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ORIGINAL ARTICLE

Noise-induced Hearing Loss among Non-Medical Workers in a Healthcare Institution

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ABSTRACT

Introduction: The effects of prolonged and excessive noise exposure on healthcare workers have not been well studied. This study aims to estimate the prevalence of hearing loss among such workers and correlate the degree of hearing loss with age, duration of exposure, and coexisting illnesses. **Methods:** From among 179 employees working in areas of excessive noise in a tertiary care hospital, a retrospective review of 117 clinical records was conducted. The association between categorical variables was studied using the Chi-square and Fisher's exact tests, while an independent samples t-test was used to compare means for continuous variables. Binary logistic regression was used to quantify the strength of association through odds ratio with 95% confidence interval. **Results:** A clinical evaluation was conducted to assess hearing loss in employees from various departments, including the Boiler Section, Central Sterile Supply Department (CSSD), Laundry, Prosthetics and Orthotics Laboratory, and Dietary services. The mean age of the participants was 38.2 years. Out of the 116 participants who underwent audiological tests, 63.8% had sensorineural hearing loss and 68.5% had absent otoacoustic emissions in at least one frequency. The incidence of hearing loss was found to increase with age ($p = 0.037$). A significant association was noted between hearing loss and the duration of noise exposure of more than 10 years ($p = 0.0013$). Considering all areas together, a significantly higher proportion of employees with hearing loss was observed ($p = 0.044$), with 69.5% in the CSSD. **Conclusion:** Noise-induced hearing loss is a prevalent occupational health hazard in healthcare settings. The risk of developing hearing loss increases with the duration of work in a noise-generating area.

Keywords: healthcare workers, noise-induced hearing loss, occupational health

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INTRODUCTION

Occupational noise-induced hearing loss (NIHL) has been steadily decreasing in industrialized nations since it was first documented in the 1930s (Lie *et al*., 2016). However, the high prevalence of adult-onset NIHL among workers in many Asian countries has been attributed to poorly enforced legislation regarding hearing conservation programs (Zhou *et al*., 2020). Globally, occupational noise contributes to 16% of disabling adult-onset hearing loss, which translates into more than four million disability-adjusted life years (DALYs). This problem is more pronounced in nations with inferior healthcare quality and poor access to it (Nelson *et al*., 2005; Haile *et al*., 2021). In the United States, hearing loss was attributed to 2.53 DALYs per 1,000 noise-exposed workers across industries in a nine-year study (Masterson, 2016). In addition to causing hearing loss, noise can also have non-auditory health effects, such as systemic hypertension, elevated cholesterol levels, coronary artery disease, and stroke (Kerns *et al*., 2018). Therefore, NIHL remains a significant public health problem.

Internal noises in healthcare centers pose a constant threat to the well-being of both the employees and the patients (Loupa *et al*., 2019).

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However, occupational NIHL is often overlooked since the prime focus remains on chemical, biological, radiological, and ergonomic hazards. Prolonged noise exposure can cause annoyance, headaches, loss of concentration and medical errors among healthcare workers, which can lead to an increase in attrition rate (Hamoud and Al-Hakkak, 2020; Pleban *et al*., 2021). Therefore, occupational health among healthcare workers is of significant importance.

In developing countries, including India, there is a need for greater awareness of occupational noise hazards in healthcare settings and their prevention. This study aims to determine the prevalence of hearing loss among healthcare employees working in noise-generating areas in a tertiary care hospital and to correlate the degree of hearing loss with their age, duration of noise exposure, and associated illnesses.

METHODS

This study was conducted at our tertiary care hospital following the ethical principles of the Declaration of Helsinki. Over a two-year period between 2015 and 2017, employees from the Central Sterile Supply Department (CSSD), Prosthetics and Orthotics (P&O) Laboratory, Laundry, Dietary and Boiler Section were screened for hearing loss as part of the Occupational Health Program. A retrospective review of electronic medical records of 117 employees working in noisy areas was conducted. The clinical profile of employees, including age and sex, associated illnesses, and duration of noise exposure, as well as the results of audiological tests, were reviewed and accurately entered in a Microsoft Excel spreadsheet for further analysis after removing employee identifiers. This study was approved by the Institutional Review Board and Ethical Committee with a certificate number 11490.

Conduct of the Institutional Occupational Noise Hazard Prevention Program

As an initiative of the Occupational Health Program at our tertiary care hospital, the noise-hazardous areas were identified through questionnaires filled out by health workers. The ambient sound pressure levels (SPLs) in these areas were measured twice daily every morning and evening by a trained audiologist using a calibrated hand-held sound level meter. Table 1 shows these areas and their average and maximum SPLs (dB). The employees received group counseling regarding occupational noise hazards and were referred to the ear, nose, and throat (ENT) outpatient services, where they underwent documentation of relevant medical history, otological examination and audiological testing.

Pure tone audiometry (PTA) was performed in a soundproof room to assess hearing thresholds in both ears and was graded according to the American Speech-Language-Hearing Association (ASHA) classification (Clark, 1981). Impedance audiometry was performed to assess the middle ear status. In addition, otoacoustic emissions (OAEs) were tested using distortion product otoacoustic emissions (DPOAEs). The audiological results were reviewed, and the employees were advised to use hearing protective devices and requested to attend annual follow-up appointments.

Statistical Analysis

Mean +/- Standard deviation (SD) was used to report descriptive statistics for continuous variables, while frequency and percentage were used for categorical data. The Chi-square and Fisher's exact tests were used to determine the associations between the categorical variables. In addition, an independent samples t-test was used to compare means for the continuous variables. The strength of association was calculated using the odds ratio with 95% confidence interval by means of binary logistic regression. A p-value of less than 0.05 was considered statistically significant. SPSS 21.0 from IBM Bangalore was used for the statistical analysis.

RESULTS

A total of 117 out of 179 employees from various departments were evaluated for hearing loss. The departments were CSSD (62 employees), P&O Laboratory (27 employees), Laundry (15 employees), Dietary (9 employees), and Boiler

Table 1. Noise Levels in Various Departments

Department	Average SPL	Maximum SPL
Boiler section	86.8 dB	97.85 dB
P&O laboratory	86.2 dB	95 dB
Dietary department	85.3 dB	88 dB
Laundry department	81.1 dB	83 dB
CSSD	77.2 dB	77.8 dB

Section (4 employees). Table 2 summarizes the clinical profile of the employees. The mean age of the employees was 38.2 years (SD = 8.2). The duration of work in noise-prone areas ranged between three months to 37 years, with eight hours of work daily for five and a half days per week, as depicted in Table 2.

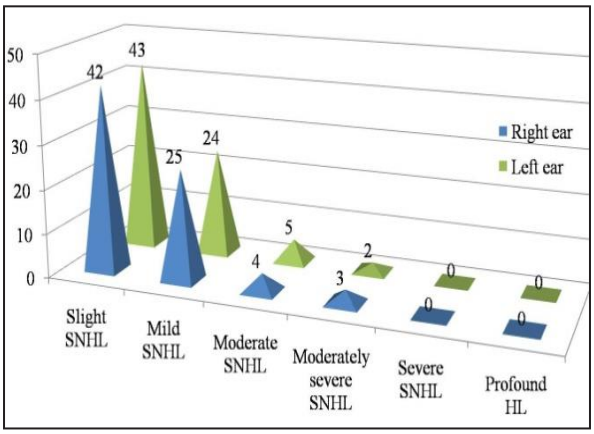
Out of the 117 employees evaluated clinically, only one person did not undergo audiological testing. Among the 116 employees who underwent pure tone audiometry, 38 employees (32.8%) had normal hearing, while 74 employees (63.8%) had sensorineural hearing loss of varying degrees, as depicted in Figure 1. Two participants had mixed hearing loss and two others had conductive loss due to either stapes footplate fixation (otosclerosis) or chronic ear infection and were excluded from further statistical analysis. Among those with sensorineural hearing loss, 57 employees (77%) had audiogram findings suggestive of NIHL, as depicted in Figure 2.

Tympanometry was carried out in 101 right ears and 100 left ears. The results showed that 93% of the ears had type A tympanogram (normal middle ear function), while 7% had type C tympanogram suggestive of Eustachian tube dysfunction, which was treated appropriately.

Furthermore, out of 73 employees who underwent DPOAE testing, 23 (31.5%) were found to have DPOAEs in both ears in all frequencies.

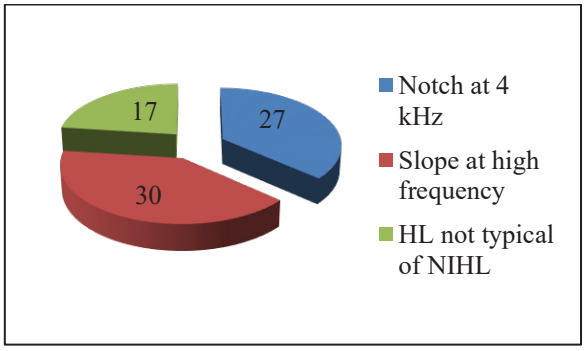
Table 2. Clinical Profile of the Employees

Parameter	Subgroup	Frequency	Percentage (%)
Age (in years)	21-30	20	17.1
	31-40	50	42.73
	41-50	37	31.62
	51-60	10	8.55
Sex	Male	80	68.4
	Female	37	31.6
Comorbid Illnesses	Diabetes mellitus	13	11.1
	Bronchial asthma	11	9.4
	Dyslipidemia	10	8.5
	Hypothyroidism	6	5.1
	Hypertension	5	4.3
	Others (cardiac, renal, neurological)	5	4.3
	Musculoskeletal	2	1.7
	Nil	65	55.6
Duration of Work	≤ 5 years	23	19.6
	6 - 10 years	44	37.6
	11 - 15 years	22	18.8
	16 - 20 years	15	12.8
	21 - 25 years	7	6
	26 - 30 years	3	2.6
	> 30 years	3	2.6



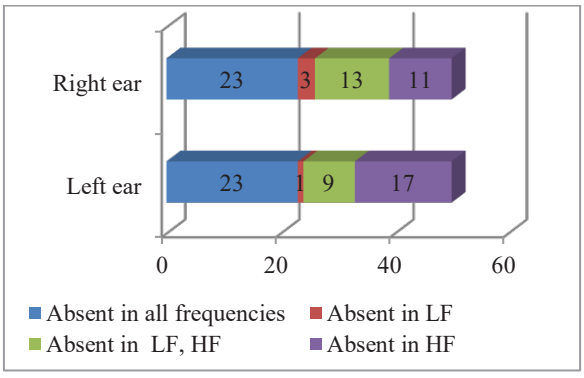
SNHL – sensorineural hearing loss, ‡HL – hearing loss

Figure 1. Sensorineural Hearing Loss (by ASHA Grading) among the Employees



†kHz – kilo Hertz, ‡HL – hearing loss

Figure 2. Audiometric Patterns of Sensorineural Hearing Loss among Employees



†LF – low frequency, ‡HF – high frequency

Figure 3. Frequency-Wise Absence of Otoacoustic Emissions in Both Ears

The remaining 50 employees (68.5%) were found to have absent DPOAEs in all or some frequencies, as shown in Figure 3.

Table 3 shows that, except for the P&O laboratory, all other departments had a significantly higher percentage of employees with hearing loss (p = 0.044). The department with the highest number of employees was CSSD (n = 59); among them, 69.5% of employees had hearing loss. A significant association was also noted between hearing loss and the duration of work in noisy areas of more than 10 years (p = 0.0013). This implies that the likelihood of developing NIHL increased with increased duration of work in noise-hazardous areas. Furthermore, logistic regression on unadjusted analysis showed that the odds of developing NIHL were 1.056 (1.003 to 1.112) for each year of age increase (p = 0.037). However, no significant association was found between hearing loss and co-existing illnesses (p = 1) or the gender of employees in the study population (p = 0.178).

DISCUSSION

Evaluation of occupational noise exposure and its effects on employees is integral to any occupational health program. Although this issue is well recognized and monitored in most industrial settings, it is often overlooked in healthcare settings. The prevalence of NIHL and other effects of occupational noise exposure in healthcare settings needs to be well documented. This study was done to investigate the effect of prolonged and excessive noise exposure on the hearing sensitivity of employees at our tertiary care hospital.

The noise levels in the service areas of the hospital were comparable to those in tertiary care hospitals in other parts of the world (Khaiwal *et al*., 2016; Hisam and Anua, 2018; Loupa *et al*., 2019). The study population consisted mostly of non-clinical employees (77%). We noted that some authors, like Astin *et al*. (2020), conducted a study on noise levels in clinical areas of a hospital. While many studies have examined various occupational hazards faced by healthcare workers (Walton *et al*., 2017), few have specifically looked at noise hazards (Ahmed, 2020; Hisam and Anua, 2018).

Table 3. Comparison of Percentage of Employees with and without Hearing Loss in Various Departments

Department	Hearing Loss		p-value
	Yes (%)	No (%)	
P & O Laboratory	11(42.3)	15(57.7)	
Boiler Section	4(100)	0(0)	
CSSD	41(69.5)	18(30.5)	0.044
Dietary dept.	7(77.8)	2(22.2)	
Laundry	11(78.6)	3(21.4)	
Total	74(66.1)	38(33.9)	

The pure tone audiogram of patients with long-term hazardous noise exposure typically shows progressive, symmetric, sensorineural hearing loss with a high-frequency notch in both ears, suggesting a permanent threshold shift. The basal portions of the cochlea are the regions that detect high-frequency sound waves. These regions are most vulnerable to noise insult (Ryan *et al*., 2016), probably due to the increased susceptibility of outer hair cells (OHCs) here to free radical damage and their increased metabolic activity (Furness *et al*., 2015). Broadband noise, often generated in industrial settings, is amplified by the fundamental resonance of the external auditory canal to a 3 kHz noise level. This leads to hearing loss that is one-half to one octave higher than the offending noise, resulting in the characteristic '4 kHz notch'. The thresholds are worse at 3, 4, or 6 kHz, but better in the lower and higher frequencies. This typical notch, combined with a history of excessive noise exposure, suggests NIHL (McBride and Williams, 2001). In this study, 36.5% of participants with sensorineural hearing loss showed the 4 kHz notch, while 40.5% showed a high-frequency slope suggestive of early NIHL.

Early acoustic damage to the inner ear occurs in the outer hair cells, which may not result in elevated hearing thresholds on a pure-tone audiogram. Therefore, it is necessary to check for the presence of otoacoustic emissions, which are recordings of the acoustic energy released from the cochlear OHCs in the external auditory canal (Gratias *et al*., 2021). Otoacoustic emissions are more sensitive than audiometry in indicating preclinical noise-induced cochlear damage (Helleman, Jansen and Dreschler, 2010). Blioskas *et al*. (2018) reported that the amplitude of otoacoustic emissions can predict the susceptibility of individuals to hearing impairment caused by impulse noise, which may result in a temporary or permanent threshold shift. Following impulse noise exposure, experimental mice models showed a significant reduction in DPOAE amplitudes and an increase in auditory brainstem evoked response audiometry thresholds (Gratias *et al*., 2021). In this study population,

68.5% of the 73 employees had absent DPOAEs in one or more frequencies in either ear, indicating noise-induced damage to the OHCs of the cochlea.

This study showed a significantly higher proportion of employees with hearing loss. More than two-thirds of CSSD employees had their hearing affected by hazardous noise exposure. This could be attributed to the larger number of workers screened, longer hours in the vicinity of noise-generating sterilization equipment and lack of rotation to less noisy areas during their work shifts.

This study found a significant association between the duration of work in noisy areas and NIHL. This study population consisted entirely of individuals under the age of 60 years. Therefore, while it is widely known that hearing thresholds decline with age (Brown *et al*., 2018), the increased odds of developing hearing loss with increasing age demonstrated in this study is likely to be due to prolonged noise exposure. Some studies conducted in industrialized countries revealed a significant association between occupational noise and NIHL while demonstrating an increase in the risk of developing hearing loss with increased duration and intensity of noise exposure. Feder *et al*. (2017) conducted a study that found that employees who worked in noise-hazardous areas for 10 years or more were extremely likely to develop hearing impairment (46%) than those who worked for less than a year (13%) in similar areas (Feder *et al*., 2017). Implementing strict measures to protect against cochlear hair cell loss is of paramount importance in reducing the incidence of NIHL, as mammalian cochlear hair cells are unable to regenerate.

Furthermore, this study found no significant association between the presence of co-existing illnesses and NIHL, although diabetes mellitus affected 10% of the study population. This could be attributed to the access to free healthcare and regular management of chronic conditions that were available to hospital employees. Han *et al*. (2018) conducted an experimental animal study and found that diabetes impairs recovery from temporary noise trauma. It was concluded that diabetic mice are more susceptible to severe noise-induced hair cell damage and synaptopathy, resulting in a significant shift in the hearing threshold compared to wild-type mice (Han *et al*., 2018). In addition, a longitudinal study of more than 2,000 male subjects exposed to noise and employed in a single company in Korea found that diabetic employees were more likely to develop hearing loss than nondiabetics or those with impaired fasting glucose levels (Kim *et al*., 2019). A retrospective industry-based cohort study conducted in Taiwan with 905 subjects concluded that employees exposed to occupational noise levels of more than 85 A-weighted decibels (dBA) had a significantly higher risk of hyperglycemia (relative risk of 1.80) than those exposed to less than 70 dBA, with the risk peaking at 31.5Hz (Chang *et al*., 2020). In another study, Chang *et al*. (2011) concluded that hearing loss in high frequencies (at 4 and 6 kHz) is a reliable biomarker of occupational noise exposure. They also found evidence suggesting that NIHL may be associated with the likelihood of developing systemic hypertension (Chang *et al*., 2011). A recent meta-analysis revealed a statistically significant association between workers exposed to high-intensity noise (sound pressure level of more than 85 dBA) over a long period of time and cardiovascular diseases, with a 2.55 times higher risk of developing high blood pressure than the control group (Yang *et al*., 2018). Another cross-sectional study among native Chinese coal miners found that employees who worked close to noise sources in the mines had a greater risk of developing hypertension and hearing loss. The study also found that occupational noise was an independent risk factor for systemic hypertension (Liu *et al*., 2016). Therefore, employees who work in noise-prone areas must be encouraged to have regular health check-ups to maintain normal glycemic and blood pressure levels and be advised on effective preventive measures against noise hazards.

The results of this study demonstrate the effects of noise on hearing among employees in a healthcare setting. It is important to note that the healthcare industry is not exempt from noise hazards, especially in non-clinical areas. The findings of this study are relevant given the need for more research data in this area. However, this study is limited by its retrospective design. Non-auditory effects of occupational noise exposure were also not assessed.

Although NIHL is recognized as a major occupational disease, its significance is often underestimated. The development and implementation of sustainable hearing conservation programs at workplaces, including health care institutions, with pre-employment hearing assessments, provision of hearing protection devices, rotation of employees between noise-prone and noise-free areas and yearly health check-ups of

employees belonging to noise-generating work environments, are of utmost importance (Brown *et al*., 2018). To maintain better staff performance and reduce work strain, it is crucial to implement administrative measures such as installing sound-absorbing ceilings, making enclosures for noisy machinery, and buying and using quiet machinery where possible (Government of Canada, 2017; CDC, 2021).

Following the completion of this study and at the recommendation of the researchers, pre-employment hearing assessment with counseling has become the standard practice for new hires in noisy areas in the hospital.

CONCLUSION

This study provides evidence that occupational NIHL is prevalent in the tertiary-level healthcare industry (66.1%). The duration of employment in the noise-generating area is directly related to the likelihood of developing NIHL. It is recommended that an ongoing robust hearing screening and conservation program is available in healthcare settings to monitor and address this occupational hazard.

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