Occupation 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 using the following criteria: (1) Observational or experimental studies conducted in India (2) English language studies (2). Published during Jan. 2010 - December 2019 (3). Primary outcome: proportion of participants detected with NIHL. We reviewed bibliographic databases (PubMED, Scopus, DOAJ) and Google Scholar, and extracted 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 category was 0.49 (95% C.I 0.22, 0.76) and that of hearing loss was 0.50 (95% C.I 0.24, 0.76). Most studies reported none of the workers using auditory protection.
Conclusions
NIHL is a major public health occupational problem in India. Sustained advocacy for implementation of legislative and behavior change communication for protecting hearing of workers is warranted.

Keywords: Occupational hearing loss; Noise induced hearing loss; India

INTRODUCTION

Prolonged, cumulative exposure to loud noise levels (> 85 dB) can damage the auditory system and induce a usually bilateral sensorineural type of hearing loss, which is defined as Noise-Induced Hearing Loss (NIHL).[1] The hearing loss produced by exposure to noise depends on many factors, including the sound pressure level, spectral content, exposure duration, and the temporal pattern with continuous noise being more damaging than intermittent noise. The 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] NIHL is the most recorded occupational disorder in Europe, and 7-21% hearing loss cases are attributable to occupational noise exposure.[4]

The World Health Organization (WHO) has estimated that billions of people worldwide are at continued risk of avoidable NIHS due to exposure to loud sound levels.[5] Studies globally have found workers engaged in construction, industrial (automotive industry, mines, and quarry, metal, textile, etc.), shipyards, firefighters, military, civil aviation, railways, agriculture, traffic policemen, teachers, etc. are at increased risk of NIHL.[6-8]

Avoiding exposure to loud sound levels is considered as the most effective preventive measure for protecting hearing health globally. Public health goals are 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 world countries where rapid industrialization, a large informal sector and lack of protective engineering and prophylactic measures for noise control expose workers to hazardous noise conditions.[12] Moreover, the workers frequently lack awareness on NIHL, miss opportunities for periodic hearing examination that enables early detection of hearing loss and are often unable to access or afford treatment and rehabilitation for hearing disabilities.

India has millions of workers employed in industries having very high sound pressure levels which increase the risk of NIHL. The Factory Act of India does not stipulate any specific provision for noise control although it recognizes NIHL as a notifiable disease.[13] A maximum of 90 dB (A) for 8 hours continuous noise exposure is the limit recommended by the Directorate General of Factories Advisory Services and Labour Institutes.[14] However, several industries routinely

exceed 90 dBA limit and pose a risk of hearing loss for their workers such as in the textile industry which provides employment to nearly 40 million workers directly with ambient noise levels often exceeding this limit especially in woolen and jute mills.[15] Furthermore, certain industries like the woodworker, marble, ceramic, etc. that are are concentrated in the developing world also often expose their workers to hazardous noise.

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 (2). Published during Jan. 2010 - December 2019 (3). Primary outcome: proportion of participants detected with NIHL The protocol was prospectively registered with PROSPERO.

Review approach

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 subject to abstract screening. Our inclusion criterion were original research with objective of detecting occupational hearing loss in any workers. Studies were included if their abstracts reported methods or results relating to noise induced hearing loss 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: 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, severe categories, use of protective hearing equipment, and factors associated with hearing loss.

The primary outcome measure was the proportion of participants detected with Noise induced hearing loss. The risk of bias (quality) assessment was assessed using a modified Joanna Briggs Institute (JBI) appraisal checklist for studies reporting prevalence data

Statistical analysis: The extracted data was entered and analyzed in IBM SPSS Version 25. Meta-analysis was conducted using the "Metaprop_one" function in STATA-14. Since there was significant heterogeneity between the studies, 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. Audiometry was performed in 10 and BERA in a single study for detection of hearing loss (52.4%). A control group was recruited in 8 (38.1%) studies.

Prevalence of Hearing loss (Table 2)

The pooled proportion of participants with NIHL irrespective of category was 0.49 (95% C.I 0.22, 0.76) (Figure 2) and that of hearing loss was 0.50 (95% C.I 0.24, 0.76) . Prolonged duration of exposure was the most common risk factor for NIHL. Most studies reported none of the workers using any auditory protection. The study by Biswas & Kumar found nearly half the workers engaged in activities involving hammering metal, welding, wood joinery, sawmilling and grain grinding having audiogram patterns typical of noise-induced hearing loss.[20] 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.[28]

Methodological quality

Only the study by Aboobakr et al assessed hearing loss in construction site workers using the brainstem evoked response audiometry (BERA) method while pure tone audiometry was performed in 10 studies (47.6%).

DISCUSSION

The results of this systematic review and meta-analysis show that nearly one in two industrial workers in India show evidence of NIHL on assessment with the pure tone audiometry method is present in nearly one in two workers. Moreover, use of personal protective equipment for

hearing protection is negligible irrespective of the duration of exposure. 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 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 were conducted in the mining and textile workers which provide employment to millions of workers and expose their workers to 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 of 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.[16] Monoaural or binoaural hearing impairment assessment was not conducted in any of the studies. Studies should also speech reception in which pure tone audiometry is normal but patient cannot comprehend speech. Symptoms like tinnitus and vertigo associated with hearing loss which can affect quality of life were not assessed in most studies. Furthermore, due to limited searches conducted only in standardized databases, research published in grey literature could have been 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 exist no specific initiatives and targets for addressing occupational NIHL. 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 the same.[39] Future studies can assess the effectiveness of interventions to preserve and protect hearing loss resulting from hazardous noise exposure at the workplace.

Sources of support: Nil

Conflicts of interest: None

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

Author	Year of publication	Effective sample size	Industry	Study design	Mean (SD) age	Men/Women
Aboobakr [16]	2014	31	Stone cutter	Cross-sectional	28 (8.9)	-
Basheer [17]	2019	57	Printing	Cross-sectional	-	0/103
Basu [18]	2018	103	Beedi/Tobacco	Cross-sectional	38.69 (8.53)	-
Bhumika [19]	2013	276	Ship building	Cross-sectional	43.20 (11.37)	-
Biswas [20]	2018	167	Industrial	Cross-sectional	-	-
Dube [21]	2011	200	Ginning	Cross-sectional	35.0	-
Edward [22]	2016	111	Plywood	Cross-sectional	-	104/7
Goteti [23]	2015	100	Heavy Metal	Cross-sectional	36.65 (6.61)	-
Gupta [24]	2015	150	Traffic police	Cross-sectional	-	150/0
Indora [25]	2017	35	Traffic police	Cross-sectional	-	35/0
Jain [26]	2017	30	Marble	Cross-sectional	-	30/0
Khadatkar[27]	2018	60	Farmer	Cross-sectional	39.90 (9.71)	-
Majumder[28]	2018	97	Admin staff	Cross-sectional	-	64/33
Oliveira [29]	2014	314	Mining	Cross-sectional	-	309/5
Raju [30]	2015	13	Explosive	Cross-sectional	-	-
Ranga [31]	2014	100	Industrial	Cross-sectional	-	100/0
Rao [32]	2015	60	Sugarcane	Cross-sectional	-	-
Singh [33]	2013	165	Steel	Cross-sectional	-	-
Singh [34]	2018	60	Handicraft	Cross-sectional	31.68 (7.31)	-
Solanki [35]	2012	50	Plastic weaver	Cross-sectional	-	-
Tikriwal [36]	2012	50	Carpet	Cross-sectional	-	-

Table 2. Prevalence of Noise Induced Hearing Loss in the included studies (2011-19)

Author	Year of publication	Effective sample size	NIHL	Hearing Loss	Grade Mild	Grade Mod	Grad Sev	Grad Profound
Aboobakr [16]	2014	31	31	-	7	24	0	0
Basheer [17]	2019	57	-	-	-	-	-	-
Basu [18]	2018	103	-	23	-	-	-	-
Bhumika [19]	2013	276	17	21	19	1	1	0
Biswas [20]	2018	167	83	-	-	-	-	-
Dube [21]	2011	200	-	192	-	-	-	-
Edward [22]	2016	111	57	57	32	22	3	0
Goteti [23]	2015	100	-	100	8	28	62	2
Gupta [24]	2015	150	33	41	29	11	1	0
Indora [25]	2017	35	35	-	-	-	-	-
Jain [26]	2017	30	14	21	9	4	7	1
Khadatkar[27]	2018	60	-	-	-	-	-	-
Majumder[28]	2018	97	-	-	-	-	-	-
Oliveira [29]	2014	314	-	116	111	4	1	0
Raju [30]	2015	13	10	11	0	1	10	0
Ranga [31]	2014	100	-	39	5	16	16	2
Rao [32]	2015	60	11	20	8	5	7	0
Singh [33]	2013	165	149	-	-	-	-	-
Singh [34]	2018	60	-	60	18	41	1	0
Solanki [35]	2012	50	42	42	19	16	6	1
Tikriwal [36]	2012	59	-	59	0	18	37	4

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

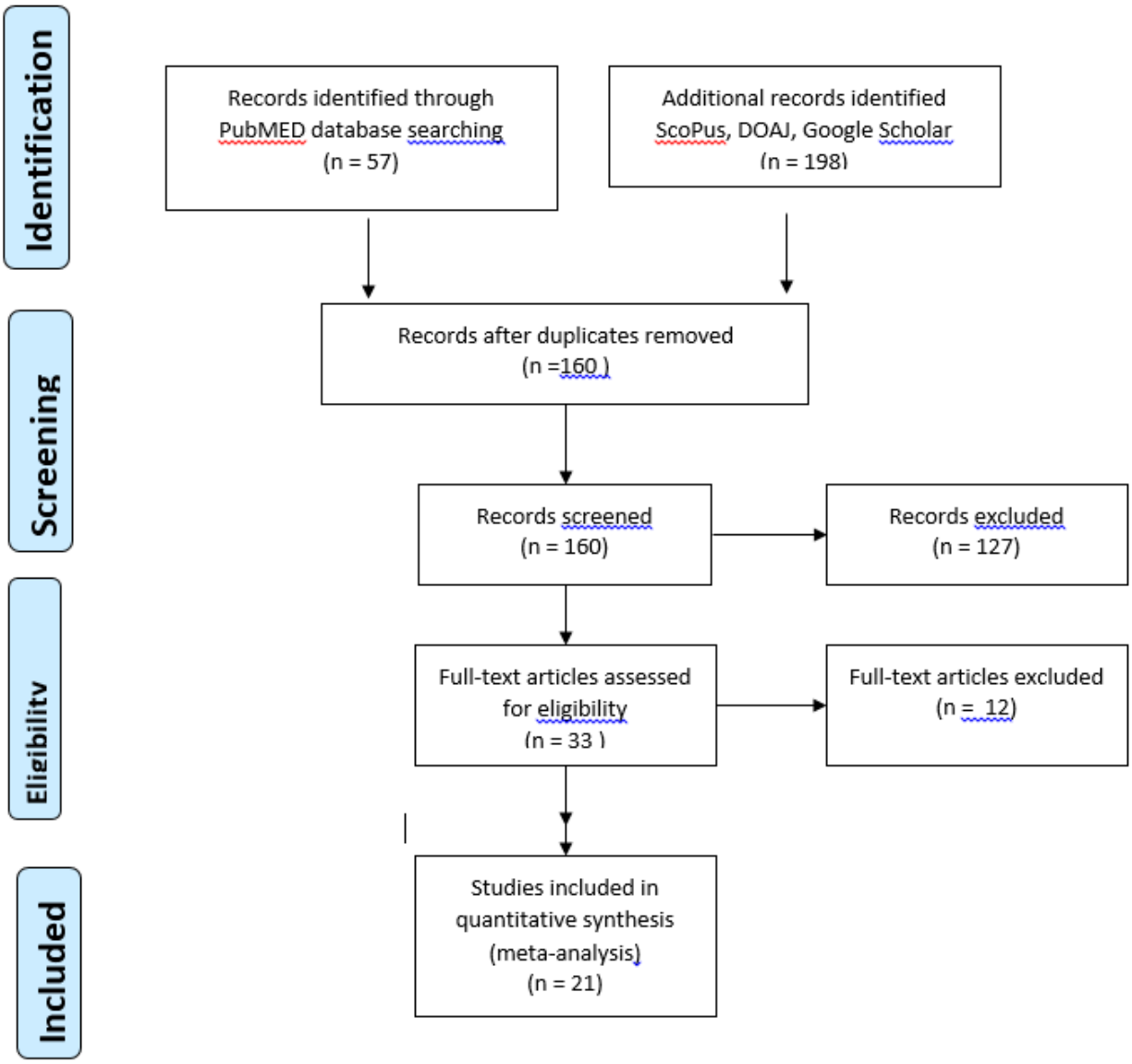


Figure 2A. Forest Plot for estimation of pooled prevalence of Noise Induced Hearing Loss

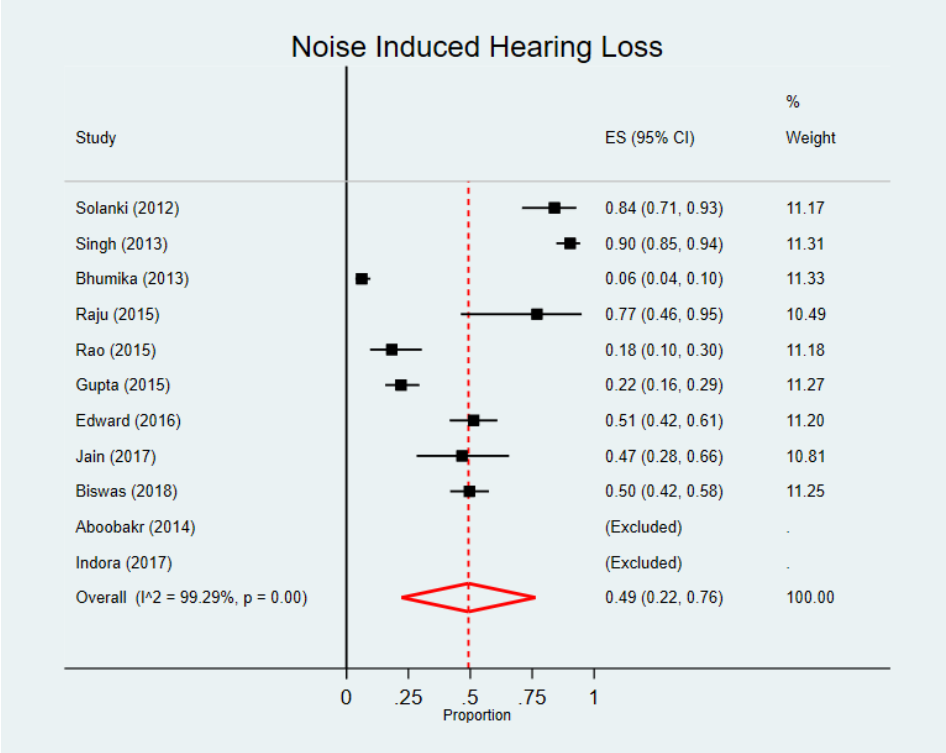
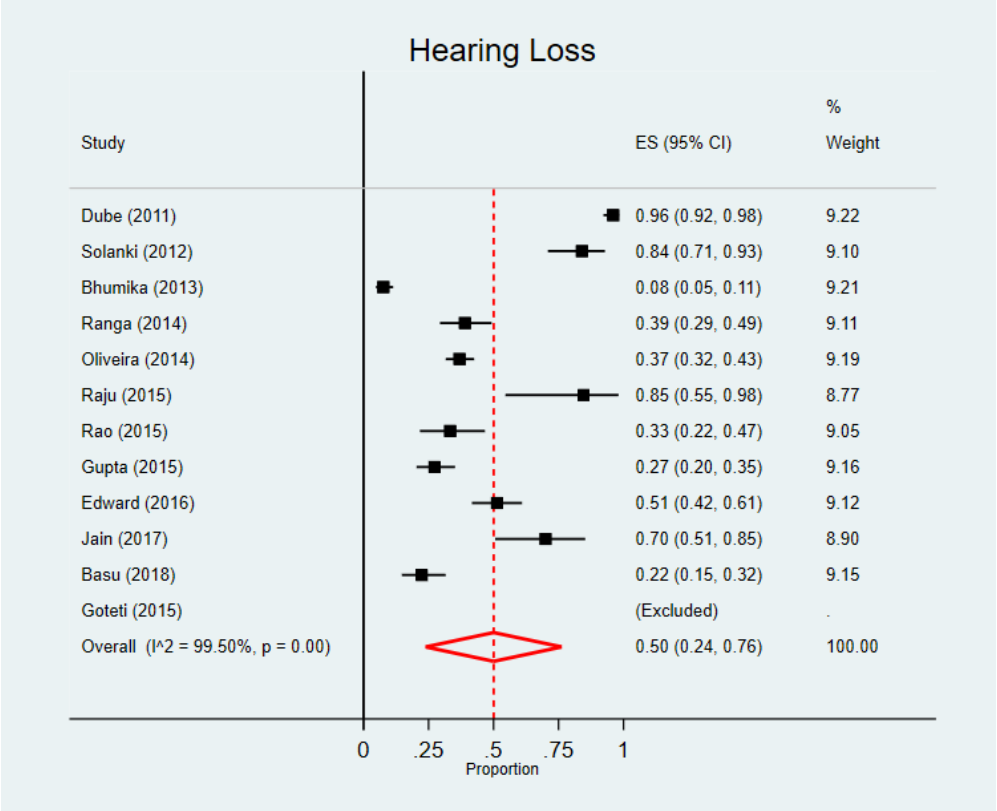


Figure 2B. Forest Plot for estimation of pooled prevalence of Hearing Loss



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