



## Noise Induced Hearing Loss: A Review

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### Abstract:

Noise induced hearing loss is one of most common hearing deficit which is almost completely preventable. The hearing loss incurred would depend on the sound qualities, duration of exposure and individual susceptibility and protection. Thereby it can be prevented as we have some set norms for the noise at work places and recreational activities. Once suspected, screening and preventive measures to prevent further progression is taken. There are legislative guidelines for noise at work places for the employers, preventive measures to be taken by employee and role of health professional in screening, assessing the hearing loss and accordingly advise for rehabilitative measures.

Keywords: Noise induced hearing loss, Occupational hearing loss, Hearing conservation program.

### EPIDEMIOLOGY

Hearing loss caused by exposure to noise commonly recreational and occupational results in devastating disability that is virtually 100 percent preventable<sup>1</sup>. Noise-induced hearing loss is the second most common form of sensorineural hearing deficit, second only to presbycusis<sup>1</sup> (age-related hearing loss). Hearing loss caused in part by excessive noise exposure in the workplace or during recreational activities thereby exposing most of the industry workers and teenagers but in today's noisy surrounding all of us are prone to noise induced hearing loss due to excessive mobile usage, heavy traffic noise in cities.

## PATHOPHYSIOLOGY<sup>2</sup>

The pathophysiology behind this is the shearing force due to any sound which makes an impact on the delicate inner ear structures especially stereocilia of the hair cells of the basilar membrane of the cochlea, more so of basal region; when excessive, these forces can cause cell death. This can cause temporary or permanent threshold shift.<sup>3</sup>

The dilemma is about what is the loudness and duration of sound which can harm cochlea and the susceptibility of an individual. This aspect is yet being studied in order to protect an individual from this common but preventable entity because once initiated, avoiding further noise exposure stops further progression of the disease but cannot revert the loss already incurred.

What is noise? According to oxford dictionary noise is "A sound, especially one that is loud or unpleasant or that causes disturbance" whereas Farlex dictionary describes it as "A sound that is loud, unpleasant, unexpected, or undesired. This is to say that not only sound level but also type of sound is important in making it a noise for an individual.

Sound level:

Noise is typically measured with a sound pressure meter in decibel dB(A) units on A scale<sup>1</sup>. A sound begins to stress the auditory system when the sound level exceeds 75-85 db range<sup>4</sup>. Noise can cause permanent hearing loss when there is an impulse noise at very high level of around 130-140 dB, or at chronic exposures equal to an average SPL of 85 dB(A) or higher for an eight-hour period. Thereby there are strict norms and guidelines for work places to save industry workers from noise induced hearing loss at occupational places<sup>6</sup>. Recently there has been advice from companies of ear phones and music devices and electronic gadgets to general public to protect themselves from loud noise even when using music as recreational activities by way of earphones.

Type of sound:

This gives rise to the big question??What is noise? This question has been raised because a music in the same disco may be pumping for a teenager to dance for hours together or feel it as a noise after enjoying it for some time but may makes another guy in the same disco to close his ears at once and leave the place. This is to say that the same sound may be music to one and noise for other. This also may lead us to say that loudness, duration of a sound as well as susceptibility<sup>8</sup> of an individual is detrimental to harm ones ears.<sup>8</sup>

This can be predicted in a way by using behavioral threshold audiometry and DPOAE<sup>4</sup> but this is still being studied to provide to give us a final say on this issue. Auditory-evoked potential correlates with susceptibility to noise-induced hearing loss.<sup>5</sup>

Type of hearing loss

The type of hearing loss incurred depends on the duration and type of sound (amplitude, frequency) which can cause symmetric or asymmetric loss. It is typically symmetric due to impact on both ears

simultaneously but the noise from sources as firearms or sirens may produce an asymmetric loss due to hearing losses of different grades in both ears depending upon susceptibility of each cochlea.

There can be two types of hearing losses due to sound, one is acoustic trauma due to sudden very high intensity sound as by explosion, second is due to chronic noise exposure which is more aptly called noise induced hearing loss.

Acoustic trauma<sup>9</sup>:

Acoustic trauma refers to a sudden permanent hearing loss caused by a single sudden exposure to an intense sound more often an explosion, the sound levels of which averages around 130-140dB. The amount of hearing loss a person suffers also varies due to susceptibility of an individual. The pathophysiology behind this is the direct shearing force to the sensory cells of the cochlea.

Patients commonly present to us with a sudden hearing loss after an antecedent impulse of noise with or without associated earache, tinnitus, vertigo, and headache. Otologic examination is often unremarkable but may reveal tympanic membrane disruption or evidence of ossicular damage or discontinuity. Audiogram often reveals a sensorineural hearing loss more often with a typical notch around 3-6kHz indicating predisposition to high frequency loss<sup>10</sup>, less commonly mixed or conductive hearing loss due to associated tympanic membrane rupture or ossicular damage or discontinuity. Management consists of avoidance of exposure to noise along with some medical treatment for tinnitus or vertigo if it so appears essential and surgical intervention for any conductive component as deemed necessary. The patient is followed up with serial audiograms till hearing stabilizes.

Chronic Noise induced hearing loss:

Chronic NIHL, in contrast to acoustic trauma, is a disease process that occurs gradually over many years of exposure to less intense noise levels than required to cause acoustic trauma. The etiology being chronic exposure to high intensity noise. The amount of sound that is capable of producing cochlear damage and subsequent hearing loss is related by so-called "damage risk criteria" which is based upon the equal energy concept. It refers that it is the total sound energy delivered to the cochlea that is relevant in predicting injury and hearing loss. Both an intense sound presented to the ear for a short period of time and a less intense sound that is presented for a longer time period will produce equal damage to the inner ear. An increase in sound intensity of 3dB is associated with a doubling of sound pressure<sup>11</sup>. Therefore, for each 3dB increase in sound exposure, the time exposed must be cut in half in order to deliver equal sound energy to the ear. Because noise levels are likely to fluctuate throughout the time of exposure, the standard accepted by OSHA is known as the 5dB rule<sup>12</sup>; for every 5dB increase in noise intensity, exposure time must be cut in half. If a 90dBA sound exposure is allowed for 8 hours, a 95dBA exposure is allowed for 4 hours, and so on to a maximum allowable intensity of 115dBA for 15 minutes<sup>12</sup>

The principal characteristics of chronic, occupational NIHL as specified by the American College of Occupational Medicine, Noise and Hearing Conservation Committee include the following<sup>13</sup>:

1. It is always sensorineural.
2. It is nearly always bilateral and symmetric.
3. It will only rarely produce a profound loss.
4. It will not progress once noise exposure is stopped.
5. The rate of hearing loss decreases as the threshold increases.
6. The 4kHz frequency is the most severely affected and the higher frequencies (3-6kHz) are more affected than the lower frequencies (500Hz-2kHz).
7. Maximum losses typically occur after 10-15 years of chronic exposure.
8. Continuous noise is more damaging than intermittent noise.

The majority of chronic NIHL is due to occupational or industrial exposure. It is important to remember, however, that in today's noisy society even people with quiet jobs may suffer from NIHL. Such non-occupational NIHL is also called socioacusis<sup>14</sup> and has same features as listed above.

The development of chronic NIHL progresses through two phases. The first stage is characterized by a temporary threshold shift (TTS). This is brief hearing loss that occurs after noise exposure and completely resolves after a period of rest. After repeated exposure to noises intense enough to produce TTS, eventually a permanent threshold shift (PTS) will occur. This is the second stage of chronic NIHL and is an irreversible increase in hearing thresholds. At this point, there has been irreversible hair cell damage.

Patients suffering from chronic NIHL commonly present with difficulty hearing more so in with significant background noise. There is high frequency hearing loss characterized by a loss of consonant discrimination. High frequency sounds (3-6kHz) are very important to the intelligibility of speech.

## MANAGEMENT

### PRIMARY PREVENTION:

These strategies emphasize on general health promotion, risk factor reduction and other health protective measures in way of health education and health programs designed to foster healthier lifestyles and programs designed to improve environmental quality.<sup>15</sup>

Physicians can easily screen for excessive noise exposure. Screening question is: "Are you exposed to excessive noise in your workplace or through music or hobbies?"

The parents of adolescents should be counselled about exposure to amplified music and adults to protect themselves at noisy places especially at work.

### EARLY SCREENING & PREVENTIVE STRATEGY:

A person exposed to significant noise should be screened to detect, counsel and take early measures to prevent further progression of hearing loss. The hearing loss is detected by way of history, clinical examination followed by a battery of audiological tests. The patient found to have recent noise induced hearing loss should be counselled and prognosticated according to the type of hearing loss reported by clinical examination and audiogram. The clinician should motivate patients to protect themselves in noisy areas by use of earmuffs, earplugs and other protective devices.

### Screening for Hearing Impairment:

The clinician ask patients if they have difficulty understanding speech in noisy environments, if they need to turn up the television volume or if they frequently have to ask people to repeat sentences to know the type and roughly the magnitude of hearing loss. The Weber and Rinnes tests, performed with a 512-Hz or 1.024-Hz tuning fork can provide clues to whether the loss is conductive or sensorineural.

A patient showing evidence of hearing loss is referred for a detailed audiologic evaluation. Audiologists confirm the laterality, amount and type of hearing whether the loss is sensorineural, conductive or mixed by way of audiograms. They can also perform tests for speech discrimination and speech reception threshold which would further help in setting of hearing aid if so required.

### Occupational hearing conservation laws, hearing conservation and role of health professional:

The Occupational Safety and Health Administration (OSHA) mandates that employers provide hearing conservation programs for their employees at workplaces where noise levels equal or exceed 85 dB(A)

for an eight-hour time-weighted average duration of exposure. Every 3db increment in noise levels allows half the duration of exposure.

Legislature for noise control

Factories Act:

The Factories Act does not contain any specific provision for noise control. However, under the Third Schedule of the Act, noise induced hearing loss (exposure to high noise levels), is mentioned as a notifiable disease. Recently introduced ISO 14001 also do not mention specific steps for prevention of noise pollution. Thereby the noise pollution rules are more specific and described as under.

The Noise Pollution (Regulation and Control) Rules, 2000 Modified upto 2010:

It is considered necessary to regulate and control noise producing and sources with the objective of maintaining the ambient air quality standards at public place, place of work, in different areas and zones in respect of noise to protect individuals from the deleterious effect of noise on human health and to maintain psychological well being. This act has responsibility as to enforcement of noise pollution control measures, serves as a complainant authority and power to prohibit. It poses restrictions on the use of loud speakers / public address system and sound producing instruments, restrictions on the use of horns, sound emitting construction equipments and bursting of fire crackers, any violation in silence zone / area.

Ambient Air Quality Standards in respect of Noise

Area code	Category of Area/Zone	Limits in dB(A) Leq*	
		Day Time	Night Time
A	Industrial area	75	70
B	Commercial area	65	55
C	Residential area	55	45
D	Silence Zone	50	40

Note: - 1. Day time shall mean from 6.00 a.m. to 10.00 p.m.

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

3. Silence zone is an area comprising not less than 100 metres around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority

4. Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.

\* dB(A) Leq denotes the time weighted average of the level of sound in decibels on scale A which is relatable to human hearing.

A “decibel” is a unit in which noise is measured.

"A", in dB (A) Leq, denotes the frequency weighting in the measurement of noise and corresponds to frequency response characteristics of the human ear.

Leq: It is energy mean of the noise level over a specified period.

### Hearing conservation program

Interventions such as education, training, audiometric testing, exposure assessment, hearing protection, and noise control measures when feasible are all components of occupational hearing conservation

An occupational hearing conservation program includes engineering and administrative controls to reduce noise exposures, employee training in the use of hearing protection and annual audiometry for all workers who are exposed to noise. To protect exposed employees from the adverse effects of noise, every workplace with a noise hazard should implement a comprehensive Hearing Conservation Programme (HCP), as part of the company's workplace safety and health programme. The objective of the HCP is to minimise the risk associated with workplace noise exposure and to prevent NIHL.

### Role of health professional

Physicians providing occupational health services to a company may supervise the hearing conservation program, review abnormal audiograms and take steps towards decreasing the disability. A worker whose audiogram shows a "standard threshold shift" (worsening of 10 dB<sup>1</sup> on average at 2.000, 3.000 and 4.000 Hz when compared with the employee's baseline test) must be notified and receive additional training and evaluation.

TREATMENT: This consists of both pharmacological<sup>16</sup> treatment and rehabilitative measures.

### Pharmacological treatment<sup>17</sup>

The ideal pharmacological treatment should address the specific mechanism of injury to delicate structures of cochlea and should be exceptionally safe, effective and yet affordable and preferably orally administered. Though there is ongoing research in this direction and is promising too but as of now no medicine has made its mark fulfilling all the above criteria of the pharmacological agent required.

There are a number of drugs most of which are yet in their research phase. This consists of N-Acetyl N Cysteine, Acetyl L Carnitine, D-Methionine, Glutamate antagonists, Creatine, Tempol, Steroids, Magnesium, Hyperbaric oxygen therapy.

### Hearing Rehabilitation

This consists of proper and complete audiological testing, thereby hearing aid fitting, assistive devices, using visual clues, dealing with conversation problems, patient and family counselling to brief about the

condition and to avoid excess noise exposure( too loud, too close or lasting for too long duration) .As far as hearing aid are concerned, there are a variety of options available nowadays depending upon the type and severity of hearing loss and most importantly the compliance of the patient.

Thus to summarize the management:

For primary prevention: education, hearing conservation programmes, legislation.

For secondary prevention: change of environment.

For tertiary prevention: hearing aids and rehabilitation.

## CONCLUSION

In brief we can say that NIHL is a preventable entity if an individual exposed to noise is made aware of the ways and means to protect oneself .This is important in a way because if damage to hair cells is once done, it cannot be reverted. Therefore strict legislation has come into place to save the interests of workers of industrial set up to prevent its occurrence in first place and rehabilitative measures if already occurred. There are also ongoing researches for audiometric tests to know prior susceptibility of an individual towards developing noise induced hearing loss .There are also researches in view of the newer pharmacological treatment and various newer rehabilitative modalities which have been made available to combat the effect of noise induced hearing loss on the physical and mental wellbeing of an individual.

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