Occupational Noise Induced Hearing Loss in India: A Systematic Review and Meta-Analysis

Saurav Basu, Abhinav Aggarwal, Kumar Dushyant, Suneela Garg
Departments of Community Medicine and ENT, Maulana Azad Medical College, New Delhi, India

Abstract

Background: India has over 50 million workers employed in industries with exposure to very high sound levels, predisposing them to noise-induced hearing loss (NIHL). Methods: We conducted a systematic review and meta-analysis by using the following criteria: (1) Observational or experimental studies conducted in India; (2) English language studies; (3) Published during January 2010–December 2019; (4) Primary outcome: proportion of participants detected with NIHL. We reviewed bibliographic databases (PubMed, Scopus, and DOAJ) and Google Scholar, and extracted the relevant data. Results: A total of 160 documents were identified after removing duplicates, and 33 full texts were screened, of which 22 studies were included. The mean (SD) effective sample size of the studies was 107.1 (78.9). The pooled proportion of participants with NIHL irrespective of the category was 0.49 (95%CI: 0.22–0.76) and that of hearing loss was 0.53 (95%CI: 0.28–0.78). Most studies reported that none of the workers, especially in the informal sectors, used auditory protection. Conclusions: NIHL is a major neglected public health occupational health challenge in India linked with adverse social determinants of health. Sustained advocacy for implementation of legislative and behavior change communication for protecting the hearing of workers is warranted.

Keywords: India, occupational health, occupational hearing loss, noise-induced hearing loss

Introduction

Prolonged, cumulative exposure to loud noise levels (>85 dB) can damage the auditory system and induce a sensorineural type of hearing loss, usually bilateral, defined as noise-induced hearing loss (NIHL). NIH in its inception is temporary, but prolonged exposure to excessive noise levels for extended periods can induce a noise-induced permanent threshold shift. Cessation of noise exposure prevents further progression of NIHL. It is estimated that 16% of the disabling hearing loss in adults worldwide accounting for 4 million DALYs is attributable to occupational noise exposure. The World Health Organization (WHO) estimated that billions of people worldwide are at continued risk of avoidable NIHL due to exposure to loud sound levels. Studies globally have found that workers engaged in construction, industrial (automotive industry, mines, quarry, metal, textile, etc.), shipyards, firefighters, military, civil aviation, railways, agriculture, traffic policemen, teachers, etc., are at increased risk of NIHL.

Public health goals include minimizing harmful noise production at the source, preventing exposure to hazardous noise, provision of effective personal protective equipment (PPE) to those exposed to hazardous noise, early detection of NIHL by periodic screening, and medical and social rehabilitation of those with hearing loss. In the United States, preventing one-fifth of the existing annual burden of hearing loss due to excessive noise exposure was estimated to result in economic benefits of nearly $123 billion. The problem of NIHL is more acute in developing countries where rapid industrialization, a large informal sector, and lack of protective engineering and prophylactic measures for noise control caused prolonged exposure of workers to hazardous noise conditions. The Factory Act of India does not stipulate any specific provision for noise control.

Address for correspondence: Dr. Saurav Basu, Assistant Professor, Indian Institute of Public Health - Delhi Sector 44, Plot No. 47, Gurugram, Haryana - 122002 India. E-mail: saurav.basu1983@gmail.com

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms. For reprints contact: WKHLRPMedknow_reprints@wolterskluwer.com

How to cite this article: Basu S, Aggarwal A, Dushyant K, Garg S. Occupational noise induced hearing loss in India: A systematic review and meta-analysis. Indian J Community Med 2022;47:166-71. Received: 04-10-21, Accepted: 24-02-22, Published: 11-07-22
although it recognizes NIHL as a notifiable disease.\cite{13} A maximum of 90 dB (A) for 8 h continuous noise exposure is the limit recommended by the Directorate General of Factories Advisory Services and Labor Institutes.\cite{14} However, several industries especially concentrated in the developing world, including India, providing employment to millions of workers routinely exceed this 90-dB (A) limit, such as the textile (woolen and jute mills), woodworker, marble, ceramic, and other industries.\cite{14}

The objective of this study was to ascertain the burden and determinants of occupational NIHL in workers potentially exposed to hazardous noise levels at the workplace in Indian industries.

**Methods**

**Search strategy and selection criteria**

We conducted a systematic review and meta-analysis using the following criteria: (1) Observational or experimental studies conducted in India; (2) English language studies; (3) Published during January 2010–December 2019; (4) Primary outcome was the proportion of participants detected with NIHL. The protocol was prospectively registered with PROSPERO (CRD42020165221).

**Review approach**

We used the following search terms “Noise-induced hearing loss” (MeSH and entry terms), “Hearing loss” (MeSH and entry terms), “occupational health” ((MeSH and entry terms), “workers” (MeSH and entry terms), and “India” in specific combinations.

A total of 57 PubMed/Medline records, 181 Scopus records, and 17 DOAJ records were identified, which were imported into Mendeley reference management software, following which the duplicate records were removed. All the titles were then subjected to abstract screening. Our inclusion criterion was original research with the objective of detecting occupational hearing loss in any workers. Studies were included if their abstracts reported methods or results relating to NIHL or hearing loss in people employed in any specific occupation [Figure 1]. We included observational studies only with no restrictions by age, gender, and sexual identity of the participants. Using a predesigned data extraction form, two reviewers extracted data from the selected articles independently, and any disagreements were resolved by consensus.

**Data extraction**

Information on the sociodemographic population characteristics, namely age, gender, the name of the first author, year of publication, study design, study period, type of industry, sample size, application of audiometry and/or BERA, prevalence of NIHL, prevalence of hearing loss and its categorization (into mild, moderate, and severe categories), use of protective hearing equipment (PPE), and factors associated with hearing loss.

The primary outcome measure was the proportion of participants detected with NIHL. The risk of bias (quality) assessment was assessed using a modified Joanna Briggs Institute (JBI) appraisal checklist for studies reporting prevalence data (https://joannabriggs.org/sites/default/
files/2019-05/JBI_Critical_Appraisal-Checklist_for_Prevalence_Studies2017_0.pdf).

Statistical analysis: The extracted data were entered and analyzed in IBM SPSS Version 25. Meta-analysis was conducted using the “Metaprop_one” function in STATA-14. As there was significant heterogeneity between the studies, the random-effects model was used to calculate the pooled estimates for measuring the prevalence of NIHL and HL. The pooled estimate was expressed as proportions with 95% confidence intervals.

Results
Identification of studies
A total of 160 documents were identified after removing duplicates, and 33 full texts were screened, of which 21 studies were included in the meta-analysis [Figure 1].

Characteristics of included studies [Table 1]
The mean (SD) effective sample size of the studies was 106.1 (80.5). The mean (SD) age of the participants in the included studies was 36.1 (5.1). The studies were conducted among workers in the following industries: stone cutting, ginning, plywood, heavy metal, farming, mining, explosive, sugarcane, steel, handicraft, and plastic weaving. All the studies employed a cross-sectional design. A control group was recruited in eight (38.1%) studies.

Prevalence of Hearing loss [Table 2]
The pooled proportion of participants with NIHL irrespective of the category was 0.49 (95%CI: 0.22–0.76) and that of hearing loss was 0.53 (95%CI: 0.28–0.78) [Figure 2a and 2b]. Prolonged duration of exposure was the most common risk factor for NIHL. Most studies reported none of the workers using any auditory protection. Interestingly, a study among steel industry workers, a formal industry, by Singh et al. (2013) [33] reported the workers avoiding the use of ear protectors primarily due to lack of comfort from failure of ergonomic fit and the reduction of annoyance from the workplace noise due to its acceptance and shifting of the hearing threshold leading to adaption to the high noise levels in their workplace environment.

The study by Biswas and Kumar found that nearly half the workers engaged in activities involving hammering metal, welding, wood joinery, sawmilling, and grain grinding had audiogram patterns typical of NIHL.[19] The study by Lokhande in Goa observed notched hearing loss in 6% of the exposed workers in a ship-building industry but none in the age-and sex-matched office controls.[36] The study among cotton ginning workers by Dube et al.[20] observed exposure to continuous noise levels of 89–106 dBA, with binaural hearing impairment present in 86% of the workers. Bilateral and symmetrical hearing loss in traffic policemen with chronic noise exposure was reported in the study by Indora et al.[24] The study by Tikriwal et al.[33] among carpet workers observed a high prevalence of both tinnitus and hearing loss, with increasing prevalence associated with the greater severity of hearing loss. Several studies reported a positive correlation between duration of hazardous noise exposure in the workplace and the degree of hearing loss in the workers.[23,25,26]

Methodological quality
Most studies had a small sample size, reducing the external
validity of the study findings [Figure 3]. Only the study by Basheer et al. [16] assessed hearing loss in construction site workers by using the brainstem evoked response audiometry (BERA) method, while pure tone audiometry was performed in 14 studies (71.4%). Audiometry examination in workers following a period of mandatory overnight rest to avoid the temporary threshold shift which recover to baseline afterwards in contrast to the permanent threshold shift was reported by eight studies [Figure 2]. [37]

**DISCUSSION**

The results of this systematic review and meta-analysis show that nearly one in two industrial workers in India have evidence of NIHL on assessment using the pure-tone audiometry method, indicating the extent of this major neglected public health challenge. Moreover, the use of personal protective equipment (PPE) for hearing protection is negligible irrespective of the duration of exposure, with only one study conducted in the steel industry reporting its availability, while most informal workers were not provided with any PPE for their hearing protection. Considering that workers in several of these industries belong to the lower socioeconomic strata with limited education, the linkage of NIHL with adverse social determinants of health and the problem resolution through a human rights-based approach warrant critical exploration.

Most studies did not report basic epidemiological parameters and were of poor quality. These findings indicate the need for the generation of rigorous primary research for...
understanding the burden and determinants of occupational hearing loss.

**Limitations of existing studies**

Only a solitary study with a small sample size was conducted in construction and welding workers who are at high risk of occupational NIHL, and being mostly informal contractual workers may lack comprehensive health protection and largely being outside the purview of implementable protective regulatory legislation. Similarly, few studies have been conducted on workers in the mining and textile industries, which provide employment to millions of workers and expose their workers to a high risk of NIHL. Less than half of the studies used pure-tone audiometry for assessing hearing function in the workers, while only a single study with a small sample size used the brainstem evoked response audiometry (BERA) method to also evaluate the auditory pathway affection. The advantage of BERA is the ability to objective assess whether the central or peripheral component of the auditory pathway is involved in individuals with NIHL. Binaural hearing impairment assessment was lacking in most studies. Similarly, future studies should also assess speech reception to assess those cases when pure-tone audiometry is normal but the individual cannot comprehend speech. Symptoms such as tinnitus and vertigo associated with hearing loss, which can affect quality of life of the affected workers, were not assessed in most studies.

This systematic review has certain limitations. The risk of NIHL is linked to the intensity and duration of occupational sound exposure; thus, the aggregate pooled prevalence of occupational NIHL estimated from studies including divergent occupational profiles can be subject to selection bias. Searches were conducted only in standardized databases; thus, research published in gray literature may have inadvertently omitted.

**Implications for future research**

India’s National Program for Prevention and Control of Deafness (NPPCD) was initiated in 2007 with the long-term objective of preventing and controlling major causes of hearing impairment and deafness to reduce the total disease burden by 25% of the existing burden. However, within the program, there exists no specific initiatives and targets for addressing occupational NIHL. The occurrence of avoidable NIHL and extreme discomfort from exposure to hazardous noise also indicates undermining of human rights of the socioeconomically vulnerable workers. Consequently, regular audiometry for screening of NIHL, health promotion through the mandatory provision of protective auditory equipment to all workers, and advancing protection to the more vulnerable informal workers is urgently warranted. Modernization of industries with safer technology has the potential to eliminate harmful noise exposure to workers, but economic constraints need to be overcome to achieve hearing protection in workers. Future studies should design and assess the effectiveness of interventions to preserve and protect hearing loss resulting from hazardous noise exposure at the workplace.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

**References**

1. Stucken EZ, Hong RS. Noise-induced hearing loss: An occupational medicine perspective. Curr Opin Otolaryngol Head Neck Surg 2014;22:388-93.
2. Wong ACY, Froud KE, Hsieh YSY. Noise-induced hearing loss in the 21st century: A research and translational update. World J Otorhinolaryngol 2013;3:58-70.
3. Nelson DI, Nelson RY, Concha-Barrientos M, Fingerhut M. The global burden of occupational noise-induced hearing loss. Am J Ind Med 2005;48:446-58.
4. Lie A, Skogstad M, Johannessen HA, Tynes T, Mehlum IS, Nordby KC,
et al. Occupational noise exposure and hearing: A systematic review. Int Arch Occup Environ Health 2016;89:351–72.

5. WHO. Hearing loss due to recreational exposure to loud sounds: A review. Geneva: World Health Organization; 2015.

6. Nandi SS, Dhakar SV. Occupational noise-induced hearing loss in India. Indian J Occup Environ Med 2008;12:53-6.

7. Soltanzadeh A, Ebrahimi H, Fallahi M, Kamalinia M, Ghassemi S, Golmohammadi R. Noise induced hearing loss in Iran: (1997-2012): Systematic review article. Iran J Public Health 2014;43:1605-15.

8. van Kamp I, Davies H. Noise and health in vulnerable groups: A review. Noise Health 2013;15:153-9.

9. Hong O, Kerr M, Poling G, Dhar S. Understanding and preventing noise-induced hearing loss. Dis Mon 2013;59:110–8.

10. Verbeek JH, Kateman E, Morata TC, Dreschler WA, Mischke C. Interventions to prevent occupational noise-induced hearing loss: A cochrane systematic review. Int J Audiol 2014;53(Suppl 2):S84-96.

11. Neitzel RL, Swinburn TK, Hammer MS, Eisenberg D. Economic impact of hearing loss and reduction of noise-induced hearing loss in the United States. J Speech Lang Hear Res 2017;60:182-9.

12. Concha-Barrientos M, Campbell-Ledium D, Steenland K. Assessing the burden of disease from work-related hearing impairment at national and local levels. Available from: http://www.who.int/quantifying_ehimpacts/publications/en/ebd9.pdf. [Last accessed on 2021 Dec 31].

13. Ministry of Labour and Employment. Government of India. The Factories Act 1948.pdf. [Last accessed on 2018 Nov 11].

14. Concha-Barrientos M, Campbell-Ledium D, Steenland K. Assessing the burden of disease from work-related hearing impairment at national and local levels. Available from: http://www.who.int/quantifying_ehimpacts/publications/en/ebd9.pdf. [Last accessed on 2021 Dec 31].

15. Ministry of Labour and Employment, Government of India. The Factories Act 1948. Available from: https://labour.gov.in/sites/default/files/TheFactoriesAct1948.pdf. [Last accessed on 2018 Nov 11].

16. Basu G, Sarkar D, Pal R, Roy SK, Dasgupta R. Morbidity audit of women beedi workers in an urban fringe of West Bengal, India. J Clin Diagnostic Res 2018;12:LC05–9.

17. Bhumika N, Prabhhu G, Ferreira A, Kulkarni M. Noise-induced hearing loss still a problem in shipbuilders: A cross-sectional study in Goa, India. Diagnostic Res 2018;12:LC05–9.

18. Gupta M, Khajuria V, Manhas M, Gupta KL, Singh O. Pattern of noise induced hearing loss and its relation with duration of exposure in traffic police personnel. Indian J Community Heal 2015;27:276–80.

19. Indora V, Khaliq F, Vaney N. Evaluation of the auditory pathway in traffic policemen. Int J Occup Environ Med 2017;8:109–16.

20. Jain A, Gupta N, Bafna G, Mehta B. Impact of noise exposure on hearing acuity of marble factory workers. Indian J Physiol Pharmacol 2017;61:295–301.

21. Khadatkar A, Mehta CR. Effect of age and duration of driving on hearing status of Indian agricultural tractor drivers. J Low Freq Noise Vib Act Control 2018;37:1037–44.

22. Majumder J, Patel RC, Kotadiya S, Shah P. Hearing threshold status and risk estimate of hearing impairment among administrative workforce. Indian J Occup Environ Med 2018;22:11-6.

23. Oliveira A, Cacodcar J, Motghare DD. Morbidity among iron ore mine workers in Goa. Indian J Public Health. 2014;58:57-60.

24. Raja G. Disability evaluation in acute and chronic noise-induced hearing loss and hearing threshold profile at high frequencies. Indian J Occup Environ Med. 2015;19:138-40.

25. Singh LP, Bhardwaj A, Deepak KK. Occupational noise-induced hearing loss in Indian steel industry workers: An exploratory study. Hum Factors. 2013;55:411-24.

26. Singh AK. Comparative assessment of shift in hearing threshold among handicraft operatives in India. Ergonomics. 2019;62:88-102.

27. Soltanzadeh A, Ebrahimi H, Fallahi M, Kamalinia M, Ghassemi S, Golmohammadi R. Noise induced hearing loss in Iran: (1997-2012): Systematic review article. Iran J Public Health 2014;43:1605-15.

28. Raju G. Disability evaluation in acute and chronic noise-induced hearing loss and hearing threshold profile at high frequencies. Indian J Occup Environ Med. 2015;19:138-40.

29. Solanki JD, Mehta HB, Shah CJ, Gokhale PA. Occupational noise induced hearing loss and hearing threshold profile at high frequencies. Indian J Otol. 2014;20:115-8.

30. Shanks E. Noise in the United Kingdom printing industry: Then and now. Available from: https://www.acoustics.asn.au/conference_files/51892751619025258383.pdf. [Last accessed on 2021 Dec 31].

31. Tao SS. Assessment of Hearing Loss among Workers of A Sugarcane Industry. IOSR J Dent Med Sci. 2015;14:33-5.

32. Singh LP, Bhardwaj A, Deepak KK. Occupational noise-induced hearing loss in Indian steel industry workers: An exploratory study. Hum Factors. 2013;55:411-24.

33. Singh AK. Comparative assessment of shift in hearing threshold among handicraft operatives in India. Ergonomics. 2019;62:88-102.

34. Solanki JD, Mehta HB, Shah CJ, Gokhale PA. Occupational noise induced hearing loss and hearing threshold profile at high frequencies. Indian J Otol. 2014;20:115-8.

35. Tekriwal R, Parmar DM. Extra auditory effect of noise - A study on textile workers of surat city. Natl J Physiol Pharm Pharmacol. 2012;2:45-51.

36. Lokhande VR. Health profile of workers in a ship building and repair industry. Indian J Occup Environ Med. 2014;18:89-94.

37. Ryan AF, Kujawa SG, Hammill T, Le Prell C, Kil J. Permanent noise-induced threshold shifts: A review of basic and clinical observations. Otol Neurotol 2016;37:e271‑5.

38. Government of India. National Program for Prevention and Control of Deafness. [Available from: https://mohfw.gov.in/sites/default/files/files/51892751619025258383.pdf]. [Last accessed on 2021 Dec 31].

39. Shanks E. Noise in the United Kingdom printing industry: Then and now. Available from: https://www.acoustics.asn.au/conference_proceedings/INTERNoise2014/papers/p196.pdf. [Last accessed on 2021 Dec 31].