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Original Article

Assessment of noise-induced hearing loss (NIHL) of weaving factory workers in West Bengal, India - a pilot study

Patel J [1], Ghosh T[1]

[1]Ergonomics and Exercise Physiology Laboratory, Department of Health and Wellness, Sri Sri University, Cuttack, Odisha 754006, India

ABSTRACT

Introduction: Excessive noise exposure is one of the majorly considered occupational stressors for industrial workers. The operation of steel weaving machinery producing a high level of noise such as weaving machines, crimping machines, and hydraulic press machines for a prolonged period increases the risk of developing noise-induced hearing loss (NIHL). The main aim of the study was to assess the auditory health of the workers exposed to a high level of noise in a steel weaving factory and the prevalence of NIHL among workers.

Methods: Twenty six (26) subjects in the age group of 25-55 years from a steel weaving industry of Chinsurah town, Hooghly district of West Bengal were randomly selected with 5 years of exposure for the study. The control group was selected from the same age group, socioeconomic status and geographical location and had no history of such exposure. The physiological parameters of the workers, noise levels in the workplace and auditory functions and the risk of NIHL were assessed by standardized protocol and statistically analyzed.

Results: The study indicated that steel weaving factory workers had significantly reduced hearing functionality at 4000Hz and 6000Hz in the left ear respectively. It also revealed that the workers were exposed to high noise exposure of 131dB near the weaving machine, 113dB at the crimping machine, and 84dB at the hydraulic press machine respectively.

Conclusion: A high level of noise exposure leads to deterioration in the hearing capabilities of steel-weaving industrial workers. Implementation of ergonomic interventions in the workplace and the use of personal protective equipment (PPE) may decrease the prevalence of NIHL and can help to prevent hearing loss in workers.

Keywords: Auditory health, NIHL, occupational stress, steel weaving factory workers

Corresponding author:

Dr. Tirthankar Ghosh,
Professor,
Ergonomics and Exercise Physiology Laboratory,
Department of Health and Wellness,
Sri Sri University, Cuttack,
Odisha 754006, India
E-mail: tirthag@gmail.com
ORCID ID: https://orcid.org/0000-0002-8953-5903

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Introduction

Hearing loss is ranked the fourth highest cause of disability across the globe estimating 466 million people having disabling hearing loss.[1] Occupational noise exposure is the major stress undergone by industrial workers and is the second major self-reported occupational illness having social, functional and economic impacts on industrial workers.[2-3] Noise harm the health of individuals and the community exposed. It disturbs the work-rest cycle and biological rhythm of the individuals leading to damaged hearing and eliciting physiological, psychological and pathological reactions.[4] Occupational hearing loss is considered one of the majorly occurring occupational diseases.

It is found about 49% of male miners undergo hearing loss at the age of 50. The figure rises to 70% by the age of 60. Occupational hearing loss is faced by a large sector of the working force.[5] It is estimated about 16% of the disabling hearing loss in adults develops on exposure to occupational noise.[6]

Hearing loss developing from chronic noise exposure leads to the gradual disruption of hearing sensitivity which on being unaware later develops into NIHL.[7]

The occupation having a high risk of NIHL includes heavy engineering, quarrying, tunneling, mining and textile machinery.[2] NIHL is defined as an incurable and irreversible disease with prevention being of primary importance. The early signs of occupational hearing loss can be detected by simple audiometric evaluations. A periodic audiometric examination can be considered the principal medical prevention of excessive noise exposure.[8-9] According to OSHA if the noise level in the workplace is 85 dB(A) or above for an average period of eight hours the employers must organize a hearing conversation program for the employees.[10]

Occupational health diseases often have a long latency period, making it difficult to diagnose at the primary stage. [11] It is important to assess workers hearing functionality for preventing the risk of developing NIHL.[12] Periodic hearing conservation program with audiometric screening tests in the workplace for the workers can increase the effectiveness of the hearing protection protocol and proper education for increasing awareness of risks of noise exposure. The present study was made to assess the auditory health of the workers exposed to the high level of noise in a steel weaving factory and the prevalence of NIHL among workers and to compare the auditory health (at varied frequencies) in both the ears of the workers working in steel weaving factory with the control group.

Methods

The study was conducted on workers of a steel weaving factory in Chinsurah town, Hooghly district of West Bengal. Twenty-six steel weaving factory workers were randomly selected for the prevailing study as the experimental group. All the selected workers were having a minimum working experience of 5 years of their present occupation and were in the age group of 25-55 years. The control group was selected from the same socioeconomic and geographical locations. The consent of the workers was taken verbally before the study.

A study was made based on the auditory complaints of the workers of a steel weaving factory for the study period. The questionnaire comprised of series of polar questions on hearing discomfort and using of PPEs- "Do you recently have difficulty in hearing words clearly?", "Are you having difficulty in hearing while working- yes or No?", "Do you feel frustrated when you do not get words clear- yes or no?"," Do you experience tinnitus after working with the machine- yes or no?", " Do you experience pain during working with noise-producing machine- yes or no?","Do you use PPE while working- yes or no?- if No then "Do you think of using PPEs while working – yes or no?"

The physiological parameters involving blood pressure, pulse rate, and mid-arm circumference of the steel weaving factory workers and the control group were assessed using a standardized protocol. The noise levels at the different areas of the steel weaving factory were taken during the working period using Cel-231 Type 2A sound level meter. Three readings were taken near the operation of machinery in the beginning hours, in the middle and at the end of the working day. The locations from where the readings were taken were near the weaving machine, crimping machine and Hydraulic press machine respectively.

All the audiograms were assessed using Arphi audiometer. Bone and air conductance for both ear were performed from 1000Hz to 8000Hz respectively.

Hearing loss can be categorized into five types.[13]

Mild HL: hearing threshold between 26-40 dB HL.
Moderate HL: hearing threshold between 41-55 dB HL.
Moderately severe HL: hearing threshold between 56-70 dB HL.
Severe HL: hearing threshold between 71-90 dB HL.
Profound HL: hearing threshold more than +90 dB HL

Student "t" test was performed among the steel weaving factory workers and the control group to find out whether there is any significant difference between the physical parameters and thresholds of hearing for frequencies 1000 Hz, 1500Hz, 2000Hz, 3000Hz, 4000Hz, 5000Hz, 6000Hz and 8000Hz respectively for the chosen level of significance($p< 0.05$). Statistical analysis was performed using SPSS version 17 (Chicago, Illinois, USA).

Results

Table 1 represents the demographic information of the male steel weaving factory workers denoted as the exposed group and the control group showing the mean age of the exposed group is 31.10 years, height and weight to be 162.93 cm and 64.62 cm while the mean age of the control group is 32.35 years, height and weight is 161.69 cm and 64.50 cm respectively. From Table 1 it was observed that there was no significant change in age, stature, and weight between the exposed and control groups.

The mean values of the physiological parameters including systolic pressure,diastolic pressure, pulse rate and Mid arm circumference of the noise exposed group and control group is represented in Table-2. It was observed that there was significance change in systolic pressure between exposed and control group.

We have observed sound levels at various workplaces where different machineries (weaving machine, cramping machine and Hydraulic press machine) are operated. The mean noise levels near weaving machine, cramping machine and Hydraulic press machine is found to be 131.83 dB, 113dB and 84.16 dB respectively as shown in Table 3.

Table 1. Demographic information about the noise Exposed group and Control group

Parameters	Exposed Group	Control Group	t value	P value
Age(years)	31.10(±7.92)	32.35(±7.73)	0.58	0.57
Height (cm)	162.93(±7.23)	161.69(±7.87)	0.59	0.57
Weight (cm)	64.62(±9.52)	64.50(±9.11)	0.04	0.96

Table 2. Physiological parameters of the Noise exposed group and control group

Parameters	Exposed Group	Control Group	t value	P value
Systolic pressure(mm Hg)	133.46(±10.89)	121.62(±5.66)	4.91	P<0.0001
Diastolic pressure(mm Hg)	79.04(±7.06)	80.08(±0.69)	0.75	0.46
Pulse rate(bpm)	76.73(±6.84)	72.19(±4.14)	2.89	P=0.005
Mid arm circumference(cm)	28.15(±2.18)	25.77(±2.09)	4.01	P=0.0002

Table 3. Noise levels in selected workplaces

Workplace areas	Noise level(dBA)
Near weaving machine	131.83±1.25
Cramping machine	113±10
Hydraulic press machine	84.16±0.76

About 73% of the steel weaving factory workers responded to having difficulty hearing words clearly. 69% of the exposed population faced difficulty in hearing properly. From the study, it was observed that about 62% of the workers responded to being frustrated when do not get the words clear. 58 % of the workers agreed on experiencing tinnitus after working with machines and ear pain during working with noise-producing machines. Only 31% of the study population used PPEs while working and 38% of the steel weaving factory workers responded to not thinking of using PPEs while working as mentioned in Table 4.

The mean hearing threshold level of both the right and left ear of the exposed group and control group at a varied frequencies of 1000Hz, 1500Hz, 2000Hz, 3000Hz, 4000Hz, 5000Hz, 6000Hz and 8000Hz respectively is shown in Table 5. It was observed that there was a significant difference in hearing threshold levels at varied tested frequencies in the exposed and control group.

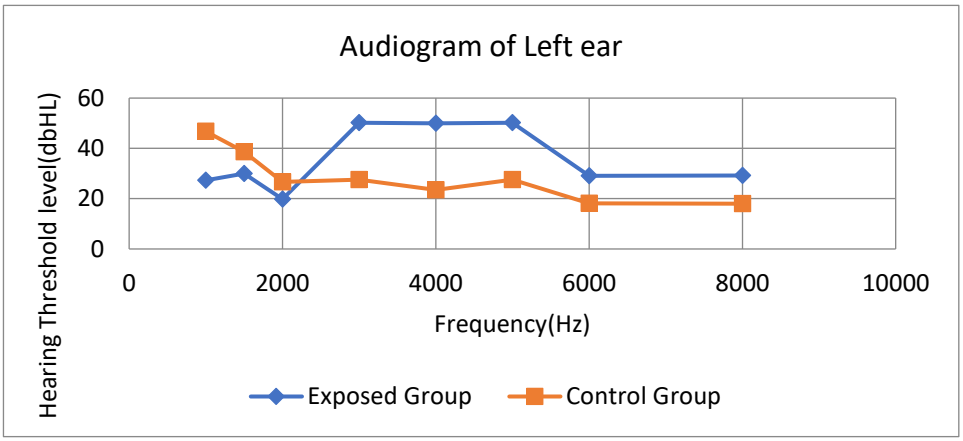
Table 4. Frequency distribution of Auditory complaints and practices

Auditory complaints and Practices	**Steel weaving factory workers**
Do you recently having difficulty in hearing words clear?	19 (73%)
Are you having difficulty in hearing while working?	18 (69%)
Do you feel frustrated when you do not get words clear?	16 (62%)
Do you experience tinnitus after working with machine?	15 (58%)
Do you experience ear pain during working with noise producing machine?	15 (58%)
Do you use PPE while working?	08 (31%)
Do you think of using PPEs while working?	10 (38%)

Table 5. Hearing Threshold of the noise exposed group and control group for the tested frequency

Frequency(Hz)	**Ear**	**Exposed group**	**Control group**	**t value**	**P value**
1000	Left	27.31(±2.54)	46.73(±4.89)	17.97	P<0.0001
1000	Right	27.50(±2.55)	50.58(±4.08)	24.46	P<0.0001
1500	Left	30(±4.00)	38.65(±5.20)	6.72	P<0.0001
1500	Right	29.81(±4.11)	39.62(±5.81)	7.02	P<0.0001
2000	Left	19.81(±3.86)	26.73(±5.46)	5.27	P<0.0001
2000	Right	17.50(±2.55)	27.31(±6.20)	7.46	P<0.0001
3000	Left	50.19(±4.57)	27.50(±2.91)	21.35	P<0.0001
3000	Right	54.23(±3.65)	29.23(±5.03)	20.51	P<0.0001
4000	Left	50.00(±5.2)	23.46(±3.67)	21.26	P<0.0001
4000	Right	47.31(±5.51)	24.23(±3.92)	17.40	P<0.0001
5000	Left	50.19(±4.57)	27.50(±2.91)	21.35	P<0.0001
5000	Right	54.04(±3.74)	29.23(±5.03)	24.81	P<0.0001
6000	Left	29.04(±3.47)	18.08(±3.76)	10.92	P<0.0001
6000	Right	28.46(±5.43)	18.65(±3.62)	7.66	P<0.0001
8000	Left	29.23(±5.94)	18.00(±3.67)	8.20	P<0.0001
8000	Right	28.46(±5.43)	18.69(±3.62)	7.63	P<0.0001

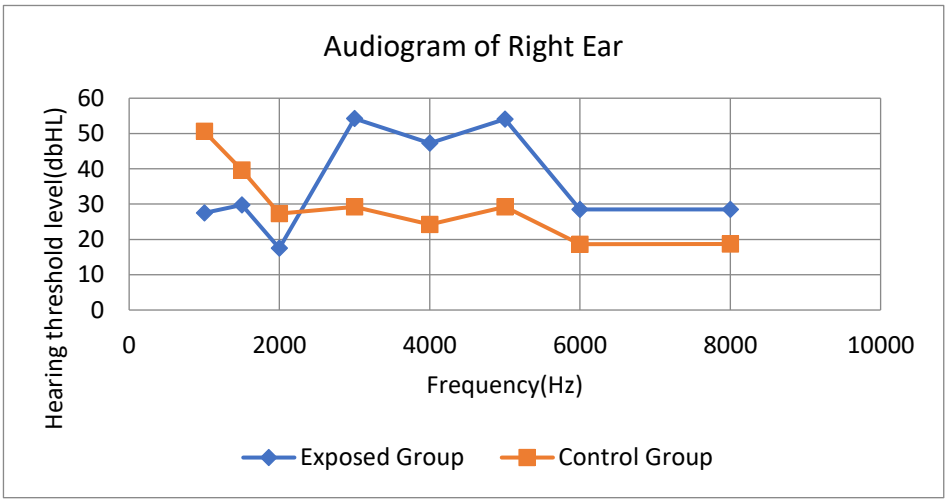
Figure 1. Mean hearing threshold levels of left ear of exposed group and control group for various tested frequency



The mean hearing threshold level of the left ear of the noise-exposed group and control group at different tested frequencies (1000Hz, 1500Hz, 2000Hz, 3000Hz, 4000Hz, 5000Hz, 6000Hz and 8000Hz) is shown in fig 1. A significant change in hearing threshold level in the left ear is observed in the exposed and control group.

The mean hearing threshold level of the right ear of the noise-exposed group and control group at different tested frequencies (1000Hz, 1500Hz, 2000Hz, 3000Hz, 4000Hz, 5000Hz, 6000Hz and 8000Hz) is shown in fig 2. A significant change in hearing threshold level in the right ear is observed in the exposed and control groups.

Figure 2. Mean hearing threshold levels of the right ear of the exposed group and control group for various tested frequency



Discussion

NIHL is considered one of the completely preventable hearing losses having significant health coupled with economic consequences primarily observed in southeast Asian countries.[14] The present study showed the mean age of the steel weaving factory workers was 31.10 years within the age group of 25-55 years as shown in Table 1. The result was found to be consistent with the studies that prevailed in Thailand and Pakistan with mean ages of 33.8 years and 34.3 years respectively. [15-16] Most of the studies conducted in industrial workers in Bhutan, Thailand belong to the age group of 31-40 years.[17-19] The workers of the steel weaving factory work in 8 hours shift duration. According to the Factories act 1951 and standardized by International Labour Organization the working hours for continuous processes in Myanmar should not

exceed 8 hours a day or 44 hours or 48 hours. In the study, a significant increase in blood pressure (systolic blood pressure) was found in the noise-exposed group than the control group shown in Table 2.

Dzhambov et al. in their study showed a significant increase in the blood pressure of the workers who were exposed to occupational noise.[20] The study showed similar results in a Taiwan study showing a positive correlation between blood pressure level and noise level.[21] The noise levels in the workplaces where various types of machinery involving weaving machines (121.83 dbA), cramping machines (113 dbA), and Hydraulic machines (84.16 dBA) were measured as shown in Table 3. The study showed the workers are exposed to highly hazardous noise levels for a prolonged period of 8 hours of work shift which may lead to hearing loss. Kerdonfag P et al. mentioned in their study one time or prolonged period of exposure to loud noise can lead to hearing loss. Continuous exposure to loud noise for a prolonged period increases the risk of progressive and irreversible hearing loss in both ears.[22] The NIOSH denotes 85dB(A) and more noise level as the restricting level for preventing hearing loss. The study made in Thailand [19] stated a significant increase in the risk of developing hearing loss among workers who are exposed to high noise levels above 85db(A). The noise-exposed group of the present study can be at higher risk of hearing loss development than the control group. The noise level measurements were made on A weighted network based on the simplicity and accuracy of the scale in evaluating hearing hazard. The scale has been internationally adopted for the assessment of noise exposure.[23-24] From the study it was found that only 31% of the steel weaving workers used PPE while working with weaving machinery shown in Table 4. This may be due to poor awareness of NIHL risk and protective measures of PPE at the workplace. A United States study has shown increased reporting of hearing loss in unprotected workers.[25] A study on industries showed the implementation of noise-reduction measures and the use of hearing PPE reduced hearing damage in young workers.[26] Use of hearing protectors such as earmuffs, ear canal caps and ear plugs to reduce the noise level to a safer level should be promoted when engineering controls and work methods cannot be under feasibility.[27] In the present study about 69% of the noise-exposed group have difficulty in hearing the words clearly. Studies mentioned a loss of clarification of perceived speech and difficulty in distinguishing particular words is observed among individuals having NIHL.[28-29] Among the 26 noise-exposed subjects 58% experience tinnitus after working in a noisy environment. Teixeira et al. stated the development of tinnitus from exposure to loud noise. The workers having hearing loss fails to mark hearing ability changes till the occurrence of a large threshold shift. The irreversible characteristic of tinnitus and severity increased with continued exposure.[30] About 62% of the exposed group feel frustrated due to poor perception of the words. This may be due to the development of tinnitus which leads to the development of annoyance and poor mood. Tinnitus is considered one of the major problems for noise-exposed workers, primarily affecting mood, sleep, concentration, and quality of life.[31] Sheppard et al. stated inability to get speech properly in the everyday situation due to hearing loss have a severe social impact.[32] In the present study we found from the audiometric results shown in Table 5 the steel weaving factory workers significantly differed from the control group and were at significantly higher risk of developing bilateral NIHL than the control group in varied tested frequencies of 1000 Hz, 1500Hz, 2000Hz, 3000Hz, 4000Hz,6000Hz and 8000 Hz respectively. Narasimhan et al. mentioned 4000Hz frequency to be severely affected by chronic noise exposure along with higher frequency (3 kHz-6KHz) than the lower frequencies (500Hz- 2KHz).[33] Based on the hearing threshold level of the exposed group and control group at higher frequencies of 3kHz- 8kHz shown in Table 3, referring to the Olusanya et al. categorization of hearing loss the noise-exposed group has the probability of developing mild hearing loss As the noise-exposed workers of the steel weaving factory are exposed to chronic noise level for a prolonged period and not using PPE for convenience while working can have a cumulative effect on the increased risk of developing bilateral NIHL.

Conclusion

From the results and analysis of the study, it can be concluded that the steel weaving factory workers are exposed to hazardous noise levels in the workplace for an extended period of 8 hours of work shift, which may result in hearing loss. About 69% of the noise-exposed populations reported complaints of difficulty in hearing and more than 58% of the workers complained of tinnitus showing the probability of the development of hearing loss. Only 31% of the steel weaving workers use PPE while exposed to chronic noise indicating poor awareness of noise exposure effect and NIHL risk in the workplace. The audiometric results showed the noise-exposed workers have the highest mean hearing threshold levels in 3KHz -5KHz than the control group suggesting the probability of developing mild hearing loss which gradually can develop into bilateral NIHL. Significant increases in blood pressure observed in the noise-exposed workers increase the risk of the development of hypertension. Occupational NIHL is considered one of the completely preventable hearing losses with significant health and economic consequences mostly occurring in developing countries. Since noise levels in the workplace are uncontrollable, the use of PPE while working on steel weaving machinery can help workers avoid hearing loss. Strict enforcement of the self-protective measures-use of noise-canceling earmuffs, ear canal caps, and ear plugs should be encouraged and periodic hearing conservation with audiometric screening tests can help to check the risk of NIHL.

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References

1. World Health Organization. Addressing the prevalence of hearing loss.[Internet] Geneva: World Health Organization; 2018 February. p. 3e10. [Accessed on 05-05-22]
2. Masterson EA, Bushnell PT, Themann CL, Morata TC. Hearing impairment among noise-exposed workers—United States, 2003–2012. Morbidity and Mortality Weekly Report. 2016 Apr 22;65(15):389-94. Available from: https://doi.org/10.15585/mmwr.mm6515a2
3. Murphy E, King EA. Environmental noise pollution: Noise mapping, public health, and policy. Elsevier; 2022 Apr 9.ISBN: 9780124115958
4. Meetham AR, Bottom DW, Cayton S. Atmospheric pollution: its history, origins and prevention. Elsevier; 2016 Jan 21. ISBN: 9780128166932
5. Nyarubeli IP, Tungu AM, Bråtveit M, Sunde E, Kayumba AV, Moen BE. Variability and determinants of occupational noise exposure among iron and steel factory workers in Tanzania. Annals of work exposures and health. 2018 Nov 12;62(9):1109-22. Available from: https://doi.org/10.1093/annweh/wxy071
6. Graydon K, Waterworth C, Miller H, Gunasekera H. Global burden of hearing impairment and ear disease. The Journal of Laryngology & Otology. 2019 Jan;133(1):18-25. Available from: https://doi.org/10.1017/S0022215118001275
7. Ding T, Yan A, Liu K. What is noise-induced hearing loss?. British Journal of Hospital Medicine. 2019 Sep 2;80(9):525-9. Available from: https://doi.org/10.12968/hmed.2019.80.9.525
8. Prokopenko LV, Courierov NN, Lagutina AV, Pochtariova ES. Calculation and assessment noise induced hearing loss excess risk in group of population. Russian Journal of Occupational Health and Industrial Ecology. 2019 May 20(4):212-8. Available from: https://doi.org/10.17116/otorino20208506127
9. TSha SH, Schacht J. Emerging therapeutic interventions against noise-induced hearing loss. Expert opinion on investigational drugs. 2017 Jan 2;26(1):85-96. Available from: https://doi.org/10.1080/13543784.2017.1269171
10. Hemmativaghef E. Exposure to lead, mercury, styrene, and toluene and hearing impairment: evaluation of dose-response relationships, regulations, and controls. Journal of occupational and environmental hygiene. 2020 Dec 1;17(11-12):574-97. Available from: https://doi.org/10.1080/15459624.2020.1842428
11. Rabinowitz P, Cantley LF, Galusha D, Trufan S, Swersey A, Dixon-Ernst C, Ramirez V, Neitzel R. Assessing hearing conservation program effectiveness. Journal of Occupational and Environmental Medicine. 2018 Jan 1;60(1):29-35. Available from:

https://doi.org/10.1097/JOM.0000000000001125

12. Abraham Z, Massawe E, Ntunaguzi D, Kahinga A, Mawala S. Prevalence of noise-induced hearing loss among textile industry workers in Dar es Salaam, Tanzania. Annals of global health. 2019;85(1). Available from: https://doi.org/10.5334/aogh.2352
13. Olusanya BO, Davis AC, Hoffman HJ. Hearing loss grades and the International classification of functioning, disability and health. Bulletin of the World Health Organization. 2019 Oct 10;97(10):725. Available from: https://doi.org/10.5334/aogh.2352
14. Davis AC, Hoffman HJ. Hearing loss: rising prevalence and impact. Bulletin of the World Health Organization. 2019 Oct 10;97(10):646. Available from: https://doi.org/10.2471/BLT.19.224683
15. Aljunid SM, Tahir NB. Noise Induced Hearing Loss in Manufacturing Industries: How Much Does It Cost to the Workers, Families and Society?. Partridge Publishing Singapore; 2020 Apr 24. (Accessed on 15-05-22)
16. Sheikh MS, Majeed S, Ali S. Noise induced hearing loss among industrial workers of South Punjab, Pakistan. The Professional Medical Journal. 2020 May 10;27(05):1022-6.Available from: https://doi.org/10.29309/TPMJ/2020.27.05.4115
17. Wangchuk P, Dendup P. Prevalence of Occupational noise induced hearing loss (ONIHL) among industrial workers in Bhutan. Bhutan Health Journal. 2020;6(1):25-31. Available from: https://doi.org/10.47811/bhj.96
18. Jhanwar D. Noise pollution: a review. Journal of Environment Pollution and Human Health. 2016;4(3):72-7. Available from: https://doi.org/10.12691/jephh-4-3-3
19. Sriopas A, Chapman RS, Sutammasa S, Siriwong W. Occupational noise induced hearing loss in auto part factory workers in welding units in Thailand. J Occup Health 2016:15e291. Available from: https://doi.org/10.1539/joh.15-0291-OA
20. Dzhambov AM, Dimitrova DD, Dzhambov A. Association between noise pollution and prevalent ischemic heart disease. Folia Med (Plovdiv). 2016 Dec 23;58(4):273-81. Available from: https://doi.org/10.1515/folmed-2016-0041
21. Lu S-Y, Lee C-L, Lin K-Y, Lin Y-H. The acute effect of exposure to noise on cardiovascular parameters in young adults. J Occup Health 2018. 2017-0225-OA. Available from: https://doi.org/10.1539/joh.2017-0225-OA
22. Kerdonfag P, Wadwongtham W, Taneepanichskul S. Hearing threshold levels among steel industry workers in Samut Prakan, Thailand. Risk Manage Health Policy 2019;12:57. Available from: https://doi.org/10.2147/RMHP.S166042
23. Zaw AK, Myat AM, Thandar M, Htun YM, Aung TH, Tun KM, et al. Assessment of noise exposure and hearing loss among workers in textile mill (Thamine), Myanmar: a cross-sectional study. Safety and Health at Work. 2020 Jun 1;11(2):199-206. Available from: https://doi.org/10.1016/j.shaw.2020.04.002
24. Smolensky MH, Reinberg AE, Sackett-Lundeen L. Perspectives on the relevance of the circadian time structure to workplace threshold limit values and employee biological monitoring. Chronobiology International. 2017 Nov 26;34(10):1439-64. Available from: https://doi.org/10.1080/07420528.2017.1384740
25. Neitzel RL, Swinburn TK, Hammer MS, Eisenberg D. Economic impact of hearing loss and reduction of noise-induced hearing loss in the United States. Journal of speech, language, and hearing research. 2017 Jan;60(1):182-9. Available from: https://doi.org/10.1044/2016_JSLHR-H-15-0365
26. Frederiksen TW, Ramlau-Hansen CH, Stokholm ZA, Grynderup MB, Hansen ÅM, Kristiansen J, et al. Noise-Induced Hearing Loss–A Preventable Disease? Results of a 10-Year longitudinal study of workers exposed to occupational noise. Noise & health. 2017 Mar;19(87):103. Available from: https://doi.org/10.4103/nah.NAH_100_16
27. Basu S, Aggarwal A, Dushyant K, Garg S. Occupational noise induced hearing loss in India: A systematic review and meta-analysis. Indian Journal of Community Medicine. 2022 Apr 1;47(2):166. Available from: https://doi.org/10.4103/ijcm.ijcm_1267_21
28. Weier MH. The Association Between Occupational Exposure to Hand–Arm Vibration and Hearing Loss: A Systematic Literature Review. Safety and health at work. 2020 Sep 1;11(3):249-61. Available from: https://doi.org/10.1016/j.shaw.2020.04.003
29. Kurabi A, Keithley EM, Housley GD, Ryan AF, Wong

AC. Cellular mechanisms of noise-induced hearing loss. Hearing research. 2017 Jun 1;349:129-37. Available from: https://doi.org/10.1016/j.heares.2016.11.013

30. Teixeira LR, Azevedo TM, Bortkiewicz A, Da Silva DT, De Abreu W, De Almeida MS, et al. WHO/ILO work-related burden of disease and injury: Protocol for systematic reviews of exposure to occupational noise and of the effect of exposure to occupational noise on cardiovascular disease. Environment international. 2019 Apr 1;125:567-78. Available from: https://doi.org/10.1016/j.envint.2018.09.040

31. Møller AR. Sensorineural tinnitus: its pathology and probable therapies. International journal of otolaryngology. 2016 Oct;2016. Available from: https://doi.org/10.1155/2016/2830157

32. Sheppard A, Ralli M, Gilardi A, Salvi R. Occupational noise: auditory and non-auditory consequences. International journal of environmental research and public health. 2020 Dec;17(23):8963. Available from: https://doi.org/10.3390/ijerph17238963

33. Narasimhan S, Rajagopalan R, Justin Margret J, Visvanathan G, Jayasankaran C, Rekha K, Srisailapathy CS. Audiometric notch as a sign of noise induced hearing loss (NIHL) among the rice and market flour mill workers in Tamil Nadu, South India. Hearing, Balance and Communication. 2022 Jan 2;20(1):21-31. Available from: https://doi.org/10.4103/0971-7749.10343