Chapter

Noise Induced Hearing Loss: A Case Study from a Speech-Language Pathologist's Perspective

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Abstract

Hearing loss is very common in the United States and the most widespread disability in the U.S. Hearing loss is the third most chronic health condition in the U.S. Noise induced hearing loss (NIHL) results from damaging external noise. This injury leads to temporarily or permanently affecting sensitive inner ear structures (e.g., cochlea, organ of Corti, and hair cells). NIHL can result from a single high-level noise exposure or repeated exposures to excessively loud noises [i.e., typically 85 dBA or greater, (A weighted decibel)]. Damage to the inner ear can also result from aging (i.e., presbycusis). This case study documents the hearing loss of an otherwise healthy 21-year-old, male individual and his progressive moderate-to-severe sensorineural hearing loss over a period of 41 years. His history will be reported along with his perspective as a speech-language pathologist and speech scientist. The individual with hearing loss has adapted to wearing hearing aids over the last five years. Issues that have occurred affecting comprehension along with compensatory strategies that assisted listening and comprehension will be discussed.

Keywords: Noise induced hearing loss, presbycusis, sensorineural hearing loss, compensatory strategies

1. Introduction

Hearing loss is very common in the United States. It is the third most chronic health condition in the U.S. [1]. A common cause of hearing loss is noise induced hearing loss (NIHL). NIHL results from damaging external noise, typically short high intensity noise. Loud sounds overstimulate delicate cells, leading to the permanent injury or death of cochlear hair cells. The hair cells cannot regenerate and there is no current cure for cochlear hair cell restoration. Therefore, once the hair cells die, the hearing loss become permanent.

NIHL injury leads to temporarily or permanently affecting sensitive inner ear structures (e.g., cochlea, organ of Corti, and hair cells). NIHL can result from a single high-level noise exposure or repeated exposures to excessively loud noises [i.e., typically 85 dBA or greater, (A weighted decibel)]. Noise induced hearing loss (NIHL) is one of the primary causes for chronic hearing loss. In the United States, NIHL from occupational noise ranges from 16–24% [2]. Up to 7% of noise induced loss in Australia has been found to arise from occupational noise [3]. Zhou, Shi, Zhou, Hu, and Zhang [4] reported that the prevalence of NIHL in Hungary was 21.3%, with 30.2% was related to high frequency NIHL. Thus, NIHL occurs with regularity in many world societies.

NIHL can result from occupational noises and/or non-occupational noise (e.g., gun blast or loud music). A characteristic of NIHL is the classic V notch occurring around 4,000 Hz. The surrounding frequencies must be at minimum 10 Hz or less than the hearing level at 4,000 Hz [5]. Noise exposure hearing loss is likely to become permanent six months after noise exposure has ceased [4].

Cutietta, Klich, Royse, and Rainbolt [5] found that high school band teachers displayed greater degrees of hearing loss than non-music teachers. Hearing loss incidence among professional musicians has been found to be very high, i.e., musicians had 3.51 fold increase rate of NIHL than non-musicians [6]. Other high-risk professions included aviation related professionals, i.e., incidence among aviators was found to be higher for certain U.S. military branches than others. Sensorineural hearing loss (SNHL) was greater for those in the U.S. Army and Air Force than the Navy or Marines [7].

1.1 Other causes of hearing loss

Nishad, Gangadhara, Mithun, and Sequeira [8] found that 30.7% of newborn babies screened for otoacoustic emission (OAE) and brain stem-evoked response audiometry (BERA) were high risk for hearing loss. Of the babies tested for high risk, 3.6% showed left ear hearing loss; 5.2% showed right ear hearing loss; while, 6.8% showed bilateral hearing loss. Consequently, congenital hearing loss and noise induced hearing loss (NIHL) are both contributors to hearing loss world-wide. Other etiological causes of hearing loss may include head injuries. Sports accidents, work related traumas, and road accidents are among the leading causes of head trauma.

1.2 Head trauma and hearing loss

Since, the case study participant (AB) experienced repeated chronic traumatic encephalopathies (CTEs) via karate for a period of years, TBI and CTEs will be reviewed. Other types of injuries may result from sports injuries (i.e., traumatic brain injuries, repeated chronic traumatic encephalopathies). Many contact sports involve CTEs with its participants (e.g., karate, football, wrestling, basketball, etc.). Some non-contact sports may also involve head traumas, such as cycling.

It has been noted that auditory issues following mild traumatic brain injury (TBI) are common [9]. Hoover et al., [9] examined speech in noise comprehension following mild traumatic brain injury (MTBI). Measures included monaural word (WIN) tasks, sentence (QuickSIN) tasks, and binaural spatial release task. The MTBI and non-MTBI participants were matched on pure-tone thresholds, thus, measuring speech in background noise. Results indicated that a high number of individuals with MTBI experienced difficulties with speech-in-noise. Speech-in- noise difficulties were related to auditory and non-auditory factors. Spatial separation was found to be related to working memory and peripheral auditory factors.

Traumatic brain injuries and head traumas arising from concussions or repeated sub-concussive impacts have been shown to be intertwined much deeper than what was previously thought [10]. While, NIHL affects the cochlea, sub-concussive impacts affect how the brain perceives sound [9] and affects the brain's ability to comprehend speech and sustain one's auditory attention to task [10, 11]. AB's sub-concussive impacts over the period of six years may have had a more lasting impact on auditory processing [10], difficulties with speech in noise [9], and/or sustaining listening abilities over time [11] than the noise induced hearing loss.

Concussions can result in auditory processing deficits without noted hearing loss [11]. Children and adolescents who have sustained a concussion were compared to a control group (non-concussive orthopedic injuries). Thompson et al. [11] found that the children with concussion had difficulties with speech in noise and with sustaining attention on cognitively taxing auditory tasks. These auditory difficulties are compounded with the existing MTBIs.

Fluctuating hearing loss is most likely to occur within the first year of the trauma [3]. Reports of head trauma and SNHL have been minimal [10]. Studies investigating trauma and hearing loss have mostly looked at immediate and short-term effects and have not investigated long term and chronic effects. There is no consensus regarding the endpoint for sensorineural hearing loss, cognitive and language difficulties after head trauma [10]. However, it appears that 90% of individuals who suffered a TBI do not experience further deterioration of hearing following the trauma [10]. Further research into auditory processing, attention, speech-in-noise processing, and other cognitive and language difficulties following a TBI are still warranted.

1.3 Hearing loss and cognitive loss

The most common cognitive loss disorder that affects memory and disruption of executive functioning (planning, organizing, sequencing, abstracting) that also interferes with activities of daily living (ADLs) is Alzheimer's dementia (AD) [12]. According to Livingston et al. and the 2017 Lancet Commission on Dementia Prevention [13], hearing impairment is one of nine modifiable risk factors associated with dementia. The other eight factors include hypertension, smoking, obesity, depression, physical inactivity, diabetes, low social contact (i.e., limiting conversation and mental processing of sounds), and less education. The National Institutes of Health (NIH) identifies social isolation (which can be perpetuated by a hearing loss) and hearing loss as a potentially modified dementia risk factor [14]. According to the 2017 Lancet Commission model [15] and their "new model of life-course risk factors"; hearing loss contributes the highest risk factor associated with dementia.

Hearing loss may contribute to dementia via social isolation and reduced opportunities for communication. However, hearing loss has been directly associated with neurodegeneration and cortical thinning in otherwise cognitively normal adults. Ha et al. [15]. They found that right ear hearing loss was associated with right superior temporal and left dorsolateral frontal areas. Neurodegeneration precedes dementia. Griffiths et al. [16] propose an important interaction occurs between auditory and cognitive processing in the medial temporal lobe and later dementia pathology.

Nadhimi and Llano [17] have found that hearing loss in animals produced cognitive decline. Specifically, Nadhimi and Llano stated that, "The data suggest that noise-exposure produces a toxic milieu in the hippocampus consisting of a spike in glucocorticoid levels, elevations of mediators of oxidative stress and excitotoxicity, which as a consequence induce cessation of neurogenesis, synaptic loss and tau hyper-phosphorylation" (p. 1). Acute noise exposure has also been shown to have detrimental effects on hippocampal physiology, particularly neurogenesis. Individuals with hearing loss may consequently experience dementia in later life. Further study in this area is needed.

1.4 Age related hearing loss

Age related hearing loss (ARHL, presbycusis) is a progressive and chronic impairment, that is often bilateral [17]. The prevalence of ARHL increases with age. ARHL, in and of itself, can lead to decreased health care. In addition, noise induced hearing loss (NIHL) and age-related hearing loss (ARHL) increase hearing thresholds over time [18]. Noise exposure creates a higher, combined burden on hearing loss. Grobler et al. [19] suggest that this combined hearing burden increases even if exposure to the excessive noise has stopped.

ARHL, in and of itself, leads to mild hearing loss in individuals over 60 years of age and moderate hearing loss in individuals over 72 years of age [20]. ARHL is a prevalent and chronic condition for individuals over 65 years of age. No international classification system takes into account frequencies above 4 kHz for ARHL [20]. ARHL accounts for 42% of hearing impairment for individuals from 60–69 years of age. This progressively increases until 85–90 years of age, at which time ARHL accounts for 100% of hearing loss issues [20].

2. Case study (AB)

This is a case study of a cognitively normal, male adult (AB) with a noise induced hearing loss (NIHL) from a young age (documented at 21 years of age). AB is a fluent Spanish-English speaker. Initial diagnoses pointed to two possible etiologies leading to sensorineural hearing loss: (a) a singular incident of shooting a loud firearm without ear protection; and/or (b) repeated sub-concussive impacts from karate over a period of six years (1973–1979) (diagnostic conversation with audiologist after an evaluation, Dr. Barbara Packer-Muti, 1992). Initial diagnosis at 21 years of age indicated a NIHL, bilateral, V notch hearing loss beginning at 1 K and progressing through 8 K. See **Table 1** which illustrates the hearing loss with audiograms obtained for following ages of 21, 34, 42, 49, 45, and 57 years of age.

AB's hearing has deteriorated over time. It is difficult to ascertain his loss over 4 kHz completely to ARHL [19]. However, his losses over time are most likely due to the combined factors of ARHL and NIHL [19]. Consistently, his worse frequencies are in the 4 KHz to 8 KHz. His bilateral loss is more severe in his right ear; however, the left ear also shows significant loss in these same frequencies and with severity. AB at the time of the last evaluation was 57 years of age. Evidence of age related hearing loss is apparent across frequencies from 25o Hz to 4 kHz. AB's hearing loss has progressed due to NIHL and age related hearing loss (ARHL) as illustrated by **Figure 1**. **Figure 1** shows contrasting audiograms obtained at 21 and 57 years of age.

2.1 Career as a speech-language pathologist

AB had been a practicing speech-language pathologist for 32 years when the last audiogram was obtained. He started as a school-based speech-language pathologist, worked later in private practice, and then as a university faculty. AB's research for the past 20 years has been in the area of speech perception, phonetics, and phonology. AB is a native Spanish speaker and has spoken English since 5 years of age and for over 52 years at the time of the last hearing evaluation in 2015.

AB has worked in a university environment (university faculty) for 30 years in speech-language pathology. His research after 10 years shifted towards phonology, phonetics, speech perception, and word identification among bilingual populations with and without disabilities/disorders. AB has been a member of his professional organization for over 30 years (i.e., the American Speech-Language-Hearing Association, ASHA). AB's research has focused on issues of transference or interference between two languages in the areas of phonetics (study of sounds), phonology (study of how sounds form words), semantics (words and word relationships), syntax (sentence structure) and pragmatics (how language is used in social

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Age	Unmasked Air			Unmasked Bone		
	Freq. (Hz)	Threshold		Freq. (Hz)	Threshold	
		R	L		R	L
21	250	15	10	250	10	
	500	10	10	500	10	
	1,000	5	5	1,000	0	
	2,000	0	0	2,000	0	
	4,000	40	0	4,000	10	
	8,000	25	25	8,000		
34	250	10	15	250	20	
	500	20	20	500	20	
	1,000	0	10	1,000	5	
	2,000	5	10	2,000	5	
	4,000	40	40	4,000	40	
	8,000	20	50	8,000		
42	250	40	40	250		
	500	35	40	500		
	1,000	25	35	1,000		
	2,000	25	35	2,000		
	4,000	80	60	4,000		
	8,000	55	65	8,000		
49	250	25	20	250		
	500	25	20	500		
	1,000	25	20	1,000		
	2,000	20	35	2,000		
	4,000	65	65	4,000		
	8,000	45	55	8,000		
54	250	20	20	250		20
	500	20	20	500		20
	1,000	25	20	1,000		20
	2,000	15	50	2,000		40
	4,000	70	65	4,000		
	8,000	65	60	8,000		
57	250	25	15	250		
	500	20	20	500		
	1,000	25	25	1,000		
	2,000	30	60	2,000		
	4,000	75	65	4,000		
	8,000	50	60	8,000		

Table 1.
Patient's audiograms over time.

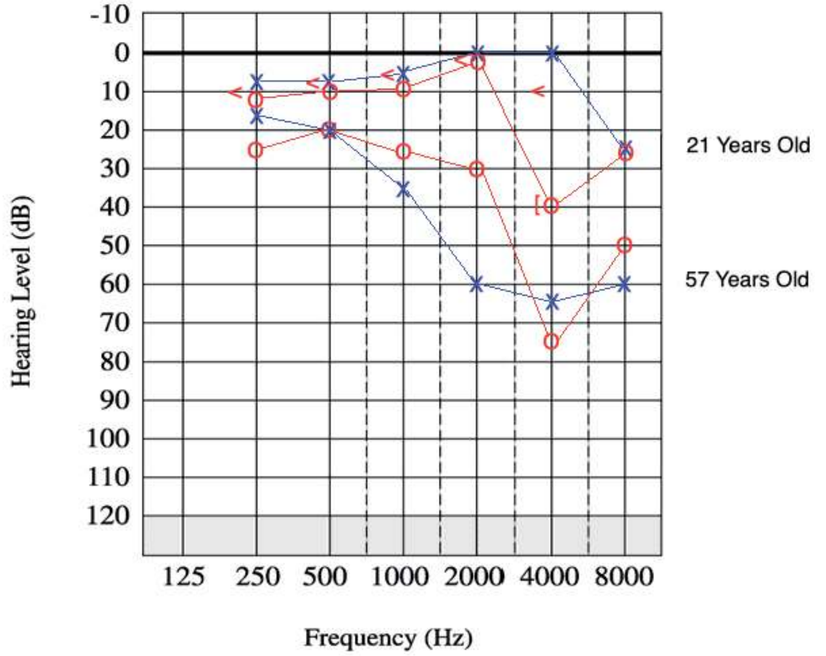

Figure 1.
Contrasting Audiograms Obtained at 21 and 57 Years of Age.

interaction) related to speech-language pathology and cognition. His clinical expertise relates to the appropriate assessment and treatment of Spanish-English speaking students and clients in the United States. Clinically, AB has worked with toddler, pre-school age children, school age children and adolescents, adults in acute care, adults in rehabilitation care, children and adults in home health care settings, and children and adults in out-patient care. AB has supervised graduate students in clinical settings. AB has worked with other professionals including audiologists, medical doctors, physical and occupational therapists, teachers, psychologists, counselors, parents, and family members. This clinical knowledge has facilitated AB's own self-care hearing rehabilitation.

2.2 Speech intelligibility

Hearing deficits impacted AB's hearing, perception, and identification of certain sounds in both Spanish and English. Sounds that have been affected have included high frequency sounds such as /p, t, k, g, h, f, s, ʃ, tʃ, θ, ð/. These sounds range from 500 Hz to 8 kHz and more specifically in the 2 to 4 kHz range.

Factors influencing speech intelligibility include loudness, distance from the speaker, pitch, unique features of consonants and vowels, and noise in the environment [21]. Sound levels (loudness) vary according to the speaker's intensity as measured in decibels (dB). The difference between speaking and shouting may vary only by 20 dB [21]. The distance from the speaker will also affect the sound's intensity. Hence, a speaker at 1 meter may produce an utterance at 55 dB, however, at 5 meters it will be heard at 45 dB [21]. Each speaker's complex speech tone (pitch) or fundamental frequency (f0) lies in the range of 100–150 Hz for men; approximately 180–250 Hz for women; and, around 300 Hz for children (exact averages vary by researchers; however, the general trends are consistent). Consonants in English speech are above 500 Hz. The energy from vowels diminishes rapidly above 1 kHz. It is not possible to increase the sound levels of consonants as one can with vowels; hence, some aspects of speech cannot be changed with increased intensity or volume. With regard to speech frequencies, most speech sounds occur around 2 kHz with the range of sounds occurring from 125 Hz to 8 kHz [21].

Difficulty with perception of sounds initially occurred when AB was in his forties and later progressed as his hearing thresholds increased. When in quiet environments, AB was able to function and adequately perform his research duties and engage in most conversations with no noise or minimal noise. However, as his hearing loss increased, in research, AB relied on the perceptual judgments of others in ascertaining sound discrimination and differentiation (i.e., use of graduate students with normal hearing). Use of amplification for discriminating participant responses and the ability to play-back responses were helpful.

Conversationally, AB was able to engage in conversation in quiet and in minimal noise without difficulties. AB's ability to discriminate sounds in noise became increasingly more difficult. Conversation in noisy environments were not possible. AB relied on visual cues, repetition, and understanding of topics to assist understanding. These strategies did not alleviate or generally improve understanding. AB's spouse tired of having to repeat herself and others tired of AB's miscommunications due to his hearing loss.

In his 50's AB experienced more hearing loss difficulties in both professional and conversational environments. AB relied more on graduate assistants in his research environment for auditory discrimination of sounds. AB continued to use previously recorded speech stimuli that was created for his experiments, thus, not needing to create new stimuli (which would require intact hearing, speech perception, and speech discrimination abilities). AB discontinued child phonology studies which involve extensive sound discrimination. Hence, AB's research was constricted by his hearing loss.

Conversationally, AB in his 50s withdrew more and had difficulty hearing and understanding others. Use of subtitles with movies became a regular feature. He consistently asked for conversation to be repeated. Even after several repetitions he still would not grasp the entire intent or message. He engaged more in attempts to read lips and to use word cues in the messages to guess at unclear words. AB's frustration with communication increased as well as those around him.

2.3 Rehabilitation

Rehabilitation began when AB conceded to using amplification (i.e., hearing aids) when he was in his late 50's. AB first attempted to make use of local government services in an attempt to obtain hearing aids (i.e., Health and Human Services). This attempt was not successful. Although, AB was ready to purchase hearing aids individually, the cost for bilateral, behind-the-ear (BTE) aids were prohibitive.

AB and his wife attended an international conference for speech-language pathologists and audiologists. It was at this conference that colleagues informed AB that the same hearing aids sold and used in the U.S. could be obtained for one half of the cost. AB's hearing was tested when he was 57 and it was at this time that he purchased his first pair of behind-the-ear (BTE) hearing aids. Over the course of five years AB continued to use his BTE aids until the point where he wears the aids 100% of the time.

AB continues to use compensatory strategies to conserve existing hearing, to make use of amplification and existing technology, and modifies his environment to enhance listening skills. Hearing conservation strategies include: (a) education about hearing; (b) reducing exposure to loud noise; (c) using hearing protection in noisy environments; (d) using hearing amplification; and, (e) participating in routine hearing evaluations [22]. AB has studied hearing loss through his professional affiliation as a speech-language pathologist. AB uses hearing protection in extremely noisy environments (i.e., ear plugs or head phones). AB wears his hearing aids regularly, makes use of closed captioning when available, and smartphone use. His hearing aids are smartphone capable; thus, AB is able to adjust different listening levels within the app program. Conversationally, AB adjusts his distance to speakers (i.e., moves closer when appropriate); AB maintains eye contact and looks at the speaker to increase visual and vocal cues; AB attunes more to key words in deciphering ambiguous words; and, AB can adjust his hearing aids via his smartphone to better hear in noisy environments.

3. Conclusion

Noise induced hearing loss is a common disorder that has many health consequences [1–4]. NIHL has many health consequences ranging from auditory processing deficits, attention and cognitive loss to social isolation. Traumatic brain injury, hearing loss, and auditory processing deficits are interwoven. Individuals who experience TBI or CTEs will most likely experience trouble with speech in noise, trouble with taxing auditory tasks, and trouble overall with speech processing. Age related hearing loss (ARHL) affects most individuals after 60 years of age. A non-hearing-impaired individual at 60 years of age will experience a mild hearing loss. If a person experiences noise induced hearing loss at an early age; then combined with ARHL, the effects can be compounded.

AB's speech in noise difficulties, resulting from his noise induced hearing loss (NIHL), were reduced through the use of hearing aids, use of aural rehabilitation strategies of paying attention to the speaker's lips, limiting loud and noisy environments, and practicing proper hearing conservation. Strategies to address AB's age related hearing loss (ARHL) consisted of wearing his hearing aids, noise conservation strategies, and scheduling regular audiological exams. It should be noted that some ARHL and NIHL strategies overlapping occurred.

AB is an adult male, currently 63 years of age. He was identified as having a noise induced hearing loss (NIHL) at 21 years of age. Over the course of 36 years, AB has documented his hearing loss with six hearing evaluations. AB's loss is a bilateral, sensorineural, and a high frequency sloping loss. AB currently wears hearing aids and practices hearing conservation. His work is minimally impacted by his hearing loss since he began wearing his hearing aids five years ago. AB is able to engage more fully in activities of daily living, i.e., conversations with others. Hearing obstacles include difficulty with high frequency speech sounds, listening in noisy environments, and maintaining strict hearing conservation.

While, noise induced hearing loss is a chronic condition with no means for improvement; hearing conservation strategies become of utmost importance. Conservation strategies include education about hearing, reducing exposure to loud noise, use of hearing protection, use of hearing amplification and making sure that continual hearing evaluations occur.

Conflict of interest

The author declares no conflict of interest. The author has no financial interest, direct or indirect, in the subject matter or materials discussed in the manuscript.

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References

[1] Masterson E, Bushnell T, Themann C, Morata T. Morbidity and mortality week report. Centers for Disease Prevention, 2016:65:389-394.

[2] National Institute for Occupational Safety and Health (NIOSH). NIOSH criteria for a recommended standard: occupational exposure to noise. 1972: Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHSS (NIOSH) Publication No. HIM 73-11001.

[3] Radi S, Benke G, Schaafsma F, Sim M. Compensation claims for occupational noise induced hearing loss between 1998 and 2008: Yearly incidence rates and trends in older workers. Australian and New Zealand Journal of Public Health, 2015: 40:181-184. DOI: 10.1111/1753-6405.12460

[4] Zhou J, Shi Z, Zhou L, Hu Y, Zhang M. Occupational noise-induced hearing loss in China: A systematic review and meta-analysis. BMJ Open, 2020;10;e039576. doi: 10.1136/bmjopen-2020-039576

[5] Cutietta R, Klich R, Royse D, Rainbolt H. The incidence of noise-induced hearing loss among music teachers. Journal of Research in Music Education, 1994:42:318-330.

[6] Schink T, Kreutz G, Busch V, Pigeot I, Ahrens W. Incidence and relative risk of hearing disorders in professional musicians. Occupational Environmental Medicine, 2014;71;472-476. DOI: 10.1136/oemed-2014-102172

[7] Orsello C, Moore J, Reese C. Sensorineural hearing loss incidence among U.S. military aviators between 1997 and 2011. Aviation, Space, and Environmental Medicine, 2013;84;975-979.

[8] Nishad A, Somayaji K, Mithun H, Sequeira N. A study of incidence of hearing loss in newborn, designing a protocol and methodology to detect the same in a tertiary health-care center. Indian Journal of Otology, 2020;26;85-88.

[9] Hoover E, Souza P, Gallun, F. Auditory and cognitive factors associated with speech-in-noise complaints following mild traumatic brain injury. Journal of the American Academy of Audiology: 2017:28:325-339. DOI: 10.3766/jaaa.16051.

[10] Segal S, Eviatar E, Berenholz L, Kessler A, Shlamkovitch N. Dynamics of sensorineural hearing loss after head trauma. Otology and Neurology, 2002:23:312-315.

[11] Thompson E, Krizman J, White-Scwoch T, Nicol T, LaBella C, Kraus N. Difficulty hearing noise: A sequela of concussion in children. Brain Injury, 2018:3;763-769. DOI: https://doi.org/10.1080/02699052.2018.1447686

[12] Brice A, Wallace S, Brice R. Alzheimer's dementia from a bilingual/bicultural perspective: A case study. Communication Disorders Quarterly;2016;6;55-64. DOI: 10.1177/1525740114524435

[13] Livingston G, Sommerlad A, Orgeta V, Costafreda SG, Huntley J, Ames D, Ballard C, Banerjee S, Burns A, Cohen-Mansfield J, Cooper C, Fox N, Gitlin LN, Howard R, Kales HC, Larson EB, Ritchie K, Rockwood K, Sampson EL, Samus Q, Schneider LS, Selbæk G, Teri L, Mukadam N. Dementia prevention, intervention, and care. Lancet, 2017; 390; 2673-2734. DOI: 10.1016/S0140-6736(17)31363-6.

[14] Daviglus ML, Bell CC, Berrettini W, et al. NIH state-of-the-science conference statement: preventing Alzheimer's disease and cognitive decline. NIH Consensus State of the Science Statements 2010; 27; 1-30.

[15] Ha J, Cho Y, Kim S, Cho, S, Kim J, Jung Y, Jang H, Shin H, Lin F, Na D, Seo S, Moon I, Kim H. Hearing loss is associated with cortical thinning in cognitively normal older adults. European Journal of Neurology, 2020;27;1003-1009. DOI: 10.1111/ene.14195

[16] Griffiths T, Lad M, Kumar S, Holmes E, McMurray B, Maquire E, Billig A, Sedley W. How can hearing loss cause dementia. Neuron, 2020;108;401-412. https://doi.org/10.1016/j.neuron.2020.08.003

[17] Nadhimi Y, Llano D. Does hearing loss lead to dementia? A review of the literature. Hearing Research, 2020;1-14. https://doi.org/10.1016/j.heares.2020.108038

[18] Smith S, Manan N, Toner S, Refaie A, Müller N, Henn P, Tauthaigh C. Age-related hearing loss and provider-patient communication across primary and secondary care settings: A cross sectional study. Age and Ageing, 2020;49;873-877. DOI: 10.1093/ageing/afaa041

[19] Grobler L, Swanepoel D, Strauss S, Becker P, Eloff Z. Occupational noise and age: A longitudinal study of hearing sensitivity as a function of noise exposure and age in South African gold mine workers. South African Journal of Communication Disorders, 2020;671-677. https://doi.org/10.4102/sajcd.v67i2.687

[20] Rodríguez-Valiente A, Álvarez-Montero O, Górriz-Gil C, Gárcia-Berrocal J. Prevalence of presbyacusis in ontologically normal population. Acta Otorrrinolaringológica Española;2020;71;175-180.

[21] DPA Microphones. Facts about speech intelligibility. Human voice frequency [Internet]. 2020. Available from https://www.dpamicrophones.com/mic-university/facts-about-speech-intelligibility#:~:text=FACTS ABOUTSPEECHINTELLIGIBILITY. Thevoice,soundfield

[22] Myers B. Sound strategies: How to establish an effective hearing conservation program. Professional Safety, 1994;39;1-4.