Review Article

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

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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).[1] NIHL 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.[2] It is estimated that 16% of the disabling hearing loss in adults worldwide accounting for 4 million DALYs is attributable to occupational noise exposure.[3,4]

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.[5] 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.[6-8]

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 NIHS by periodic screening, and medical and social rehabilitation of those with hearing loss.[9,10] 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.[11]

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.[12] The Factory Act of India does not stipulate any specific provision for noise control,

Access this article online

Quick Response Code:

Website: www.ijcm.org.in

DOI: 10.4103/ijcm.ijcm_1267_21

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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.[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.[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.[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/

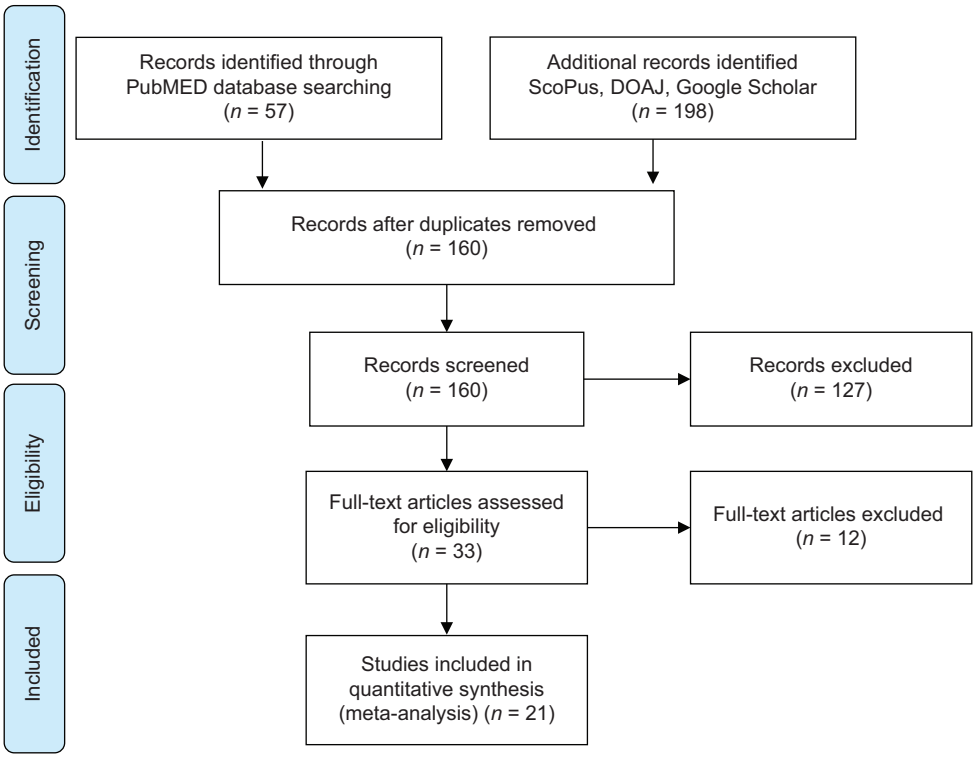

Figure 1: PRISMA flow diagram of the systematic review and meta-analysis

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.[35] 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*.[35] 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.[21,23,25,26]

Methodological quality

Most studies had a small sample size, reducing the external

Table 1: Characteristics of the included studies (2011-19)

Author	Year	Sample size	Industry	Mean (SD) age	Men/Women	Control group
Aboobackr[15]	2014	31	Stone cutter	28 (8.9)	-	-
Basheer[16]	2019	57	Printing	-	0/103	-
Basu[17]	2018	103	Beedi/Tobacco	38.69 (8.53)	-	-
Bhumika[18]	2013	276	Ship building	43.20 (11.37)	-	-
Biswas[19]	2018	167	Industrial	-	-	-
Dube[20]	2011	200	Ginning	35.0	-	-
Edward[21]	2016	111	Plywood	-	104/7	-
Goteti[22]	2015	100	Heavy Metal	36.65 (6.61)	-	Yes
Gupta[23]	2015	150	Traffic police	-	150/0	-
Indora[24]	2017	35	Traffic police	-	35/0	Yes
Jain[25]	2017	30	Marble	-	30/0	-
Khadatkar[26]	2018	60	Farmer	39.90 (9.71)	-	Yes
Majumder[27]	2018	97	Admin staff	-	64/33	-
Oliveira[28]	2014	314	Mining	-	309/5	-
Raju[29]	2015	13	Explosive	-	-	-
Ranga[30]	2014	100	Industrial	-	100/0	-
Rao[31]	2015	60	Sugarcane	-	-	Yes
Singh[32]	2013	165	Steel	-	-	Yes
Singh[33]	2018	60	Handicraft	31.68 (7.31)	-	Yes
Solanki[34]	2012	50	Plastic weaver	-	-	Yes
Tikriwal[35]	2012	50	Textile	-	-	Yes

Table 2: Prevalence of noise-induced hearing loss in the included studies (2011-19)

Author	Year	Sample size	NIHL	Hearing Loss	Grade Mild	Grade Mod	Grade Severe	Grade Profound
Aboobackr[15]	2014	31	31	-	7	24	0	0
Basheer[16]	2019	57	-	-	-	-	-	-
Basu[17]	2018	103	-	23	-	-	-	-
Bhumika[18]	2013	276	17	21	19	1	1	0
Biswas[19]	2018	167	83	-	-	-	-	-
Dube[20]	2011	200	-	192	-	-	-	-
Edward[21]	2016	111	57	57	32	22	3	0
Goteti[22]	2015	100	-	100	8	28	62	2
Gupta[23]	2015	150	33	41	29	11	1	0
Indora[24]	2017	35	35	-	-	-	-	-
Jain[25]	2017	30	14	21	9	4	7	1
Khadatkar[26]	2018	60	-	-	-	-	-	-
Majumder[27]	2018	97	-	-	-	-	-	-
Oliveira[28]	2014	314	-	116	111	4	1	0
Raju[29]	2015	13	10	11	0	1	10	0
Ranga[30]	2014	100	-	39	5	16	16	2
Rao[31]	2015	60	11	20	8	5	7	0
Singh[32]	2013	165	149	-	-	-	-	-
Singh[33]	2018	60	-	60	18	41	1	0
Solanki[34]	2012	50	42	42	19	16	6	1
Tikriwal[35]	2012	50	-	43	0	37	6	0

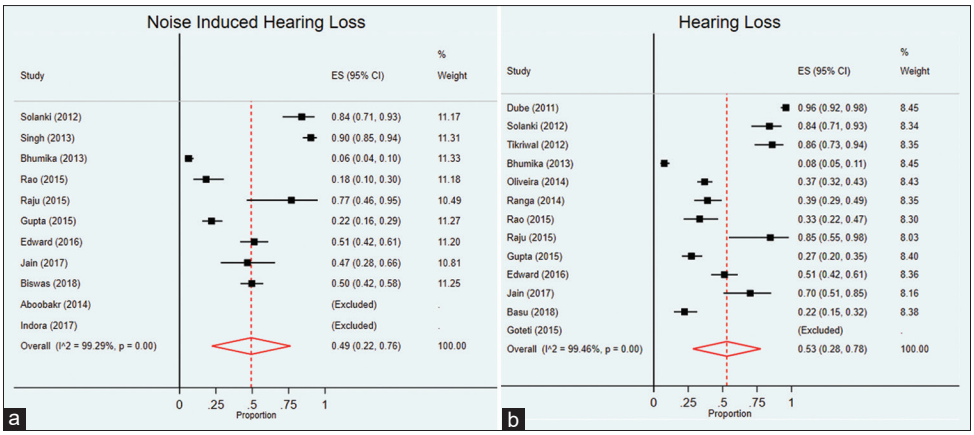

Figure 2: (a) Forest Plotplot for estimation of pooled prevalence of Noise Induced Hearing Lossnoise-induced hearing loss (b) Forest Plotplot for estimation of pooled prevalence of Hearing Losshearing loss

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

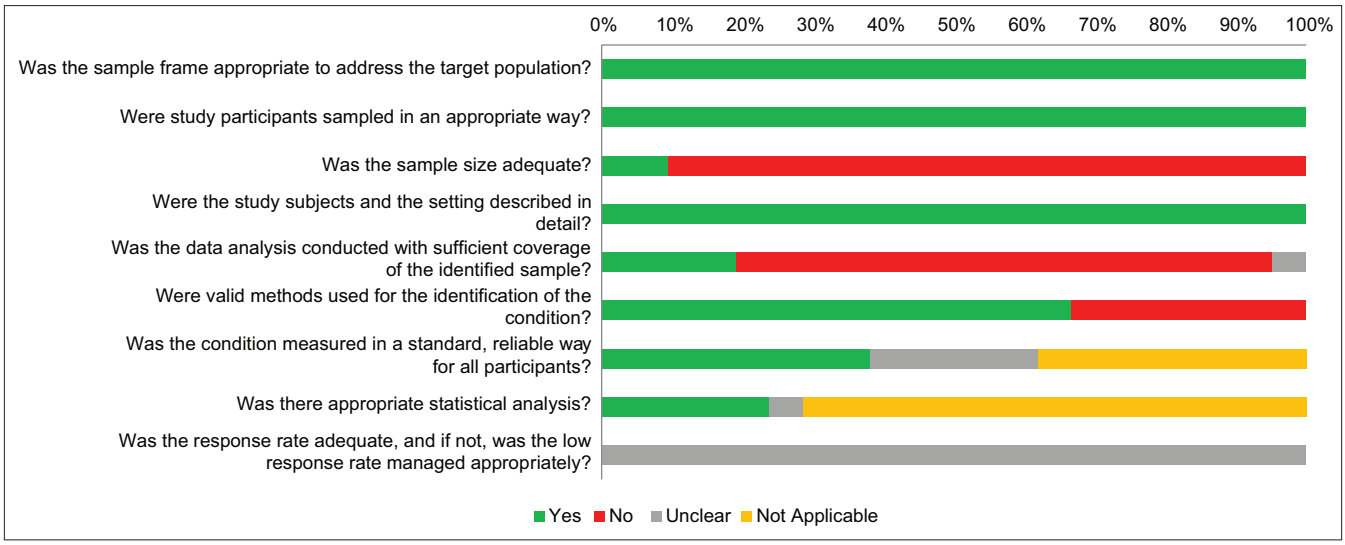

Figure 3: Quality of the included studies

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.[19] 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.[15] Binoaural 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 been 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.[38] 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.[39] 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.

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