6.3	0	1.81	0.931	Low Perception
Annoyance/ Irritation	19	19	44.4	15.9	1.6	2.62	1.023	High Perception
Social Behavior Change	39.7	38.1	14.3	4.8	3.2	1.94	1.014	Low Perception
Workplace accidents and injuries by making it difficult to hear warning signals	76.2	7.9	14.3	1.6	0	1.41	0.796	Low Perception
Headaches and migraines	36.5	20.6	41.3	1.6	0	2.08	0.921	High Perception
Mental fatigue	31.7	28.6	30.2	7.9	1.6	2.19	1.03	High Perception
Mood Disorders	56.5	24.2	16.1	3.2	0	1.66	0.867	Low Perception
Decreased Job Satisfaction	25.4	12.7	44.4	15.9	1.6	2.56	1.089	High Perception
Frustration	31.7	12.7	42.9	11.1	1.6	2.38	1.099	High Perception
Ringing Ears	58.7	23.8	14.3	3.2	0	1.62	0.851	Low Perception

3.4.1 Health-Related Perceptions

Hearing Loss was perceived as a minimal risk, with a low mean score of 1.41. This is concerning given the well-established correlation between long-term noise exposure and auditory damage. The low rating may stem from the delayed onset of symptoms or a general lack of awareness. Similarly, Cardiovascular and Heart Disease was rated with the lowest perception (1.25), suggesting that respondents are largely unaware of the link between chronic noise exposure and cardiovascular issues such as hypertension. Changes in Blood Pressure and Body Temperature received a mean of 1.56, reinforcing the limited association made between noise and physiological stress responses. Ringing in the Ears (Tinnitus) also had a low perception (1.62), potentially due to a lack of understanding or personal experience. In contrast, Headaches and Migraines were rated higher (2.08), indicating that some physical symptoms of noise exposure are more readily recognized by respondents.

3.4.2 Mental Well-being and Work Performance

The effects of noise on mental functioning received mixed responses. Sleep Disturbances (1.84) and Inability to Focus (1.81) were both rated as low perception items, despite well-documented links between noise and reduced sleep quality and concentration. However, Increased Stress Levels was rated with a high perception (2.10), reflecting a clear recognition of the emotional strain induced by noise. Similarly, Mental Fatigue was rated even higher (2.19), suggesting awareness of the cumulative toll of noise exposure on mental energy and productivity. Reduced Work Performance, despite its relevance, received a low perception score (1.81), implying that workers may undervalue the influence of noise on their efficiency.

3.4.3 Communication and Social Behavior

Miscommunication or Misinterpretation of Information was the most highly rated item (3.21), highlighting strong awareness of how noise interferes with verbal communication, particularly in work settings. This underscores the importance of effective noise control and acoustic design in such environments. Social Behavior Change had a low mean score (1.94), suggesting that respondents did not perceive noise as significantly affecting interpersonal behavior. Likewise, Workplace Accidents and Injuries due to difficulty hearing warning signals were rated low (1.41), possibly due to minimal recorded incidents or a general underestimation of this risk.

3.4.4 Psychological Effects

The psychological impact of noise pollution was more widely acknowledged. Annoyance and Irritation had a high mean score of 2.62, aligning with literature that associates noise exposure with discomfort and irritability. Mood Disorders, however, were perceived with low concern (1.66), indicating limited recognition of noise as a contributor to emotional health issues. Decreased Job Satisfaction (2.56) and Frustration (2.38) were both perceived as high, suggesting that noise-related emotional fatigue may indirectly influence morale and job fulfillment.

4. Conclusions

This study on construction noise pollution in Kohalpur Municipality provides valuable insights into the sources, perceptions, and impacts of construction-related noise on workers and surrounding communities. The findings reveal that while general ambient noise frequencies remain stable, construction equipment such as handheld angle grinders, demolition hammers, and JCB backhoe loaders produce fluctuating and often higher noise frequencies, frequently exceeding recommended safety thresholds.

This aligns with previous studies [2], [4] that highlighted the significant challenges posed by construction noise, particularly in rapidly developing urban areas.

Demographic factors such as age, experience, and education level were found to influence workers' perceptions and awareness of construction noise. While many workers reported disruption from construction noise, a lack of awareness about the broader physical, psychological, and social risks of chronic exposure remained a key issue. This finding is consistent with research by [10], who found that workers' noise pollution control behavior was influenced by their awareness of noise pollution's consequences. However, many workers were not fully cognizant of the long-term health risks associated with noise, indicating a need for better education and training programs on noise pollution.

The study also identified a significant gap in the implementation of noise control measures, including a lack of regular training, personal protective equipment (PPE), and noise monitoring. These findings align with existing research on the challenges of managing construction noise and the effectiveness of preventive measures [3], [11]. However, despite these shortcomings, many workers expressed a willingness to participate in workplace noise awareness programs, suggesting a potential for adopting better noise control practices if adequately trained and equipped. In terms of health impacts, the study found that noise exposure led to both auditory and non-auditory effects, such as frustration, mental fatigue, and reduced job satisfaction, like the findings of [2] and[8] . The physiological effects, including heart rate and respiratory changes, echo the broader health impacts noted in prior studies, underscoring the need for updated noise regulations to safeguard workers and community health. Finally, the study's findings confirm the importance of effective noise control through site layout planning, equipment selection, and the implementation of active noise control (ANC) systems. Research by [14]and [13] on optimizing construction practices and using simulation-based frameworks to reduce noise exposure and costs reinforces the significance of these approaches.

Hence this study assessed the levels and implications of occupational noise exposure in construction sites within Kohalpur Municipality, Nepal. It revealed high noise levels associated with heavy equipment use, gaps in protective behavior despite awareness, and limited on-site noise optimization practices. While earlier research has emphasized laboratory-based assessments or urban traffic noise, this study fills a critical gap by providing real-world insights from an under-researched developing context. Moving forward, integrating behavioral training, smarter equipment scheduling, and stronger regulation enforcement will be key to protecting workers and communities from the adverse effects of construction noise. The findings underscore the urgent need for localized, data-driven noise management policies in Nepal's growing urban centers.

Recommendations

1. *Implement Comprehensive Noise Control Measures:*
   - Install noise barriers, acoustic enclosures, and insulation around noisy machinery to minimize sound propagation, aligning with the findings of [11] on active noise control during construction.
   - Prioritize the use of low-noise machinery and encourage the design and purchase of quieter equipment to reduce the overall noise generated on-site, as suggested by [9] .

2. *Ensure Effective Use of Personal Protective Equipment (PPE):*
   - Provide high-quality earplugs and earmuffs to workers exposed to elevated noise levels. Regular training should be conducted to ensure proper use of PPE.
   - Mandate the use of hearing protection for all workers operating near heavy machinery or in noisy environments, as emphasized in research by [17].
3. *Regular Noise Monitoring and Adherence to Regulations:*
   - Conduct routine noise assessments at construction sites to monitor noise levels, ensuring compliance with local and international noise standards, similar to the model developed by [5] using elastic net regression for noise management.
   - Ensure construction sites adhere to noise regulations, particularly those set by bodies like OSHA, and maintain detailed records to track noise exposure.
4. *Raise Awareness Through Training and Education:*
   - Implement noise awareness and safety training for both workers and supervisors to educate them about the health risks of noise pollution. This aligns with research by [3] on noise sensitivity and its relation to protective behaviors.

- Foster a safety-first culture in which workers are encouraged to report excessive noise concerns, and their feedback is valued, thereby increasing worker engagement in noise management practices.

5. *Noise Reduction Through Strategic Site Layout and Scheduling:*
   - Plan construction sites with noise reduction in mind, separating high-noise areas from the workers' primary work zones. This approach is supported by [13] and should be incorporated into preconstruction site planning.
   - Implement work shifts to limit exposure time to noisy activities, ensuring a balance between safety, productivity, and worker well-being.
6. *Health Monitoring and Early Detection:*
   - Provide annual hearing tests and integrate regular health check-ups to detect any noise-induced hearing damage, like recommendations by [17].
   - Include noise-related health evaluations in workplace safety programs, ensuring early intervention for workers experiencing health issues related to construction noise exposure.
7. *Employer Responsibility and Policy Enforcement:*
   - Employers should proactively reduce noise hazards by ensuring the availability of appropriate PPE and implementing noise control policies, as suggested by [10].
   - Strict enforcement of noise control policies should be a priority, and workers should be educated about the long-term consequences of noise-induced hearing loss, with compensation provided for any job-related hearing impairment.

Despite the potential benefits, optimization practices at the studied sites were minimal. Lack of formal planning, poor coordination, and limited awareness among contractors hindered the effective implementation of noise-reducing strategies. Future projects should prioritize noise optimization during the preconstruction and operational phases by integrating planning tools, training site managers, and mandating noise-reduction strategies as part of the construction permit process.

By implementing these recommendations, construction sites in Kohalpur Municipality and similar rapidly developing regions can reduce the risks associated with noise exposure. Combining noise control measures, effective PPE usage, training, health monitoring, and strong employer policies will enhance worker safety, improve health outcomes, and increase overall productivity. Furthermore, these efforts can create safer, more sustainable work environments while contributing to the broader management of environmental noise pollution.

Limitations and Further Studies

This study, while offering valuable insights into construction noise exposure in Kohalpur Municipality, has several limitations:

1. Geographic Limitation: Findings are specific to Kohalpur and may not apply to other urban or rural settings with different construction practices or noise regulations.
2. Cross-Sectional Design: The use of a single-time data collection limits the ability to assess long-term effects of noise exposure on health and behavior. Longitudinal research is needed for deeper insights.

3. Focus on Workers Only: The study primarily examined construction workers and did not assess the impact of noise on nearby residents, a critical area for future research.
4. Lack of Economic Evaluation: The financial feasibility and effectiveness of noise control measures like low-noise equipment or barriers were not analyzed, limiting practical implementation planning.
5. Organizational and Policy Factors: Broader influences such as site management practices, enforcement of regulations, and safety culture were not explored, though they play a crucial role in shaping noise mitigation behaviors.
6. Structured Likert Scale: While the study effectively captured general awareness and perception of noise pollution, the current Likert-scale questionnaire primarily assessed overall impacts rather than equipment-specific perceptions. Structured Likert-scale items for individual equipment types were not included. Incorporating such items in future research would improve the ability to correlate subjective perceptions with objective field measurements, offering deeper insight into equipment-specific risks and mitigation needs.

Despite these limitations, the study contributes to understanding occupational noise exposure in developing urban areas. Future research should include multi-site assessments, long-term data, community impact analysis, and cost-effectiveness of mitigation strategies to inform more comprehensive policy and practice.

Conflicts of Interest Statement

The authors declare no conflicts of interest for this study.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

1. A. M. Wani, "Noise Pollution Due to Construction Activities," 2021.
2. M. Mir, F. Nasirzadeh, H. Bereznicki, P. Enticott, S. Lee, and A. Mills, "Construction noise effects on human health: Evidence from physiological measures," Sustain. Cities Soc., vol. 91, p. 104470, Apr. 2023, doi: 10.1016/j.scs.2023.104470.
3. D. Chong, L. Chen, Y. Peng, and A. Yu, "Occupational noise-related perception and personal protection behavior among Chinese construction workers," Saf. Sci., vol. 147, p. 105629, Mar. 2022, doi: 10.1016/j.ssci.2021.105629.
4. H. P. Lee, Z. Wang, and K. M. Lim, "Assessment of noise from equipment and processes at construction sites," Build. Acoust., vol. 24, no. 1, pp. 21–34, Mar. 2017, doi: 10.1177/1351010X16678218.
5. J. Y. Hong, B. Lam, Z.-T. Ong, K. Ooi, W.-S. Gan, and S. Lee, "A multidimensional assessment of construction machinery noises based on perceptual attributes and psychoacoustic parameters," Autom. Constr., vol. 140, p. 104295, Aug. 2022, doi: 10.1016/j.autcon.2022.104295.
6. S. C. Lee, J. H. Kim, and J. Y. Hong, "Characterizing perceived aspects of adverse impact of noise on construction managers on construction sites," Build. Environ., vol. 152, pp. 17–27, Apr. 2019, doi: 10.1016/j.buildenv.2019.02.005.
7. A. Pinsonnault-Skvarenina et al., "Construction of a large road infrastructure in a metropolitan area; what can the analysis of community complaints to noise tell us?,"

Environ. Impact Assess. Rev., vol. 106, p. 107504, May 2024, doi: 10.1016/j.eiar.2024.107504.
8. J. Xiao, X. Li, and Z. Zhang, "DALY-Based Health Risk Assessment of Construction Noise in Beijing, China," Int. J. Environ. Res. Public. Health, vol. 13, no. 11, p. 1045, Oct. 2016, doi: 10.3390/ijerph13111045.
9. A. Mostafavi and Y.-J. Cha, "Deep learning-based active noise control on construction sites," Autom. Constr., vol. 151, p. 104885, Jul. 2023, doi: 10.1016/j.autcon.2023.104885.
10. M. Kaluarachchi, K. G. A. S. Waidyasekara, and R. Rameezdeen, "Antecedents of noise pollution control behaviour of employees of construction companies," Built Environ. Proj. Asset Manag., vol. 12, no. 2, pp. 277–292, Feb. 2022, doi: 10.1108/BEPAM-04-2020-0071.
11. N. Kwon, M. Park, H.-S. Lee, J. Ahn, and M. Shin, "Construction Noise Management Using Active Noise Control Techniques," J. Constr. Eng. Manag., vol. 142, no. 7, p. 04016014, Jul. 2016, doi: 10.1061/(ASCE)CO.1943-7862.0001121.
12. J. Hong, H. Kang, T. Hong, H. S. Park, and D.-E. Lee, "Development of a prediction model for the proportion of buildings exposed to construction noise in excess of the construction noise regulation at urban construction sites," Autom. Constr., vol. 125, p. 103656, May 2021, doi: 10.1016/j.autcon.2021.103656.
13. X. Ning, J. Qi, C. Wu, and W. Wang, "Reducing noise pollution by planning construction site layout via a multi-objective optimization model," J. Clean. Prod., vol. 222, pp. 218–230, Jun. 2019, doi: 10.1016/j.jclepro.2019.03.018.
14. H. Baek, S. Jung, J. Hong, and T. Hong, "Simulation-based framework for optimal construction equipment allocation considering construction noise emissions," J. Asian Archit. Build. Eng., vol. 22, no. 5, pp. 2959–2976, Sep. 2023, doi: 10.1080/13467581.2023.2172324.
15. K. B. Rayamajhi, "Assessment of Noise Pollution in Different Hatbazars of Butwal City, Rupandehi, Nepal," Himal. Phys., pp. 61–64, Oct. 2017, doi: 10.3126/hj.v6i0.18362.
16. C. A. Kardous and P. B. Shaw, "Evaluation of smartphone sound measurement applications," J. Acoust. Soc. Am., vol. 135, no. 4, pp. EL186–EL192, Apr. 2014, doi: 10.1121/1.4865269.
17. E. A. Masterson and C. L. Themann, "Prevalence of hearing loss among noise-exposed U.S. workers within the Construction sector, 2010–2019," J. Safety Res., vol. 92, pp. 158–165, Feb. 2025, doi: 10.1016/j.jsr.2024.11.005.