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Risk Factors for Hearing Loss in the Railway Transportation Sector: Literature Review

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ABSTRACT

Introduction: Hearing loss, a significant global health problem, can significantly impact quality of life**.** The railway sector, with its high noise levels, is particularly vulnerable. To address this, it is crucial to focus on mitigating risk factors through noise control, PPE promotion, and regular hearing assessments.

Objective: The study aims to identify factors related to hearing loss in railway sectors. By understanding these factors, the research seeks to contribute to improved workplace safety and hearing conservation programs.

Method: This study employed a literature review methodology, utilizing sources from Scopus and Google Scholar. Articles were searched using the keywords "hearing loss," "NIHL," "hearing impairment," "railway transport," "railway industry," and "train transportation" published within the last 10 years from 2014 to 2024.

Result: The result of the article search revealed 10 articels that match the criteria set. The result show that various factors were identified that can increase the risk of hearing loss in the railway sector. Overall, risk factors for hearing loss among workers include duration of noise exposure, age, sex, individual habits, and the use of personal protective equipment (PPE).

Conclusion: The need for comprehensive hearing conservation programs in the railway sector that address not only noise control, but also individual risk factors and the effective use of personal protective equipment. Further research is needed to investigate the long-term effects of combined noise and vibration exposure and the potential benefits of advanced audiometric techniques in the early detection and prevention of hearing loss.

Keywords: Hearing Loss; Railway Sectors; Risk Factors; Hearing Protection

INTRODUCTION

Hearing loss is a medical condition that occurs when a person has a decreased or lost ability to hear sounds. It can occur in one or both ears and varies from mild to severe, depending on the underlying cause and condition (1). Hearing loss is one of the health problems that has a significant impact for the life of individuals, especially for those who work in environments with high noise exposure (2,3). WHO data for 2023 shows that more than 1.5 billion people have hearing loss. This high number indicates that hearing loss is a significant global health problem, as it affects the ability to hear, not only impacting the quality of life of individuals, but also affecting productivity (4).

Noisy work environments are one of the main causes of hearing loss (5-7). Other factors such as age, duration of work and use of personal protective equipment (PPE) also contribute to the risk of hearing loss (8). Hearing loss can be triggered by-a-number of factors outside of work which, if left unchecked, have the potential to cause permanent hearing loss, such as the habit of listening to music at high volume or prolonged exposure to noise without protection, which can accelerate damage to the hearing system (9). The influence of the number of cigarettes smoked is also more strongly correlated with the occurrence of hearing loss (10). A significant correlation has also been found in hearing loss patients with a history of hypertension, where there is a reduction in the flow of blood to the cochlea, result in a reduced transport of nutrients, which indirectly leads to secondary degeneration of the auditory nerve (11).

Trains are one of the modes of transportation that most people are interested in. For the convenience of the community as consumers, facilities and infrastructure play an important role in train maintenance. The maintenance of railway facilities consists of trains and locomotives, which is carried out in the locomotive depot (12). Research on hearing loss among machinists has shown that noise is the dominant factor in hearing loss. The study showed that there is a relationship between tenure and hearing function of machinists because it is quite difficult to apply the use of ear protection because it hinders communication between machinists and assistant machinists (13). A risk assessment carried out to identify hazards in the train maintenance and repair area identified potential hazards with extreme values in the activities of exterior wall installation and welding, the manufacture of air conditioning stands and train bogies, where there is a potential noise hazard that can affect the hearing of these workers (14). Unfortunately, there is no incidence prevalence of hearing loss in the railway sector, even though the development of transportation will develop massively, both in development and use of technology. Therefore, the main objective of this study is to identify the risk factors for hearing loss in the railway sector in order to prevent and reduce the prevalence of such disorders in the future.

METHOD

The methodology applied in preparing this article is a Literature Review using PRISMA (15). The guidelines, which begin with a literature search using search engines on Scopus and Google Scholar. The next step was screening by selecting titles, abstracts, years of research, and research methods. The inclusion criteria in this study are Journals related to risk factors for hearing loss in the railroad industry published in the last 10 years from 2014-2024. Exclusion criteria were those not related to risk factors for hearing loss in the railroad industry, not available in full text, and published before 2014. The search was conducted using the keywords “hearing loss”, “NIHL”, “hearing Impairment”, “Railway transport”, “Railway industry”, and “train transportation”. Figure 1 shows the Prisma Flow Diagram, which depicts the article search process.

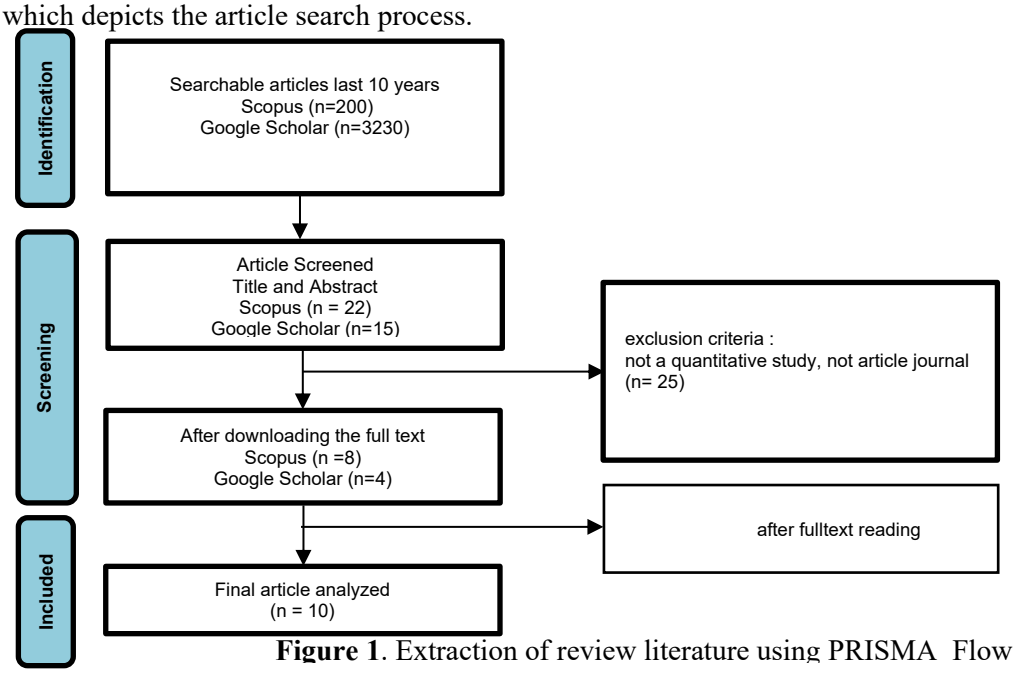

Figure 1. Extraction of review literature using PRISMA Flow

RESULTS
Review Articles

Tabel 1. Review Articles

Author	Title	Research Location	Method	Results
Loukzadeh, et.al (2019) (16)	Effect of combined exposure to noise and vibration on hearing	Iran	Cohort study	There was no association observed between noise and vibration in this study. Future prospective research in real workplace settings, utilizing advanced audiometric methods like otoacoustic emissions and auditory brainstem responses, is advised.
Andarani, et.al (2019) (17)	Noise exposure assessment and estimated excess risk of cabin personnel in the locomotive-CC 205	Indonesia	Case Control	Based on the chi-square statistical analysis, the cabin crew group was exposed to noise levels that surpassed the time-weighted average. This finding supports the conclusion that noise exposure is a significant factor in causing noise-induced hearing loss among cabin personnel.
Yong Peng, et.al (2019) (18)	Tunnel driving occupational environment and hearing loss in train driver in China	China	Cross-Sectional	This study revealed a significant link between the internal driving environment and hearing loss. Train drivers working in environments with higher noise levels, as measured by the Traffic to Road (T/R) ratio, exhibited more severe hearing impairment.
N. Sylviana et.al (2017) (19)	Extend noise exposure induced health impairment in machinist at Bandung	Indonesia	Cross-Sectional	Extended exposure to noise can have negative health consequences, especially affecting hearing. The study revealed a strong relationship between the length of time working in noisy conditions and the occurrence of noise-induced hearing loss.
Lie A, et.al (2016) (20)	Noise Induced hearing loss in Norwegia longitudinal study of Norwegian railway workers	Norwegia	Longitudinal	This study's goal is to assess the risk of noise-induced hearing loss among train drivers, conductors or cabin

Author	Title	Research Location	Method	Results
				crew, and maintenance's train workers at the Norwegian State Railway. With a mean observation period of ten years (1991-2014), this study found that this risk was probably low.
Lie A, et.al (2015) (21)	The prevalence of notched audiograms in a cross ectional study of 12.055 railway workers	Norwegia	Cross-sectional	This study revealed that audiometric notches are common among workers at a Norwegian train company, regardless of their noise exposure. Age and gender have a role in the prevalence of these notches. Consequently, audiometric notches may not be a reliable indicator of Noise-Induced Hearing Loss.
Lie A, et.al (2014) (22)	A cross sectional study of hearing thresolds among 4627 Norwegan train and track maintenance workers	Nowegia	Cross-Sectional	The workers of Train and track maintenance who 45 year or older exhibited slightly more hearing loss and a higher incidence of audiometric notches compared to the reference group, which was not exposed to noise. Younger workers had hearing thresholds comparable to the control group.
Hanifa, et.al (2018) (9)	The correlation between noise levels and individual attributes in relation to hearing loss among workers in Madiun	Indonesia	Case Control	While workplace noise is a significant factor, it's not the only cause of hearing impairment in workers. Other lifestyle factors can play a role as well.
Shah Ravi (2018) (23)	The effect of brief subway station noise exposure on commuter hearing	United State	Randomized Crossover trial	Although brief exposure to Subway noise did not lead to hearing loss with or without noise protection, the un expected finding of changes in pure tone audiometry or PTA suggest that there may be intricate and varied short-term and long-term cochlear responses to noise exposure that warrant further investigation

Author	Title	Research Location	Method	Results
Sangadi, et.al (2024) (14)	Hearing function analysis of machinist of PT KAI (Persero): A study of locomotive noise levels	Indonesia	Quantitative Description	There was a correlation between duration of work and hearing loss, as the longer a machinist is exposed to noise, the higher the risk of developing hearing impairment.

DISCUSSION

Based on the collected research that met the inclusion criteria, various factors were identified that can increase the risk of hearing impairment in the railway sector. Overall, risk factors for hearing loss among workers include duration of noise exposure, age, sex, individual habits, and the use of personal protective equipment (PPE). Noise plays a significant role in the development and progression of hearing impairment within the railway sector. Noise-Induced Hearing Loss (NIHL), which occurs due to excessive and prolonged exposure to noise, results in permanent damage to the delicate structures of the inner ear, particularly the hair cells in the cochlea. Theoretically, NIHL is a consequence of mechanical damage to the inner ear caused by sound pressure levels exceeding safe thresholds. In occupational health, NIHL is one of the most serious problems faced by workers in industrial sectors exposed to heavy machinery, electrical equipment, and noisy working environments.

Noise-Induced Hearing Loss and Exposure Time

As previously mentioned, noise is a primary cause of hearing loss. Yong Peng's study (2019) found that train drivers working in environments with high noise intensity had a significantly higher risk of developing hearing disorders. Specifically, train drivers exposed to the highest noise levels (30-45%) had an odds ratio (OR) of 3.72 (95% CI 1.43 to 9.69) for developing a hearing threshold shift compared to those exposed to the lowest noise levels (<15%). Additionally, the corresponding OR for speech hearing loss was 1.75 (95% CI 0.38 to 8.06) (18). Prolonged exposure to noise, particularly at levels ranging from 75 dB to 120.9 dB, as commonly experienced by train drivers, has been shown to contribute to hearing impairment (13). Several studies have consistently demonstrated a strong correlation between the duration of noise exposure and the development of noise-induced hearing loss (17, 19). While previous studies have not established a definitive link between combined noise and vibration exposure and hearing loss, further prospective research in actual workplaces using advanced audiometric techniques like otoacoustic emissions and auditory brainstem responses is recommended to delve deeper into this potential association (16). This is in line with Al-Harthy et al. (2022) found that individuals exposed to noise levels exceeding 85 dB for more than eight hours per day were at a significantly increased risk of hearing loss (24). This prolonged exposure leads to gradual and irreversible damage to the hair cells in the cochlea. Workers directly involved in operating machinery or heavy equipment, such as construction or manufacturing workers, are at a particularly high risk due to their prolonged proximity to noise sources (25). These findings underscore the need for a comprehensive hearing conservation program in the railway sector that addresses not only noise control measures, such as the use of technology to reduce train noise

Age

The worker's age has a correlation with the occurrence of hearing loss. Arve Lie's (2014) research on 4267 train officers in Norway showed that workers in the train and track maintenance who had 45 years age or older had a small mean hearing impairment in the 3–6 kHz area of 3–5 dB. The hearing loss was less among younger workers (less than 45 years). They may therefore be-a-sensitive measure in disclosing an early hearing loss at a group level (22). The prevalence of men of notches in audiograms, specifically coles notches and 4 kHz notch, increases with both age and noise exposure. These notches are most prevalent in the 45-54 age group, then decline. However, the prevalence of a notch index greater than 0 continues to rise with age (21). The deterioration of the ear structure with age, characterized by reduced elasticity of the tympanic membrane and loss of sensory hair cells, leads to decreased sensitivity, especially to high frequency sounds. This is a common feature of age-related hearing loss (26).

Sex

sex also to be a role in the prevalence of these notches. The prevalence of women of notches is approximately less that of men. The association between noise exposure and notches is less pronounced in women compared to men. Among lady maintenance workers, train drivers, and conductors, the prevalence of notches and the differences compared to the reference group were smaller and significant only for the Coles notch (21). In general, the prevalence of hearing loss is higher in the male population than in the female population. This disparity can be attributed to greater exposure to risk factors in men, particularly in workplace (27). In addition, hormonal factors play an important role. Estrogen, the predominant female sex hormone, exerts a protective effect on the auditory system through mechanisms such as increased cochlear blood flow and protection against oxidative damage to hair cells. (28). Conversely, the decline in estrogen levels after menopause is associated with increased susceptibility to hearing loss in women (29).

Individual Habits

While workplace noise is a significant contributing factor, it is not the sole cause of hearing impairment among workers. Other lifestyle factors can also play a role, such as prolonged exposure to loud music through headphones (9). Studies investigating individual habits have found that active smokers have a significantly higher risk of developing hearing impairment compared to non-smokers (30). Excessive alcohol consumption can also impair the brain's ability to process sound, particularly in noisy environments (31).

Personal Protective Equipment or PPE

While the use of PPE is mandatory, hearing protection devices in this case have the potential to hinder effective communication between the train operator and assistant operator, as well as reduce the effectiveness of locomotive radio use (14). Brief exposure to subway noise does not cause hearing loss with or without noise protection. Although insignificant of clinically, the un-expected finding of a decrease in PTA suggest that there are heterogeneous and complex short-term and long-term cochlear responses to noise exposure that warrant further exploration (23). In another study, hearing impairment among workers in the small railway sector was found to occur even in countries with well-implemented occupational health and safety (OHS) standards. Therefore, hearing may develop differently in railway-workers in other countries with poor habits environments of work and higher noise exposure (20).

CONCLUSION

This study highlights the multifaceted nature of hearing loss in the rail industry, which is influenced by a complex interaction of factors. While noise exposure remains a major contributor, individual characteristics such as age, gender, lifestyle and PPE use also play an important role. These findings underscore the need for a comprehensive hearing conservation program in the railway sector that addresses not only noise control measures, such as the use of technology to reduce train noise, but also individual risk factors and the effective use of personal protective equipment, such as regular hearing screening and awareness of potential hearing hazards and PPE countermeasures.

SUGGESTION

Further research is needed to investigate the long-term effects of combined noise and vibration exposure, the potential benefits of advanced audiometric techniques in the early detection and prevention of hearing loss, and other factors such as lifestyle and health conditions that contribute to hearing loss in railway workers**.**

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