Analyzing Sensorineural Hearing Loss Among Family Members of Railway Workers Living Near Railway Tracks: A Case Study

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Abstract: This article investigates the prevalence and potential causes of Sensorineural Hearing Loss (SNHL) among individuals living near Railway tracks. Sensorineural Hearing Loss is a significant Public Health concern globally, affecting millions of individuals. While the etiology of SNHL is multifaceted, environmental factors, including exposure to Noise pollution, have been implicated. Railway tracks are recognized sources of Noise pollution, characterized by high-intensity Sound emissions from passing Trains. Audiometric tests were conducted on a sample comprising Railway employees and their family members who sought medical care for ear complaints at the Hospital. The participants were divided into two groups based on their proximity to Railway tracks. The collected data were analyzed to determine the relationship between distance from Railway tracks and the prevalence of Hearing loss. Analysis of the data reveals a significant association between distance from Railway tracks and the severity of Hearing loss. Participants residing further from Railway tracks exhibited lower rates of Hearing loss compared to those living closer to the tracks. The findings suggest a potential link between proximity to Railway tracks and Sensorineural Hearing Loss among family members of Railway workers. This underscores the importance of implementing effective Noise control measures and providing adequate Hearing protection for both Railway workers and their families living in close proximity to Railway tracks.

Keywords: Sensorineural Hearing Loss, Railway Tracks, Noise Pollution, Audiometry, Railway employees, Hospital

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Introduction:

Sensorineural Hearing Loss (SNHL) is a prevalent health condition characterized by damage to the Inner ear or Auditory nerve pathways, leading to diminished Hearing sensitivity and Speech discrimination. SNHL can result from various factors, including Genetic predisposition, Aging, Ototoxic medications, and Exposure to excessive Noise levels. Among these factors, environmental Noise pollution has emerged as a significant contributor to SNHL, with chronic exposure to loud sounds exerting detrimental effects on Auditory function. [1]

The Railway system stands as one of the largest Organizations within the country, boasting an extensive network of Rail tracks spanning Urban, Rural, and even uninhabited areas. Previous researches have investigated the Health effects of Noise produced by the Train movement on the people. Studies have focussed on its association with Hearing impairment, ill effects on Cardiovascular system and with Sleep disturbances.[2] Epidemiological investigations have revealed higher rates of Hearing loss among individuals residing near railway lines compared to control populations living in quieter environments. However, the specific contribution of Railway noise to SNHL remains an area of ongoing inquiry.

Railway tracks represent a prominent source of environmental Noise, generating substantial sound emissions due to the passage of Trains. The proximity of residential areas to Railway infrastructure exposes inhabitants to prolonged Noise exposure, raising concerns regarding its potential impact on hearing Health[3]. Despite growing recognition of the adverse effects of Noise pollution on public Health, limited research has focused specifically on the incidence of SNHL among individuals residing near Railway tracks. This article aims to address this gap by synthesizing existing evidence and exploring the relationship between proximity to Railway tracks and SNHL.

Literature Review:

Introduction to Noise-

Noise is commonly described as sound that is unwanted or a blend of sounds that can potentially have a negative impact on individuals. There are different types of noise like Environment, Occupation, Social, Electronic, Psychological. [4] Concerning to the present discussion our study focuses on Environment noise. Types of Environment noise includes Background noise and Discrete noise. Background noise consists of sound from sources that encompass a range of everyday occurrences such as distant vehicular traffic, the rustling of wind through obstacles, and industrial or construction activities in the vicinity. This background noise tends to remain relatively stable over short periods but may exhibit gradual fluctuations over longer time frames due to changes in natural phenomena and human activities. [5]

Interwoven within this background noise are discrete, identifiable events of shorter duration that punctuate the ambient sound landscape. These events, such as the passage of individual vehicles, flyovers by aircraft, or sudden braking sounds, introduce transient spikes in the noise level, causing momentary fluctuations in Acoustic intensity. Despite their brevity, these events can significantly alter the Auditory experience, drawing attention and potentially disrupting activities in the surrounding environment. Thus, the Environmental noise is characterized by a combination of continuous Background noise and intermittent, identifiable events, shaping the Acoustic backdrop of daily life [5].

Effects of Train Operations- [5]

The Train motion on ground has following impact on environment.

i) Air-borne noise

ii) Ground-borne vibration in neighbouring buildings

iii) Ground-borne noise in neighbouring buildings

Typically, vibrations from Railway tracks shouldn't pose a significant threat to well-designed and adequately maintained buildings. Comparatively, these vibrations are minor in intensity compared to seismic activity. However, vibrations within structures can impact individuals and delicate equipment found in settings like Hospitals, broadcasting facilities, religious establishments, and other sensitive environments. Additionally, Heritage structures are susceptible to the effects of vibrations.

For the purposes of this discussion, the review will concentrate solely on the noise generated by trains, excluding any discussion of the effects of vibration.

Source-Path-Receiver (SPR) framework- [5]

The sound produced travels and reaches the receiver. The Railways uses Source-Path-Receiver (SPR) framework as a fundamental model for understanding Environmental noise produced. According to this framework, every noise source in the environment emits sound waves that propagate outward, generating noise levels in their vicinity. The intensity and characteristics of these noise levels are influenced by factors such as the type of source and its operational parameters. As sound waves travel from the sources to the receivers, they undergo attenuation along the propagation path. This attenuation occurs due to several factors, including the distance travelled, the presence of obstacles or barriers, atmospheric conditions, and other environmental variables. These factors collectively contribute to the reduction of noise levels experienced at the receivers compared to the levels emitted directly by the sources. At the receivers, which can represent locations such as residential areas, workplaces, or recreational spaces, the noise from all nearby sources converges. This amalgamation of noise from multiple sources can potentially interfere with activities and tasks performed at the receiver locations. The resulting noise exposure experienced by individuals or equipment at the receivers depends on the cumulative effects of noise from all contributing sources.

Source-Path-Receiver framework provides an approach to analyze and address environmental noise, allowing for the assessment of noise generation, propagation, and reception in diverse settings. By understanding the interactions between sources, paths, and receivers, researchers and policymakers can develop effective strategies for noise management and mitigation to promote healthier and more livable environments.

Noise produced by Train Operations- [5,8]

Transit noise arises from the operation of vehicles in transit, encompassing various sources associated with vehicle propulsion and motion. So, the Noise being propulsion-related noise, and additional noise during motion through their interaction with the running surfaces:

i) Whine from Electric Control Systems and Traction Motors: Electric control systems and traction motors, particularly in rapid transit cars, can emit a high-pitched whine as they propel the vehicle forward. This noise is characteristic of electric propulsion systems and is often associated with the modulation of electrical currents.

ii) Diesel-Engine Exhaust Noise: Both diesel-electric locomotives and transit buses produce noise from their diesel engine exhausts. This noise emanates from the combustion process within the engine and is a common feature of vehicles powered by diesel fuel.

iii) Rolling Noise: The continuous rolling contact between steel wheels and Rails generates rolling noise as transit vehicles move along the track. This noise arises from the frictional interaction between the wheel and Rail surfaces and is a characteristic feature of Rail transit systems.

iv) Impact Noise: When a wheel encounters a disruption in the running surface, such as a Rail joint, turnout, or crossover, it can produce impact Noise. This noise occurs as the wheel momentarily experiences increased forces upon contact with the discontinuity, leading to Acoustic emissions.

v) Squeal: Friction between the wheel and Rail, particularly on tight curves, can result in squealing Noise. This high-pitched sound is a consequence of the frictional forces acting between the contacting surfaces and is most pronounced during manoeuvres on curved track sections.

vi) Air-Turbulence Noise from Cooling Fans: Cooling fans associated with propulsion systems generate Air-turbulence Noise as they operate to dissipate heat generated by vehicle components. The airflow produced by these fans can contribute to the overall Noise emitted by transit Vehicles.

vii) Gear Noise: Mechanisms such as gears within propulsion systems can produce noise due to their operational interaction. This Gear noise can manifest as whirring or grinding sounds and is often indicative of mechanical activity within the vehicle.

viii) Vehicle Motion: The sound is low frequency due to movement of vehicle on the Tracks. When a noise spectrum is predominantly composed of low-frequency components, it tends to exhibit characteristics similar to the deep rumble of thunder. This phenomenon occurs because low-frequency sounds have longer wavelengths, which can propagate over greater distances and penetrate obstacles more effectively than high-frequency sounds. As a result, Noises with a prevalence of low-frequency components often create a sensation akin to the prolonged, rolling thunder commonly associated with thunderstorms. This distinctive characteristic adds to the perceptual and environmental impact of the noise, influencing how it is perceived and experienced by individuals within its vicinity. This Noise also produces Vibrations which leads to rumbling sound caused by the vibration of room surfaces is called Ground-borne noise.

Overall, Transit noise comprises a complex interplay of propulsion-related noise and noise generated during vehicle motion, influenced by factors such as Propulsion technology, track conditions, and vehicle speed. Effective noise mitigation strategies aim to address these various sources to minimize the overall impact of Transit noise on surrounding environments and communities.

Measure Noise Levels- [4]

Average noise level at a location

If the noise levels at a particular location are L1 ,L2, L3 in bels (10 dB =1B)

measured during an hour of the day, the average noise level at the location is arrived at

by logarithmetic averaging.

L= 10x log10 [(10L1 + 10L2 +10L3)]/3

Other than Intensity, Duration of noise is equally worrisome. People react to the duration of noise events, judging longer events to be more annoying than shorter ones.[4]

Effects of Noise Pollution on Hearing Health- [6]

Numerous studies have demonstrated the deleterious effects of Noise pollution on Auditory function. Typically, Noise-induced hearing loss refers to a gradual decline in hearing abilities occurring over an extended duration (often spanning several years), attributable to prolonged exposure to either continuous or intermittent loud noises. Prolonged exposure to high-intensity noise can lead to permanent damage to the hair cells in the cochlea, resulting in Sensory-Neural Hearing Loss. The mechanisms underlying noise-induced hearing loss involve both mechanical trauma and metabolic pathways, ultimately causing cellular dysfunction and apoptosis within the Auditory system. Hearing loss can manifest in two primary forms: Temporary and Permanent. Temporary hearing loss typically resolves on its own once exposure to the triggering noise ceases. Patients with Permanent hearing loss may suffer from symptoms like Decreased hearing, Tinnitus. Temporary hearing loss may have symptoms in addition Ear Pain and occasionally Giddiness.

Railway Noise and Its Impact on Communities- [7]

Railway tracks are associated with elevated noise levels, particularly during train passage. The noise generated by Trains encompasses a broad spectrum of frequencies, including low-frequency rumbling and high-frequency screeching. Residents living in close proximity to railway tracks are subjected to continuous exposure to this noise, which can exceed recommended thresholds for safe environmental noise levels.

The audible range for human hearing ranges from 0 dB to 120 dB. This Human hearing covers the frequency range of 20 Hz to 20,000 Hz.

To represent the way people, respond to normal, very low and very high frequencies, frequency response functions are developed, called A, B and C weighted curves. Environmental noise generally falls in the ‘normal’ category for which the A-weighted decibel (dBA) is considered best to represent the human response. Typical A-weighted Sound Levels range from the 40 dBA to 90 dBA, where 30 is very quiet and 90 is very loud.

Sound in dB approximately measured from Train- [5]

Rail transit on old steel structure at 50mph – nearly 100 dB

Rail transit horn – 90 dB

Rail transit on modern concrete structure at 50 mph- nearly 85 dB

Rail transit in station – nearly 65 dB

Effect of Proximity from Railway Tracks- [5,7]

The close proximity of residential areas to railway infrastructure subject's residents to prolonged noise exposure, prompting concerns about its potential effects on hearing Health.

The transmission of sound from its source (Railway tracks) to a receiver primarily occurs through the air medium. Along these transmission paths, the intensity of sound diminishes with distance due to several factors

(a) Divergence

(b) Absorption/Diffusion

(c) Shielding

Regulations for Noise control:

The ambient air quality standards in respect of noise in different areas /zones have been notified by the Ministry of Environment & Forests, Government of India vide 'The Noise Pollution (Regulation and Control) Rules, 2000.

For Residential area permissible Day time noise is 55 dB and for Night-time limit is 45 dB

Day time shall mean 6.00 a.m. to 10.00 p.m. and Night time shall mean from 10.00 p.m. to 6.00.a.m.

The Railway system adheres to the aforementioned standards meticulously, ensuring that constructions are carried out in accordance with these guidelines. [9] Additionally, they rigorously maintain the speed of trains in alignment with safety protocols and operational regulations. This commitment to standards not only enhances the efficiency and safety of railway operations but also contributes to the overall well-being of surrounding communities.

Regarding the residence of people near Railway tracks, the permission of construction near railway track is given by local body like Corporation or Municipal Council. It is desirable according to Railways that a vacant space of 3 meters be kept between Railway track boundary and face of any construction. For construction 'No Objection Certificate' needs to be obtained by the Local body from Railway Authorities if the construction is between 3 metres to 30 meters from the Railway track boundary. [10]

Methodology:

This study employs a cross sectional study to examine the incidence of SNHL among Railway employee families living near railway tracks. The study was conducted at Railway hospital which comes under Indian railways. The patients included were those who attended the Out-patient department in ENT department and were referred to us for Pure Tone Audiometry (Hearing test). The study was conducted for 6 months duration. Total 372 patients underwent Audiometry test. Patients included on the basis of location of their house, whether living in 100-meter vicinity of railway tract. Those living at distance more than 100 meters were excluded from the study. The measurement was considered based on previous studies which suggest lowest level of noise is measured at 100-meter distance. [3]

Patients who underwent Audiometry were divided into two groups, those living between 3-50 meters from Railway tracks and those between 50-100 meters.

Table 1- According to the Distance of Residence from tracks patient included are -

Distance from Tracks	3-50 meters	50- 100 meters
Number of Patients (N= 372)	214	158
Percentage wise Distribution	57.5%	42.47%

The Patients were assessed on the basis of their gender.

Table 2- Gender Distribution-

Gender Distribution	Male	Female
Number of Patients (N= 372)	278	94
Percentage wise Distribution	74.73%	25.27%

Patients Hearing loss was measured according to the three types Conductive, Sensory-Neural and Mixed type and Percentage was taken.

Table 3- Type of Hearing Loss-

Type of Hearing loss	Conductive	Sensorineural	Mixed
Number of Patients	15	206	151
Percentage wise Distribution	4.03%	55.37%	40.59%

Patients divided in two groups according to the Distance of residence from Railway tracks were assessed separately and data collected.

1. 3-50 meters
2. 50- 100 meters

First group – 3-50 meters-

For the people living nearer to the tracks gender distribution was measured.

Table 4- Gender Distribution-

Gender Distribution	Male	Female
Number of Patients (N=214)	179	35
Percentage wise Distribution	83.64%	16.36%

Patients were divided into groups according to the age, to assess the age group living which is affected the most.

Table 5-Age wise distribution of patients-

Age group	Number of Patients (N=214)	Percentage distribution
0-20 yrs	10	4.67 %
20-40 yrs	74	34.57 %
40-60 yrs	95	44.39 %
More than 60 yrs	35	16.35 %

Patients data was divided according to the complaints they have.

Table 6- Distribution according to Complaints-

Complaint	Number of Patients	Percentage Distribution
Decreased Hearing	210	98.13%
Tinnitus	152	71.02%
Ear Discharge	48	22.42%
Ear Pain	40	18.69%
Giddiness	11	5.14%
	N= 214	

The Percentage of type of hearing loss is measured.

Table 7- Type of Hearing Loss-

Type of Hearing loss	Conductive	Sensorineural	Mixed
Number of Patients (N=214)	6	142	66
Percentage wise Distribution	2.8 %	66.35 %	30.84%

Second group - 50- 100 meters

Similar measurement for a comparative assessment was done. Gender distribution was done.

Table 8- Gender Distribution-

Gender Distribution	Male	Female
Number of Patients (N=158)	99	59
Percentage wise Distribution	62.65 %	37.34 %

Percentage of different age groups were measured for patients referred for Audiometry.

Table 9- Age wise distribution of patients-

Age group	Number of Patients (N=158)	Percentage distribution
0-20 yrs	23	14.55 %
20-40 yrs	40	25.31 %
40-60 yrs	45	28.48 %
More than 60 yrs	50	31.64 %

According to the similar complaints the number of patients were measured.

Table 10- Distribution according to Complaints-

Complaint	Number of Patients	Percentage Distribution
Decreased Hearing	140	88.6 %
Tinnitus	100	63.29 %
Ear Discharge	84	53.16 %
Ear Pain	14	8.86 %
Giddiness	8	5.06 %
	N= 158	

Percentage of people was measured for the type of Hearing loss.

Table 11- Type of Hearing Loss-

Type of Hearing loss	Conductive	Sensorineural	Mixed
Number of Patients (N=158)	9	64	85
Percentage wise Distribution	5.69 %	40.5 %	53.79 %

Results and Discussion:

A total of 372 patients participated in the study. The data revealed that a higher proportion of patients visited were those residing within a proximity of 3-50 meters from the Railway track. Specifically, 57.5% of the patients lived near the tracks. Among all patients, the majority were male (74.73%). Sensorineural Hearing Loss emerged as the predominant cause of hearing impairment, affecting 55.37% of the patients.

Participants were categorized into two groups based on their distance from the tracks. The first group comprised individuals living within 3-50 meters from the tracks, totalling 214 patients. Among them, 83.64% were male, predominantly from the middle-age bracket, and primarily employed individuals. The most common complaints included Hearing loss and Tinnitus, with a minority reporting Ear discharge, Pain, and Dizziness. Audiometry tests indicated that the majority (66.35%) exhibited Sensorineural Hearing Loss.

In the second group, consisting of those residing 50-100 meters from the track, the majority were male (62.65%). Most patients were aged above 60 years, suggesting a population of retired Senior citizens. This group included family members, indicating that not all seniors necessarily had past employment with the Railways but may have been dependents of Railway personnel. Complaints predominantly included Hearing loss and Tinnitus, along with issues related to Suppurative Otitis media such as Ear discharge and Pain, with a minority experiencing Dizziness (5%).

The data unequivocally indicates a lower incidence of Sensorineural Hearing Loss among individuals in the second group, who reside farther from the tracks. This group notably comprised a larger proportion of Senior citizens, implying that the occurrence of Sensorineural Hearing Loss may have been even lower among those residing at a greater distance from the railway tracks.

The synthesis of available evidence suggests a consistent association between proximity to Railway tracks and an increased risk of SNHL.

Epidemiological studies conducted in various countries have reported higher prevalence rates of Hearing loss among residents residing near Railway lines compared to control populations. The magnitude of this association appears to correlate with the intensity and duration of exposure to Railway noise, with individuals exposed to higher noise levels exhibiting greater susceptibility to SNHL.

Several factors may contribute to the observed relationship between Railway noise and hearing impairment. The continuous nature of Train traffic results in chronic exposure to noise, potentially leading to cumulative damage to Auditory structures over time. [8] Additionally, the specific characteristics of Railway noise, including its low-frequency components and impulsive nature, may exacerbate its adverse effects on hearing Health.

Blessing in disguise being the assumption that Hearing loss may have less chances of Heart problems and changes in heart rate. [2]

Conclusion:

In conclusion, the incidence of Sensorineural Hearing Loss is notably elevated among individuals living in proximity to Railway tracks, highlighting the importance of addressing Environmental Noise pollution as a public Health concern. Efforts to mitigate the impact of Railway noise on hearing Health should encompass Sound insulation measures, Urban planning strategies, and regulatory interventions aimed at reducing Noise emissions from Railway operations. Furthermore, longitudinal studies are warranted to elucidate the long-term consequences of chronic exposure to Railway noise on Auditory function and to inform evidence-based interventions for Noise-induced hearing loss prevention.

Limitations and Scope for Further Research:

The study was conducted at a single location, and there is potential for conducting similar investigations in diverse geographical settings, taking into account the landscape's influence on the Sound Path Receiver framework. Variations in terrain, urban density, and natural features can impact sound propagation, warranting broader geographical coverage to enhance the generalizability of findings. Additionally, future research could consider incorporating the type of home construction, such as distinguishing between traditional structures like "kachcha" (made of mud, thatch, or similar materials) and modern constructions known as "pakka ghar" (built with durable materials like concrete or bricks). These different building types may exhibit varying levels of sound insulation and transmission, influencing the noise exposure experienced by occupants. By examining the interaction between building construction types and environmental noise, researchers can gain insights into how housing infrastructure affects sound propagation and reception, thereby informing strategies for noise mitigation and urban planning.

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Declaration-

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Conflicts of interest

There are no conflicts of interest.