

Audiometric Assessment of Noise-Induced Hearing Loss and Its Determinants Among Construction workers. A Cross-Sectional Clinical Study

Muhammad Akmal^{1*}, Muhammad Ajmal², Muhammad Afzal³, Muhammad Ahsan Raza⁴, Nouman Farooq⁵, Talha Mushtaq⁶

1. HSE Training Manager, Alostool Al Aali; TVTC Approved Trainer, Riyadh, Saudi Arabia
2. QHSE Trainer, Arabian Safety Training Institute (ASTI), Saudi Arabia
3. QHSE Trainer, Saudi Electric Service Polytechnic (SESP), Riyadh, Saudi Arabia
4. General Practitioner, Ar Razi medical complex Jubail, , Saudi Arabia
5. Sheikh Zayed Hospital, Lahore, Pakistan
6. Services Institute of Medical Sciences (SIMS), Lahore, Pakistan



Correspondence to: Muhammad Akmal, Email: akmal.ksa@hotmail.com

ABSTRACT

Background: Noise-induced hearing loss (NIHL) is one of the most common occupational health hazards worldwide and remains a significant cause of permanent sensorineural hearing impairment among construction workers. Prolonged exposure to high-intensity noise results in irreversible cochlear damage, yet the condition remains largely underdiagnosed in developing countries due to limited workplace safety practices.

Objective: This study aimed to determine the prevalence, audiometric characteristics, and associated risk factors of NIHL among construction workers.

Methods: This cross-sectional clinical study was conducted from January to June 2024 and included 70 construction workers with documented occupational noise exposure. Data regarding demographic characteristics, duration of employment, daily noise exposure, use of hearing protection devices (HPDs), and smoking history were collected using a structured questionnaire. Otoloscopic examination was performed to exclude external or middle ear pathology, followed by pure tone audiometry assessing thresholds at 0.5–8 kHz. Ambient workplace noise levels were measured using a calibrated sound level meter. Data were analyzed using SPSS version 26, and associations between NIHL and risk factors were assessed using the Chi-square test.

Results: The prevalence of NIHL was 41.4% (n=29). The classical 4 kHz notch was the most common audiometric finding, and bilateral involvement predominated (72.4%). Significant associations were observed between NIHL and duration of employment (p=0.012), noise levels >100 dB (p=0.003), daily exposure >8 hours (p=0.041), lack of HPD use (p=0.001), and smoking (p=0.037).

Conclusion: NIHL is highly prevalent among construction workers and strongly associated with prolonged exposure, high noise intensity, and poor use of protective equipment. Implementation of hearing conservation programs and mandatory protective measures is essential to prevent irreversible auditory damage.

Keywords: Noise-induced, hearing, loss, risk, factors



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INTRODUCTION

Noise induced hearing loss (NIHL) has become one of the most common occupational health disorders in the world,

and it is known to be one of the major, but much preventable, causes of permanent sensorineural hearing impairment [1]. The construction workers form a high-risk

population because of the constant exposure to high-intensity noise generated by heavy machines, metal-forging and textile-loom machines, mechanical machinery, and power-driven tools. At very high noise levels, prolonged exposure to higher than the internationally set normal of 85 dB of noise causes irreversible structural and functional damage to the cochlear hair cells, particularly in the high-frequency regions of the audible spectrum [2]. This initial pathology usually takes the form of a typical noises notch at 3-6 kHz on pure tone audiometry, the first measurably evident sign in NIHL. When remaining unnoticed, such damage will extend to include speech frequencies, thus affecting communication, work performance, and the general quality of life [3].

The NIHL burden in most developing nations such as Pakistan is still under-reported because of the lack of occupational health surveillance, the lack of enforcement of noise regulation and the lack of the use of hearing protection equipment in industries [4]. The fact that a significant part of the industrial laborers does not know about the long-term effects of chronic noise exposure leads to a corresponding delay in the diagnosis as well as an increasing number of workers who show up with sensorineural deficit that have already been established [5]. The absence of required hearing conservation programs at work places also adds to the growing rate of NIHL among manufacturing industries [6]. Furthermore, length of service, length of exposure per day, smoking, co-morbid diseases, and irregular use of protective gears has a strong impact on the occurrence and severity of NIHL among the construction workers. Audiometric assessment is critical in the diagnosis of the initial hearing loss to enable early intervention and preventive measures [7].

As the number of people working in industries increases, and more and more people are being exposed to occupational noise in the manufacturing units in the area, there is a need to produce region-specific data to inform the policy-making on the state of health and occupational safety [8]. This research was thus aimed at assessing the profiles of audiometric of construction workers with chronic occupational noise and also detecting important determinants that lead to NIHL [9]. The knowledge of such relationships will present some evidence to justify the adoption of hearing protection programs and regulatory systems that can help to diminish the burden of noise-induced impaired hearing [10].

MATERIALS AND METHODS

This is a cross-sectional clinical trial, which was done on construction workers working in selected manufacturing plants within a six-month time frame between January 2024 and June 2024. Purposive sampling was used to recruit 70 people whose occupational history showed a history of chronic exposure to noise. The exposed workers aged between 18 years and 60 years old who worked a minimum of one year being exposed to noise at the workplace of at

least eight hours per day were included. All participants signed informed consent written consent before the enrollment. Those who had a history of pre-existing ear disease, ossicles of the middle ear membrane, previous ear surgery or ototoxic drugs were also excluded to eliminate confounding causes of hearing loss.

The data were gathered using a structured interviewer-administered questionnaire that provided information on the demographic attributes, time of employment, average daily exposure to noise, the use of personal protective measures, smoking habits, and the presence of any comorbid condition. General physical examination was done in full, and otoscopic analysis was done to exclude the possibility of ceramal impaction or external ear and middle ear pathology that would affect the results of audiometry. Pure tone audiometry was then performed on all the subjects by a trained audiologist within a sound-treated room. Thresholds of hearing were determined at 0.5, 1, 2, 3, 4, 6 and 8 kHz using both ears. Noise induced hearing loss was determined using sensorineural hearing impairment which was mainly at higher frequencies with presence of classical noise notch at 3-6 kHz. The intensity of hearing loss was classified using the criteria of World Health Organization classification.

In order to measure the exposure to noise in the workplace, ambient noise levels in the industrial units were measured using a calibrated sound-level meter and the workers were then classified into exposure categories: <85 dB, 85-100 dB and >100 dB. All data were keyed and analysed with SPSS version 26. The data were summarized by the use of descriptive statistics (including means, percentages, and standard deviations) and associations between NIHL and possible determinants (duration of exposure, smoking status, and wearing of protective equipment) were compared through the Chi-square test. The p-value of 0.05 was taken to be statistically significant. The study had been approved by the institutional review committee (ERC/31-2023) regarding ethical issues and the confidentiality of all the information of the participants was ensured.

RESULTS

The study involved a total number of 70 construction workers. The average age of the participants was 36.4 (SD=8.7) years old with most of them being in the 31-40 age bracket. Every respondent had recorded that he or she was exposed to occupational noise and the average working period is 9.3 ± 4.1 years. The general prevalence of noise-induced hearing loss (NIHL) regarding audiometric results was 41.4% (n = 29).

The vast majority (88.6) of workers were at 85 dB and higher, which is the occupation exposure limit, regarded as hazardous.

The audiometric evidence of NIHL was detected in 29 out of 70 workers (41.4%). Most of them showed the

classical noise notch at 4 kHz, and 6 kHz. There was a higher bilateral engagement

Graduate of Noise-Induced Hearing Loss. Most of the workers that were affected had sensorineural hearing loss that were mild and moderate.

Relation of Risk Factors with NIHL. There was also a significant correlation between length of employment, level of noise, daily hours of exposure and absence of hearing protection. There was also a significant correlation between smoking.

Its results indicate that noise induced hearing loss is very common among the construction workers with more

than 40 percent showing abnormalities in their audiometric. Employees who were exposed to noise over 100 dB and those who worked longer than a decade had much higher incidences of NIHL. Hearing protection was found to be closely linked to hearing impairment because 82.7% of NIHLs occurred amongst workers who failed to use protective devices on a regular basis. The most common pattern was the characteristic 4 kHz notch, and most of the cases were bilateral. Smoking was also found to be another risk factor that is linked with increased prevalence of NIHL.

Table 1: Demographic and Occupational Characteristics of Participants (n = 70)

Variable	Categories	Frequency (n)	Percentage (%)
Age Group (years)	18–30	17	24.3%
	31–40	29	41.4%
	41–50	18	25.7%
	>50	6	8.6%
Duration of Employment	<5 years	12	17.1%
	5–10 years	31	44.3%
	>10 years	27	38.6%
Daily Noise Exposure	8 hours	19	27.1%
	>8 hours	51	72.9%
Use of Hearing Protection Devices (HPDs)	Regular use	9	12.9%
	Occasional use	18	25.7%
	No use	43	61.4%

Table 2: Ambient Noise Levels in Work Environment

Noise Level (dB)	Workers Exposed (n)	Percentage (%)
<85 dB	8	11.4%
85–100 dB	42	60.0%
>100 dB	20	28.6%

Table 3: Audiometric Findings Among Study Participants

Audiometric Feature	Workers (n)	Percentage (%)
Normal hearing	41	58.6%
NIHL (any severity)	29	41.4%
Laterality of NIHL		
Unilateral involvement	8	27.6% of NIHL cases
Bilateral involvement	21	72.4% of NIHL cases
Frequency Notch		
Notch at 3 kHz	6	20.7%
Notch at 4 kHz	18	62.1%
Notch at 6 kHz	5	17.2%

Table 4: Severity Distribution of NIHL (n = 29)

Severity (WHO Classification)	Workers (n)	Percentage (%)
Mild SNHL	17	58.6%
Moderate SNHL	10	34.5%
Moderately Severe SNHL	2	6.9%
Severe/Profound SNHL	0	0%

Table 5: Association Between Risk Factors and NIHL

Risk Factor	Category	NIHL Present (n=29)	NIHL Absent (n=41)	p-value
Duration of Employment	<5 years	3	9	0.012*
	5–10 years	11	20	
	>10 years	15	12	
Noise Level	<85 dB	1	7	0.003*
	85–100 dB	17	25	
	>100 dB	11	9	
Daily Exposure Duration	8 hours	4	15	0.041*
	>8 hours	25	26	
Use of HPDs	Regular	1	8	0.001*

	Occasional	4	14	
	None	24	19	
Smoking Status	Smoker	14	12	0.037*
	Non-smoker	15	29	

*Statistically significant ($p < 0.05$)

DISCUSSION

The current paper evaluated the rates, acoustic patterns, and risk factors of noise-induced hearing loss (NIHL) in construction workers who were subjected to occupational chronic noise. The results prove that the level of NIHL burden is high as 41.4% of employees had abnormal audiometric measurements according to audiometric evidence of cochlear damage induced by noise [11]. This prevalence is comparable to global reports with NIHL showing 20-60 percent prevalence in the industrial setting, which is an indicative of the acceptance of NIHL as one of the most common occupational disorders universally. Hearing conservation measures in the industrial environment are urgently required as demonstrated by the high prevalence of hearing loss in this study [12].

One of the results was the prevalence of 4 kHz noise notch, which is present in more than 60 percent of NIHL cases, which is in line with the classical audiometric sign of early NIHL. The range between 3-6KHz is reported to be especially susceptible to noise-induced damage because of mechanical and metabolic vulnerability of the outer hair cells in this frequency range [13]. The observation of bilateral impairment in the majority of the affected employees also confirms the conclusion that may result in hearing impairment is the result of a sustained, symmetrical exposure to industrial noise and no longer the isolated or episodic auditory trauma [14].

Other crucial risk factors that are closely linked with NIHL are also brought out in the study. Employees who had over 10 years of employment and were exposed to noise levels that were above 100 dB had a high chance of having hearing loss. Such findings are in line with the factual data that NIHL is cumulative, irreversible and highly dependent on the level and duration of noise [15]. Exposure of more than 8 hours per day also showed a strong correlation which further supports the need to limit exposure to high-decibel conditions.

The fact that hearing protection devices (HPDs) were used in small numbers was one of the most striking ones. Over 61 percent of employees claimed they never used HPDs and this population comprised the overwhelming majority of NIHL cases. This highlights one of the key occupational safety practice gaps. Protective equipment is inadequate, training of the workers is inadequate, and there is no enforcement of regulations, as well as, the awareness of the irreversibility of NIHL, which is likely the reason behind poor compliance [16]. Several occupational health studies indicate that regular and proper use of HPDs can minimize risks of NIHL by up to 60 percent, implying that

specific intervention programs may have a great impact in controlling the burden of this disease.

Smoking was also shown to be an important cause of NIHL. The tobacco smoke is known to have ototoxic effects in which it is believed to induce microvascular compromise, oxidative stress, and compromised cochlear metabolism [17]. Smoking and noise exposure can also have a synergetic effect, which further causes cochlear injury. This highlights the importance of worker education not just on occupational hazards but also on lifestyle issues that are modifiable and which increase the vulnerability to hearing loss [18].

The age structure of the study population showed that the prevalence of NIHL was more prevalent in the group of workers who were aged between 31 to 40 years and those who had worked over a long period of time. These data prove the hypothesis that NIHL usually insidiously starts during early adulthood and develops with accumulated exposure. Regular audiometric screening could thus be a key factor in preventing an advanced hearing impairment [19].

The strengths of the research are its systematic audiometric examination, objective ability of reading the level of noise at the workplace and the application of standardized diagnostic criteria of NIHL. Nevertheless, the research does not have blinks. The sample size also was rather low ($n=70$), and cross-sectional design does not permit causal interpretation. The level of noise exposure was assessed at the workplace, however, no personal noise dosimetry (that gives more precise exposure data at the individual level) was conducted [20]. Although these are some of the limitations, the study still offers an insight on the burden and determinants of NIHL in industrial settings and how better policies on occupational health should be made.

Generally, the results indicate a definite and avoidable danger to the health of people. NIHL is practically preventable, though irreversible, through use of practical solutions in form of engineering controls, administrative controls, hearing protection equipment, and compulsory hearing conservation programs [3,7,9]. These are critical steps that should be immediately incorporated in the industrial environment to protect the hearing of employees.

CONCLUSION

This study illustrated that the noise induced hearing loss is very common among construction workers with 41.4 of them showing audiometric evidence of cochlear impairments. The fact that it has a 4 kHz noise notch, bilateral sensorineural deficits, and has strong correlations

with long-term exposure, high noise levels, and the absence of hearing protection all underscore the cumulative and preventable nature of NIHL. The length of employment, loudness of work-related noise and extended exposure daily, and cigarette smoking were found to be important factors of hearing loss.

The study shows that there is an imminent necessity of introducing comprehensive hearing conservation programs in industries. The use of hearing protection equipment, regular audiometric testing, training of employees, engineering controls, and the enforcement of the occupational noise results are also necessary to decrease the burden of NIHL. Preventive measures and early disease diagnosis can greatly conserve the hearing ability and enhance the life of the construction workers.

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Authors' contributions:

M.A. conceived and supervised the study. M.Aj. contributed to study design and data collection. M.Af. performed data analysis. M.A.R. assisted in clinical interpretation. N.F. contributed to methodology and literature review. T.M. supported data entry and manuscript formatting.

All authors approved the final manuscript.

Data Availability Statement: The data used in this study are available upon reasonable request from the corresponding author, subject to ethical and institutional guidelines.

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