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Review Article

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An Overview of Noise-Induced Hearing Loss: Systematic Review

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ABSTRACT

The term "noise-induced hearing loss" (NIHL) refers to sensorineural hearing loss brought on by either acute acoustic trauma or prolonged exposure to loud noises. Noise exposure has the potential to permanently change the hearing threshold due to irreparable damage to the inner ear. Many risk factors affect the incidence of NIHL including personal factors; such as genetic factors, age, sex, and lifestyle; and elements relating to the noise; such as the length of exposure, its volume, and frequency. This study aims to explore the updated evidence concerning the causes, risk factors, diagnosis, and management of Noise Induced Hearing Loss that were carried out worldwide. The following databases were searched: PubMed, Web of Science, Science Direct, EBSCO, and the Cochrane Library. Using Rayyan QCRI, study papers were screened by title and abstract before being subjected to a full-text evaluation. Eleven research studies with participants of different ages and sexes appropriate to NIHL were included in this review and the relation between different variables with NIHL was discussed. NIHL is a significant problem, especially among industry workers with a high risk of noise exposure. The primary risk factors for NIHL are noise exposure type, intensity, and duration. Smoking and alcohol consumption also significantly affect hearing performance.

Key words: *Hearing loss, Noise, Occupational noise, Noise exposure time, Deafness, Noise-induced hearing loss.*

INTRODUCTION

Noise is defined as any "unwanted sound" that hurts one's health. Noise-induced hearing loss (NIHL) is brought on by permanent damage to the inner ear's cochlear hair cells [1]. When wearing headphones for an extended period, the high-intensity sound will be transmitted to the inner ear, causing damage to the hair cells in the vestibule of the cochlea leading to sensorineural hearing loss [2].

NIHL can be unilateral or bilateral, and the severity is determined mainly by the duration and intensity of noise exposure [3]. The intense loud sound for an extended period can result in irreversible hearing loss [1]. A previous study has shown that prolonged listening of audio at 60% of the volume for more than 60 minutes can lead to NIHL. Furthermore, people who listen to 85db for 8 hours daily may develop permanent hearing loss [4].

Hearing loss is usually unnoticed until it becomes so severe that conversing becomes impossible [5]. NIHL is a significant social and public health issue, Even though it is almost entirely avoidable [6]. Without adequate hearing protection, widespread headphones' potential consequences put users at greater risk of hearing loss when these devices are misused [7].

A study of university students discovered that parents/relatives/peers, high school education, and the Internet were the most typical sources of knowledge about the consequences of noise exposure and NIHL. Furthermore, few respondents stated that They were ignorant of the connection between NIHL and the consequences of noise exposure [8]. The possibility of reduced awareness experienced by listeners while in noisy or other environments is a significant concern regarding the use of headphones among college students [7]. This could be explained by ineffective education in this area and the absence of hearing protection among most kids [8]. Early and continuous hearing health and conservation education programs are required to raise awareness of hearing damage caused by noise exposure, particularly at the elementary school level [8].

According to WHO recommendations, college students' excessive use of PLDs should be limited by limiting the user's time or sound volume [9]. Long-term headphones users should be educated on detecting early symptoms of hearing loss and take appropriate action to prevent further deterioration [10]. The first step toward prevention is understanding which loud sounds can harm the hearing system [11]. A few preliminary signs and symptoms usually indicate the presence of NIHL. According to a previous study that included college students from the United States, tinnitus frequently occurs immediately after exposure to excessive noise sources [8].

Study objective

In this study, we aim to explore the updated evidence concerning the causes, risk factors, diagnosis, and management of Noise Induced Hearing Loss that were carried out worldwide.

MATERIALS AND METHODS

This systematic review was carried out in accordance with the established principles (Preferred Reporting Items for Systematic Reviews and Meta-Analyses, PRISMA).

Study design

This was a meta-analysis and systematic review.

Study duration

From February to July 2022.

Study condition

This review investigates the available literature on noise-induced hearing loss and affections, its prevalence, and risk factors and also discussed the relationship between the different risk factors and lifestyle models.

Search strategy

To incorporate the eligible literature, a systematic literature search of five major databases, including PubMed, Web of Science, Science Direct, EBSCO, and the Cochrane library, was done. Our search was restricted to the English language and was tailored to each database as needed. The following keywords were modified into Mesh terms in PubMed to identify suitable studies: "noise," "noise exposure time," "occupational noise," "hearing loss," "deafness," and "noise-induced hearing affection." The relevant keywords were combined with the "OR" and "AND" Boolean operators. The search results included full-text publications in English, freely available papers, and human trials.

Selection criteria

Our evaluation included papers that met the following criteria:

- Cohort and retrospective cohort studies, as well as study methods that offered qualitative or quantitative data on the occurrence, and risk factors of noise-induced hearing loss (NIHL).

The following were among the exclusion criteria:

- Studies that are not conducted in English.
- No free access to studies.

Data extraction

Rayyan (QCRI) [12] was utilized to discover duplicate features of the search strategy results. The researchers determined the adequacy of the titles and abstracts by assessing the pooled search results against a set of inclusion/exclusion criteria. The reviewers evaluated the whole texts of the papers that met the inclusion criteria. To resolve any disputes, the writers held conversations. A data extraction form was built to contain the eligible study. The authors extracted information on the research titles, authors, study year, study design, study population, participant number, age, NIHL incidence, study population and occupation, and significant findings.

Assessment of the risk of bias

The ROBINS-I technique for non-randomized studies was used to assess the quality of the included research. The reviewers identified and corrected any anomalies in the quality evaluation.

Strategy for data synthesis

Summary tables with the gathered details from the relevant studies were produced to offer a qualitative overview of the included study components and result data. Following the completion of the data extraction in this systematic review, judgments were done on how best to utilize the available data from the included study articles. Studies that satisfied the full-text inclusion criteria but did not give any information on the prevalence, risk factors, or effect of noise on hearing loss were eliminated.

RESULTS AND DISCUSSION

Search results

The systematic search yielded 540 study papers, after which 57 duplicates were deleted. 483 titles and abstracts were screened, with 390 being rejected. Only 10 items were not retrieved even though 93 reports were searched. Finally, 83 papers were screened for full-text evaluation; 52 were removed due to incorrect research results, 5 due to insufficient data, and 13 due to the incorrect population type. This systematic review included eleven study articles. **Figure 1** depicts a summary of the study selection process.

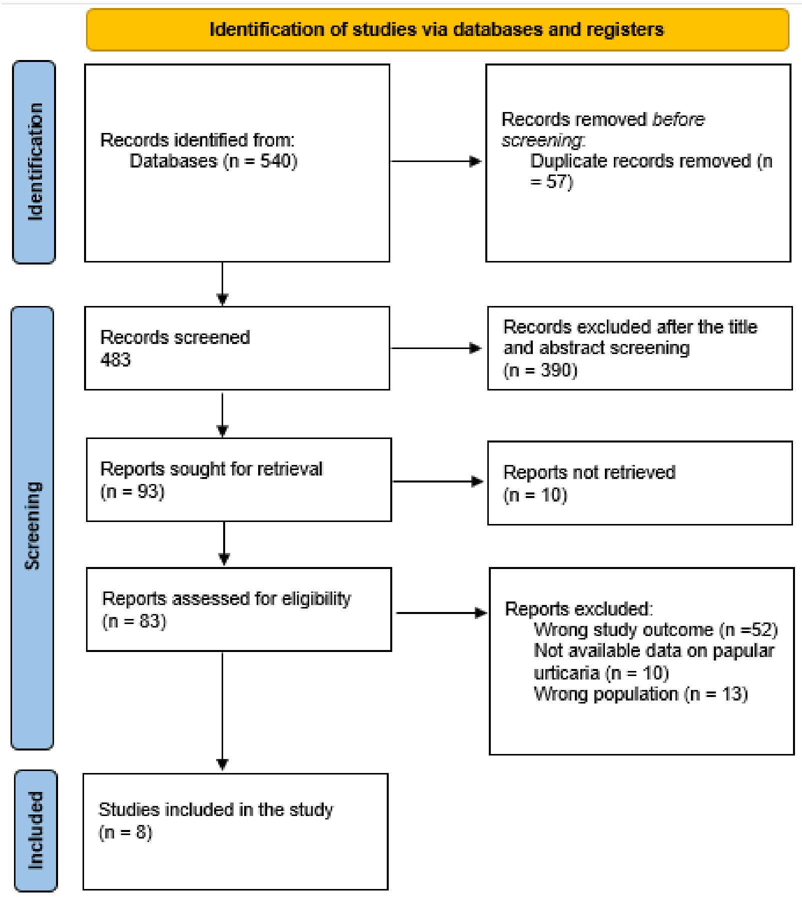

Figure 1. PRISMA flowchart (1) summarises the study selection process.

Characteristics of the studies included

This review includes 11 papers in total. The main topic of most of these studies was ranging from noise-induced hearing loss prevalence and risk factors (NIHL) or examines the impact of noise on hearing capacity in various groups was included among them. The study included a large number of different participants with different characters and lifestyles. The entire included sample was tested for detecting the ear function and hearing ability and threshold by different tests and they all were diagnosed with different levels of NIHL or had its symptoms. Additionally, the relation between characteristic items and lifestyle was correlated. Our findings imply that NIHL is a substantial issue, particularly among industry employees who are at high risk of noise exposure. The key risk factors for NIHL include age, gender, profession type, genetic variables, and the kind, amount, and duration of noise exposure. Smoking and alcohol consumption also significantly affect hearing performance.

This review emphasizes the effect that ambient or occupational noise can have on the function of the inner ear, resulting in major changes and transitory or permanent hearing loss.

In **Table 1** we have included the summary of the included previous studies with their main objectives, key findings, and the year of publication.

Table 1. Summarises the features of the collected research publications.

Study	**Study design**	**Sample size**	**Study population**	**Age of participants**	**Objectives**	**Prevalence of NIHL**	**Key findings and management**
Pollarolo *et al.*, 2022 [13]	systematic review	3273	police officers	23-55	to gather and analyze current data and evidence available in public databases to assess police officers' hearing loss in relation to occupational risk factors and clinical-anamnestic features.	641	Noise exposure during leisure activities and failure to utilize ear protection is common in a large number of topics. NIHL is also linked to the patient's age, as well as the quantity and duration of noise exposure. Furthermore, NIHL is impacted by shooting practice sessions needed by police personnel, as well as chronic exposure to road noises, particularly among motorcycle police officers.
Basu *et al.*, 2022 [14]	A Systematic Review and Meta-Analysis	2229	Industry workers	20-60	to determine the prevalence and risk factors for occupational NIHL in employees possibly exposed to harmful noise levels at work in Indian businesses.	--	In India, NIHL is a serious unaddressed public and occupational health concern associated with negative socioeconomic determinants of health. Sustained lobbying for the adoption of legislation and behavior change communication for the worker's hearing protection is required.
Aboobackr *et al.*, 2014 [15]	A cross-sectional study.	31 cases and 30 controls	stone cutting workers	21-55	to assess the involvement of the auditory pathway among stone-cutting workers	Mild: 7 Moderate: 24	The study came to the conclusion that stone cutters are at risk of acquiring NIHL (mild to moderate) which may damage the peripheral component of the auditory system.
Gupta *et al.*, 2015 [16]	cross-sectional study	150	traffic policemen	25 - 56	To assess the prevalence pattern of NIHL and its relation with the duration of exposure to noise in traffic policemen.	33	The majority of NIHL patients (69.7%) had mild to severe hearing loss in both ears. There were no subjects who had substantial hearing loss. A strong relationship was found between NIHL and exposure length. To combat occupational noise hazards, both businesses and people must take action.

Indora *et al.*, 2017 [17]	observational comparative study	35 cases and 35 controls	traffic policemen	25 - 40	Brainstem evoked response audiometry (BERA), mid-latency response (MLR), and slow vertex response (SVR) were used to investigate the hearing pathway in traffic police (SVR).	--	Chronic noise exposure resulted in delayed conduction in the peripheral auditory pathway, i.e., the auditory nerve up to the level of the superior olivary nucleus; no impairment was detected at the sub-cortical, cortical, or association regions.
Jiang *et al.*, 2021 [18]	Cross-sectional study	50539	shipbuilding workers	25 - 55	Using a subsample of people with severe symptoms, researchers will assess individual vulnerability to NIHL and uncover the underlying genetic risk variations.	2108	Based on a promising technique for analyzing individual susceptibility using ML models, this work discovered two genetic variations in CDH23 rs41281334 and WHRN rs12339210 that are related to NIHL risk.
Gopinath *et al.*, 2021 [19]	a cross-sectional and longitudinal study	1932	Previously worker adults	50+	to investigate the prevalence, 10-year incidence, and development of hearing loss in older persons connected with occupational noise exposure.	227	Prior workplace noise exposure was not linked to the advancement of hearing loss. Noise exposure at work raised the chance of incident hearing loss in older persons. Our findings highlight the relevance of preventative interventions that reduce noise exposure in the workplace, which may help to reduce the burden of hearing loss later in life.
Zhou *et al.*, 2020 [20]	a systematic review and meta-analysis	71 865	Adult workers	20 - 55	Using data from relevant research, examine the frequency and features of occupational NIHL in the Chinese population.	15307	The widespread dispersion of noise in many industries, as well as high-level and long-term noise exposure, were all linked to China's high prevalence of occupational NIHL. Exposure to complicated noise or coexposure to noise and certain substances exacerbated the incidence. Additional measures are required in China to limit occupational noise exposure.
Mostaghaci *et al.* 2013 [21]	a follow-up study	555	workers from 5 tile and ceramic factories	20 - 50	to track hearing threshold changes during a 2-year follow-up among tile and ceramic workers.	--	This study has documented a high incidence of noise-induced hearing loss in tile and ceramic workers that would put stress on the importance of using hearing protection devices.
You *et al.* 2020 [22]	A Systematic Review and Meta-Analysis	--	Young adults using PLDs	18 - 30	to conduct a review of fresh and recent research to compare short-term and long-term hearing alterations in young PLD users who use these devices often and heavily.	--	After using a PLD, there are a few transitory hearing alterations at 4 kHz, but the effects are subsequently reversed. However, heavy PLD users have reported lasting alterations in their hearing thresholds at high frequencies, and the public should be advised of this concern.
Kraaijenga *et al.* 2018 [23]	Prospective study	51	adults attended a music festival	20 - 35	To analyze the behavior of music festival participants and to determine which characteristics are connected with the development of a transient threshold shift (TTS) following music exposure.	--	The main result was a TTS on a typical audiogram at frequencies of 3.0 and 4.0 kHz. To discover which variables are related to TTS, multivariable linear regression was used. Before and after the event, participants were given a questionnaire on their behavior, hearing, and tinnitus.

Sensorineural hearing loss caused by acute or chronic high-intensity noise exposure is referred to as NIHL. Many factors influence the occurrence of NIHL, including personal factors such as genetic factors, the inner ear susceptibility to noise after equivalent noise exposure varies greatly from person to person [24, 25], and noise-related factors such as duration of exposure, intensity, and frequency of noise, and how quickly the sound pressure level increases [26, 27]. Individuals' susceptibility to noise varies also because of other individual and lifestyle factors. The primary factor that contributes to the development of NIHL is the increasing age [28-31]. This connection is influenced in part by the cumulative noise exposure that comes with getting older. Second, alcohol intake is a previously reported known factor associated with NIHL [32, 33]. An experiment done in 1978 indicated that alcohol lowers the protective function of the acoustic reflex in those with normal hearing [32]. In terms of alcohol intake, Upile *et al*. discovered a link between breath alcohol content and the size of hearing thresholds when subjected to recreational noise [33].

Most NIHL cases are related to occupational noise exposure, this may be because of the long time exposure during working places or the nature of some working places with high noise levels such as industries and machine works. Also, several studies on occupational NIHL [28, 29, 31, 34] Men are more prone than women to get NIHL, according to studies. Kovalova *et al*. discovered substantially greater NIHL in males than in women for the same quantity of occupational noise [34].

Previous epidemiological data reveal that roughly one-half of all older persons exposed to industrial noise had compromised hearing from the start. Workplace noise was found to be a substantial, independent predictor of incident sensorineural hearing loss. In other research, however, noise in the workplace was not a major risk factor for hearing loss development in older persons.

In a recent systematic review and meta-analysis, Saurav Basu *et al*. investigated the relationship between occupational noise exposure and NIHL among workers in the following industries: stone cutting, ginning, plywood, heavy metal, farming, mining, explosive, sugarcane, steel, handicraft, and plastic weaving, and they discovered that nearly one in every two industrial workers in India has evidence of NIHL when assessed using the pure-tone audiometry method [14]. The most frequent risk factor for NIHL was prolonged exposure. Tikriwal *et al*. discovered a high incidence of both tinnitus and hearing loss among carpet workers, with rising prevalence related to the increased severity of hearing loss [35]. Several studies have found a link between the length of hazardous noise exposure at work and the degree of hearing loss in workers [16, 36-38].

Indora *et al*. discovered bilateral and symmetrical hearing loss in traffic cops exposed to chronic noise [17]. They discovered that chronic noise exposure resulted in delayed conduction in the peripheral part of the auditory pathway, ie, auditory nerve up to the level of the superior olivary nucleus; no impairment was observed at the level of sub-cortical, cortical, or association areas.

Gupta *et al*. also studied occupational NIHL in traffic policemen as a risky population to noise exposure and found similar results [16]. A strong relationship was found between NIHL and exposure length. Another study was done among policemen by Marco Pollarolo *et al*. they found a strong relationship between occupational noise exposure of policemen and NIHL [13]. Furthermore, NIHL is impacted by shooting practice sessions needed by police personnel, as well as chronic exposure to road noise, particularly among motorcycle police officers.

According to Bamini Gopinath *et al*., 44.9% of research participants who reported exposure to noise in the workplace at baseline had hearing loss [19]. This is slightly higher than Ferrite *et al* stated.'s 38%. [39] among those reporting occupational noise exposure, this might be related to the research sample being younger, ranging from 41 to 55 years.

According to Soltanzadeh *et al*., occupational noise levels in Iran reached 90.29 dB (A), whereas the total hearing threshold was 26.44 dB [40]. Kim. also revealed that in South Korea, more than 90% of workplace noise levels were above the occupational exposure limit, and 92.9% of suspected occupational disorders were occupational NID [41]. Rubak *et al* colleagues discovered a dose-response association between NIHL and noise intensity among Danish employees, i.e., a greater noise level was related to a higher prevalence of NIHL [42].

According to Jiena Zhou *et al*., the prevalence of occupational NIHL in China was 21.3%, with 30.2% related to high-frequency NIHL (HFNIHL), 9.0% related to speech-frequency NIHL, and 5.8% related to noise-induced deafness, and the average age of the workers was 33.58.7 years, with the risk of HFNIHL increasing with age [20]. Meanwhile, sex was a risk factor for HFNIHL, with males having a considerably greater frequency than women.

Another component is smoking, which, when paired with noise exposure, is thought to be related to hearing thresholds and NIHL [39, 43]. A similar link between cannabis use and NIHL has been proposed, however, no research to support this claim has been discovered. individual exposure to other substances such as 2.4-

methylenedioxymethamphetamine (MDMA) and cocaine are described to influence susceptibility to NIHL as well [44-47].

Ear protection tools are a known factor to decrease the incidence of NIHL. Kraaijenga *et al*., Disuse of earplugs, use of alcohol and narcotics, and male sex were all linked to TTS during an outdoor music festival [23]. The absence of earplugs was associated with subjective hearing loss and tinnitus. The amount of time spent near loudspeakers rose as alcohol consumption increased. The intention to use earplugs was related to the loudness and appreciation of music, as well as the perception of speech with earplugs. A systematic review looked at the effectiveness of earplugs, and one RCT found that earplugs had a favorable effect on minimizing postconcert threshold changes [48].

You *et al*. also studied music exposure as a risk factor for NIHL with its time and strength exposure, They discovered that using a PLD causes a few brief hearing alterations at 4 kHz, but the effects are soon rectified [22]. However, heavy PLD users and People who have had a lot of exposure to music noise have lasting modifications in their hearing sensitivities at high frequencies. In four experiments [49-51], participants were exposed to a high intensity of 85 dB (C) to 100.3 dB (A) with a long exposure duration of 30 minutes to 4 hours. However, the measurement units were varied, limiting generality. The studies that found no significant differences were subjected to music levels ranging from 50.8 to 98.7 dBA for 30 minutes to 1 hour, which may not have been a strong enough music level or a long enough period to generate substantial threshold alterations in healthy young individuals [52, 53]. Previous research found that PLD users' hearing thresholds were considerably greater than non-PLD users' at the standard testing frequencies of 0.25 to 8 kHz [54, 55].

CONCLUSION

We concluded that NIHL is a pathological condition that affects several populations and can affect their ability to hear or induce IND.

Many factors can lead to this condition: age of the subjects, sex, occupation nature, and genetic factors, in addition to the quantity and duration of noise exposure. Smoking and alcohol consumption also significantly affect hearing performance.

This review emphasizes the effect that ambient or occupational noise can have on the function of the inner ear, resulting in major changes and transitory or permanent hearing loss. Our findings imply that NIHL is a substantial issue, particularly among industry employees who are at high risk of noise exposure.

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