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Original Article

Impact of Noise Exposure on Hearing Acuity of Marble Factory Workers

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Abstract

Noise induced hearing loss (NIHL) is an irreversible but preventable disorder. As population lives longer and industrialization spreads, NIHL adds substantially to the global burden of disability. Even though the disease reaches endemic proportions in industrial areas like Kishangarh (Ajmer district, Rajasthan), studies to show its prevalence are relatively scarce which forms the basis of our objective. The study was planned to observe the impact of noise on hearing acuity of marble factory workers and its association with age and length of noise exposure. Following the written informed consent, 30 marble factory workers; age group 20-40 years with daily sound exposure of 8hrs/day for at least 5-10 years were included. Subjects were first examined otoscopically to rule out any external/middle ear disease followed by audiometry. The data was analysed using ANOVA and Chi-square test. The study revealed, 46.7% had noise induced hearing loss (NIHL) congruent with the audiogram. Hearing impairment significantly increased with age [p=0.019] and duration of exposure to occupational noise [p=0.000].Since the prevalence is relatively high, annual check-ups and use of personal protective equipments like earmuffs and plugs should be made mandatory.

Introduction

Noise and vibration are both fluctuations in the pressure of air (or other medialike water and even solids) (other media should be specified) which affect the human body. Vibrations that are detected by the human ear are classified as sound. We use the term ‘noise’ to indicate unwanted sound.

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Bridger (1) defined noise as a sound or sounds at such amplitude as to cause annoyance or to interfere with communication. Sound can be measured objectively but noise is a subjective phenomenon which affects at the audiological, biological and behavioural level.

Noise induced hearing loss (NIHL) is an irreversible but preventable disorder (2) and is the second most common form of acquired hearing loss, after presbycusis (3, 4). It is defined as a gradual reduction in auditory acuity due to continuous exposure to high sound pressure levels, causing injury to the inner and outer hair cells in the organ of Corti. It is characterized by sensorineural loss, irreversible, often bilateral and symmetrical, not to exceed 40 dB (NA) in the low frequencies and 75 dB (NA) in high frequencies; is manifested, first, in 6000 Hz, 4000 Hz and / or 3000 Hz, extending to 8000 Hz, 2000 Hz, 1000 Hz, 500 Hz and 250 Hz(5).

In face of populations living longer and industrialization growing, NIHL adds substantially to the global burden of disability hence is an important public health priority.

Due to unemployment, the workers have accepted the jobs with low resource settings including health and safety consideration particularly in small-scale units like marble factories. This has made them more prone to the hazards of technology. Ironically, industrialization in India is primarily focused on production, whereas health and safety are given very low priority.

Due to lack of accurate population-based studies, prevention of deafness and hearing impairment (PDH), a WHO program, is especially planned for developing countries about the prevalence and causes of deafness and hearing loss (6-8). Occupational Safety and Health Administration (OSHA) recommended that all workers exposed to noise more than 85dB should be screened for NIHL annually (9). In India, NIHL has been a compensable disease since 1948. It is only in 1996 that the first case got compensation. Awareness should be created among workers about harmful effect of noise on hearing and other body systems by implementing compulsory education and training programmes.

Unfortunately, even though disease reaches endemic proportions in industrial areas like Kishangarh (Ajmer district, Rajasthan), studies to show prevalence of NIHL are relatively scarce. So our study aims to investigate the ill effects of noise among marble workshop workers (Kishangarh, Ajmer district) and its association with age and duration of occupational exposure.

As these workers are rarely screened for hearing loss so they become potential subjects to be studied. Also these workers are constantly exposed to noise level of 110dB for more than 8 hours/day. Because of such working conditions and easy accessibility of workers to J.L.N. Medical College, Ajmer, we have selected them for our study. Since audiometry is an easy, feasible, less time consuming and cost-effective method of accessing hearing acuity so, we have chosen this method to evaluate our cases.

Annual audiometric evaluation helps in detecting changes in hearing status before clinically significant hearing loss develops (10).

Materials and Methods

After getting approval of the institutional ethical committee, this epidemiological observational study was performed at J.L.N. Medical College Ajmer, in the months of August and September 2015. Our cohort constituted of 30 marble workshop workers; age group 20-40 years with daily sound exposure of 8 hrs/day or 34 hrs/week for at least 5-10 years. At the outset, the noise level was recorded in a marble factory in Kishangarh (District Ajmer), using sound level meter (DOSIMETER). It was found to be 110dB which was far more than the tolerated limit of noise in the work environment during 8 hours (i.e. 85dB). Subjects having history of head injury with unconsciousness, taking ototoxic drugs like aminoglycosides, frusemide etc, diabetes, hypertension, smoking, alcoholism and familial disease were excluded. An informed consent was taken from each of the participants after clearly explaining them the purpose of the study. Demographic data like name, age, sex, weight and address were carefully recorded. A personal history regarding drug addiction, tobacco chewing & stress was taken in detail. The subjects satisfying the inclusion criteria were then called to the ENT department of J.L.N. Medical College, Ajmer in order to estimate their hearing loss. They were specifically asked to arrive after taking 14 hours of acoustic rest. The subjects were briefed about the procedure of test. All subjects were first examined otoscopically by an otolaryngologist to rule out any external/middle ear disease.

This was followed by audiometry. An audiometer is an electronic device which produces pure tones, the intensity of which can be increased or decreased in 5 dB steps.

The type of audiometer used in our study was AC40 which includes an articulating, high-resolution 8.4 inch colour display that presents crystal images for easy to read audiograms. The intuitive keypad design enabled quick acclimatisation without losing efficiency or speed. Audiometric test included air and bone conduction thresholds for pure tone in both the ears. In pure tone audiometry (PTA) each ear was tested separately, while other was shielded against sound. The subject being tested wore an earphone and sat in front of a loudspeaker in a quite test chamber with instructions to give a hand signal whenever a brief tone was heard. The audiologist proceeded to determine the lowest intensity for each frequency at which the subject was just able to hear the tone 50% of time. Air conduction thresholds were measured for tones of 125, 250, 500, 1000, 2000 and 4000, and 8000 Hz and bone conduction thresholds for 250, 500, 1000, and 2000, and 4000 Hz. The amount of intensity that had to be raised above the normal level was taken as a measure of the degree of hearing impairment at that frequency. It was charted in the form of a graph called audiogram. The difference in the thresholds of air and bone conduction (A-B) was taken as a measure of the degree of conductive deafness.

When difference between the two ears was found out to be 40 dB or above in air conduction threshold, the better ear was masked to avoid getting a shadow curve from the non-test better ear. Similarly, it was essential in all bone conduction studies also. Masking was done by employing a narrow-band noise to non-test ear.

To classify hearing loss according to its intensity, Silman and amp; Silverman (1991) (11) methodology was adopted, and hearing level <25dB was deemed as normal, between 26-40dB was considered as mild hearing loss, between 41-55dB as moderate hearing loss, between 56-70dB as moderately severe, between 71-90dB was deemed as severe and over 90dB was considered as profound hearing loss.

Workers who presented an indentation with audiometric thresholds over 25dB (i.e thresholds more than 55dB) in 3KHz, 4KHz or 6KHz frequencies air and bone conduction (sensorineural hearing loss) were suggestive of NIHL. Audiograms that did not fit in this pattern were classified as non suggestive of NIHL (i.e with audiometric thresholds between 25 to 55dB at higher frequencies). These workers, although had hearing loss but not to the extent as to classify them under NIHL. They may be considered 'pre-NIHL' cases that may eventually develop NIHL with continued exposure to that environment. (audiometric findings between non-suggestive NIHL and normal should be clarified. All the three parts of Fig. 1 should be compared clearly in terms of audiometric findings).

Statistical analysis

Statistical analysis of the data so obtained was done by primer of biostatistics version 6.0 by Stanton A. Glantz. The outcome variables were classified in three groups- NIHL, hearing loss non-suggestive of NIHL and those with normal hearing. The frequencies and proportions were compared for age range and exposure variables in all three groups. Statistical analysis of data was done by chi-square test. A value of less than 0.05 was taken as the level of significance.

Results

TABLE I : Prevalence of hearing loss.

Variable	*N*	*%*
Normal	9	30%
Suggestive of NIHL	14	46.7%
Non-suggestive of NIHL	7	23.3%
Total	30	100%

Table I shows-70% of workers had hearing loss out of which 46.7% had hearing loss suggestive of NIHL.

TABLE II : Prevalence of hearing loss according to age range.

*Agerange**	*NormalN (%)*	*NIHL (%)*	*Non-NIHL (%)*	*Total*
21-25 years	5(83.3%)	1(16.6%)	0(0%)	6
26-30 years	3(50%)	2(33.3%)	1(16.6%)	6
31-35 years	1(16.6%)	3(50%)	2(50%)	6
36-40 years	0(0%)	8(66.6%)	4(33.3%)	12
Total	9	14	7	30

*P=0.019

Workers of 36-40years age group presented with highest prevalence of NIHL. It is 57.1% of total diagnosed cases of NIHL.

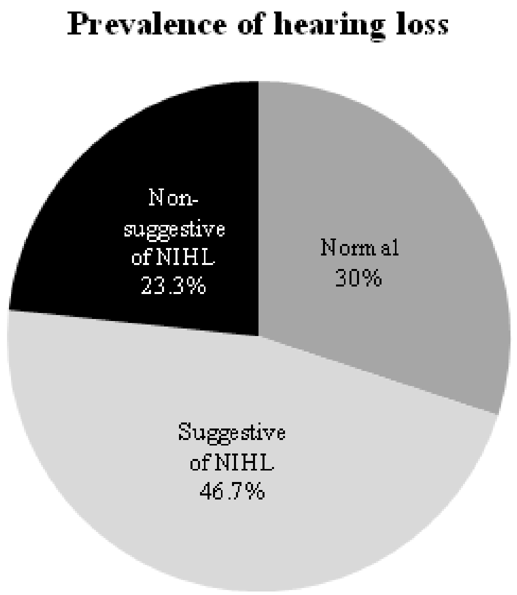

Fig. 1 : Prevalence of hearing loss.

TABLE III : Prevalence of hearing loss according to duration of occupational exposure to noise.

*Duration of exposure**	*Normal*	*NIHL*	*Non-NIHL*	*Total*
5-6 years	8(66.66%)	2(16%)	2(16.60%)	12
7-8 years	1(9%)	5(45.54%)	5(45.52%)	11
9-10 years	0(0%)	7(100%)	0(0%)	7
Total	9	14	7	30

*P=0.000

Table III shows-100% of workers having exposure of 9-10 years had NIHL. It is 50% of total diagnosed cases.

TABLE IV : Distribution of degree of hearing loss according to age range in NIHL cases.

Age group (in years)	*Number of workers*	*Mild 26-40 dB*	*Moderate 41-55 dB*	*Moderately severe 56-70 dB*	*Severe 71-90 dB*	*Profound 91-120 dB*
21-25	1	1	–	–	–	–
26-30	2	1	1	–	–	–
31-35	3	–	1	–	2	–
36-40	8	–	–	1	6	1

Table IV – Shows-With advancing age severity of hearing loss increases.

TABLE V : Distribution of degree of hearing loss according to duration of occupational exposure to noise in NIHL cases.

Duration of exposure	*Number of workers*	*Mild 26-40 dB*	*Moderate 41-55 dB*	*Moderately severe 56-70 dB*	*Severe 71-90 dB*	*Profound loss 91-120 dB*
5-6 yrs	3	1	2	-	-	-
7-8 yrs	4	-	-	2	2	-
9-10 yrs	7	-	-	-	6	1

Table 5 : shows - as duration of noise exposure increases severity hearing loss tends to increase.
Chi-square test-
For age range - X^2=15.159, df=6, p=0.019.
For duration of noise exposure- X^2=19.834, df=4, p=0.000.

Discussion

Government of India, Ministry of labour, model rules under Factories Act 1948; Occupational safety and health administration (OSHA) and International organisation of standardization (ISO) recommended that the maximum permissible noise level in work place for 8 hours shift is 85dB (9). The noise level was found to be 110 dB in marble factory Kishangarh (Ajmer district) which was far higher than the recommended level.

Our study showed that occupational exposure to noise has marked detrimental effect on the hearing acuity of workers. In the present study it was found that 70% of workers had hearing loss among which 46.7% were suggestive of NIHL. Other studies show the occurrence of hearing loss in various proportions among the workers exposed to occupational noise in different parts of world. Higher prevalence was observed by Chadha et al (50%) (12), Hong D et al (60%) (13), Harger M R et al (48%) (14), while a lower prevalence was observed by Ahmed H O et al (32.4%) (15), Landen D et al (37%) (16), Amedofu G K et al (23%)(17), & Boateng C A F et al (30%) (18). In our study prevalence was slightly higher than in other studies because younger age group (15-20 yrs) was not included.

Our study also demonstrated that prevalence of NIHL increases with age (x^2=15.159, df=6, p=0.019). These results are in concurrence with a study done in Japan Press Industry by Tabuchi T et al (19).

Further, the present study revealed that the prevalence of NIHL increased with the duration of noise exposure. Our results are supported by the studies done by Amedofu G K et al (17) and Boateng C A et al (18).

Physiologically, an acoustic signal enters into the external auditory canal, and passes through to the tympanic membrane which vibrates like a diaphragm. This is then transferred to the middle ear system and sets the ossicles into motion. This mechanical energy is transmitted to the cochlea through the stapes footplate hammering against the oval window. This causes movement in perilymph and endolymph which stimulates the hair cells and thus transmit signals to the brain.

The over stimulation of the hair cells, when the ear is exposed to excessive sound levels or loud sounds over time, leads to heavy production of reactive oxygen species, such as superoxide and hydroxyl anion radicals, resulting in oxidative cell death (20). (Specify which reactive oxygen species. Also reference for this should be coated).

NIHL is therefore the consequence of over stimulation of the hair cells and supporting structures. Structural damage to hair cells (primarily the outer hair cells) results in Noise induced hearing loss (NIHL). One of the typical early signs of NIHL is a V-shaped notch which is worst at 4000 Hz with recovery at 8000 Hertz (Hz). 6000Hz and 3000Hz are the second and third frequencies to be affected. It is typical for NIHL to affect frequencies higher than 3000Hz (13, 21). Doctoral students at the University of Iowa have termed this notch, specific to a noise-induced etiology, as “muna.” This notch is frequently seen in audiometric reports of NIHL cases of present study. (22) (give the reference for this para)

This typical 4000 Hz notch is due to the transfer function of the ear (23). Actually, the ear acts as a passive filter -a low pass : the high frequencies are more absorbed by the object, as these high frequencies inflict a higher pace of compression-decompression to the object. Eventually, the high frequency harmonics of a sound are proved to be more harmful to the inner-ear. These high frequencies cause injury to the organ of Corti injury in the basal turn of the cochlea, the area responsible for sound 3kHz to 6 kHz, regardless of the frequency spectrum of the offending noise.

Also in majority of cases of NIHL, the affected people are not even aware of their impairment, because for daily conversation, low audiometric frequencies are much more important (13, 24).

The present study has a limitation as it is difficult to differentiate whether the hearing loss found, was by NIHL or presbycusis, since both diseases have similar audiological features. But since our cohort constituted participants less than 40 years of age, we can safely rule out the chances of presbycusis which typically occurs around 60 years of age. The female workers and age group 15-20 years were not included in our study otherwise better interpretation of effect of age and duration of occupational exposure could be done.

We recommend that the study should be conducted on a larger sample size including the female participants to get a larger view of NIHL and the results could then be extrapolated to the general population.

Conclusion

This cross-sectional study revealed the audiological profile of marble factory workers (Kishangarh, Ajmer) with a high prevalence of bilateral severe level sensorineural hearing loss. The prevalence of hearing loss suggestive of NIHL was 46.7%. An association of hearing loss with age and duration of occupational exposure to noise was verified. Thus, it is concluded that high incidence of NIHL is present in marble workers of Kishangarh, Ajmer.

However after completion of the study, the following preventive, promotional and rehabilitative health care facilities were recommended to enhance activities:-

Before putting up an employee in an industry with high noise area, pre-placement and periodic medical particularly audiological examination is vital. An audiologist should be appointed for noise exposed zones like marble factories, mining industries.

Monitoring of working environment, health education to motivate the employees to use personal protective equipments like Hearing protection devices (HPDs)-such as earmuffs and plugs and rehabilitation of the affected employees are essential.

Based on the study findings, implementation of hearing conservation programme through development and enforcement of regulations to identify and monitor occupational risk groups, restriction of importation of equipments which emit dangerous levels of noise, are recommended. In addition, engineering modifications of buildings and machinery to reduce noise levels, and promotion of safety and health programmes, including promotion of workers, awareness on self protective measures, such as the use of personal protective device (PPD), should be considered.

A national program should be established considering the amount of damage the NIHL causes to the quality of life of workers.

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