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Hearing Loss and Noise Exposure: A Review

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ABSTRACT: *Hearing loss is the inability to hear sounds, in part or whole, and may affect one or both ears. It caused difficulties with language, education, and psychological functioning, cognitive decline, binaural hearing and speech perception in noise, depression, behavioral changes, and decreased functional status. The range of hearing level is normal (-10 to 20 dB), mild (20 to 34 dB), moderate (35 to 49 dB), moderately severe (50 to 64 dB), powerful (65 to 79 dB), and severe to profound. There are three types of hearing impairment, including conductive, sensorineural, and mixed hearing loss. Conductive hearing loss happens when a problem with the outer or middle ear stops sound from reaching the inner ear. Sensorineural hearing loss is caused by injury to the inner ear or the nerve path leading to the inner ear. Mixed hearing loss indicates that the outer or middle ear, the inner ear, and the auditory nerve have been damaged. The most common cause of noise-induced hearing loss (NIHL) and a severe threat to public health is the rising levels of ambient noise from working and the surrounding environment. Audiometry tests allow for the diagnosis of hearing loss, the measurement of the degree to which hearing loss has occurred, and the monitoring of changes in a person's hearing throughout their lifetime. Audiometry tests allow for the diagnosis of hearing loss, the measurement of the degree to which hearing loss has occurred, and the monitoring of hearing changes throughout their lifetime.*

Keywords: *hearing loss; noise exposure; conductive hearing loss; sensorineural hearing loss; audiometry.*

I. INTRODUCTION

Hearing loss is the inability to hear sounds, in part or whole, and may affect one or both ears. Persons of any age can develop the condition and several other causes, such as inherited factors, prolonged exposure to loud sounds, infections, head trauma, or even aging. Hearing loss may make it more difficult for a person to communicate, interact with others, and carry out their customary tasks. The acoustic energy received from the external ear is transferred to the middle ear, where it is transformed into mechanical energy and sent to the smallest bones in the body. These vibrations then convert the neurological reaction into the form that can be understood by the hair cells in the inner ear's cochlea. Hearing loss may be caused by any disruption in transmitting acoustic signals from the outer, middle, or inner ear to the hair cells (Vohr, 2018; Hayes et al., 2013).

Hearing loss may occur for various reasons and has a variety of consequences in everyday life. Prenatal etiologist may cause hearing loss, inner ear malformations, congenital infections, aging, ear infection, genetics, head injuries, chemotherapy agents, ototoxic medication or antibiotics, as well as excessive noise exposure (Rusinek, 2021; Aline et al., 2020; Borges et al., 2020; Vohr, 2018; Lauer et al., 2019). Hearing loss has several consequences, including difficulties with language, education, and psychological functioning, cognitive decline,

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binaural hearing and speech perception in noise, depression, behavioral changes, and decreased functional status. Gradual noise-induced hearing loss damage outer and inner hair cells, as well as cochlear nerve endings may result in permanent chronic illness (Augusto et al., 2017; Kumar et al., 2016; Hutchinson Marron et al., 2015; Tung & Chao, 2013; Hayes et al., 2013; Vogel et al., 2011). The degree of hearing loss detects from the clinical audiogram hearing level threshold. The range of hearing level is normal (-10 to 20 dB), mild (20 to 34 dB), moderate (35 to 49 dB), moderately severe (50 to 64 dB), powerful (65 to 79 dB), severe to profound (Rusinek, 2021) and profound (>80 dB) hearing loss (Aline et al., 2020; Couth et al., 2020; Vohr, 2018; Burkard, 2016). Hearing loss is the inability to hear sounds, partially or wholly. It may occur in one or both ears and can affect people of any age (Rusinek, 2021; Borges et al., 2020; Vohr, 2018; Hayes et al., 2013). There are several types of hearing impairment, including sensorineural, conductive, and mixed hearing loss (a combination of two or three hearing deficits). Auditory neuropathy (neural HL), persistent conductive HL, and transitory conductive HL (middle ear fluid/debris in the ear canal) are also possible (Vohr, 2018).

II. TYPES OF HEARING LOSS

2.1. Conductive hearing loss

Conductive hearing loss happens when there is a problem with the outer or middle ear that stops sound from reaching the inner ear. This sort of hearing loss may develop in either or both ears. This hearing loss is common in people of advanced age. Ear infections, ear canal blockages, damage to the eardrum or bones in the middle ear, and abnormal bone formation in the middle ear have all been suggested as possible causes of this illness (Chordekar et al., 2018; Lauer et al., 2019; Shabana et al., 2021; Temirbekov & Celikyurt, 2020; Wroblewska-Seniuk et al., 2018). In addition to these possible causes, ear canal blockages and eardrum trauma are possibilities. Conductive hearing loss may result in a range of symptoms, including a sensation of fullness in the ear that is affected, trouble hearing soft sounds, muffled or distorted sounds, and trouble hearing quiet noises. Hearing evaluations, commonly called audiograms, are the gold standard for diagnosing conductive hearing loss. The treatment for conductive hearing loss is individualized to the patient's situation and determined by the underlying cause of the hearing loss.

2.2 Sensorineural Hearing Loss

Sensorineural hearing loss is caused by injury to the inner ear or the nerve path leading to the inner ear. This hearing loss limits a person's ability to recognize individual sounds. Age, prolonged exposure to loud noise, certain medications, infections, head trauma, and other medical issues may all contribute to hearing loss. The inner ear is home to a large population of microscopic hair cells, essential in converting sound waves into electrical impulses. These signals are then sent to the brain, which deciphers them. If these hair cells are damaged, they cannot function properly, which may result in sensorineural hearing loss (Rusinek, 2021; Vohr, 2018; Augusto et al., 2017; Hayes et al., 2013). Sensorineural hearing loss may result in various symptoms, including difficulty hearing certain types of sounds, a reduced capacity to understand speech, ringing in the ears (often referred to as tinnitus), and a feeling that the ears are full of pressure. Hearing aids, cochlear implants, and a wide variety of other assistive devices are some potential treatments for sensorineural hearing loss that may examine. In some instances, medical or surgical treatments can be required to address the underlying condition causing hearing loss effectively.

2.3 Mixed Hearing Loss

It is possible to suffer from both sensorineural and conductive hearing loss simultaneously, a condition referred to as mixed hearing loss. It indicates that the outer or middle ear, inner ear, and auditory nerve have been damaged, which is the cause of conductive hearing loss (also known as sensorineural hearing loss). Mixed hearing loss is often brought on by a combination of factors, the most frequent of which are age-related hearing loss, recurrent ear infections, otosclerosis (an abnormal bone growth in the middle ear), head trauma, and prolonged exposure to high noise levels. Hearing loss that occurs just due to advancing age is another typical reason. Mixed hearing loss may result in various symptoms, including difficulty understanding spoken

language. These noises come across as muddled, and to hear well, people have to crank up the volume on the television or radio (Vohr, 2018).

Research has shown that noise's auditory effects may be caused by a rapid, loud blast sound or long-term exposure to moderate sound pressure levels (Wang et al., 2019; Jafari et al., 2019; Shah et al., 2018). Both scenarios have the potential to damage hearing. According to Aras (2003), the NIHL is often a dip or notch at four or six kilohertz (kHz). According to Hayes et al. (2013), presbycusis is a disease of the inner ear that affects how sound waves transform into nerve impulses. Hearing loss brought on by exposure to loud music is a very regular occurrence. Young adults in today's society are subjected to loud music without being informed of the potential consequences in the long run (You & Kwak, 2020; Gilliver et al., 2017). The difference in a person's hearing threshold level between their air and bone conduction systems is called the air-bone gap. It is essential to define the kind and degree of hearing loss and the treatment that will be the most effective (Ismail et al., 2021; Shabana et al., 2021). If the difference is more than 10 dB, the individual likely has conductive hearing loss, which may have problems in either the outer or the middle ear. There is a difference in the volume of the sound that is heard via the bone compared to the volume of the sound that is heard through the air, which referred to as the air-bone gap. The air-bone gap is the difference between the air conduction and bone conduction threshold.

III. HUMAN SOUND EXPOSURE

The acoustic sound is something that everyone is exposed to consistently. Some noises may be adequately heard, while others are deafeningly loud because their amplitude and frequency are much higher than the standard rate. This causes the hearing sense to deteriorate over time. Prendergast et al. (2017) said that high noise settings or activities with a decibel level of more than 85 dBA, to which they had been exposed with some degree of repetition throughout their lifetime, were associated with an increased risk of developing hearing loss. One year of exposure to a daily operational noise level of ninety decibels (dBA) is equivalent to one noise exposure unit. This formula [1] is used to evaluate the length of exposure, the frequency of exposure, and the state.

$$U = 10(L-A-90)/10 \times Y \times W \times D \times H / 2080 \quad [1]$$

where:

U = cumulative noise exposure,
L = estimated noise exposure level in dBA,
A = attenuation provided by hearing protection in dB,
Y = years of exposure,
W = weeks of exposure per year,
D = days of exposure per week,
H = hours of exposure per day,
2080 = number of hours in a working year.

Noises up to 90 decibels (dB) are tolerable for the human auditory system; sounds that are louder than this cause discomfort and sometimes even pain. In addition, according to Augusto et al. (2017), louder sounds over 130 dB SPL may damage the auditory system. This claim is supported by the findings of Manivasagam (2019), who explains that the Department of Occupational Safety and Health in Malaysia (DOSH) has set an excessive daily noise exposure limit of no more than 82 dB in conjunction with a daily personal dose rate of no more than 50%. The maximum sound pressure level must never exceed 115 decibels, and the peak sound pressure level must never exceed 140 decibels. OSHA's permissible exposure level (PEL) is 90 decibels (dB) (Eggermont, 2017). Currently, most nations utilize 85 dBA and a three-decibel conversion factor to calculate a person's daily noise dosage and duration. The recommended daily noise dose maximum over eight hours does not exceed an average of 85 dB (Arenas & Suter, 2014).

National Institute for Occupational Safety and Health (1998) highlighted if the sound intensity increases by three decibels, the sound level doubles, and the exposure duration falls by half (Jiang et al., 2016). Using this

formula [2], we can determine the length of this exposure.

$T = 8 / [2^{(L-85)/3}]$ [2]

where:

T = the number of hours

L = the level of exposure

Tung and Chao (2013) investigated the influence of exposure to recreational noise on hearing impairment by having participants fill out a questionnaire and undergo a hearing test on the same day as their physical examination. Based on the students' frequency and participation in recreational activities, a calculation was made to determine the total number of times in a year that students use earbuds (N_{ear}) and attend recreational activities (N_{re}). The questionnaire was also designed to evaluate the mean length (Fear) and volume (V_{ear}) of each frequency of use of the earphone, in addition to the average duration (F_{re}) of each recreational activity. Both measurements were based on the frequency of use of the earphone. The total dosage of recreational noise exposure (T_{exp}) [2] has been characterized as the sum of the total amount of time spent wearing earphones (T_{ear}) and the total amount of time spent participating in noisy recreational activities (Tre) during the previous 12 months. This formula [3] was used to calculate the total dosage of exposure to ambient noise that an individual has received.

$T_{exp} = T_{ear} + T_{re} = N_{ear} \times F_{ear} \times V_{ear} + N_{re} \times F_{re}$ [3]

The most common cause of noise-induced hearing loss (NIHL) and a severe threat to public health is the rising levels of ambient noise from working and surrounding environments. According to Diviani et al. (2019), NIHL is a severe condition that cannot be reversed and burdens the public. Music may be entertaining to people, but it also carries the risk of hurting them. Even though they do less direct damage, sounds associated with pleasure, such as music, are nevertheless a risk factor for hearing loss. According to a document published by the World Health Organisation (WHO) in Guidelines for Community Noise, it was emphasized that young adults who were active in activities such as going to parties, nightclubs, concerts, theatres, and other outdoor activities were exposed to the high-intensity noise exposure (> 100 dB) that may contribute to hearing loss (Augusto et al., 2017).

IV. NOISE EXPOSURE

U.S. Army Centre for Health Promotion and Preventive Medicine (2008) emphasized that the acoustic stress of military personnel experience due to high-level impulsive explosions and continuous noise puts them at risk for hearing loss. Cave et al. (2007) explained that noise-induced hearing loss is the most prevalent condition experienced by returning United States military personnel. Manning et al. (2016) researched using communication devices to explore voice recognition in loud contexts. The capacity to recognize a person's speech even when background noise is evaluated using air and bone conduction sensors. In addition, it may provide evidence for the widespread use of bone conduction technology or demonstrate the distinctions between normal hearing, sensorineural hearing loss, and sensorineural hearing loss combined with clinically significant tinnitus regarding the hearing profile.

Furthermore, Eggermont (2017) stated that 28.6% of MP3-player-using teens were identified as listeners at risk for hearing damage due to estimated exposure of 89 dB for more than one hour per day. The study showed a connection between habit strength and risky listening. It has been proposed that avoiding MP3-induced hearing loss requires a multifaceted strategy. Estimates of earphone or MP3 player noise exposure also exceeded current occupational safety requirements associated with transient hearing issues. McNeill et al. (2010) compared Vogel et al. (2011)'s study on lowered MP3 volume settings to the listening habits and subjective hearing health measurements of 28 university students. This was done in courses with background sound levels ranging from 43 to 52 decibels. According to the statistics, the average usage is two hours per day, 6.5 days per week. The average and worst-case median sound levels were 71 and 79 decibels (dB). In the survey, 19 students reported having at least one symptom of noise-induced hearing loss. Tinnitus patients' MP3 listening habits differed considerably from non-tinnitus patients (Eggermont, 2017). Noise-induced hearing loss occurs when loud noise promotes apoptosis in cochlear hair cells, resulting in serious public health problems

(Diviani et al., 2019). Furthermore, ototoxic drugs such as aminoglycoside antibiotics and platins may cause hearing loss by inducing apoptosis in hair cells. Finally, loud noise promotes apoptosis in outer hair cells, contributing to presbycusis (Eggermont, 2017).

V. HEARING APPARATUS

American Speech-Language-Hearing Association (ASHA), an audiometer is "electronic equipment that is used to measure hearing sensitivity for pure tones and speech" (Hye et al., 2020). It is within the capabilities of audiometers to produce pure tone signals throughout a broad spectrum of frequency and intensity ranges. These signals can be used to determine a person's hearing threshold, which refers to the sound level at which a person can still perceive it, as well as their aptitude to understand spoken language. Audiometry evaluates a person's hearing using an audiometer in a controlled environment. An audiometer, controlled by an audiologist or another hearing healthcare professional, measures the patient's hearing ability to provide a diagnosis and treatment plan. The results of the examination are then written down and documented. According to the World Health Organization (WHO), audiometry is "the measurement of hearing capacities at different frequencies and intensities." (WHO, 2021). Audiometry tests allow for the diagnosis of hearing loss, the measurement of the degree to which hearing loss has occurred, and the monitoring of changes in a person's hearing throughout their lifetime. An audiogram is a chart that shows the results of an audiometry exam. The chart plots the patient's hearing sensitivity over a spectrum of frequencies ranging from 250 Hz to 8,000 Hz. An audiogram displays the findings of an audiometry test. The patient's hearing threshold, or the quietest sound that they can differentiate at each frequency, is also shown on the audiogram. An audiogram is a graphical depiction of the outcomes of an audiometry test. It is used in diagnosing hearing loss and determining the kind of impairment and the degree to which it has an effect.

A diagnostic instrument known as a pure tone audiometer determines a person's hearing sensitivity over various frequency ranges. Pure tones are sounds with just one frequency and devoid of harmonic overtones. This apparatus can create pure tones of varied intensities. The individual being evaluated puts on headphones and is prompted to click a button or raise their hand when they hear a tone to demonstrate how they respond. Audiometers offer a wide range of uses and may be discovered in various settings, such as medical facilities, audiology clinics, and educational institutions. They are used relatively often in the screening for hearing loss, the diagnosis of hearing issues, and the monitoring of the efficiency of therapy (Chiong et al., 2018; Mukari et al., 2017; Ishak et al., 2017). Pure tone audiometry (PTA) can detect the threshold at 1000 Hz, 2000 Hz, 4000 Hz, 8000 Hz, 500 Hz, and 250 Hz for both bone conduction and air-conduction sounds for children and adults. On the other hand, certain audiometers can produce tones with a frequency of up to 20,000 Hz. The tone will be heard at varying intensities, denoted by the decibels (dB) of hearing level (HL), a unit of measurement used to express the amount of sound pressure that a person with normal hearing can detect.

Standard audiometry is often restricted to measuring thresholds at octave-spaced frequencies ranging from 250 Hz to 8000 Hz (Eggermont, 2019). This is the case, although we can hear up to 20,000 Hz at a young age. The frequency trajectories (2000, 4000, and 8000 Hz) that make up the pure-tone average for high frequencies show that declines in high-frequency hearing began before the age-related decline in listening comprehension. In contrast, the low-frequency thresholds, which are 250, 500, and 1000 Hz, do not shift significantly until beyond the age of 65 (Eggermont, 2019). The decibel scale on a clinical audiometer is randomly set to start at zero decibels, which is the hearing level for normal ears. Each increment of 10 dB reflects a tenfold increase in sound intensity. However, the same 10 dB increase reflects a double rise in loudness. The average hearing range ranging from barely audible to the loudest human sound that can be processed without intense pain, reaches over 120 dB (Elaine N. Marieb & Hoehn, 2011).

VI. CONCLUSION

Hearing loss and impairment, impacted by genetics, environment, and lifestyle, may have severe everyday effects. Hearing loss can cause language, education, and psychological difficulties, cognitive decline,

binaural hearing and speech perception in noise, depression, behavioral changes, and decreased functional status. The clinical audiogram threshold determines hearing loss. There are several types of hearing impairment, including sensorineural, conductive, and mixed hearing loss. Pure-tone audiometers measure children's and adults' bone-conduction and air-conduction thresholds at 1000 Hz, 2000 Hz, 4000 Hz, 8000 Hz, 500 Hz, and 250 Hz. Hearing loss may be diagnosed based on observations, types, and severity.

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