PREVALENCE AND CHARACTERISTICS OF HEARING LOSS IN OLDER ADULTS REGISTERED AT AIISH IN 2019

AMAN KUMAR

19AUD005

This Dissertation is submitted as part of fulfilment for the Degree of

Master of Science in Audiology

University of Mysore, Mysuru

All India Institute of Speech and Hearing

Manasagangotri, Mysuru- 570006

September, 2021

CERTIFICATE

This is to certify that this dissertation entitled **"Prevalence and characteristics of hearing loss in older adults registered at AIISH in 2019"** is the bonafide work submitted as part of fulfilment for the Degree of Masters of Science in Speech Language Pathology of the student with Registration No. 19AUD005. This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other Universities for the award of any other diploma or degree.

Mysuru

September, 2021

Prof. M. Pushpavathi

Director,

All India Institute of Speech and Hearing

Mysuru- 57006

CERTIFICATE

This is to certify that this dissertation entitled **"Prevalence and characteristics of hearing loss in older adults registered at AIISH in 2019"** has been prepared under our supervision and guidance. It is also certified that this has not been submitted earlier to any other Universities for the award of any other diploma or degree.

Mysuru

September, 2021

Guide

Dr. Mamatha N. M

Assistant Professor, Dept. of Audiology

All India Institute of Speech and Hearing

Mysuru- 570006

DECLARATION

This dissertation entitled **"Prevalence and characteristics of hearing loss in older adults registered at AIISH in 2019"** is the result of my own study under the guidance of Dr. Mamatha N.M, Assistant Professor in Department of Audiology, All India Institute of Speech and Hearing and has not been submitted earlier to any other Universities for the award of any other diploma or degree.

Mysuru

September, 2021

Register Number: 19AUD005

Acknowledgments

This dissertation has been a great learning experience throughout its course. On the very outset of this report, as I stand to complete this work, I would like to extend my sincere and heartfelt obligation towards all the personages who have helped me in this endeavour. Without their active guidance, support, help, cooperation and encouragement, I would not have made headway in this study.

I am extremely thankful to my faculty guide ***Dr. Mamatha N. M.*** *for her guidance and for her valuable guidance and support to accomplish this study. The small little things that you have taught me regarding reviewing an article, writing, presentation and the overall approach is impeccable. Thank you for trusting, believing in me and playing a significant role in moulding me into the student researcher I am today.*

I would like to extend my gratitude to our beloved director, ***Dr. M Pusphavathi****, for providing me with the opportunity to undertake this research.*

Special to mention to ***Dr. Animesh Barman, Dr. Sandeep M, Dr. Prashanth P., Dr. Sharath K, Dr. Ganpathy, Dr. Sujith Sinha, Dr. Prashant Prabhu, Dr. Manjula P.*** *for your guidance and support all throughout.*

I also acknowledge with a deep sense of reverence, my gratitude towards my ***parents*** *and* ***Anupama and Chanchal*** *who has always supported me morally.*

A huge thank to Mr. Srinivas and Mrs. Vasanth Lakshmi who support me a lot in statistics.

Sunny, Akshit, Jeevan, Madhu, Siddhi Patel, Anima, Namita, Aiza, Zohra, and Shejal *you have been my powerhouses. Thank you for all those fun and work, those countless conversation and discussion we had. Thank you for being my extended family.*

Harish kumar, *the confidence that you induced in me is that which I now have in this area. Thank you for always watching out for me and being there for support.*

Shanky, Sumit, Shanu, Roopak, Nikita, Rahul, vineet, vihal, ashwani and Archana *thank you for your timely motivation, right from the beginning and throughout the journey in MYSORE, as you guys always say, it's different when I'm here.*

Anjana K, Jagdish Anna, Sonal Nage, Hitesh Rajvanshi and Rashmi Rajvanshi *we laughed at the silliest jokes, put up with the worst mood of each other, had endless daily doses of fun and went along with the craziest ideas and plans. Those stupid things that we did together made my college life filled with wonderful memories.*

Bandhan, Suryakant, Shyam, Praveen, Atul, Muthu, Dilli, Freddy and Khakha The BOSS *thank you for being good friends throughout and all the amazing chats we have had.*

A special mention goes to ***Rashika ma'am, Asha ma'am, Raghav sir, Jitendra sir, Ishu sir, Appas sir, Keshav Sir, Shiva Sir, Srikant Sir, Ethesham Sir, Mayur Sir,***

Akhil sir, Ravinder sir, Shabin Sir, Gatla Sir, Sachin Sir, Kristi ma'am, Kriti ma'am and Babloo Bhaiya,*Thank you for all the little things I picked up from you people.*

Shubham, Rohit, Jergar, Ahnaf, Shashish, Sahil , Bikram, Anirban, Akshay, Amar and Dibendu: *My brothers who made my hostel life better. Just so you know, you're few of the people I truly look up to.*

Thank you ***Guru, Delvin, Bahis, Amit, Ranjit, Abraniel, Manjunath, Ashwin, Shyam Biswayan, Anees, bisvajit and Manoj.*** *It was fun with you all for helping me with a lot of things during Hostel Journey.*

Thank you ***Jyothi, Laxmi, Harshinee, Urmi, Taranjeet, Anu and Navya*** *. It was fun in my college life to have such amazing juniors.*

Special thanks to our "Joint family" and "L.L" group for the unforgettable memory of Gents Bodhi Hostel.

At last but not least gratitude goes to all my friends, faculties, juniors and seniors who directly or indirectly helped me to complete the study. Any omission in this brief acknowledgement does not mean lack of gratitude.

And, dear readers, the value of this research lies in the way you see it. I trust you, and thank you for the proper use in advance.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

INTRODUCTION

Hearing loss results from impaired auditory acuity and poorer speech intelligibility of the physiological auditory process (ASHA, 2020). Individuals with hearing loss are often defined as deaf or difficulty in hearing speech sounds and hearing impairment is primarily based on type, degree, and configuration (Katsarkas, 1994). Hearing loss is found to occur in all age groups: children, adults and geriatrics as congenital or acquired type. Congenital hearing loss includes herpes, rubella, meningitis, cytomegalovirus, congenital anomalies, non-syndromic inherited hearing loss, and acquired loss can be pre or post-lingual, caused by the external, middle, or inner ear. In adults, the onset of hearing loss is considered an age-related hearing loss and noise-induced cause (Nelson et al., 2005; Walling & Dickson, 2012). Hearing loss is also found to be seen in some chronic conditions such as hypertension (Agrawal et al., 2008; Nelson et al., 2005), diabetes mellitus (Agrawal et al., 2008; Nelson et al., 2005), hypothyroidism, cardio-vascular diseases and among others can be more deficient (Nelson et al., 2005).

Hearing loss is reported to result in incapacity to validate speech sounds, reduced capacity to communicate, difficulty in language acquisition, an educational and economic liability, social withdrawal, and stigmatization (Mathers et al., 2000). Hearing loss in childhood affects literacy, language development, social communication and self-confidence; untreated hearing loss results in scholastic underachievement, which results in diminished work openings in later life. In the case of adults, hearing loss leads to fatigue, impaired memory, depression and social withdrawal. In older adults presence of

hearing loss can degrade the trade of information and significantly influence everyday lifestyles causing isolation, loneliness, dependence, depression, falls and frustration, as precise as conversation sickness (Ciorba et al., 2012; Davis et al., 2016; Lin & Ferrucci, 2012; Mener et al., 2013). In older adults, hearing loss can be a conductive type caused by various causes such as foreign body, otitis externa, larger exostoses, tympanosclerosis, otitis media with effusion, cholesteatoma, otosclerosis, ossicular chain dysfunction, glomus tumours.

The sensorineural is caused by several conditions such as ototoxic drug, noise trauma, Meniere disease, meningitis, labyrinthitis, acoustic neuroma, hypertension, folic acid supplementation, diabetes, hypothyroidism and cardiovascular diseases (Agrawal et al., 2008; K. E. Bainbridge et al., 2008; Cruickshanks et al., 2010; Davis et al., 2016; Durga et al., 2007; Friedland et al., 2009; Walling & Dickson, 2012; Yueh et al., 2003). In older adults, hearing is independently associated with dementia and can be a marker of the initial stage of dementia (Davis et al., 2016; Lin et al., 2011). The nature of growth-related hearing loss is slowly progressive and affect both ears equally (Agrawal et al., 2008)(Fook & Morgan, 2000). With the advancement in age, hearing ability slowly deteriorates in most of the elderly population, termed as Presbycusis (Fook & Morgan, 2000).

Bilateral hearing loss is more common in men 28.7%, than women 17.0% in 60-69 years of the aged population (Gopinath et al., 2009). According to 2003-2004, data of the United States population aged between 20-69 years shows that 7.3% had bilateral and had 8.9% unilateral hearing loss (Agrawal et al., 2008). Prevalence in the United Kingdom population was aged 61-80 years, having hearing loss 45 dB or above in better

ear for conductive pathology is 3.1%, sensorineural pathology is 14.3% and older adults (52 years or above) prevalence of hearing loss is 90% (Fook & Morgan, 2000). The prevalence of hearing loss is found to vary across different countries.

The overall prevalence rate of hearing loss is nearly 50% in individuals aged more significant than 80-84 years and above 70% in individuals greater than 85 years in the United States (Homans et al., 2017) and the prevalence of hearing loss rate is found to be 61% for men & 63% for women. (Hilton et al., 2008) conducted a study on age-related hearing loss and reported that presbycusis is the primary neuro-sensory deficit associated with ageing, which causes communication problems and depression and social isolation. Avoidance of key risk factors and early identification are the best ways to prevent age-related hearing loss. However, several treatments, such as the use of hearing aids and cochlear implants exist. They also reported that presbycusis starts affecting the high frequencies first. Genetic predisposition and sound exposures were identified as the significant contributors to hearing loss. Stem cell research may also one day become a treatment option for people with presbycusis.

1.1 Need for the study

According to WHO (2018) report, the prevalence of hearing loss in India is reported as 6.3% (63 million people who have significant hearing loss) and the overall prevalence rate of hearing loss in an adult is 7.6% and in children is 1.2% (Davey et al., 2018). The estimated prevalence rate of adult deafness in India is 7.6%, and childhood deafness is 2%. In India, Telangana District, the prevalence of hearing loss is found to increase with age from 0.4% in those aged 4 to 17 years to 34.7% in individuals older than 65 years; Overall prevalence of reported hearing loss was 2.6%, ranging from 0.6%

in 0 to 3 years to 14.4% in older than 65 years; Hearing loss affects approximately 1 in 23 people overall and a third of older people more aged than 65 (Bright et al., 2019).

In China, hearing loss is more common; nearly 58.85% of older adults aged more than 60 years are affected and mainly caused by chronic diseases such as diabetes, hypertension, hyperlipidaemia, and atherosclerosis, ear diseases, and noise-induced hearing loss (Gong et al., 2018a). Prevalence studies were conducted in the United States across different geographical areas has revealed that hearing loss is less prevalent in women than in men in individuals younger than 80 years (Gopinath et al., 2009). The high prevalence rate of 96.6% in men and 86.1% in women of deteriorating listening ability over 80 years of age in Wisconsin, United States (Wiley, et al., 1998).

In the united states, the prevalence of hearing loss is found to have increased up to 89% in individuals aged 80 years or above (Mormer et al., 2017; Walling & Dickson, 2012); nearly one-third of older adults aged 61-70 years are affected with hearing loss (Walling & Dickson, 2012); roughly two-third hospitalized older patients are reported to have affected from hearing loss (Mormer et al., 2017).

Roehm et al., (2013) reported that presbycusis is a condition that can lead to irreversible age-related sensorineural hearing loss. The worsening auditory function in individuals with presbycusis is characterized by an increase in the hearing thresholds, especially at high frequencies and decreased sound localization ability, speech comprehension, and central auditory processing, resulting in difficulty hearing in noisy listening environments. The accumulation of various insults to the auditory system,

including noise exposures, otologic diseases, hair cell loss due to ageing, strial dysfunction, and ototoxic exposure, leads to presbycusis.

The prevalence rate of age-related hearing loss is reported mainly in western countries. The prevalence of hearing loss in older adults has been studied across various countries and it is found to vary across the studies. There is significantly less information regarding the prevalence and audiological detail of hearing loss cases in India in the older population.

Based on several studies found that there is a positive correlation between, high risk of cardiovascular pathology and males with age-related hearing loss in older adults (Agrawal et al., 2009; Gates et al., 1993; Kiely et al., 2012; Lin et al., 2013; Wallhagen et al., 2008). Hearing loss improved significantly in those 85 years older adults born in 1930 than aged 85 years of older adults born 30 years earlier (1901-1902) (Göthberg et al., 2020). Support for previous studies of the prevalence of slowly progressive hearing loss with the progression of higher age (Fook & Morgan, 2000)(Kiely et al., 2012)(Linssen et al., 2014).

Based on several studies has been noticed that in older adults with chronic conditions such as diabetes, hypertension, hyperlipidaemia, and atherosclerosis, the prevalence rate of hearing loss is high (Gong et al., 2018a). The prevalence varies within and across the country, which may differ because of the different populations and regions. From the review, it is evident that the prevalence of hearing loss has increased over the years and this may be due to lifestyle and the increase of certain medical conditions.

Hence, the present study was planned to provide details about the prevalence of hearing loss in older adults in India. This would help to develop better rehabilitation programs and determine early risk factors in older adults so that intervention programs may be implemented effectively and efficiently. All India Institute of speech and hearing (AIISH) is a specialized rehabilitation centre to provide services for communication disorders. In AIISH, many hearing loss cases are reported yearly, and age-related hearing loss is the most common across the older population. Also, the cases visiting AIISH represents different parts of India. Hence, there is a need to document the audiological profiling; type, degree, gender, age, nature of hearing loss, unilateral/bilateral, medical history, and risk factors associated with age in the older population to take necessary rehabilitation measures.

1.2 Aim of the study

To estimate the prevalence and characteristics of hearing loss in older adults registered at AIISH in 2019.

1.3 Objectives of the Study

1. To determine the total number of hearing loss in the older population (greater than 60 years) reported to AIISH, Mysuru, between the duration from January 2019 to December 2019.
2. To estimate the degree and gender predominance of hearing loss in older adult cases.
3. To study the risk factors associated with hearing loss in older adults.

Chapter 2

REVIEW OF LITERATURE

Hearing loss is the inability to perceive sound in one or both ears, either partially or entirely. Noise exposure, genetic mutation, age-related degenerative process, exposure to the therapeutic drug, smoking, adiposity and chronic diseases are all factors that contribute to hearing loss (Cunningham & Tucci, 2017). Conversations with coworkers, friends, and family may be difficult for people with hearing loss. They may also have difficulty comprehending medical advice, reacting to warnings, and hearing doorbells and sirens. Any age range of hearing loss is a significant source of disability, linked to severe communication and behavioral issues and high healthcare expenses, with society and individual economic ramifications (Cunningham & Tucci, 2017; National institute on ageing, 2018).

Hearing loss is found to cause multiple physical, mental, and social consequences to both individuals with hearing loss and their caregivers (Chia et al., 2007; Manchaiah et al., 2012). Also, hearing loss has been observed to affect most communities concerning financial, social and psychological aspects. As people grow older, hearing loss becomes more common.

2.1 Prevalence of hearing loss

Hearing loss is strongly age-related and it is found to be one of the most frequent chronic conditions in the older population having a 30 to 46% prevalence rate in various populations. It has been estimated that worldwide there are nearly 0.36 billion people (5% of the population) having disabling hearing loss (WHO, 2015). It is also observed that one-third of persons over 65 years suffer from moderate to profound hearing loss

(Bright et al., 2019). According to (Pleis & Coles, 2002; Ries, 1982), about 16% of adults in the United States have some hearing difficulty. Hearing loss is the third most prevalent chronic disorder in individuals above 65 years due to hypertension and arthritis. It has been reported that approximately 30% of the individuals suffer from hearing loss by the age of 70 years, and 50% of the population gets hearing impairment by the age of 80 years (Desai et al., 2001).

It has also been indicated that the hearing loss among the elderly population in the age range of 45 to 69 increases, especially in males (Wallhagen et al., 2008). In most studies, it was found that males had more significant hearing-related issues than females regardless of race (Bainbridge & Wallhagen, 2014). Also, hearing impairment was more observed in white than black adults (Desai et al., 2001; Pleis & Lethbridge-Cejku, 2007). Thus, race and ethnicity are also found to affect the prevalence of hearing impairment.

As per Barnett & Franks, (1999) National Health Interview Survey, it has been reported that the elderly of African and Asian descent experienced more minor hearing problems (20.1% & 17.2% respectively) compared to whites or the native Americans (17.2% & 20.1%, respectively). Also, 15% of the non-Hispanic white adults, 6% of Hispanic white adults, and 6% of non- Hispanic black adults were reported to have some form of difficulty in hearing. The National Health Interview Survey also reported a similar pattern of results. It concluded that hearing loss leads to frustration, increasing dependency, social isolation and the need for support services, earlier nursing home placement and hospital care (Caban et al., 2005).

A clinical study done in Saudi Arabian population by (Ruwali et al., 2010) estimated the prevalence of hearing impairment in the elderly population. They used a

cross-sectional design and self-administered questionnaire Hearing Handicap Inventory for the Elderly (screening version) for 500 people aged 41 to 75 years. The results of their study indicated that the prevalence of hearing loss increased with age, i.e., 10.17% for 46 to 50 years old and 38.3% for 71 to 75 years old, with males being affected more than females (52% to 48%).

In India, 72% of its population and 75% of the elderly live in rural areas. A validation study was done through screening hearing tools among older adults above 60 years of age in two villages of Bangalore district, Karnataka. Total of 257 elderly persons were given a questionnaire in their native language to collect data. The prevalence of hearing loss detected by pure-tone audiometry was 72.0 % (Deepthi & Kasthuri, 2012).

A cross-sectional community-based observational study was conducted across 306 individuals in the Shimla, Himachal Pradesh, India, urban region (Mohindroo et al., 2017). Clinical ENT examinations, structured questionnaires and audiological testing were used to obtain information about hearing loss. Results indicated that hearing loss was affected in 13.1% of the population. A total of 57.5% of the population with hearing loss were found to be above the age of 60 years.

2.2 Characteristics of Hearing loss

Allen et al. (2010) examined the configuration of hearing loss who were at risk of presbycusis in 960 subjects tested for their peripheral hearing sensitivity using pure tone audiometry (250 to 8000 Hz) and DPOAE (F2 mean = 1-6.4 kHz). The results indicated that the different configurations of hearing loss did not divide themselves into different classes of presbycusis. However, they had to be differentiated into categories

based on the configuration of hearing loss itself. The results also showed that most phenotypes show the different configurations of hearing loss between the extremes of flat to sloping configurations. If the configuration of hearing loss does predict presbycusis etiology, then a mixed origin is the most prevalent.

Lee et al. (2005a) conducted a longitudinal study and estimated high-frequency pure-tone threshold in 188 older adults (97 males & 91 females) to get the threshold changes over time and the various factors affecting these changes. The ages of the subjects were from 60 to 81 years when they joined the study. The conventional pure tone thresholds were measured from 250 to 8000 Hz during each visit and extended high-frequency thresholds were measured from 9000 to 18000 Hz every 2 to 3 years throughout 3 to 11.5 years. The results revealed that the average rate at which the threshold changed was higher at high frequencies than at lower frequencies. An average rate of hearing threshold progression was found to be 1 dB per year for subjects above 60 years. Factors affecting these rates were: above 70 years of older individuals showing a faster rate of change; females showing a faster rate of change; and initial threshold levels-poor thresholds at the low and mid frequencies showing a faster rate of change.

The audiological profile of individuals with hearing impairment was studied through a cross-sectional study carried out at a tertiary care hospital in Manipal, India (Agarwal et al., 2015). They measured the degree of hearing loss and used otoacoustic emissions to correlate age and gender with hearing loss. The study consisted of 40 individuals aged 18 to 50 years with no history of head injury, ear discharge, ear surgery, otitis media, meningitis, exposure to acute/chronic noise, treatment with

ototoxic drugs and presence of a family history of hearing loss. They measured pure tone thresholds for air conduction (250 to 8000 Hz) and bone conduction (250 to 4000 Hz) using the Modified Hughson-Westlake (1959) procedure (Carhart & Jerger, 1959). Immittance evaluation was used to rule out the presence of any middle ear pathology and Transient Evoked OAE's was done to check the functioning of outer hair cells. The results indicated that most patients had bilateral minimal to mild sensorineural hearing loss. OAE's were found to be absent in 30% of the subjects. Hence, they concluded that age progression is found to affect hearing thresholds more (from mild to profound degree) compared to gender predominance.

A study was carried out to tap the early occurrence of presbycusis by evaluating hearing loss (Arvin et al., 2013). They included high-frequency pure tone audiometry up to 16 k Hz in adults aged 20 to 49 years who were grouped into three different categories of 10 years of age range. The authors reported the presence of symmetrical high-frequency sensorineural hearing loss. The younger age group of 40 to 49 years also showed a balanced high-frequency sensorineural hearing loss. Thus, proving that high-frequency presbycusis occurs at an earlier age.

2.3 Immittance findings in older adults

Wiley et al. (1996) conducted a study to report the tympanometry findings in older adults aged 48 to 90 years (n = 1240 & 2147 ears). The tympanometry measures such as Peak Compensated Static Admittance (Peak Ytm), Equivalent Ear Canal Volume (Vea) and Tympanometry Width (TW) were obtained using 226 Hz probe tone, positive-to-negative direction of pressure change, and pump speed of 600/200 daPa/sec. All subjects were screened for the presence of conductive hearing loss. Compared to the

younger adults, older adults showed variability such as lower mean Peak (Ym-0.54 mmho) and significantly higher meant Equivalent Ear-canal Volume (Vea-1.49 cm3). It was found that across age, females had decreased Vea-1.20 cm3 and increased (TW-90dapa). Also, compared to females, the males had higher peak Ym (0.77 mmho) values, higher Vea(1.55 cm3) values, and slightly lower TW- (88dapa) values.

Golding et al. (2007) studied the tympanometry and acoustic stapedius reflex measures in Australian older adults aged 49 years (n = 1565). Tympanometry peak pressure (TPP), peak Ytm and Acoustic Stapedius Reflex (ASR) thresholds were measured for Tympanograms were obtained for both ears with a 226 Hz probe tone with pressure change from +200 to -200 daPa, or -400 daPa. The admittance value was kept as a reference at +200 daPa to Peak Ytm. The contralateral ASR thresholds were obtained at the point of maximum admittance at 500, 1000, and 2000 Hz, and ipsilateral ART was obtained for both ears at 500 and 1000 Hz. The results indicated that there was no significant age and gender effects were found for the TPP. Also, differential effects were seen across age and gender, with peak admittance measures decreasing with age (left ear) and higher for males than females. Also, contralateral ART's were increased with ageing at 500 Hz and 1 kHz.

Sogebi (2015a) conducted a cross-sectional comparative study on 103 elderly individuals aged 60 years and above. They studied the variations in middle ear impedance related to ageing and its relation to the inner ear. A structured questionnaire was used to rule out middle ear abnormalities. Pure tone audiometry, tympanometry, and acoustic reflexes were done and compared intergroup differences. The results indicated that more than 50% of subjects showed an age-related hearing loss, 39.3% presented with abnormal

tympanograms and 37.9% had absent acoustic reflexes. The results also revealed that populations of older individuals with normal and abnormal tympanograms and those with and without acoustic reflexes were not significantly different.

Nondahl et al. (2013) determined the changes over sixteen years on the Peak Ytm measurements in older adults aged 48 to 84 years (n = 3753) participants. (Vea), (TPP) and (TW) were measured using 226-Hz probe tone, the positive-to-negative direction of pressure changes, and pump speed of 600/200 daPa/s were used. The results indicated that, across 16 years, Peak Ytm declined at an average rate of 0.009 mmho/year. The results also varied with the gender; that is, older females showed a more significant decline in the Peak Ytm, while in men the changes were non-linear. It was also observed that, with time, a slight increase in the middle-ear stiffening was observed. However, it has not influenced clinical diagnosis.

2.4 Speech identification scores in older adults

Kirkim et al. (2005) investigated the communicative profile in middle-aged and older individuals with high-frequency hearing loss in a total of 300 subjects in the age range of 40 to 89 years with bilateral high-frequency hearing loss. All subjects were evaluated with pure tone audiometry, speech audiometry, middle ear immittance and TEOAE evaluations. The results indicated that speech discrimination scores of individuals above 60 years were significantly lower than individuals in the lower age group. Hence, ageing on audiological measures is evident through 60 years and above.

Humes (1996) investigated speech understanding in elderly subjects aged 63 and 84 years (n = 950). The study identified differences in monaural and binaural

speech- identification performance. Also, the effect of age and hearing loss on the identification of non-sense syllables (monaural speech identification performance) was assessed. The subjects were asked to identify non-sense syllables (closed-set) and the final word in meaningful sentences (open-set). The results indicated that the patients who performed poorly in one speech task also performed poorly in the other speech tasks. It also suggested that the degree of sensorineural hearing loss affected the non-sense syllable identification. That is when the hearing loss is more significant; the speech identification scores were poorer.

Humes et al. (1990) assessed the speech recognition difficulties of the elderly hearing-impaired individuals and the contribution of their auditory ability. A total of 36 subjects participated in the study consisting of two groups where 23 were normal hearing young adults (19 to 34 years), and 13 were elderly hearing impaired individuals (65 to 75 years). Hearing sensitivity within normal limits young adults and elderly hearing impaired adults, 11- Subset version of the City University of New York (CUNY) Non-sense Syllable Test (NST) (Resnick et al., 2005) was used to assess speech recognition scores. The results of the study suggested greater difficulty in understanding speech in elderly hearing-impaired individuals. Young adults with simulated sensorineural hearing loss performed similarly to elderly hearing impaired subjects. The results also suggest that sensorineural hearing loss is a significant factor for the poor speech recognition abilities in the elderly, which results in loss of sensitivity and loudness recruitment for the high-frequency stimuli.

2.5 Auditory brainstem response in older adults

Otto & McCandless (1982) studied the effects of ageing on Auditory Brainstem Responses in 30 subjects with normal hearing in the age range of 17 to 45 years, 30 elderly subjects aged from 60 to 80 years, and 30 young subjects aged 18 to 31 years with comparable sensorineural hearing loss. The ABR was recorded using 0.1 millisecond, 1024 unfiltered clicks at the rate of 10 clicks per second at 50 and 80 dB n HL. The results indicated that the waveforms were degraded in the elderly subjects compared to the younger groups. Also, in the elderly subjects, the morphology of early peaks was poor and hence less frequently identifiable. There was also evidence of neural conduction time delay for the elderly subjects. Thus, there is evidence of neural changes in the elderly population compared to the younger ones.

Martini et al. (1991) tried to determine the characteristics of Auditory Brainstem Responses (ABR) in elderly individuals. For this purpose, 36 healthy older individuals (18 males & 18 females) were considered for the study between 58 to 76 years. The ABR was obtained with 0.1 millisecond, 2000 rarefaction clicks at the rate of 21.1 stimuli per second at 75 dB n HL with a filter setting of 30 to 3000 Hz. The latency-intensity function was obtained. The results revealed that even slight presbycusis could shift the latency of all the ABR peaks. Also in the subjects who had more hearing loss at 4000 Hz had more latency shifts. Thus, the latency shifts depend on the degree of peripheral hearing loss, which produces a partial delay and de-synchronization of the neural discharge. The presence of a moderate high frequency hearing loss (30-35dBHL) also results in ABR abnormalities.

Ottaviani et al. (1991) measured ABR in 74 elderly subjects aged 60 to 80 years (38 males & 36 females). ABR was recorded using 2000 alternating polarity, unfiltered 0.1 ms clicks, presented through a TDH 49 headphone with an inter stimuli interval of 75 ms, an analysis time of 12 ms, and 70 dB nHL. The filter setting used was 50 to 3000 Hz. The absolute latency of waves I, III and V and the interpeak latency of waves III-I, V-III, V-I were measured. The mean auditory threshold was found to be between 36 and 40 dB HL. The ABR latencies and the interpeak interval values showed a statistically significant difference between the aged norm subjects concerning their waves III to V and V to I interpeak interval. Thus, prolonged latency of ABR peaks was seen in the elderly subjects.

2.6 Prevalence of Presbycusis

The clinical characteristic of presbycusis was studied in Nigeria by Sogebi et al., (2014) that consisted of 69 subjects who had presbycusis between January 2007 and December 2010. The subjects were divided into five different age groups: less than 50 years, 51 to 60 years, 61 to 70 years, 71 to 80 years, and more than 81 years. The results of the study indicated that hearing loss was experienced by 61 (88.4%) of the patients, tinnitus by 55 (79.7%) of the subjects, vertigo by 23 (33.3%) of the subjects, otalgia by 17 (24.6%) of the subjects, fullness in the ear by 18 (26.1%) of the subjects. The number of patients with a history of hypertension was 24 (34.8%), and 9 (13.0%) had osteoarthritis. Five of the participants had normal hearing, 13, 18, 6, 7 and 10 with mild, moderate, moderately severe, severe and profound hearing loss.

Shah & Prabhakar (1997) reported that hearing impairment is the most prevalent morbidity in the elderly, followed by blindness; however, variability across studies has

been noted. A similar survey conducted by the Indian Council of Medical Research (2006) in the rural population of Pondicherry reported that the prevalence of hearing impairment in the elderly population is 15.4%.

Demeester et al. (2009) analyzed the prevalence of various audiogram patterns in older adults (55 to 65 years) by classifying the audiograms of 1147 individuals according to the configuration of hearing loss. They also correlated variations of age and gender with different audiogram patterns. The results indicated that the flat audiograms were more frequent (37%). The least common were of low frequency ascending, mid-frequency U-shape and mid-frequency reverse U shapes (All were less than 1%). In females, the 'flat' configuration was found to be significantly more common than males, in whom the high frequency steeply sloping' configuration was found to be more common.

Deepthi & Kasthuri (2012) carried out a community-based study among the rural elderly of South India and reported that 66.9% of individuals had hearing impairment; 24.6% had disabling hearing loss, 26.9% had vision and hearing problems, 10.2% had blindness associated with hearing impairment. The results also indicated a direct correlation between age and these impairments.

Roth et al. (2011) assessed the prevalence of presbycusis in Europe based on systematically reviewed 24 case reviews by considering epidemiological studies conducted in English since 1970 with individuals in European countries aged more than 60 years. When these data were analyzed, about 30% of the men and 20% of the women in Europe were found to have 30 dB hearing loss or more by the age of 70 and

55% of men and 45% of women by the age of 80 years and this indicates the need for standardized procedures while conducting epidemiological data on hearing loss.

Chapter 3

METHODS

The present study was conducted to estimate the prevalence and characteristics of hearing loss of various degrees in older individuals (greater than 60 years) who had registered at AIISH. A register-based retrospective case analysis was carried out by reviewing the case files of those who visited the AIISH audiology Out Patient Department (OPD) presenting with hearing loss related complaints. The following method was adopted to meet the aim of the study.

3.1. Participants

The Clinical Database Management software (CDMA) and excel based application register were used to obtain the OPD case file numbers of the older individuals aged 60 years and above who had visited the Audiology OPD from January 2019 to December 2019 and were diagnosed with hearing loss of various degrees. The retrospective case review consisted of 2460 case files of older adults (1686 males & 774 females) who visited AIISH between January 1^{st,} 2019, to December 31st 2019, to estimate various degrees of hearing loss prevalence and characteristics in various degrees of hearing loss older individuals. The case files were retrieved from the registration section to review for the following information:

- Demographic details such as age, gender, socioeconomic status, occupation and regional background.
- Primary and secondary complaints include ear discharge, ear pain, itching sensation, blocking sensation, tinnitus, difficulty in hearing, difficulty in speech understanding in noise, headache, giddiness, nausea, vertigo etc.

- Clients with age-related hearing loss reported medical history and significant risk factors such as hypertension, diabetes, cardiovascular diseases, and atherosclerosis.
- Audiological findings including results of pure tone audiometry (pure tone thresholds at 0.25, 0.5, 1, 2, 4, 8 kHz), speech audiometry (SDT/SRT & SIS scores), immittance audiometry (tympanogram & acoustic reflex), auditory brainstem response (threshold estimation).
- Unilateral or bilateral hearing loss, types of hearing loss (conductive, sensorineural or mixed), degree of hearing loss (normal, minimal, mild, moderate, moderately severe, severe or profound) and configuration of hearing loss (sloping, rising, flat) across gender.

Based on the above details collected, the information about the degree, type, and configuration of hearing loss was noted from the audiogram of individuals above 60 years who reported to the Department of Audiology. Along with audiogram information, the results obtained from tympanometry and acoustic reflexes obtained and utilised for the audiological diagnosis were also noted.

3.2. Degree of Hearing loss

The degree of hearing loss (from hearing within normal limits to a profound degree of hearing loss) classified based on the Pure tone Average (Goodman's Classification., 1965) was considered. The subjects with a Pure tone average (PTA) ≤ 15 dB were classified as having hearing sensitivity within normal limits. Those with PTA of 16 to 25 dB as minimal hearing loss, with 26 to 40 dB as having mild hearing loss, with 41 to 55 dB as having moderate hearing loss, with 56 to 70 dB as having moderately

severe hearing loss, with 71 to 90 dB as having severe hearing loss and those with ≥ 90dB as having profound hearing loss. The results of Speech recognition threshold &/Speech detection threshold and Speech identification scores were noted and correlated with pure tone thresholds for diagnosis of hearing loss.

3.3 Type of Hearing loss

The type of hearing loss for the subjects profiled was based on air conduction, bone conduction thresholds and air-bone gap. The subjects whose air conduction threshold was affected with normal bone conduction thresholds and the air-bone gap should less than 10 dB were classified as having Conductive Hearing Loss. The subjects for whom both air and bone conduction thresholds were affected and with the air-bone gap ≤10 dB were classified as having Sensorineural Hearing Loss. Furthermore, the subjects whose air conduction and bone conduction thresholds were affected and with an air-bone gap of more than 10 dB were classified as having Mixed Hearing Loss (Frank et al., 1983; Studebaker, 1967).

3.4 Configuration of hearing loss

Based on the degree and pattern of hearing loss across frequencies represented as sloping: the slope should be at least between 15 dB from 500 Hz to 4000 Hz and thresholds occurred at equal or progressively higher levels from low frequencies to high frequencies (Stephens & Rintelmann, 1978). With only one or two thresholds in the low-frequency region, severe to profound hearing impairments can be considered corner audiograms. For rising patterns, from 250 Hz to 8000 Hz, thresholds occurred at comparable or progressively lower levels at high frequencies and higher at low and mid-

frequency regions (Ross et al., 1967). For flat patterns, the difference between two octaves should not exceed 5-10 dB (ASHA, 2015; Pittman & Stelmachowicz, 2003).

3.5 Immittance (Tympanometry & Acoustic reflex)

In Immittance, the type of tympanogram categorized based on the tympanometry peak pressure and the static admittance was noted. Tympanogram was classified as A-type when the tympanometry peak pressure was within -100 to +60 daPa, and the static admittance was within 0.5 to 1.75 mmho; As-type when the tympanometry peak pressure was within -100 to +60 daPa, and the static admittance was less than 0.5 mmho; B-type when the tympanogram was flat, and the compliance could not be stabilized; Ad-type when the tympanometry peak pressure was between -100 to +60 daPa, and the static admittance was more than 1.75 mmho and C-type when the tympanometry peak pressure was less than -100 daPa; Cs-type when the tympanometry peak pressure was less than -100 daPa, and the static admittance was less than 0.05 mmho and Cd-type when tympanometry peak pressure was less than -100 daPa, and static admittance was more than 1.75 mmho (Jerger, 1970; Jerger et al., 1972; Silman, & Silverman, 1984).

3.6 Statistical analysis

The collected case details from the case files were systematically segregated and tabulated in Microsoft Excel and Statistical Package for the Social Sciences (SPSS Version 25), and descriptive analysis was carried out. The data were analysed further to find the prevalence and characteristics of hearing loss in older adults across age groups. The prevalence of hearing loss in older adults across gender was analysed and the various medical history associated with hearing loss in older adults were also analysed separately.

Chapter 4

RESULTS

The present study aimed to determine the prevalence and characteristics of hearing loss in older adults (greater than 60 years) who reported to the All India Institute of Speech and Hearing (AIISH), Mysuru, from January 2019 to December 2019. A register-based retrospective study was carried out by reviewing the case files of 4069 from the outpatient department (OPD) as revealed by Client Database Management Software. The collected case details from the case files were systematically segregated and tabulated in Microsoft Excel and Statistical Package for the Social Sciences (SPSS Version 25), and descriptive analysis was carried out. Pearson Chi-square test was done to see the association between the degree of hearing loss and medical history.

4.1. Prevalence of hearing loss in older adults

In 2019 from January to December, a total of 4069 older adult cases were reported to AIISH OPD for speech and hearing evaluation. In order to find the prevalence and characteristics of hearing loss in older adults, case files of only 2489 clients (1686 male, 774 females) who reported to AIISH audiology evaluation were studied. All the case files were reviewed and their demographic details and audiology findings were documented. Later, another 29 subjects were excluded from calculating prevalence as their hearing sensitivity was within the normal limit. Thus remaining 2460 (1686 male, 774 females) were considered for further analysis. The age range of the participants who visited the department was between 60 to 100 years.

The total prevalence was calculated by taking the total number of subjects reporting their primary complaint as reduced hearing sensitivity and diagnosed as having

some degree of hearing loss (minimal to profound) by the total number of subjects reported to the AIISH audiology OPD in the year 2019. The total prevalence came up to be 60.45%, with 2460 subjects diagnosed as having hearing loss (minimal to profound). The older adults considered were divided into four age groups: 60-70, 70-80, 80-90 and > 90 years of age. The prevalence of hearing loss in four distinct age groups and genders considered for this study has been mentioned in Tables 1 and 2.

Table 4.1

Prevalence of Hearing Loss in Different Older Age Groups

Age Groups	Total cases	Hearing loss cases	Prevalence (%)
60-70 years	1993	1226	61.51%
70-80 years	1554	996	64.09%
80-90 years	479	222	46.03%
>90 years	43	16	37.02%
Total	**4069**	**2460**	**60.45%**

Table 4.2

Prevalence of Hearing Loss across Gender

Genders	Total cases	Hearing loss cases	Prevalence (%)
Male	2707	1686	62.28%
Female	1362	774	56.82%
Total	4069	2460	60.45%

From Table 4.1, it can be noted that more cases were reported in the 60-70 and 70-80 years age group than the 80-90 and >90 years old age group. The hearing loss was more prevalent in the 70-80 years age group followed by 60-70 years age group, 80-90 years age group and > 90 years old age group. It can also be observed from Table 4.2 that

hearing loss was more prevalent in male subjects compared to females.

4.2 Categorization of the degree of hearing loss

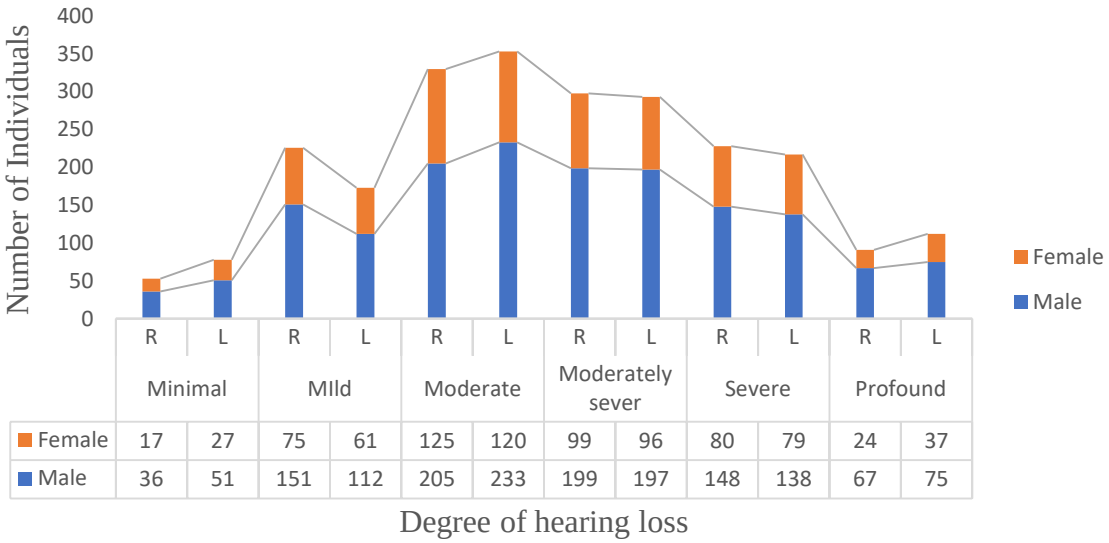
The degree of hearing loss was noted for all the older subjects aged >60 years of age. The degree of hearing loss was categorized separately in four different age groups: 60 to 70 years, 70 to 80 years, 80 to 90 years and >90 years old and is given below.

4.2.1 Age group of 60 to 70years

The total number of subjects who reported to audiology OPD was found to be 1993 (Males:1300 & females:693) and the total number of subjects having hearing loss in the 60-70 years old age group were found to be 1226 (Males:806 & females:420), respectively. The details of gender, ear and degree of hearing loss of the subjects considered in 60-70 age groups in terms of the number of subjects and percentage are given in Table 4.3. The gender, ear specific and various categories of the degree of hearing loss of the subjects considered in the 60-70 years age group are given in Figure 4.1. and Table 4.3.

Figure 4.1

Distribution of Degree of Hearing Loss in Males and Females in 60-70 Years Age Group



	R	L	R	L	R	L	R	L	R	L	R	L
	Minimal		MIld		Moderate		Moderately sever		Severe		Profound	
Female	17	27	75	61	125	120	99	96	80	79	24	37
Male	36	51	151	112	205	233	199	197	148	138	67	75

Table 4.3.

Distribution of Degree of Hearing Loss in Males and Females in Older Adults Age 60-70 Years

	Minimal		**Mild**		**Moderate**		**Moderately severe**		**Severe**		**Profound**	
	Right	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**
Male	36 (4.4%)	51 (6.3%)	151 (18.4%)	112 (13.8%)	205 (24.9%)	233 (28.9%)	199 (24.2%)	197 (24.4%)	148 (18.0%)	138 (17.1%)	67 (8.2%)	75 (9.3%)
Female	17 (4.0%)	27 (6.4%)	75 (17.5%)	61 (14.5%)	125 (29.1%)	120 (28.5%)	99 (23.1%)	96 (22.8%)	80 (18.6%)	79 (18.8%)	24 (5.6%)	37 (9.2%)

In the older adults of age group 60-70 years, there were 20 (1.2%) and 24 (1.4%); 9 (1.1%) and 5 (0.6%) male and females had normal hearing sensitivity in their right and left ear respectively. Also, it can be observed from Table 4. 3. male subjects were found to have a higher degree of hearing loss than females and a moderate degree of hearing loss were common in both genders in their right and left ear, respectively.

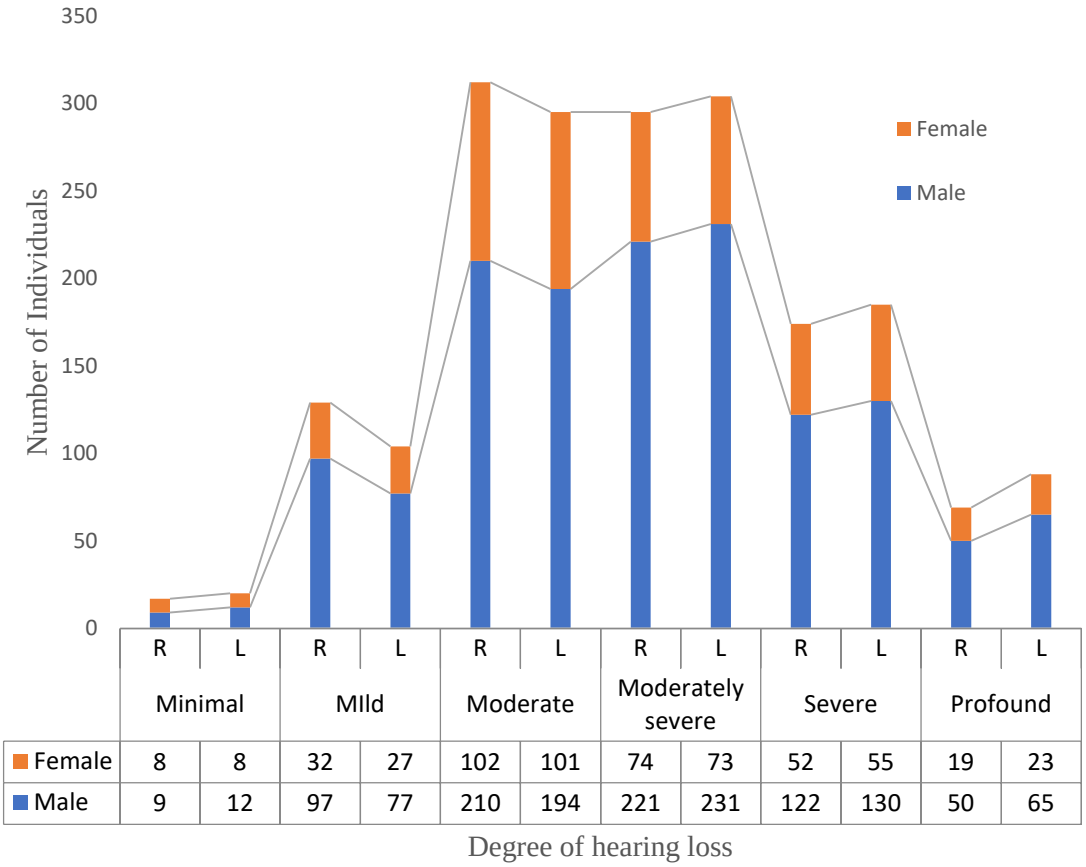
As shown from figure 4.1, moderate hearing loss was more prevalent, followed by moderately severe hearing loss, severe, mild, profound and minimal hearing loss in both ears in older adults aged 60-70 years age group.

4.1.2 Age group of 70 to 80 years

The total number of subjects who reported to audiology OPD was found to be 1554 (Males:1036 & females:518) and the total number of subjects having hearing loss in the 70-80 years old age group were found to be 996 (Male:709 & female:287), respectively. The details of gender, ear specific, and degree of hearing loss of the subjects considered in the 70-80 years age group in terms of the number of subjects and percentage are given in Table 4.4. The gender, ear specific and various categories of the degree of hearing loss of the subjects considered in 70-80 years age groups are given in Figure 4.2

Figure 4.2

Distribution of Degree of Hearing Loss in Males and Females in Older Adults Age 70-80 Years



	R	L	R	L	R	L	R	L	R	L	R	L
	Minimal		MIld		Moderate		Moderately severe		Severe		Profound	
Female	8	8	32	27	102	101	74	73	52	55	19	23
Male	9	12	97	77	210	194	221	231	122	130	50	65

Degree of hearing loss

Table 4.4

Distribution of Degree of Hearing Loss in Males and Females in Older Adults Age 70-80 Years

	Minimal		**Mild**		**Moderate**		**Moderately severe**		**Severe**		**Profound**	
	Right	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**
Male	9 (1.3%)	12 (1.7%)	97 (13.6%)	77 (10.8%)	210 (29.5%)	194 (27.2%)	221 (31.0%)	231 (32.4%)	122 (17.1%)	130 (18.2%)	50 (7.0%)	65 (9.1%)
Female	8 (2.8%)	8 (2.8%)	32 (11.1%)	27 (9.4%)	102 (35.5%)	101 (35.2%)	74 (25.8%)	73 (25.4%)	52 (18.1%)	55 (19.2%)	19 (6.6%)	23 (8.0%)

In the older adults of age group 70-80 years, there were 4 (0.6%) males and all of the females were found to have normal hearing sensitivity in this age group, as can be observed from Table 4.4 male subjects were found to have a higher degree of hearing loss as compared to females. Moderately severe degrees of hearing loss were common in males and moderate degrees of hearing loss were common in females in both ears.

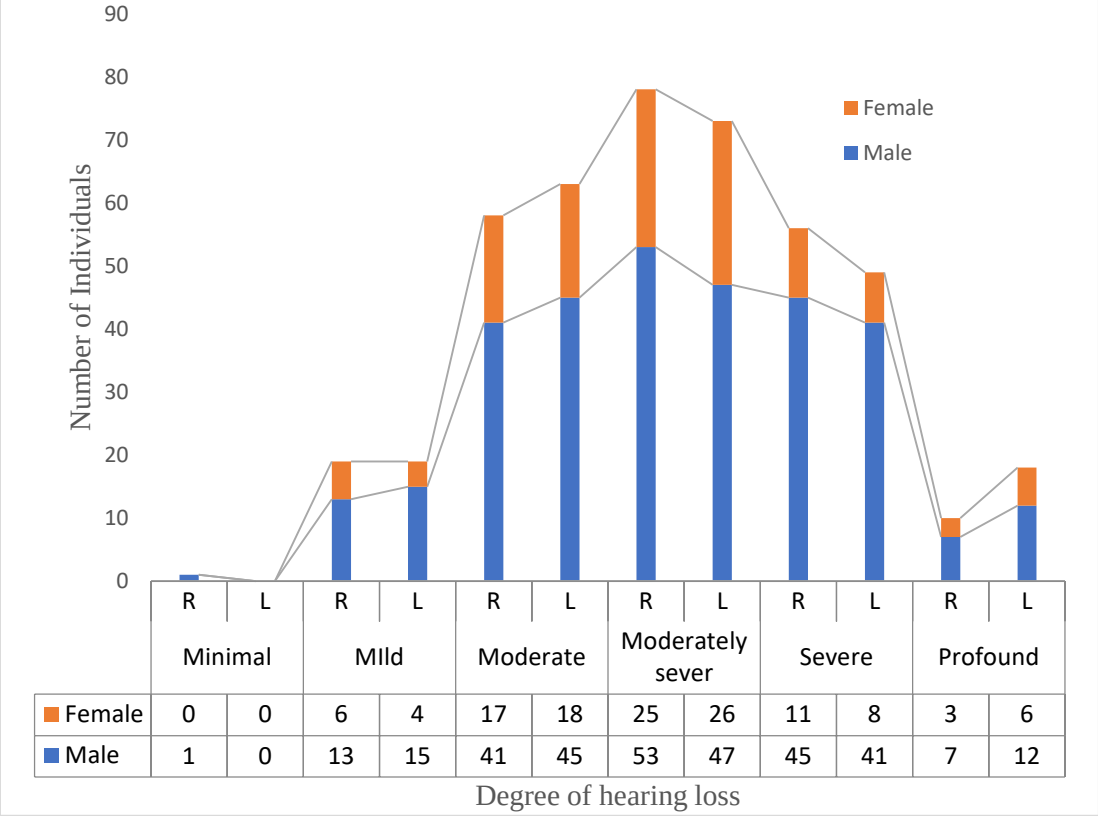
As seen from figure 4.2 moderate hearing loss was more prevalent, followed by moderately severe hearing loss, mild, severe, profound and minimal hearing loss in both ears in adults aged 70-80 years age group.

4.1.3 The age group of 80 to 90 years

The total number of subjects who reported to audiology OPD was found to be 479 (Males:336 & females:143) and the total number of subjects with hearing loss in the 80-90 years old age group were found to be 222 (Males:160 & females:62), respectively. The gender, ear, and degree of hearing loss details of the subjects considered in 80-90 age groups in terms of the number of subjects and percentage are given in Table 4.5. The gender, ear and degree of hearing loss of the subjects considered in 70-80 years age groups in terms of the number of subjects are given in Figure 4.3.

Figure 4.3

Distribution of Degree of Hearing Loss in Males and Females in Older Adults Age 80-90 Years



	R	L	R	L	R	L	R	L	R	L	R	L
	Minimal		MIld		Moderate		Moderately sever		Severe		Profound	
Female	0	0	6	4	17	18	25	26	11	8	3	6
Male	1	0	13	15	41	45	53	47	45	41	7	12

As it can be observed from Table 4.5, male subjects were found to have a higher degree of hearing loss than females. Moderately severe degree of hearing loss was common in males and females in their both ears, respectively.

As shown from figure 4.3, moderately severe hearing loss was more prevalent, followed by moderate hearing loss, severe, mild, profound and minimal hearing loss in both ears in adults aged 80-90 years age group.

Table 4.5

Distribution of Degree of Hearing Loss in Males and Females in Older Adults Age 80-90 Years

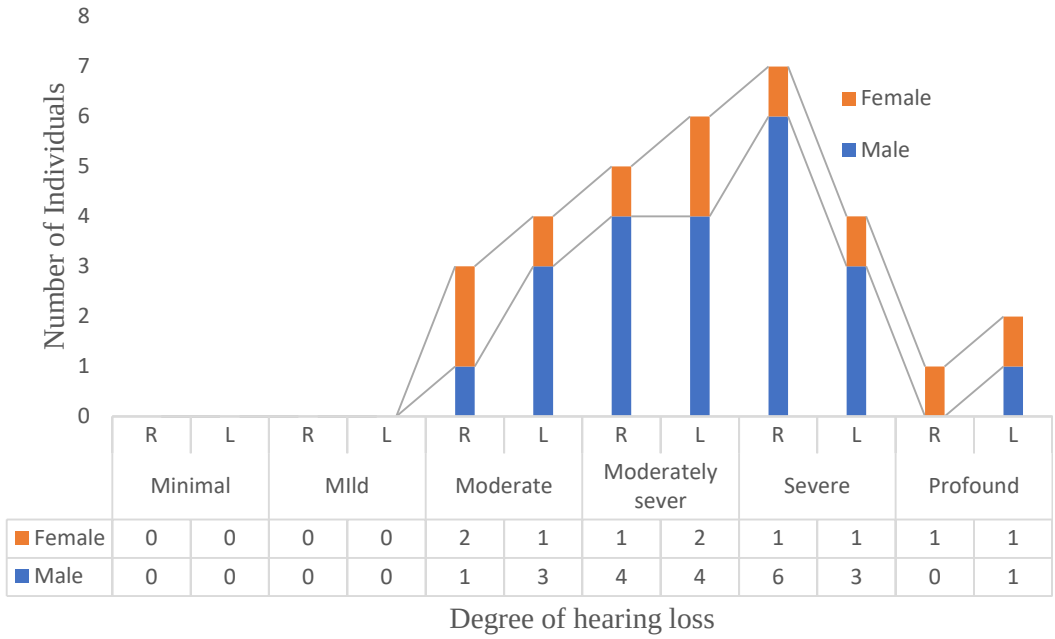
	Minimal		**Mild**		**Moderate**		**Moderately severe**		**Severe**		**Profound**	
	Right	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**
Male	1 (0.6%)	0	13 (8.1%)	15 (9.4%)	41 (25.6%)	45 (28.1%)	53 (33.1%)	47 (28.1%)	45 (28.1%)	41 (25.6%)	7 (4.4%)	12 (7.5%)
Female	0	0	6 (9.7%)	4 (6.5%)	17 (27.4%)	18 (29.0%)	25 (40.3%)	26 (41.9%)	11 (17.7%)	8 (12.9%)	3 (4.8%)	6 (9.7%)

4.1.4 The age group of more than 90 years

The total number of subjects who reported to audiology OPD was found to be 42 (Males:34 & females:8) and the total number of subjects with hearing loss in more than 90 years old age group were found to be 16 (Males:11 & females:5) respectively. The gender, ear, and degree of hearing loss details of the subjects considered in more than 90 age groups in terms of the number of subjects and percentage are given in Table 4.6. The gender, ear and degree of hearing loss of the subjects considered in more than 90 years age groups in terms of the number of subjects are given in Figure 4.4.

Figure 4.4

Distribution of Degree of Hearing Loss in Males and Females (>90 years)



	R	L	R	L	R	L	R	L	R	L	R	L
	Minimal		MIld		Moderate		Moderately sever		Severe		Profound	
Female	0	0	0	0	2	1	1	2	1	1	1	1
Male	0	0	0	0	1	3	4	4	6	3	0	1

Table 4.6.

Distribution of Degree of Hearing Loss in Males and Females (>90 years)

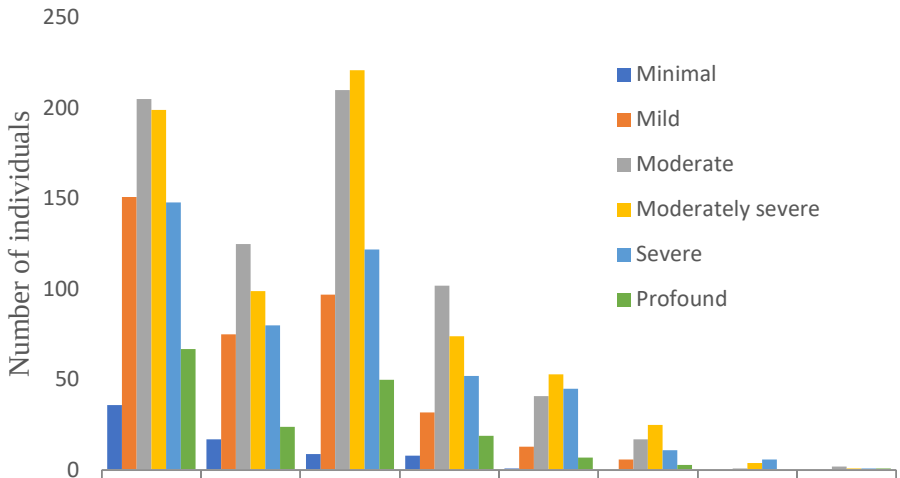
	Minimal		**Mild**		**Moderate**		**Moderately severe**		**Severe**		**Profound**	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Male	0	0	0	0	1 (9.1%)	3 (27.3%)	4 (36.4%)	4 (36.4%)	6 (54.5%)	3 (27.3%)	0	1 (9.1%)
Female	0	0	0	0	2 (40.0%)	1 (20.0%)	1 (20.0%)	2 (40.0%)	1 (20.0%)	1 (20.0%)	1 (20.0%)	1 (20.0%)

As it can be observed from Table 4.6, Male subjects were found to have a higher degree of hearing loss than females. Moderately severe and severe degrees of hearing loss were common in both genders in their right and left ears respectively.

As shown from figure 4.4, moderately severe and severe hearing loss was more prevalent, followed by moderate hearing loss and profound hearing loss in both ears in adults aged more than 90 years age group.

Figure 4.5

Distribution of degree of hearing loss in males and females across age in their right ear.

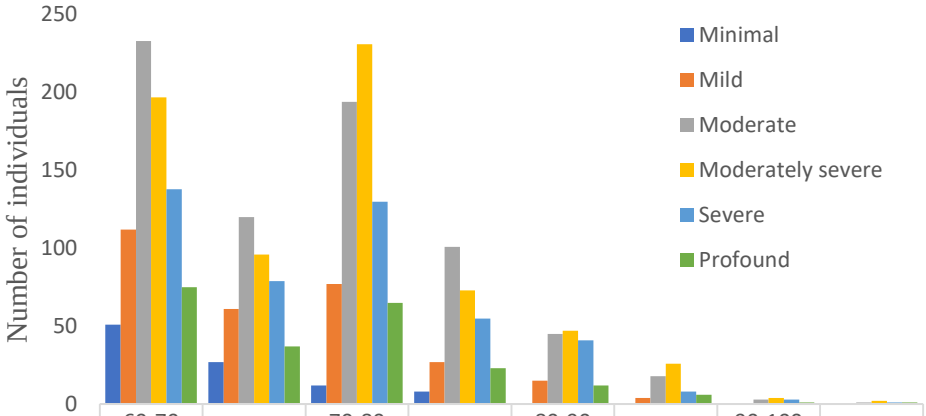


	M	F	M	F	M	F	M	F
	60-70 years		70-80 years		80-90 years		90-100 years	
Minimal	36	17	9	8	1	0	0	0
Mild	151	75	97	32	13	6	0	0
Moderate	205	125	210	102	41	17	1	2
Moderately severe	199	99	221	74	53	25	4	1
Severe	148	80	122	52	45	11	6	1
Profound	67	24	50	19	7	3	0	1

Age specfic across genders

Figure 4.6

Distribution of degree of hearing loss in males and females across age in their left ear.



	60-70 years		70-80 years		80-90 years		90-100 years	
Minimal	51	27	12	8	0	0	0	0
Mild	112	61	77	27	15	4	0	0
Moderate	233	120	194	101	45	18	3	1
Moderately severe	197	96	231	73	47	26	4	2
Severe	138	79	130	55	41	8	3	1
Profound	75	37	65	23	12	6	1	1

Age specfic across genders

Other figures 4.5 and 4.6 show the distribution of hearing loss in their right ear and left ear across various age groups (60-70 years, 70-80 years, 80-90 years & more than 90 years) for right and left ear, respectively. From figure 4.5, it can be observed that males (1686) had a higher number of subjects with hearing loss than females (774). Furthermore, most subjects were found in the 60-70 years age group (total 1226; male: 806; female: 420) among the four groups in both the genders for both right ear and left ear. It is concluded that across age-group for males, the maximum number of subjects had moderately severe hearing loss (Right ear: 477 subjects & Left ear: 475 subjects). Moderate hearing loss was most common (Right ear: 246 subjects & Left ear: 240 subjects).

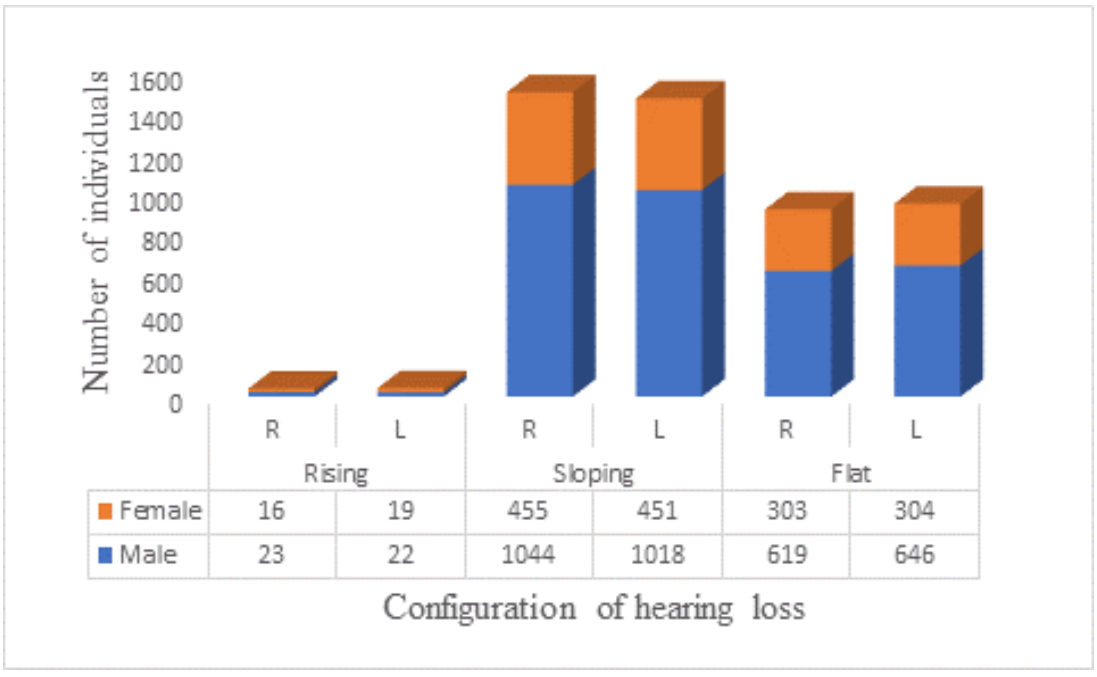
4.2 Configuration of hearing loss

The total number of subjects in the 60-98 years older adults age group was 2460 (Males:1636 & females:774) respectively. The details about gender, ear specific, and configuration of hearing loss of the subjects considered in 60-98 years age groups in terms of the number of subjects are given in Figure 4.7.

The number of subjects who had the rising configuration of hearing loss was found to be 23 (1.36%) and 22 (1.30%); 16 (2.06%) and 19 (2.45%) in male and female subjects in their right and left respectively. Similarly, the number of subjects who had the flat configuration of hearing loss were found to be 619 (36.71%) and 646 (38.31%); 303 (39.14%) and 304 (39.27%) in male and female subjects in their right and left respectively. The number of subjects who had the sloping configuration of hearing loss was found to be 1044 (61.92%) and 1018 (60.37%); 455 (58.78%) and 451 (58.26%) in male and female subjects in their right and left ear respectively.

Figure 4.7

Distribution of Configuration of Hearing Loss in Males and Females.



As shown in figure 4.7, males were more affected than females, and sloping hearing loss was more than the flat and rising configuration of hearing loss in males and females, respectively.

4.3 Type of hearing loss

The total number of subjects with hearing loss in the 60-98 years older adult age group was 2460 (Males:1686 & females:774). The gender, ear, and hearing loss details of the subjects considered in 60-98 years age groups in terms of the number of subjects are given in Figure 4.8.

Among the number of subjects whose type of hearing loss were not specified in male and female in their right and left ears were found to be 105 (6.22%) and 110 (6.52%); 49 (6.33%) and 53 (6.84%) respectively.

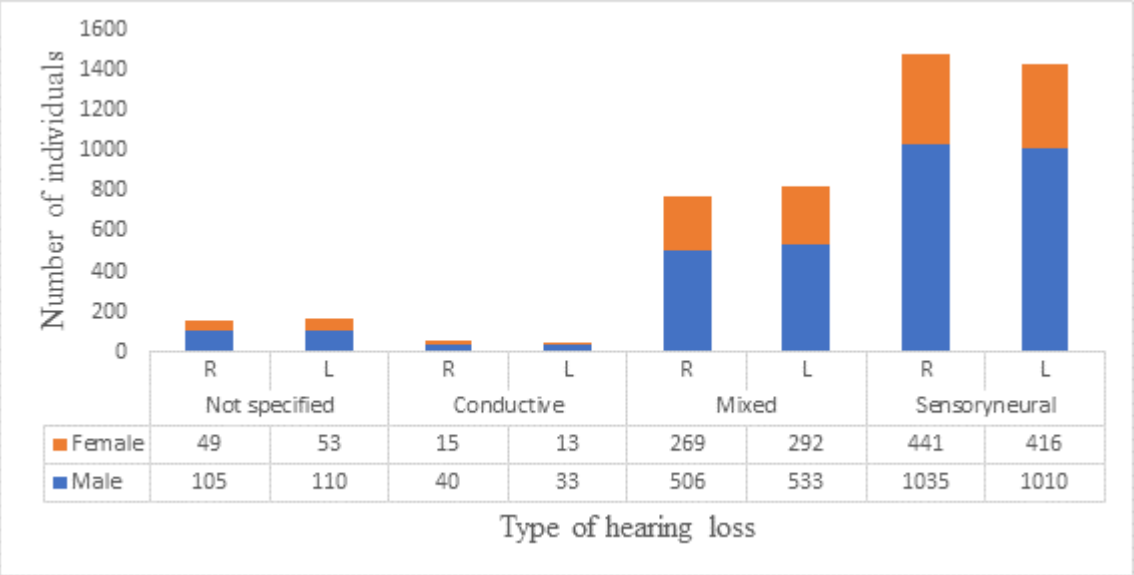
Similarly, the number of subjects who had the conductive type of hearing loss was found to be 40 (2.37%) and 33 (1.95%); 15 (1.93%) and 13 (1.67%) in male and female subjects in their right and left respectively.

Among the number of subjects who had mixed types of hearing loss were found to be 506 (30.01%) and 533 (31.61%); 269 (34.75%) and 292 (37.72%) in male and female subjects in their right and left ear respectively.

Among the number of subjects who had the sensorineural type of hearing loss were found to be 1035 (61.38%) and 1010 (59.90%); 441 (56.97%) and 416 (53.74%) in male and female subjects in their right and left respectively.

Figure 4.8

Distribution Type of Hearing Loss in Males and Females

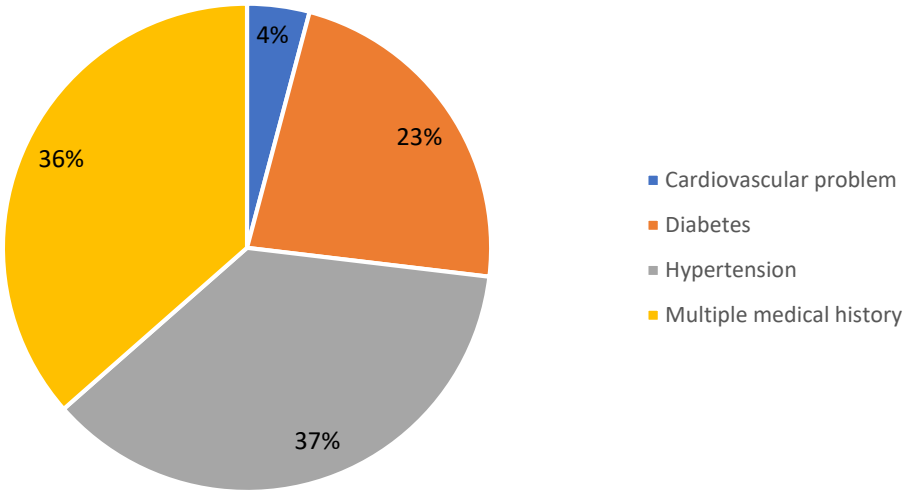


Among all three types of hearing loss in males and females, as shown in figure 4.8, sensorineural hearing loss was more common in males than females. Similar trends were followed in the mixed and conductive type of hearing loss.

4.3 **Association of Medical history with a degree of hearing loss**

Figure 4.9

Distribution of Medical History in 60-100 Years of Age,

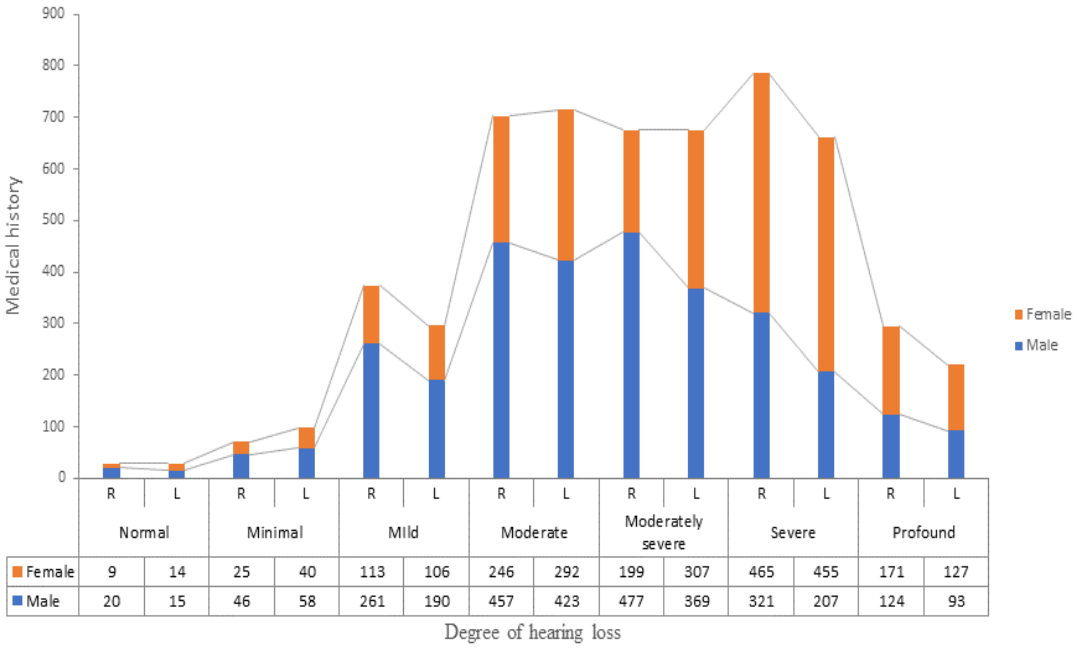


The distribution of medical history across the degree of hearing loss in males and females in older adults aged 60-100 years of age are given in Figure 4.9.

Out of 2460 subjects, 1338 (54.4%) had associated medical history and 1122 (45.6%) had no medical history, across which maximum subjects had a history of hypertension 470 (35.12%) followed by diabetes 292 (21.82%), most minor subjects had a history of cardiovascular problem 53 (3.96%).and the number of subjects who reported more than one medical history was found to be 523 (39.08%) respectively.

Figure 4.10

Distribution of Medical History across The Degree of Hearing Loss.



	R	L	R	L	R	L	R	L	R	L	R	L	R	L
	Normal		Minimal		MIld		Moderate		Moderately severe		Severe		Profound	
Female	9	14	25	40	113	106	246	292	199	307	465	455	171	127
Male	20	15	46	58	261	190	457	423	477	369	321	207	124	93

Among 169 subjects, minimal hearing loss with the presence of medical history had 40 (56.3%) & 58 (43.7%) subjects & without medical history had 31 (43.7%) & 40 (40.8%) subjects in the right and left ears respectively.

Among 670 subjects, mild hearing loss with the presence of medical history

had 237 (63.7%) and 137 (36.6%) subjects & without medical history had 190 (64.2%) and 106 (35.8%) subjects in the right and left ear respectively.

Among 1418 subjects, moderate hearing loss with the presence of medical history had 419 (59.6%) and 284 (40.4%) subjects & without medical history had 423 (59.2%) and 292 (40.8%) subjects in the right and left ear respectively.

Among 1352 subjects, moderately severe hearing loss with the presence of medical history had 370 (54.7%) and 306 (45.3%) subjects & without medical history had 369 (54.6%) and 307 (45.4%) subjects in the right and left ear respectively.

Among 920 subjects, severe hearing loss with the presence of medical history had 208 (44.7%) and 257 (55.3%) subjects & without medical history had 207 (45.5%) and 248 (54.5%) subjects in the right and left ear respectively.

Among 391 subjects, profound hearing loss with the presence of medical history had 64 (37.4%) and 107 (62.6%) subjects & without medical history had 93 (42.3%) and 127 (57.7%) subjects in the right and left ear respectively.

Pearson Chi-square test was done to check if there was an association between the degree of hearing loss and medical history in their right and left ear. There was an association between degree of hearing loss and medical history in their right ear [χ^2 (6) =57.532, p =0.000] and left ear [χ^2 (6) =46.560, p =0.000] respectively.

Chapter 5

DISCUSSION

In the current study, 2460 case files were reviewed and analyzed for various factors like degree, type of hearing loss and configuration of the audiogram. These data confirmed that age-related hearing loss is a significant health issue in the ageing population reported to the AIISH audiology clinic in 2019.

5.1 Prevalence of hearing loss in older adults

The total prevalence of hearing loss in the older adults aged ≥60 years who reported to AIISH in 2019 is 60.45%. Compared to the current study, a higher prevalence of 72.0% in the Bangalore district in older adults has been reported by Deepthi and Kasthuri (2012). The western based study have reported a prevalence of 41 % of adults over 60 years and above reporting hearing difficulties in the United States (Gates et al., 1990). In comparison, 30 to 46 % prevalence of hearing loss has been reported in more than 60 years of age in the United States (WHO, 2015).

The difference obtained with regard to prevalence of hearing loss in older adults among the various studies could be due to the type of research method adopted to study the prevalence, geographical area considered, the awareness among the individuals about the treatment options available about hearing loss, as well as availability of workforce in the identification of individuals having hearing loss.

5.2 Degree of Hearing Loss

In the present study, as age increased, hearing loss was also increased in older adults. In the age group 60-70 years and 70-80 years, moderate hearing loss

was most common. In the 80-90 years age group, moderately severe hearing loss was most common. Individuals in the age group of > 90 years had moderately severe, and severe hearing loss was most common. Normal hearing was present in only a few ears in individuals aged 60-70 years and 70-80 years. Across age groups, the prevalence of hearing loss was more in males (62.28%) than females (56.82%). In males, the moderately severe hearing was most common, and in females, moderate hearing loss was most common.

The results obtained in the current study are supported by previous studies that have reported that the ageing auditory system typically exhibits a loss in the pure tone threshold sensitivity (Mościcki et al., 1985). However, there is significant individual variability in absolute hearing thresholds and the amount of change with age (Gates et al., 1990). Similarly, Wiley et al. (1998) reported that as age increases, the severity of hearing loss increases in a group of 3753 participants in the age range of 48-92 years old. Desai et al. (2001) and Lee et al. (2005) also reported an increase in the degree of hearing loss with an increase in age. The authors reported that the average rate of change in thresholds was 0.7 dB per year at 0.25 kHz, increasing gradually with an increase in the frequency of 1.2 dB per year at 8 kHz.

It has also been noted that a decline in pure-tone threshold occurs throughout life with the increase in age at a greater rate after 50 years of age (Brant & Fozard, 1990). Pure tone thresholds generally start to decline after 50 years (Wiley et al., 2008). However, it has also been reported that the initial signs of age-related hearing impairments are detected in females and males of 30-39 and 40-49 years of age, respectively, and hearing loss is more in high frequencies (Lee et al., 2005b; Sharashenidze et al., 2007). In the following decades that is 50-59, 60-69 and 70-79 years, the hearing losses increase in magnitudes from no hearing loss in

lower frequencies and mean thresholds at 6,8 and 10 kHz was 30.0, 34.0, and 47.3 dB in 50-59 years old to thresholds in the range of 35-75 dB for 2-10 kHz and 20-25 dB in lower frequencies. In all the age groups, females had better hearing sensitivity than males (Sharashenidze et al., 2007) which supports the current study findings.

The results are supported with anatomical, physiological changes, i.e., the decline in pure tone thresholds has been correlated with the anatomical and functional changes occurring in the auditory system. The organ of Corti is the structure most susceptible to age-related histopathologic changes (Schuknecht & Gacek, 1993). Both types of hair cells undergo degenerative changes in the basal turn of the cochlea with apical and mid cochlear involvement of the outer hair cells (Willott, 1991). The decrease in the hair cells population is greatest in persons over 70 years of age and is most pronounced for outer hair cells. The population of outer hair cells reduces to 78% in the age between 50-60 years, among the people having hearing loss.

Also, loss of inner and outer hair cells have been reported after 45 years of age (Engström et al., 1987), whereas for the subjects aged more than 60 years, the degeneration was observed to be widespread along with all the cochlear turns (Scholtz et al., 2001). Ageing also found to result in a decrease in the number of spiral ganglion cells, and it has been demonstrated that the total number of spiral ganglion cells in the cochlea's of young adults varies between 30,000 and 40,000 and declining to less than 20,000 for individuals aged between 81-90 years. There is a progressive loss of about 2,000 neurons per decade. All these changes might be leading to elevation of pure tone threshold change in the older population (Otte et al., 1978).

5.2 Type of Hearing Loss

In all age groups considered, the most common type of hearing loss is sensorineural hearing loss, mixed hearing loss, and conductive hearing loss. Sensorineural types of hearing loss were reported maximally in the older adults age group (Hilton et al., (2008); Liu & Yan, (2007); Sogebi, (2015). This is because there is found to be significant age-related degeneration seen in the basilar membrane, organ of Corti, stria vascularis, ganglion cells and other inner ear structures (Fischer et al., 2020; Howarth & Shone, 2006). Also, ageing results in the alteration of cochlear fluids (Hilton et al., 2008). Ageing can lead to a structural or a functional deficit at various levels of the central auditory system (Hinojosa & Nelson, 2011; Suta et al., 2011; Walton et al., 1997). The prevalence of the sensorineural type of hearing loss in the present study indicates that the changes in the auditory system occur more in the inner ear structures than the outer and the middle ear organs.

The second most prevalent type of hearing loss was mixed hearing loss, which suggests that the inner and middle ear structures undergo several anatomical changes. In the lateral most of the middle ear, the prominent changes associated with ageing are; stiffening, thinning and loss of vascularity of the tympanic membrane (Covell, 1952; Rosenwasser, 1964); arthritic changes in the incudo-malleal and incudo-stapedial joints (Etholm & Belal, 1974); atrophy and degeneration of the fibers of the middle ear muscles and the ossicular ligaments (Covell, 1952); ossification of the ossicles (Covell, 1952); calcification of the cartilaginous support of the Eustachian tube and muscle function that opens the tube (Belal, 1975). These various anatomical changes associated with ageing in the middle ear and inner ear changes would have resulted in mixed hearing loss.

Some of the individuals in the current study had only conductive hearing loss and did not have inner ear involvement despite ageing. This could be because of the individuals' lifestyle and food habits that would not have affected inner ear structures, and hence not resulting in presbycusis. However, these individuals' external/middle ear structures would have undergone specific age-related changes, resulting in conductive hearing loss. Also, it could be that the subjects considered in the current study would have had some kind of middle ear dysfunction/pathology occurring, such as otitis media or eustachian tube dysfunction, etc., at the time of evaluation, resulting in conductive conduct hearing loss.

5.3 Configuration of Slope of Audiogram

In the present study, sloping audiogram was the most common configuration of audiogram for both the genders, followed by flat type and rising pattern of audiogram was occurred less commonly.

The current study's findings are supported by several studies that have reported a greater decline of auditory thresholds in higher frequencies than in the lower frequencies (Lee et al., 2005b) who have reported that high-frequency thresholds were always poorer for all age groups than low-frequency thresholds. Lee et al. (2005) reported that the average rate of change in pure-tone thresholds for all subjects was approximately 0.7 dB per year at 0.25 kHz, with a gradual increase to 1.2 dB per year at 8 kHz and 1.23 dB per year at 12 kHz. Hannula et al. (2011) also reported that steeply sloping audiograms were most dominantly represented in men (65.3% left ear, 51.2% right ear) than in females, followed by high-frequency gently sloping (33.0% left ear, 31.5% right ear). High-frequency sloping configurations were more in older adults across genders.

The results can be correlated to the anatomical changes occurring in older individuals i.e., loss of both inner and outer hair cells has been reported after the age of 45 years (Engström et al., 1987), whereas for the subjects above the age of 60 years, degeneration was widespread along with all the cochlear turns (Felder & Fischer, 1995; Scholtz et al., 2001) The high-frequency area is more sensitive and impacted early due to apparent histological damage in of the inner ear. For many years, it has been known that as people get older, they lose more outer and inner hair cells and peripheral and central neurons, starting from the basal part of the cochlea and progressing to involve apical part cochlea also (Fischer et al., 2020).

Furthermore, increasing stria vascularis atrophy is associated with increasing age is known to cause changes in endocochlear potential. Similarly, as age increases, the thickness and calcification of the basilar membrane starts from the basal part of the cochlea and in later stages to other turns (Fischer et al., 2020). In recent years, research into the inner ear has revealed that the loss of cochlear nerve synapses is also a factor in age-related hearing loss. Sharashenidze et al. (2007) reported that as age increases, hearing loss extends from high-frequency regions to low-frequency regions. Hence, these changes reflect that the sloping type of audiograms may be more prevalent than the flat and rising type of audiograms.

5.4 Hearing loss associated with medical history

In the present study, the overall prevalence rate of individuals with hearing loss was 60.45%, and those subjects who had medical history present was 54.4%. Medical history was found more in a moderate degree of hearing loss followed by moderately severe, mild, severe, and profound hearing loss. Hypertension was maximally reported, followed by diabetes and cardiac problems, which supports the findings of Gong et al. (2018), who in their study stated that non-infectious chronic

diseases such as hypertension (69.91%), diabetes (71.91%), cardiac problem (71.90%) and atherosclerosis (74.90%) have a greater impact in older adults.

Similar findings were reported by several authors who have stated that individuals were having such medical factors having a higher effect in subjects more than 60 years of age group (Bainbridge et al., 1999; Brant et al., 1996; Cruickshanks, Klein, et al., 1998; Dalton et al., 1998).

It was reported that diabetes was 100% associated with low and mid-frequency hearing loss in older adults (Bainbridge et al., 2010). The older population is found to have a high prevalence of hypertension and hearing loss. This is most likely due to structural changes in the entire body, including the hearing system, as age progresses (Marchiori et al., 2006). Also, it has been analyzed that as age increases and subjects have a history of cardiac problems, there could be a sign of alteration in the stria vascularis microvascular system within the cochlea. The stria vascularis is a capillary blood supply structure that is connected to the spiral ligament on the lateral wall of the scala media. The stria uses up a significant amount of metabolic energy in order to maintain the endocochlear potential. Any degeneration occurring in stria vascularis leads to disruption in chemical and physical process of the organ of Corti (TorreIII et al., 2005).

Some studies have also suggested that ageing-related sensorineural hearing loss is linked to microcirculatory insufficiency caused by vascular occlusion, which can result from embolism, hemorrhage, or vasospasm. These occur due to a syndrome of hyper viscosity or microangiopathy as a manifestation of diabetes or hypertension, with the latter potentially causing sensorineural hearing loss (Marchiori et al., 2006).

Chapter 6

SUMMARY AND CONCLUSION

The present study was conducted with an aim of documenting the various audiological findings in older individuals who had visited the Department of Audiology at All India Institute of Speech and Hearing between the period from January 2019 and December 2019. The audiological findings were documented and profiled for 2460 participants (male: 1686 & female: 774) in older adults aged > 60 years.

6.1 Results of current studied summarized below

The total prevalence of hearing loss in older adults in the current study is 60.45% and prevalence of hearing loss was found to be more in male subjects (62.28%) compared to females (56.82%) in individuals aged 60-100 years. Among the four groups (60-70, 70-80, 80-90, > 90 years), most participants are found in the age group of 60-70 years. In all age groups considered, moderately severe hearing loss was common in males and moderate degree of hearing loss was most common in females. Results also indicated that with increase in age there was increment in the degree of hearing loss. For most of the participants, the degree of hearing loss varied from mild to profound degree of hearing loss. In 60-70 and 70-80 years age group moderate hearing loss was more common. In 80-90 years old age group moderately severe hearing loss was more common and in subjects aged >90 years severe hearing loss (right ear) moderately severe hearing loss (left ear) was more common.

Sensorineural hearing loss was predominant type of hearing loss in the older participants followed by mixed hearing loss. Conductive hearing loss was present in lesser number of participants. The degree of hearing loss was more at higher

frequencies compared to lower frequencies in both males and females as age increases. The most prominent audiogram that was present in elderly individuals was sloping configuration followed by flat and rising configuration across gender. The majority of the elderly individuals reported with the complaint of reduced hearing sensitivity followed by tinnitus, ear pain, blocking sensation, vertigo, ear discharge, itching sensation, headache and nausea. In medical history, maximum number of subjects has hypertension followed by diabetes and cardiac problems.

Thus, the findings of current study with regard to various degree and type of hearing loss in older participants is in agreement with previous literature. Most of the studies reported in literature about various audiological findings in the older participants is in western population. Present study gives a good insight in to various audiological findings and age-related changes obtained in the older participants in the Indian population.

6.2 Clinical implications of the study

- The findings of the current study would provide data regarding the prevalence and characteristics of hearing loss in older adults for the duration of one year (2019) who visited AIISH audiology clinics.
- The study would provide information regarding prevalence of different degrees, types and configuration of hearing loss in older adults.
- Based on the results obtained certain health programs can be initiated to create awareness about prevention, causes and management of older adults with hearing loss.
- The results obtained can be utilized in convincing both government and non-government organizations to take certain initiatives with regard to increasing manpower in treating individuals with hearing loss.

REFERENCES

Agarwal, Pujary, K., Ganapathy, K., Balakrishnan, R., Nayak, D. R., & Hasan, F. (2015). Pure tone audiometry and otoacoustic emissions for the assessment of hearing loss in diabetic patients. *Indian Journal of Otology*, *19*(1), 13. https://doi.org/10.4103/0971-7749.108154

Agrawal, Y., Platz, E. A., & Niparko, J. K. (2008). Prevalence of hearing loss and differences by demographic characteristics among US adults: data from the National Health and Nutrition Examination Survey, 1999-2004. *Archives of Internal Medicine*, *168*(14), 1522–1530.

Agrawal, Y., Platz, E. A., & Niparko, J. K. (2009). Risk factors for hearing loss in US adults: data from the National Health and Nutrition Examination Survey, 1999 to 2002. *Otology & Neurotology*, *30*(2), 139–145.

Al-Ruwali, N., Sciences, A. H.-J. of T. U. M., & 2010, U. (2010). Prevalence of presbycusis in the elderly Saudi Arabian population. *Elsevier*. https://www.sciencedirect.com/science/article/pii/S1658361210701207

Allen, P., Research, D. E.-H., & 2010, U. (2010). Presbycusis phenotypes form a heterogeneous continuum when ordered by degree and configuration of hearing loss. *Elsevier*. https://www.sciencedirect.com/science/article/pii/S0378595510000304?casa_token=eBdrAv9i7G4AAAAA:fyFh7KJU_4t0Vgp3_v-NrBmpxBxJ60-DHDiITWi3AU70RnRAWbtWDX1VT6tmrdPExrIfprZG

Arvin, B., Prepageran, N., & Raman, R. (2013). "High frequency presbycusis"-is there an earlier onset? *Indian Journal of Otolaryngology and Head and Neck Surgery*, *65*(SUPPL.3). https://doi.org/10.1007/S12070-011-0356-X

ASHA. (2015). *Audiology Information Series AUDIOLOGY Information Series TYPES OF HEARING LOSS CONFIGURATION OF HEARING LOSS*. www.asha.org

ASHA. (2020). *Hearing Loss- Beyond Early Childhood*. https://www.asha.org/PRPSpecificTopic.aspx?folderid=8589935335&section=O

verview

Bainbridge, K., Cheng, Y., care, C. C.-D., & 2010, undefined. (1999). Potential mediators of diabetes-related hearing impairment in the US population: National Health and Nutrition Examination Survey 1999–2004. *Am Diabetes Assoc*. https://doi.org/10.2337/dc09-1193

Bainbridge, K. E., Cheng, Y. J., & Cowie, C. C. (2010). Potential mediators of diabetes-related hearing impairment in the U.S. population: National Health and Nutrition Examination Survey 1999-2004. *Diabetes Care*, *33*(4), 811–816. https://doi.org/10.2337/dc09-1193

Bainbridge, K. E., Hoffman, H. J., & Cowie, C. C. (2008). Diabetes and hearing impairment in the united states: Audiometric evidence from the National Health and Nutrition Examination Survey, 1999 to 2004. *Annals of Internal Medicine*, *149*(1), 1. https://doi.org/10.7326/0003-4819-149-1-200807010-00231

Bainbridge, K. E., & Wallhagen, M. I. (2014). Hearing loss in an aging American population: Extent, impact, and management. *Annual Review of Public Health*, *35*, 139–152. https://doi.org/10.1146/annurev-publhealth-032013-182510

Barnett, S., & Franks, P. (1999). Deafness and mortality: analyses of linked data from the National Health Interview Survey and National Death Index. *Public Health Reports*, *114*(4), 330. https://doi.org/10.1093/PHR/114.4.330

Belal, A. (1975). Presbycusis: physiological or pathological*. *The Journal of Laryngology & Otology*, *89*(10), 1011–1025. https://doi.org/10.1017/S0022215100081329

Brant, L., & Fozard, J. L. (1990). Age changes in pure-tone hearing thresholds in a longitudinal study of normal human aging. *The Journal of the Acoustical Society of America*, *88*(2), 813–820. https://doi.org/10.1121/1.399731

Brant, L. J., Gordon-Salant, S., Pearson, J. D., Klein, L. L., Morrell, C. H., Metter, E. J., & Fozard, J. L. (1996). Risk factors related to age-associated hearing loss in the speech frequencies. *Journal of the American Academy of Audiology*, *7*(3), 152–160. http://www.umdhearinglab.com/s/Brant-et-al-1996.pdf

Bright, T., Mactaggart, I., Kim, M., Yip, J., Kuper, H., & Polack, S. (2019). Rationale

for a Rapid Methodology to Assess the Prevalence of Hearing Loss in Population-Based Surveys. *International Journal of Environmental Research and Public Health 2019, Vol. 16, Page 3405*, *16*(18), 3405. https://doi.org/10.3390/IJERPH16183405

Caban, A. J., Lee, D. J., Gómez-Marín, O., Lam, B. L., & Zheng, D. D. (2005). Prevalence of Concurrent Hearing and Visual Impairment in US Adults: The National Health Interview Survey, 1997–2002. *Https://Doi.Org/10.2105/AJPH.2004.056671*, *95*(11), 1940–1942. https://doi.org/10.2105/AJPH.2004.056671

Chia, E. M., Wang, J. J., Rochtchina, E., Cumming, R. R., Newall, P., & Mitchell, P. (2007). Hearing impairment and health-related quality of life: The blue mountains hearing study. *Ear and Hearing*, *28*(2), 187–195. https://doi.org/10.1097/AUD.0b013e31803126b6

Ciorba, A., Bianchini, C., Pelucchi, S., & Pastore, A. (2012). The impact of hearing loss on the quality of life of elderly adults. In *Clinical Interventions in Aging* (Vol. 7, pp. 159–163). Dove Press. https://doi.org/10.2147/CIA.S26059

Covell, W. P. (1952). Histologic changes in the aging cochlea. *Journal of Gerontology*, *7*(2), 173–177. https://doi.org/10.1093/geronj/7.2.173

Cruickshanks, K. J., Klein, R., Klein, B. E. K., Wiley, T. L., Nondahl, D. M., & Tweed, T. S. (1998). Cigarette smoking and hearing loss: The epidemiology of hearing loss study. *Journal of the American Medical Association*, *279*(21), 1715–1719. https://doi.org/10.1001/JAMA.279.21.1715

Cruickshanks, K. J., Nondahl, D. M., Tweed, T. S., Wiley, T. L., Klein, B. E. K., Klein, R., Chappell, R., Dalton, D. S., & Nash, S. D. (2010). Education, occupation, noise exposure history and the 10-yr cumulative incidence of hearing impairment in older adults. *Hearing Research*, *264*(1–2), 3–9. https://doi.org/10.1016/j.heares.2009.10.008

Cruickshanks, K. J., Wiley, T. L., Tweed, T. S., Klein, B. E. K., Klein, R., Mares-Perlman, J. A., & Nondahl, D. M. (1998). Prevalence of hearing loss in older adults in Beaver dam, Wisconsin. The epidemiology of hearing loss study. *American Journal of Epidemiology*, *148*(9), 879–886.

https://doi.org/10.1093/oxfordjournals.aje.a009713

Cunningham, L. L., & Tucci, D. L. (2017). Hearing Loss in Adults. *The New England Journal of Medicine*, *377*(25), 2465. https://doi.org/10.1056/NEJMRA1616601

Dalton, D. S., Cruickshanks, K. J., Klein, R., Klein, B. E. K., & Wiley, T. L. (1998). Association of NIDDM and hearing loss. *Diabetes Care*, *21*(9), 1540–1544. https://doi.org/10.2337/diacare.21.9.1540

Davey, S., Maheshwari, C., Raghav, S., Singh, N., Muzammil, K., & Pandey, P. (2018). Impact of Indian public health standards for rural health care facilities on national programme for control of deafness in India: The results of a cohort study. *Journal of Family Medicine and Primary Care*, *7*(4), 780. https://doi.org/10.4103/jfmpc.jfmpc_115_18

Davis, A., Mcmahon, C. M., Pichora-Fuller, K. M., Russ, S., Lin, F., Olusanya, B. O., Chadha, S., & Tremblay, K. L. (2016). Literature Review Aging and Hearing Health: The Life-course Approach What Is Hearing Loss and Why Is It a Public Health Problem Worldwide? *Academic.Oup.Com*. https://doi.org/10.1093/geront/gnw033

Deepthi, R., & Kasthuri, A. (2012). Validation of the use of self-reported hearing loss and the Hearing Handicap Inventory for elderly among rural Indian elderly population. *Archives of Gerontology and Geriatrics*, *55*(3), 762–767. https://doi.org/10.1016/J.ARCHGER.2012.07.006

Demeester, K., Van Wieringen, A., Hendrickx, J. J., Topsakal, V., Fransen, E., Van Laer, L., Van Camp, G., & Van De Heyning, P. (2009). Audiometric shape and presbycusis. *International Journal of Audiology*, *48*(4), 222–232. https://doi.org/10.1080/14992020802441799

Desai, M., Pratt, L. A., Lentzner, H., & Robinson, K. N. (2001). Trends in vision and hearing among older Americans. *Aging Trends (Hyattsville, Md.)*, *2*, 1–8. https://doi.org/10.1037/e620682007-001

Durga, J., Verhoef, P., Anteunis, L. J. C., Schouten, E., & Kok, F. J. (2007). Effects of folic acid supplementation on hearing in older adults: A randomized, controlled trial. *Annals of Internal Medicine*, *146*(1), 1–9. https://doi.org/10.7326/0003-

4819-146-1-200701020-00003

Engström, B., Hillerdal, M., Laurell, G., & Bagger-Sjöbäck, D. (1987). Selected pathological findings in the human cochlea. *Acta Oto-Laryngologica*, *104*(S436), 110–116. https://doi.org/10.3109/00016488709124983

Etholm, B., & Belal, A. (1974). Senile changes in the middle ear joints. *Annals of Otology, Rhinology & Laryngology*, *83*(1), 49–54. https://doi.org/10.1177/000348947408300109

Felder, E., & Schrott-Fischer, A. (1995). Quantitative evaluation of myelinated nerve fibres and hair cells in cochleae of humans with age-related high-tone hearing loss. *Hearing Research*, *91*(1–2), 19–32. https://doi.org/10.1016/0378-5955(95)00158-1

Fischer, N., Johnson Chacko, L., Glueckert, R., & Schrott-Fischer, A. (2020). Age-Dependent Changes in the Cochlea. In *Gerontology* (Vol. 66, Issue 1, pp. 33–39). Gerontology. https://doi.org/10.1159/000499582

Fook, L., & Morgan, R. (2000). Hearing impairment in older people: a review. *Postgraduate Medical Journal*, *76*(899), 537–541.

Frank, T., Klobuka, C. S., & Sotir, P. J. (1983). Air-bone gap distributions in normal-hearing subjects. *The Journal of Auditory Research*, *23*(4), 261–269. https://europepmc.org/article/med/6681327

Friedland, D. R., Cederberg, C., & Tarima, S. (2009). Audiometric pattern as a predictor of cardiovascular status: Development of a model for assessment of risk. *The Laryngoscope*, *119*(3), 473–486. https://doi.org/10.1002/lary.20130

Gates, G. A., Cobb, J. L., D'Agostino, R. B., & Wolf, P. A. (1993). The relation of hearing in the elderly to the presence of cardiovascular disease and cardiovascular risk factors. *Archives of Otolaryngology–Head & Neck Surgery*, *119*(2), 156–161.

Gates, G. A., Cooper, J. C., Kannel, W. B., & Miller, N. J. (1990). Hearing in the elderly: The framingham cohort, 1983-1985 Part 1. Basic audiometric test results. *Ear and Hearing*, *11*(4), 247–256. https://doi.org/10.1097/00003446-199008000-00001

Golding, M., Doyle, K., Sindhusake, D., Mitchell, P., Newall, P., & Hartley, D. (2007). Tympanometric and acoustic stapedius reflex measures in older adults: The blue mountains hearing study. *Journal of the American Academy of Audiology*, *18*(5), 391–403. https://doi.org/10.3766/JAAA.18.5.4

Gong, R., Hu, X., Gong, C., Long, M., Han, R., Zhou, L., Wang, F., & Zheng, X. (2018a). Hearing loss prevalence and risk factors among older adults in China. *International Journal of Audiology*, *57*(5), 354–359.

Gong, R., Hu, X., Gong, C., Long, M., Han, R., Zhou, L., Wang, F., & Zheng, X. (2018b). Hearing loss prevalence and risk factors among older adults in China. *Https://Doi.Org/10.1080/14992027.2017.1423404*, *57*(5), 354–359. https://doi.org/10.1080/14992027.2017.1423404

Gopinath, B., Rochtchina, E., Wang, J. J., Schneider, J., Leeder, S. R., & Mitchell, P. (2009). Prevalence of age-related hearing loss in older adults: Blue Mountains Study. *Archives of Internal Medicine*, *169*(4), 415–418.

Göthberg, H., Rosenhall, U., Tengstrand, T., Rydén, L., Wetterberg, H., Skoog, I., & Sadeghi, A. (2020). Prevalence of hearing loss and need for aural rehabilitation in 85-year-olds: a birth cohort comparison, almost three decades apart. *International Journal of Audiology*, 1–10.

Hannula, S., Bloigu, R., Majamaa, K., Sorri, M., & Mäki-Torkko, E. (2011). Audiogram configurations among older adults: Prevalence and relation to self-reported hearing problems. *Http://Dx.Doi.Org/10.3109/14992027.2011.593562*, *50*(11), 793–801. https://doi.org/10.3109/14992027.2011.593562

Hilton, C., Aging, T. H.-G., & 2008, U. (2008). Age-related hearing loss. *Healthplexus.Net*. https://www.healthplexus.net/files/content/2008/October/1109hearing.pdf

Hinojosa, R., & Nelson, E. G. (2011). Cochlear nucleus neuron analysis in individuals with presbycusis. *Laryngoscope*, *121*(12), 2641–2648. https://doi.org/10.1002/lary.22383

Homans, N. C., Metselaar, R. M., Dingemanse, J. G., van der Schroeff, M. P., Brocaar, M. P., Wieringa, M. H., Baatenburg de Jong, R. J., Hofman, A., &

Goedegebure, A. (2017). Prevalence of age-related hearing loss, including sex differences, in older adults in a large cohort study. *The Laryngoscope*, *127*(3), 725–730.

Howarth, A., & Shone, G. R. (2006). Ageing and the auditory system. *Postgraduate Medical Journal*, *82*(965), 166. https://doi.org/10.1136/PGMJ.2005.039388

Humes, L. E. (1996). Speech understanding in the elderly. *Journal of the American Academy of Audiology*, *7*(3), 161–167. https://www.academia.edu/download/49270853/Speech_understanding_in_the_elderly20161001-31055-brph25.pdf

Humes, L., Speech, L. R.-J. of, Language, undefined, Research, and H., & 1990, undefined. (1990). Speech-recognition difficulties of the hearing-impaired elderly: The contributions of audibility. *ASHA*, *33*(4), 726–735. https://doi.org/10.1044/jshr.3304.726

Jerger, J. (1970). Clinical Experience With Impedance Audiometry. *Archives of Otolaryngology*, *92*(4), 311–324. https://doi.org/10.1001/archotol.1970.04310040005002

Jerger, J., Jerger, S., & Mauldin, L. (1972). Studies in Impedance Audiometry: I. Normal and Sensorineural Ears. *Archives of Otolaryngology*, *96*(6), 513–523. https://doi.org/10.1001/archotol.1972.00770090791004

Katsarkas, A. (1994). Dizziness in aging: A retrospective study of 1194 cases. *Otolaryngology–Head and Neck Surgery*, *110*(3), 296–301. https://doi.org/10.1177/019459989411000306

Kiely, K. M., Gopinath, B., Mitchell, P., Browning, C. J., & Anstey, K. J. (2012). Evaluating a dichotomized measure of self-reported hearing loss against gold standard audiometry: prevalence estimates and age bias in a pooled national data set. *Journal of Aging and Health*, *24*(3), 439–458.

Kirkim, G., Serbetcioglu, B., Odabasi, O., Surgery, B. M.-, & 2005, U. (2005). Hearing loss and communication difficulty in the elderly. *Advancedotology.Org*. https://www.advancedotology.org/content/files/sayilar/62/buyuk/Kirkim1.pdf

Lee, F. S., Matthews, L. J., Dubno, J. R., & Mills, J. H. (2005a). Longitudinal study

of pure-tone thresholds in older persons. *Ear and Hearing*, *26*(1), 1–11. https://doi.org/10.1097/00003446-200502000-00001

Lee, F. S., Matthews, L. J., Dubno, J. R., & Mills, J. H. (2005b). Longitudinal study of pure-tone thresholds in older persons. *Ear and Hearing*, *26*(1), 1–11. https://doi.org/10.1097/00003446-200502000-00001

Lin, F. R., & Ferrucci, L. (2012). Hearing loss and falls among older adults in the United States. *Archives of Internal Medicine*, *172*(4), 369–371. https://doi.org/10.1001/archinternmed.2011.728

Lin, F. R., Metter, E. J., O'Brien, R. J., Resnick, S. M., Zonderman, A. B., & Ferrucci, L. (2011). Hearing Loss and Incident Dementia. *Archives of Neurology*, *68*(2), 214–220. https://doi.org/10.1001/archneurol.2010.362

Lin, F. R., Yaffe, K., Xia, J., Xue, Q.-L., Harris, T. B., Purchase-Helzner, E., Satterfield, S., Ayonayon, H. N., Ferrucci, L., & Simonsick, E. M. (2013). Hearing loss and cognitive decline in older adults. *JAMA Internal Medicine*, *173*(4), 293–299.

Linssen, A. M., van Boxtel, M. P. J., Joore, M. A., & Anteunis, L. J. C. (2014). Predictors of hearing acuity: cross-sectional and longitudinal analysis. *Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences*, *69*(6), 759–765.

Liu, X., & Yan, D. (2007). Ageing and hearing loss. *The Journal of Pathology*, *211*(2), 188–197. https://doi.org/10.1002/PATH.2102

Manchaiah, V. K. C., Stephens, D., Zhao, F., & Kramer, S. E. (2012). Audiological Medicine The role of communication partners in the audiological enablement/rehabilitation of a person with hearing impairment: an overview. *Taylor & Francis*, *10*(1), 21–30. https://doi.org/10.3109/1651386X.2012.655914

Marchiori, L. L. D. M., Rego Filho, E. D. A., & Matsuo, T. (2006). Hypertension as a factor associated with hearing loss. *Brazilian Journal of Otorhinolaryngology*, *72*(4), 533–540. https://doi.org/10.1016/S1808-8694(15)31001-6

Martini, A., Comacchio, F., & Magnavita, V. (1991). Auditory evoked responses (ABR, MLR, SVR) and brain mapping in the elderly. *Acta Oto-Laryngologica*,

111(S476), 97–104. https://doi.org/10.3109/00016489109127261

Mathers, C., Smith, A., & Concha, M. (2000). Global burden of hearing loss in the year 2000. In *Global Burden of Disease*.

Mener, D. J., Betz, J., Genther, D. J., Chen, D., & Lin, F. R. (2013). Hearing loss and depression in older adults. In *Journal of the American Geriatrics Society* (Vol. 61, Issue 9, pp. 1627–1629). NIH Public Access. https://doi.org/10.1111/jgs.12429

Mohindroo, S., Guleria, T. C., Mohindroo, N. K., & Azad, R. K. (2017). Prevalence and etiology of hearing impairment in urban area of Shimla, Himachal Pradesh, India: a cross sectional observational study. *International Journal of Research in Medical Sciences Guleria TC et Al. Int J Res Med Sci*, *5*(4), 1252–1255. https://doi.org/10.18203/2320-6012.ijrms20170990

Mormer, E., Cipkala-Gaffin, J., Bubb, K., & Neal, K. (2017). Hearing and health outcomes: Recognizing and addressing hearing loss in hospitalized older adults. *Seminars in Hearing*, *38*(02), 153–159.

Mościcki, E. K., Elkins, E. F., Baurn, H. M., & McNarnara, P. M. (1985). Hearing loss in the elderly: An epidemiologic study of the framingham heart study cohort. *Ear and Hearing*, *6*(4), 184–190. https://doi.org/10.1097/00003446-198507000-00003

National institute on aging. (2018). *Hearing Loss: A Common Problem for Older Adults | National Institute on Aging*. National Institute on Aging. https://www.nia.nih.gov/health/hearing-loss-common-problem-older-adults

Nelson, D. I., Nelson, R. Y., Concha-Barrientos, M., & Fingerhut, M. (2005). The global burden of occupational noise-induced hearing loss. *American Journal of Industrial Medicine*, *48*(6), 446–458. https://doi.org/10.1002/ajim.20223

Nondahl, D. M., Cruickshanks, K. J., Wiley, T. L., Tweed, T. S., & Dalton, D. S. (2013). Sixteen-year change in acoustic-admittance measures among older adults: Data from a population-based study. *Journal of Speech, Language, and Hearing Research*, *56*(6), 1745–1750. https://doi.org/10.1044/1092-4388(2013/12-0381)

Ottaviani, F., Maurizi, M., D'alatri, L., & Almadori, G. (1991). Auditory brainstem responses in the aged. *Acta Oto-Laryngologica*, *111*(S476), 110–113. https://doi.org/10.3109/00016489109127263

Otte, J., Schuknecht, H. F., & Kerr, A. G. (1978). Ganglion cell populations in normal and pathological human cochleae. Implications for cochlear implantation. *The Laryngoscope*, *88*(8), 1231–1246. https://doi.org/10.1288/00005537-197808000-00004

Otto, W. C., & McCandless, G. A. (1982). Aging and the auditory brain stem response. *International Journal of Audiology*, *21*(6), 466–473. https://doi.org/10.3109/00206098209072759

Pittman, A. L., & Stelmachowicz, P. G. (2003). Hearing loss in children and adults: Audiometric configuration, asymmetry, and progression. *Ear and Hearing*, *24*(3), 198–205. https://doi.org/10.1097/01.AUD.0000069226.22983.80

Pleis, J. R., & Coles, R. (2002). Summary Health Statistics for U.S. Adults: National health interview survey, 1998. *Vital and Health Statistics, Series 10: Data from the National Health Survey*, *10*(209).

Pleis, J. R., & Lethbridge-Cejku, M. (2007). Summary health statistics for U.S. adults: National Health Interview Survey, 2006. *Vital and Health Statistics. Series 10, Data from the National Health Survey*, *235*, 1–153. http://www.ncbi.nlm.nih.gov/pubmed/18361164

Resnick, S. B., Dubno, J. R., Hoffnung, S., & Levitt, H. (2005). Phoneme errors on a nonsense syllable test. *The Journal of the Acoustical Society of America*, *58*(S1), S114. https://doi.org/10.1121/1.2001878

Ries, P. (1982). *Hearing ability of persons by sociodemographic and health characteristics, United States*. https://books.google.com/books?hl=en&lr=&id=frDWgL4MNUcC&oi=fnd&pg=PA1&dq=Ries,+P.+W.+(1982).+Hearing+ability+of+persons+by+sociodemographic+and+health+characteristics:+United+States.+Vital+and+Health+Statistics+Series+10:+Data+From+the+National+Health+Su

Roehm, C. E., Marino, J., & Parham, K. (2013). Presbycusis. *Encyclopedia of*

Otolaryngology, Head and Neck Surgery, 2191–2199. https://doi.org/10.1007/978-3-642-23499-6_551

Rosenwasser, H. (1964). OTITIC PROBLEMS IN THE AGED. *Geriatrics*, *19*, 11–17.

Ross, M., Disorders, N. M.-J. of S. and H., & 1967, undefined. (1967). The rising audiometric configuration. *ASHA*, *32*(4), 377–382. https://doi.org/10.1044/jshd.3204.377

Roth, T. N., Hanebuth, D., & Probst, R. (2011). Prevalence of age-related hearing loss in Europe: A review. In *European Archives of Oto-Rhino-Laryngology* (Vol. 268, Issue 8, pp. 1101–1107). Springer Verlag. https://doi.org/10.1007/s00405-011-1597-8

Scholtz, A. W., Kammen-Jolly, K., Felder, E., Hussl, B., Rask-Andersen, H., & Schrott-Fischer, A. (2001). Selective aspects of human pathology in high-tone hearing loss of the aging inner ear. *Hearing Research*, *157*(1–2), 77–86. https://doi.org/10.1016/S0378-5955(01)00279-9

Schuknecht, H. F., & Gacek, M. R. (1993). Cochlear pathology in presbycusis. *Annals of Otology, Rhinology and Laryngology*, *102*(1 II), 1–16. https://doi.org/10.1177/00034894931020s101

Shah, B., & Prabhakar, A. K. (1997). Chronic morbidity profile among elderly. In *Indian Journal of Medical Research* (Vol. 106, Issue OCT., pp. 265–272). https://europepmc.org/article/med/9361460

Sharashenidze, N., News, J. S.-G. M., & 2007, U. (2007). Age-related hearing loss: gender differences. *Researchgate.Net*. https://www.researchgate.net/profile/Markus-Pietsch/publication/6357358_The_Proper_Time_for_Hearing_Screening_in_Newborns/links/575bc13e08aec91374a63062/The-Proper-Time-for-Hearing-Screening-in-Newborns.pdf#page=18

Silman, S., & Silverman, C.A. (1984). Auditory Diagnosis:... - Google Scholar. (n.d.). Retrieved September 2, 2021, from https://scholar.google.co.in/scholar?hl=en&as_sdt=0%2C5&as_vis=1&q=Silma

n%2C+S.%2C+%26+Silverman%2C+C.A.+%281984%29.+Auditory+Diagnosis%3A+Principles+and+Applications+%28pp.+71-136%29.+San+Diego%3A+Singular+Publishing.&btnG=

Sogebi, O. A. (2015a). Middle ear impedance studies in elderly patients implications on age-related hearing loss. *Brazilian Journal of Otorhinolaryngology*, *81*(2), 133–140. https://doi.org/10.1016/j.bjorl.2014.09.007

Sogebi, O. A. (2015b). Middle ear impedance studies in elderly patients implications on age-related hearing loss. *Brazilian Journal of Otorhinolaryngology*, *81*(2), 133–140. https://doi.org/10.1016/J.BJORL.2014.09.007

Sogebi, O., Olusoga-Peters, O., Sciences, O. O.-A. health, & 2013, U. (2014). Clinical and audiometric features of presbycusis in Nigerians. *Ajol.Info*. https://www.ajol.info/index.php/ahs/article/view/100194

Stephens, M. M., & Rintelmann, W. F. (1978). The influence of audiometric configuration on pure-tone, warble-tone and narrow-band noise thresholds of adults with sensorineural hearing losses. *Journal of the American Auditory Society*, *3*(5), 221–226. https://europepmc.org/article/med/659294

Studebaker, G. A. (1967). *Intertest Variability and the Air-Bone Gap*. *32*(1), 82–86. https://doi.org/10.1044/JSHD.3201.82

Šuta, D., Rybalko, N., Pelánová, J., Gerontology, J. P.-E., & 2011, U. (2011). Age-related changes in auditory temporal processing in the rat. *Elsevier*. https://doi.org/10.1016/j.exger.2011.05.004ï

TorreIII, P., Cruickshanks, K. J., Klein, B. E. K., Klein, R., & Nondahl, D. M. (2005). *The Association Between Cardiovascular Disease and Cochlear Function in Older Adults*. *48*(2), 473–481. https://doi.org/10.1044/1092-4388(2005/032)

Wallhagen, M. I., Strawbridge, W. J., Cohen, R. D., & Kaplan, G. A. (2008). An increasing prevalence of heating impairment and associated risk factors over three decades of the Alameda County Study. *American Journal of Public Health*, *87*(3), 440–442. https://doi.org/10.2105/AJPH.87.3.440

Walling, A. D., & Dickson, G. M. (2012). Hearing loss in older adults. *American Family Physician*, *85*(12), 1150–1156. www.aafp.org/afp.

Walton, J. P., Frisina, R. D., Ison, J. R., & O'Neill, W. E. (1997). Neural correlates of behavioral gap detection in the inferior colliculus of the young CBA mouse. *Journal of Comparative Physiology A 1997 181:2*, *181*(2), 161–176. https://doi.org/10.1007/S003590050103

WHO. (2015). *Addressing the rising prevalence of hearing loss*.

Wiley, T. L., Cruickshanks, K. J., Nondahl, D. M., Tweed, T. S., Klein, R., & Klein, B. E. (1996). Tympanometric measures in older adults. *Journal of the American Academy of Audiology*, *7*(4), 260–268. https://www.researchgate.net/profile/Terry-Wiley-2/publication/14377292_Tympanometric_measures_in_older_adults/links/5942dd98a6fdccb93ab26ce0/Tympanometric-measures-in-older-adults.pdf

Wiley, Terry L., Chappell, R., Carmichael, L., Nondahl, D. M., & Cruickshanks, K. J. (2008). Changes in hearing thresholds over 10 years in older adults. *Journal of the American Academy of Audiology*, *19*(4), 281–292. https://doi.org/10.3766/jaaa.19.4.2

Willott, J. F. (1991). Aging and the auditory system. In *ci.nii.ac.jp*. https://ci.nii.ac.jp/naid/10010918365/

Yueh, B., Shapiro, N., MacLean, C. H., & Shekelle, P. G. (2003). Screening and Management of Adult Hearing Loss in Primary Care: Scientific Review. In *Journal of the American Medical Association* (Vol. 289, Issue 15, pp. 1976–1985). American Medical Association. https://doi.org/10.1001/jama.289.15.1976