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Prevalence of Noise Induced Hearing Loss in Bus Drivers: A Comparative Cross-Sectional Study from North India

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ABSTRACT

Background: Road traffic noise is a major cause of noise pollution, especially in large cities. Various studies have shown the health compromises in drivers, since the duties of professional drivers is of great responsibility. The professional bus drivers who drive the buses at the busy traffic lanes are always at a risk of exposure to high levels of noise due to traffic congestion along roadside. Hence, this study was done on bus drivers in western Uttar Pradesh as they were more vulnerable to the health hazards of noise pollution. Hearing loss was assessed by audiometry test in bus drivers and was compared with the individuals employed in office jobs. **Material and Methods:** The present study was carried out in the Department of ENT Head & Neck Surgery, GIMS Greater Noida, after obtaining the IEC approval. Two groups were studied in the present study which included "Test Group" (Bus drivers) and "Control group" (age matched males working as staffs, clerks or office assistants within the hospital and college premises). The minimum sample in each group was 250. The subjects were enrolled in the study using consecutive sampling method. The data was collected in the pre-structured questionnaire. The audiometric analysis using a GLOBAL REAL audiometer by an experienced audiologist, who will be unaware of the subject's hearing status and was done to assess the degree and the type of the hearing loss for both groups. The classification into conductive and sensorineural hearing impairment was done on the basis of audiometry. The hearing impairment was expressed in terms of percentage using method used in India. Independent T Test and Chi square test were done for Intergroup comparison. **Results:** In present study, 12.5% bus drivers had mean hearing loss > 25 dB in the age group of < 30 years, 27.8% bus drivers in the age group of 31‑40 years showed mean hearing loss > 25 dB, about 68.8% drivers in age group > 50 years showed hearing loss > 25 dB, All >25db. Please see a statistically significant difference in the hearing threshold levels in both right and left ears of bus drivers (test group) and office workers (control group) at frequencies of 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 6000 Hz, and 8000 Hz. The difference in the hearing loss of test group and control group was statistically significant across all the three age groups and overall, in all age groups. **Conclusion:** It was seen in the present study that bus drivers (test group) who were exposed to louder noise had more sensorineural hearing loss than the office workers (control group). These results shall be used to implement educational measures and / or preventive in this population.

Keywords: Acoustic traumatic injury, Occupational hearing loss, Noise-induced hearing loss, Audiometry, Drivers.

INTRODUCTION

Occupational hearing loss includes acoustic traumatic injury (acoustic trauma) (definition - Permanent damage to hearing can be caused by a single brief exposure to very intense sound without this being preceded by a temporary threshold shift). Also called impulse noise, such noise can arise from an explosion, gun fire or a powerful cracker and may reach or cross 140 dB. Noise-induced hearing loss (NIHL) (Definition- NIHL follows chronic exposure to less intense sounds than seen in acoustic trauma and is mainly a hazard of noisy occupations), and can be defined as a partial or complete hearing loss in one or both ears as the result of one's employment.[1] Hearing loss associated to work in noisy surroundings has been the interest of studies in the field of public health that affect communicative skills and quality of life of workers. Noise induced hearing loss is an occupational disease of high prevalence.[2]

Nearly 10% of the world population is known to be suffering from hearing loss because of exposure to very loud noise.[3] NIHL is characterized by sensorineural hearing loss, irreversible, almost always bilateral and symmetrical, manifesting itself first in 6000 Hz, 4000 Hz and / or 3000Hz, extending up to frequencies of 8000 Hz, 2000 Hz, 1000 Hz, 500 Hz, 250 Hz and progressive in character, but preventable.[4]

Road traffic noise is a major cause of noise pollution, especially in large cities. Various studies have shown the health compromises in drivers, since the duties of professional drivers is of great responsibility. The professional bus drivers who drive the buses at the busy traffic lanes are always at a risk of exposure to high levels of noise due to traffic congestion along roadside.[5]

Studies have shown that long term exposure to loud noise affects the hearing capacity of drivers eventually resulting in hearing loss and a decrease in their work performance.[6,7,8] The lifetime risk of developing NIHL is 8% at 85 dB(A) and 25% at 90 dB(A).[9] As early hearing loss usually does not accompany complaints of hearing loss, audiometry is the most efficient method for diagnosing and screening of NIHL.[9] The pure-tone audiometry screening test usually performed by audiometers, and this test have become the standard method for measuring hearing ability.[10]

Impairment of hearing at high frequencies will initially cause a loss of clarity in perceived speech and then interfere with daily activities as hearing loss progresses. Hearing loss-related symptoms, such as trouble in normal and telephone conversation, turning up the radio/television volume and tinnitus, usually occur in the early stages of NIHL. The risk of hearing loss and injury to the ears increases with the sound intensity, the length of time an employee is exposed to noise and the individual susceptibility to NIHL. In India, occupational permissible exposure limit for 8 h time weighted average is 90 dB.[11]

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Permissible exposure in cases of continuous noise or a number of short-term exposures (Govt. of India, Ministry of labor, Model rules under factories act 1948 (Corrected up to 31.3.87)	
Noise level (dBA)	**Permitted daily exposure (h)**
90	8.0
92	6.0
95	4.0
97	3.0
100	2.0
102	11/2
105	1.0
110	1/2
115	¼

Permissible limits of noise as per the noise pollution (regulation and control) rules 2000, Ministry of environment and forest, Govt. Of India		
Zone/Area	**Day (6 am to 10 pm) Limits in dB(A) Leq**	**Night (10 pm to 6 am) Limits in dB(A) Leq**
Industrial	75	70
Commercial	65	55
Residential	55	45
Silence	50	40
Leq = Energy mean of noise level over a specified period.		

Western Uttar Pradesh is currently facing the problem of increasing noise pollution due to the growing population and industrialization. Hence, this study was done on bus drivers in western Uttar Pradesh as they were more vulnerable to the health hazards of noise pollution. Hearing loss was assessed by audiometry test in bus drivers and was compared with the individuals employed in office jobs.

MATERIAL & METHODS

The present study was carried out in the Department of ENT Head & Neck Surgery, after obtaining the approval of GSRC & GIMS Institute Ethics Committee (GIEC). The present cross-sectional comparative study included bus drivers without ear complaints who were referred to GIMS Greater Noida to obtain their medical certificate from September to November 2019 and provided their consent for participation in the study. Subjects with previous history of any ear disease; suffering from auditory impairment; family history of hearing defects; using hearing protective equipment; service period of less than 10 years; and having conductive or mixed hearing loss were excluded from the study. Two groups were studied in the present study which included "Test Group" (Bus drivers) and "Control group" (age matched males working as staffs, clerks or office assistants within the hospital and college premises). It is reasonable to assume that aging makes some contribution to loss of hearing in people exposed to excessive noise, so that the hearing threshold would increase with age. The effect of aging on hearing thresholds has been reported long ago.[12] Adjustment was needed about aging to clearly determine if work duration as a contributing variable was having any effect on hearing threshold level. The international standard organization equation (ISO-7029) was used to carry out these adjustments.

The sample size was calculated according to Patwardhan et al., study[13], where prevalence of noise induced hearing loss among workers was 89%. According to the sample size formula: n= {(Z*Z)*p*(1-p)}/ME*ME and considering Z=1.96, p=0.89 (89%), 1-p = 0.11 (11%), ME

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= 0.09, the minimum sample size was calculated as 230. Considering dropout rate as 10% for missing data and lost follow up of patients, the final sample size calculated was 250, so the minimum sample in each group was 250. The subjects were enrolled in the study using consecutive sampling method.

The data was collected in the pre-structured questionnaire. The basic hearing test for both groups included pure tone audiometry. After local ENT examination, audiometry was done by using a GLOBAL REAL audiometer by an experienced audiologist, who was unaware of the subject's hearing status. The hearing thresholds of air and bone conduction of both ears were obtained at frequencies of 250, 500, 1000, 2000, 4000, 6000 and 8000 Hz. Air conduction was measured by ear phones placed on the ears, while bone conduction was measured by placing a vibrator in contact with the skull on the mastoid bone behind the ears. Each ear was evaluated separately and test results are reported on a graph known as an audiogram

The audiometric analysis was done to assess the degree and the type of the hearing loss. Hearing was considered as normal when pure-tone audiometry (PTA) was between 0–25 dB, mild hearing loss was considered when PTA will be 26–40 dB, moderate hearing loss at PTA 41–55 dB, moderate– severe hearing loss at PTA 56–70 dB, severe hearing loss was PTA over 71-91 dB, Profound hearing loss when PTA was above 91 dB. The classification into conductive and sensorineural hearing impairment was done on the basis of audiometry.

The effect of temporary threshold shift (TTS) was controlled by considering 16 hours interval between any exposure to noticeable noise and pure tone audiometry. Before test, the subjects were clearly instructed about the test procedure and necessary information was logged by audiometric technician. The hearing impairment was expressed in terms of percentage using method used in India. The percentage handicap of an individual is calculated using the formula: (Better ear % × 5) + (worse ear %) divided by 6.[14]

Formula

(i) Take an audiogram and calculate the average of thresholds of hearing for frequencies of 500, 1000 and 2000 Hz say = A.
(ii) Deduct from it 25 dB (as there is no impairment up to 25 dB), i.e. $A - 25$.
(iii) Multiply it by 1.5, i.e. $(A - 25) \times 1.5$.

This is the percentage of hearing impairment for that ear. Similarly calculate the percentage of hearing impairment for the other ear.

Total percentage handicap of an individual

$$= \frac{(\text{better ear\%} \times 5) + \text{worse ear\%}}{6}$$

Statistical Analysis

Data was tabulated in MS Excel and analysed using SPSS Ver 23. Descriptive statistics were done for scale data, Frequencies were done for ordinal data. Independent T Test and Chi square test were done for Intergroup comparison.

RESULTS

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Table 1. shows that most of the drivers in both groups, that is, in test group and in control group belong to Hindu by religion (66.0% and 80.0%), were married (74.0% and 76.0%), were living in nuclear family (62.0% and 64.0%), and were residing in urban areas (82.0% and 82.0%). The mean age at which subjects in test group and control group started work was 23.91 ± 7.63 years and 23.60 ± 5.58 years, respectively.

Table 1: Sociodemographic characteristics of test and control groups

Variables	**Number (%)/ Mean ±SD**		**Overall**
	Test group (n=50)	**Control group (n=50)**	
Age (in years)	34.05±9.42	34.74±8.14	34.82±8.28
Age group (in years)			
Age group <30 years	16 (32.0)	15 (30.0)	31 (31.0)
Age group 31-40 years	18 (36.0)	18 (36.0)	36 (36.0)
Age group > 40 years	16 (32.0)	17 (34.0)	33 (33.0)
Religion			
Hindu	33 (66.0)	40 (80.0)	73 (73.0)
Muslim	16 (32.0)	10 (20.0)	26 (26.0)
Others	1 (2.0)	0 (0.0)	1 (1.0)
Education			
Illiterate	15 (30.0)	4 (8.0)	19 (19.0)
Primary school	21 (42.0)	13 (26.0)	34 (34.0)
Middle or secondary school	12 (24.0)	25 (50.0)	37 (37.0)
Graduate and above	2 (4.0)	8 (16.0)	10 (10.0)
Marital status			
Single	12 (24.0)	12 (24.0)	23 (23.0)
Married	37 (74.0)	38 (76.0)	76 (76.0)
Divorced/Widowed	1 (2.0)	0 (0.0)	1 (1.0)
Type of family			
Joint	18 (36.0)	16 (32.0)	34 (34.0)
Nuclear	31 (62.0)	32 (64.0)	63 (63.0)
Three generation	1 (2.0)	2 (4.0)	3 (3.0)
Residence			
Urban	41 (82.0)	41 (82.0)	82 (82.0)
Rural	8 (16.0)	7 (14.0)	15 (15.0)
Urban slum	1 (2.0)	2 (4.0)	3 (3.0)
Age at start work (in years)	22.19±6.37	22.06±4.85	22.57±5.86

Table 2. shows that a statistically significant difference in the hearing threshold levels in both right and left ears of bus drivers (test group) and office workers (control group) at frequencies of 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 6000 Hz, and 8000 Hz.

Table 2: Hearing threshold level (in dB) detected by audiometric test at different frequencies

Frequency in KHz	**Mean ±SD**		**P-value**
	Test group (n=50)	**Control group (n=50)**	

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Right ear			
0.25	15.32±10.49	6.67±7.86	< 0.0001
0.5	19.07±11.91	11.37±8.27	0.0003
1	17.02±11.54	9.36±5.39	< 0.0001
2	24.37±11.42	13.54±5.34	< 0.0001
3	30.70±13.87	15.04±6.93	< 0.0001
4	33.79±14.32	17.04±6.36	< 0.0001
6	29.73±16.83	13.08±7.87	< 0.0001
8	29.78±18.79	12.76±9.76	< 0.0001
Left ear			
0.25	16.38±12.57	10.68±9.04	0.0107
0.5	14.55±11.78	10.04±7.47	0.0244
1	17.04±11.87	12.02±7.63	0.0135
2	22.35±10.42	16.71±5.69	0.0011
3	29.02±13.53	17.09±7.71	< 0.0001
4	33.78±14.43	21.30±7.95	< 0.0001
6	29.32±16.78	15.38±9.41	< 0.0001
8	31.05±21.15	15.36±12.45	< 0.0001

Table 3. shows that the average hearing loss in age group < 30 years in bus drivers (test group) was 14.32±4.54 dB and in office workers (control group), it was 10.72±3.70 dB. Subjects belonging to age group 31‐40 years showed an average loss of 18.47±4.38 dB and 11.46±2.57 dB among test group and control group, respectively. Also, the subjects in the age group of > 50 years showed mean hearing loss of 27.62±7.69 dB and 15.71±6.37 dB among test group and control group, respectively. The difference in the hearing loss of test group and control group was statistically significant across all the three age groups and overall, in all age groups.

Table 3: Comparison of average loss of hearing levels (in dB) in better ear

The average loss of hearing levels (in dB) in better ear*	**Mean ±SD**		**P-value**
	Test group (n=50)	**Control group (n=50)**	
Age group <30 years	14.32±4.54	10.72±3.70	< 0.0001
Age group 31-40 years	18.47±4.38	11.46±2.57	< 0.0001
Age group > 40 years	27.62±7.69	15.71±6.37	< 0.0001
Overall (in all age groups)	20.51±7.56	12.43±4.97	< 0.0001

**At combined frequencies of 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz*

Table 4. shows that in test group, about 12.5% bus drivers had mean hearing loss > 25 dB in the age group of < 30 years, 27.8% bus drivers in the age group of 31‐40 years showed mean hearing loss > 25 dB, about 68.8% drivers in age group > 50 years showed hearing loss > 25 dB, while in control group, no subject had hearing loss of > 25 dB in age group of < 30 years and age group of 31-40 years; however, 5.9% drivers in the age group > 50 years had hearing loss of > 25 dB. There was a statistically significant difference among subjects of test group and control group in whom average hearing loss was > 25 dB (at combined frequencies of 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz) in the better ear across all the three age groups and overall, in all age groups except for the age group < 30 years of age.

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Table 4: Comparison of average hearing loss of > 25 dB in better ear

Average hearing loss of > 25 dB in better ear*		Number (%)		P-value
		Test group (n=50)	Control group (n=50)	
Age group <30 years	Present	2 (12.5)	0 (0.0)	0.156
	Absent	14 (87.5)	15 (100.0)	
Age group 31-40 years	Present	5 (27.8)	0 (0.0)	0.015
	Absent	13 (72.2)	18 (100.0)	
Age group > 40 years	Present	11 (68.8)	1 (5.9)	0.0001
	Absent	5 (31.2)	16 (94.1)	
Overall (in all age groups)	Present	18 (36.0)	1 (2.0)	< 0.0001
	Absent	32 (64.0)	49 (98.0)	

**At combined frequencies of 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz*

DISCUSSION

Worldwide, 16% of the disabling hearing loss in adults is attributed to occupational noise, ranging from 7 to 21% in the various sub regions.[1] In present study, about 12.5% bus drivers had mean hearing loss > 25 dB in the age group of < 30 years, 27.8% bus drivers in the age group of 31‑ 40 years showed mean hearing loss > 25 dB, about 68.8% drivers in age group > 50 years showed hearing loss > 25 dB. The overall hearing loss of > 25 dB among 36.0% of bus drivers.

In present study, the hearing loss was greatest at 3000 Hz (30.70±13.87 dB) and 4000 Hz (33.79±14.32 dB) for right ear; and for left ear hearing loss was greatest at 4000 Hz (33.78±14.43 dB) and 6000 Hz (31.05±21.15 dB). The study by Alizadeh et al., showed that hearing loss of heavy-vehicle drivers is greatest at 6000 Hz followed by 4000 Hz.[15] In an Indian study conducted in Calcutta, India, on 90 male individuals with similar age, height and weight, the risk of hearing loss in professional drivers was assessed. The participants were categorized as drivers with under 10 years of experience, drivers with over 10 years of experience, and office clerks. Audiometry of both ears was performed at frequencies 125–8000 Hz. The office clerks were found to have hearing thresholds of under 25 dB at the mentioned frequencies, while the threshold was over 25 dB for both groups of drivers. Hearing loss was more prevalent at frequencies of 3000 and 4000 Hz.[16]

One study in India has identified noise levels in bus cabs of 89-106 dB and observed that 89% of the bus drivers had abnormal audiograms i.e. they had impaired hearing.[13] Mukherjee et al. investigated some occupational harmful agents (noise, heat, dust and volatile organic compounds) of bus drivers in Kolkata and indicated that drivers undertaking three consecutive trips within Kolkata city traffic routes in a special bus have higher noise exposure than the recommended standard.[17] Previous bus driver noise exposure studies, generally done in foreign countries, have found bus driver noise exposures routinely above 85 dB with an estimated 12% of employees in transportation services globally regularly exposed above this level.[13]

We, the human beings, are born with a limited and fixed number of cochlear inner hair cells and due to exposure to noise, these hair cells attributed to metabolic exhaustion and degenerate.[18,19,20] Degenerated cochlear hair cells do not recover, repair, or regenerate in

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human beings and other mammals. There were considerable efforts made on research to regenerate the cochlear inner hair cells, either by growth of suitable hormones or genetic cell differentiation process.[21,22,23] But, the fact remains that once cochlear inner hair cells damaged by noise exposure, they will not recover and lost forever. Therefore, presently, early identification and prevention of noise‑ induced hearing loss is the only viable solution. Our present study supporting the research literature that effect of noise exposure is cumulative, results shows that the difference of hearing loss between exposed and unexposed group was found increasing with years of exposure.

WHO estimated that 466 million persons of the world live with disabling hearing loss in 2018, which is loss unequally distributed all around the world and South Asia is the highest contributor (27%) and also projected that number of persons with disabling hearing loss grows with the years, 630 million by 2030 and 900 million by 2050.[24] It is reported that out of total prevalence of hearing loss in adults worldwide, the occupational noise contributes to 16% (range: 7-21%) of the preventable noise‑ induced hearing loss.[25]

Limitations

The drivers might be exposed to noise in other places and activities. As the pre-employment health certificate examinations were performed 8 years before this study, there might be some hearing loss before professional driving.

CONCLUSION

It was seen in the present study that bus drivers (test group) who were exposed to louder noise had more sensory neural hearing loss than the office workers (control group). These results shall be used to implement educational measures and / or preventive in this population. Special awareness and preventive programmes need to be conducted for the bus drivers to enlighten them about the harmful effects of noise pollution on their health and to stress the importance and need for the usage of protective ear devices. Enhanced bus designs and better implementation of noise control programmes will also aid in improving their overall health profile.

REFERENCES

1. Nandi SS, Dhatrak SV. Occupational noise-induced hearing loss in India. Indian J Occup Environ Med 2008;12:53-6.
2. Diseases of ear, nose, throat & head and neck surgery 7th Ed, New Delhi: Reed Elsevier India Pvt. Ltd. ; 2018, Ch. 5, Hearing loss, pg. no. 36-38
3. Daniel E. Noise and hearing loss: a review. J Sch Health. 2007;77:225–31.
4. Harger MR, Barbosa-Branco A. Efeitos auditivos decorrentes da exposição ocupacional ao ruído em trabalhadores de marmorarias no Distrito Federal [Effects on hearing due to the occupational noise exposure of marble industry workers in the Federal District, Brazil]. Rev Assoc Med Bras (1992) 2004;50:396-9.

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022

5. Balaji R, Rajasegaran R, John NA, Venkatappa US. Hearing Impairment and High Blood Pressure among Bus Drivers in Puducherry. J Clin Diagn Res 2016;10(2):CC08-10.
6. Lopes AC, Otowiz VG, Lopes PM, Lauris JR, Santos CC. Prevalence of noise-induced hearing loss in drivers. Int Arch Otorhinolaryngol 2012;16:509–14.
7. Pushpa K, Girija B, Veeraiah S. Effect of traffic noise on hearing in city bus drivers of Bangalore. Indian J Public Health Res Dev 2013;4:227-30.
8. Rodrigues CHF, Scarlazzari CL, Luiz HE, Gomes PMA, Ribeiro NLC, Catarina de ME. Noise-induced hearing loss and high blood pressure among city bus drivers. Rev. Saúde Pública [Internet] 2002;36:693-701.
9. Meyer JD, Mccunney RJ. Occupational exposure to noise. In: Environmental and occupational medicine. Philadelphia: Lippincott Williams & Wilkins 1301; 2007.
10. British Society of Audiology. Recommended procedures for British Society of Audiology. Recommended procedures for pure-tone audiometry. Br J Audiol 1981;15:213-6.
11. Suter A. Noise standards and regulations. In: Stellman J, editor. Encyclopedia of Occupational Health and Safety. 4th ed. Volume 2. Geneva: International Labour Office; 1998. pp. 47.15–47.18.
12. Niland J. Occupational hearing loss, noise, and hearing conservation. In: Zenz C, Dickerson O, Horvarth E, editors. Occupational medicine.3rd ed. St Louis Missouri: Mosby Publication; 1994. pp. 258–96.
13. Celik O, Yalcin S, Ozturk A. Hearing parameters in noise exposed industrial workers. Auris Nasus Larynx 1998;25:369-75.
14. Patwardhan MS, Kolate MM, More TA. To assess effect of noise on hearing ability of bus drivers by audiometry. Indian J PhysiolPharmacol 1991;35:35-8
15. Alizadeh A, Etemadinezhad S, Charati JY, Mohamadiyan M. Noise-induced hearing loss in bus and truck drivers in Mazandaran province, 2011. Int J Occup Saf Ergon 2016;22:193-8.
16. Majumder J, Mehta CR, Sen D. Excess risk estimates of hearing impairment of Indian professional drivers. Int J Ind Ergon 2009;39(1):234-8.
17. Mukherjee AK. Exposure of drivers and conductors to noise, heat, dust and volatile organic compounds in the state transport special buses of Kolkata city. Trans Res Part D Trans Environ 2003;8:11-9.
18. Stockwell CW, Ades HW, Engström H. Patterns of hair cell damage after intense auditory stimulation. Ann Otol Rhinol Laryngol 1969;78:1144‑ 68.
19. Spoendlin H. Primary structural changes in the organ of Corti after acoustic overstimulation. Acta Otolaryngol 1971;71:166‑ 76.
20. Kurabi A, Keithley EM, Housley GD, Ryan AF, Wong AC. Cellular mechanisms of noise‑ induced hearing loss. Hear Res 2017;349:129‑ 37.
21. Morest DK, Cotanche DA. Regeneration of the inner ear as amodel of neural plasticity. J Neurosci Res 2004;78:455‑ 60.
22. Breuskin I, Bodson M, Thelen N, Thiry M, Nguyen L, Belachew S, et al. Strategies to regenerate hair cells: Identification of progenitors and critical genes. Hear Res 2008;236:1‑ 10.

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022

23. Kros CJ. How to build an inner hair cell: Challenges for regeneration. Hear Res 2007;227:3‑ 10.
24. World Health Organization. Addressing the rising prevalence of hearing. 2018. Available from: https://www.who.int/pbd/deafness/estimates/en. [Last accessed on 2022 Feb 12].
25. Nelson DI, Nelson RY, Concha‑ Barrientos M, Fingeruhut M. The global burden of occupational noise induced hearing loss. Am J Ind Med 2005;48:446‑ 58.