



Hearing Loss in the Elderly and Risk Factors Affecting the Condition of Hearing Loss Amongst the Elderly

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Background and Objectives Presbycusis, or age-related hearing loss, emerges as an unavoidable consequence of aging, profoundly disrupting communication and diminishing quality of life. This study seeks to delve into the nuanced characteristics of audiograms and identify critical risk factors influencing presbycusis in individuals aged 60 years and above.

Subjects and Method This study employs a comprehensive retrospective and prospective cross-sectional design to analyze presbycusis in 149 patients aged 60 years or older at the Institute of Biomedical Research in Ho Chi Minh City between January 2020 and August 2023.

Results The mean age of participants was 74.3 years, with a male-to-female ratio of 1.44. Audiometric analyses revealed bilateral hearing loss in all participants, predominantly at grade 3 severity (47% of right ears, 51.7% of left ears). Sensorineural hearing loss was prevalent in 75% of right ears and 77% of left ears, while the remaining cases presented with mixed hearing loss. Audiogram configurations were primarily flat patterns (53%–56%). A strong positive correlation was identified between advancing age and increasing severity of hearing loss. Furthermore, hearing impairment severity showed significant associations with comorbid hypertension (22.8%), smoking history (16.8%) and female with maternal family history of hearing loss (11.4%), suggesting a higher likelihood of severe presbycusis.

Conclusion The severity of hearing loss increases significantly in older patients. In addition to age-related degeneration, risk factors such as hypertension, tobacco use, and maternal familial history in female patients further contribute to the progression and severity of presbycusis.

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Keywords Aging; Audiometry; Elderly; Hearing loss; Presbycusis.

Introduction

Hearing loss in the elderly (presbycusis) is an inevitable consequence of aging, profoundly impacting communication and overall quality of life. Among individuals aged 60 years and above, hearing loss often develops gradually and without obvious early symptoms, making timely detection and intervention challenging. Population aging is a global phenomenon that poses significant challenges for healthcare systems, particularly in managing the medical and social needs of the elderly. According to the World Health Organization, by 2025,

the global population over 60 will reach approximately 1.2 billion, with 500 million individuals expected to experience hearing loss. Among these, 60% to 70% may suffer from severe hearing impairment.¹⁾

The primary aim of this study is to investigate the audiogram characteristics and risk factors contributing to hearing loss in individuals aged 60 years and older. By identifying these factors, this research seeks to inform preventive strategies and enable timely interventions, thereby improving the quality of life for the elderly population.

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Subjects and Methods

Research design

This research employed a cross-sectional design, combining retrospective and prospective approaches to evaluate 149 patients aged 60 years or older diagnosed with presbycusis.

Participants

All participants (149 patients) exhibited audiogram-confirmed bilateral hearing loss of Grade 1 severity or higher. These patients were assessed at the Institute of Biomedical Research, Ho Chi Minh City, between January 2020 and August 2023. Comprehensive otolaryngological evaluations were conducted to exclude acute external and middle ear pathologies, congenital hearing loss, and ear malformations. Informed consent was obtained from each patient before participating in the study.

Data collection methods

Key demographic and clinical data were collected through detailed questionnaires. The question list was designed to obtain essential information: family history of hearing loss, specifically in first-degree relatives (parents, siblings); history of noise exposure, categorized into occupational, recreational, or firearm-related noise; smoking history; medical history, with a focus on hypertension and diabetes mellitus. Due to challenges in obtaining precise details such as noise exposure duration, intensity, and frequency, responses were recorded in binary form ('0' for no exposure, '1' for exposure).

Pure-tone audiometry was performed to measure the following parameters. Data of air conduction thresholds at frequencies of 125, 250, 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz and bone conduction thresholds at frequencies of 500, 1000, 2000, and 4000 Hz were collected. Audiogram analysis focused on three dimensions: severity, type, and shape. Hearing loss severity is categorized based on World Health Organization (WHO) standards: Grade 0 - normal hearing (≤ 25 dB), Grade 1 - mild hearing loss (26–40 dB), Grade 2 - moderate hearing loss (41–60 dB), Grade 3 - severe hearing loss (61–80 dB), Grade 4 - profound hearing loss (≥ 81 dB). The severity classification relies on the average thresholds of four primary frequencies (500, 1000, 2000, and 4000 Hz).²⁾ Types of hearing loss are also classified on specific audiometric criteria. Conductive hearing loss is identified if air conduction thresholds were >20 dB, bone conduction thresholds were near 0 dB, and an air-bone gap

was ≤ 60 dB. Sensorineural hearing loss was confirmed if parallel air and bone conduction thresholds with an air-bone gap were <10 dB across all frequencies. Mixed hearing loss occurred as elevated air and bone conduction thresholds, with air conduction thresholds were consistently worse than bone conduction thresholds. Audiograms were furthermore categorized into six distinct shapes following Demeester's classification.³⁾ A flat audiogram configuration was defined when there were minimal threshold differences (≤ 15 dB) between low (250/500 Hz), mid (1000/2000 Hz), and high (4000/8000 Hz) frequencies. A high frequency gently sloping (HFGS) configuration occurred when threshold differences were 15–29 dB between mid- and high-frequencies. A high-frequency steeply sloping configuration showed a threshold difference of exceeding 30 dB between mid and high frequencies. A low-frequency ascending configuration had a threshold difference of greater than 15 dB improvement between the poorer low frequency and better high frequencies. A mid-frequency U-shape had the worst thresholds at mid frequencies, with differences exceeding 15 dB compared to low and high frequencies. A mid-frequency reverse U-shape had the best thresholds at mid frequencies, with differences exceeding 15 dB compared to low and high frequencies.

Data analysis

All statistical analyses was performed using SPSS 20.0 software (IBM Corp.). Descriptive statistics, including frequencies and percentages, were presented in tables. Associations between risk factors and hearing loss severity were evaluated using chi-square tests and Fisher's exact tests. A significance threshold of $p < 0.05$ was employed to identify statistically meaningful results.

Ethical considerations

All sampling procedures employed in this study were reviewed and approved by the ethics committee of University of Health Sciences, Vietnam National University Ho Chi Minh City (Decision number: 03/QĐ-IRB-VN01.017). Written informed consent was obtained from the patients who agreed to take part in the study.

Results

Between January 2020 and August 2023, 149 patients aged 60 years or older with clinically confirmed presbycusis were evaluated at the Institute of Biomedical Research, Ho Chi

Minh City. All patients exhibited bilateral hearing loss, with assessments conducted independently for each ear. The cohort comprised 88 males and 61 females, leading to a male-to-female ratio of 1.44. Patient ages ranged from 60 to 93 years, with a mean age of 74.3 ± 8.92 years. The study population was categorized into three age groups: 60–69 years (27.5%), 70–79 years (28.9%), and 80 years or older (43.6%).

The clinical characteristics of the patients revealed a notable prevalence of comorbid conditions and lifestyle risk factors. Hypertension was reported in 34 patients (22.8%), while diabetes mellitus was documented in 9 patients (6.0%). Smoking history was identified in 25 patients (16.8%), and noise exposure from occupational, recreational, or other sources was noted in 29 patients (19.5%). These findings suggest that medical and lifestyle factors contribute substantially to the burden of hearing loss in the elderly.

Family history emerged as a notable factor within the study population, with 43 patients (28.9%) reporting a familial predisposition to hearing loss. The most prevalent pattern was observed among female patients with a maternal history of hearing loss (17 cases, 11.4%), followed by male patients with a paternal history (16 cases, 10.7%). Less common were male patients with maternal history (3 cases, 2%), female patients with paternal history (2 cases, 1.3%), and individuals reporting affected siblings (5 cases, 3.4%). These findings suggest a potential sex-specific and lineage-related influence in hereditary patterns of hearing impairment.

In Table 1, we study population of 149 patients, hearing loss severity showed consistent patterns between the right and left ears, with Grade 3 being the most common severity level in both ears, affecting 47.0% of right ears and 51.7% of left ears. When analyzed separately for each ear, 112 ears (75%) exhibited sensorineural hearing loss in the right ear, while 115 ears (77%) showed this type in the left ear. Among these, Grade 3 sensorineural hearing loss was the most prevalent, occurring in 39.3% (44/112) of right ears and 46.1% (53/115) of left ears. For mixed hearing loss, 37 cases (25%) were observed in the right ear and 34 cases (23%) in the left ear. Grade 3 mixed hearing loss accounted for approximately 70% of these cases in both ears. The audiogram shapes were also consistent between the right and left ears. The majority of cases fell into four main categories: flat shape configuration—56% of right ears and 53% of left ears; gently sloping (descending) configuration—22% of right ears and 20% of left ears; Steeply sloping (descending) configuration—18% of right ears and 24% of left ears; U-shape configuration—4% of right

Table 1. Audiological characteristics of patients aged 60 years and above with hearing loss

Side	Severity	Frequency
Hearing loss		
Right ear (n=149)	Grade 1	7 (4.7)
	Grade 2	34 (22.8)
	Grade 3	70 (47.0)
	Grade 4	38 (25.5)
Left ear (n=149)	Grade 1	4 (2.7)
	Grade 2	38 (25.5)
	Grade 3	77 (51.7)
	Grade 4	30 (20.1)
Sensorineural hearing loss		
Right ear (n=112)	Grade 1	6 (5.4)
	Grade 2	25 (22.3)
	Grade 3	44 (39.3)
	Grade 4	37 (33.0)
Left ear (n=115)	Grade 1	3 (2.6)
	Grade 2	29 (25.2)
	Grade 3	53 (46.1)
	Grade 4	30 (26.1)
Mixed hearing loss		
Right ear (n=37)	Grade 1	1 (2.7)
	Grade 2	9 (24.3)
	Grade 3	26 (70.3)
	Grade 4	1 (2.7)
Left ear (n=34)	Grade 1	1 (2.9)
	Grade 2	9 (26.5)
	Grade 3	24 (70.6)
	Grade 4	0 (0.0)
Audiogram patterns		
Right ear (n=149)	Flat	84 (56.0)
	Gently sloping	33 (22.0)
	Steeply sloping	27 (18.0)
	U-shaped	5 (4.0)
	Reverse U-shaped	0 (0.0)
	Rising	0 (0.0)
Left ear (n=149)	Flat	79 (53.0)
	Gently sloping	29 (20.0)
	Steeply sloping	35 (24.0)
	U-shaped	6 (3.0)
	Reverse U-shaped	0 (0.0)
	Rising	0 (0.0)

Data are presented as n (%)

ears and 3% of left ears.

In Table 2, we study revealed notable patterns in hearing loss severity across different demographic and clinical factors, emphasizing its multifactorial nature. Grade 3 hearing loss emerged as the most prevalent severity level in both males

and females, affecting 52.3% of males and 45.1% of females among the research patients. Notably, females exhibited higher rates of mild (Grade 1) and profound (Grade 4) hearing loss compared to males, whereas males showed higher proportions of moderate (Grade 2) and severe (Grade 3) hearing loss. Statistical analysis demonstrated a significant correlation between gender and hearing loss severity ($\chi^2=9.318$, $p=0.025$), underscoring gender-specific susceptibility patterns.

Age was strongly correlated with hearing loss severity, highlighting its progressive nature (Table 2). Mild hearing loss (Grade 1) was predominantly observed in the 60–69 age group (11.0%), whereas moderate (Grade 2) and severe (Grade 3) cases were most common in the 70–79 age group (26.7% and 52.3%, respectively). Profound hearing loss (Grade 4) was primarily found in individuals aged 80 and above (30.8%). This age-dependent progression was statistically significant ($F=23.226$, $p<0.0001$), emphasizing the role of aging in auditory decline.

We examined the relationship between the severity of hearing loss and internal medical conditions: hypertension and diabetes, as shown in (Table 2). Hypertension emerged as a significant risk factor for hearing loss severity. Grade 3 hearing loss among hypertension patients was the most frequent

($\chi^2=12.466$, $p=0.006$), suggesting a strong association between cardiovascular health and auditory function. Patients with diabetes mellitus predominantly exhibited Grade 3 hearing loss (44.4%), no statistically significant correlation was found between diabetes and hearing loss severity ($p=0.263$).

For the noise exposure factor, the analysis results indicate that there is no statistically significant correlation between hearing impairment and complaints about noise exposure, as determined by the chi-square test ($p=0.099>0.05$) (Table 2).

Smoking history presented a compelling link to hearing loss severity (Table 2). Patients with a history of smoking were significantly more likely to exhibit severe hearing loss, with Grade 3 being particularly prevalent ($\chi^2=22.921$, $p<0.0001$).

The relationship between hearing loss severity and a family history of hearing impairment was examined in this study (Table 3). Among 149 patients, 43 individuals (28.9%) reported a familial history of hearing loss. The analysis revealed that a family history of hearing loss was significantly associated with increased severity of hearing impairment ($\chi^2=34.878$, $p<0.05$). Patients with a familial history were more likely to exhibit severe (Grade 3) and profound (Grade 4) hearing loss compared to those without such a history. Gender-specific analysis further highlighted the impact of maternal inheri-

Table 2. Correlation between hearing loss severity and risk factors

	Grade 1	Grade 2	Grade 3	Grade 4	p value
Sex					0.025*†
Male (n=176)	2 (1.1)	45 (25.6)	92 (52.3)	37 (21.0)	
Female (n=122)	9 (7.4)	27 (22.1)	55 (45.1)	31 (25.4)	
Age					<0.0001**†
60–69 years (n=82)	9 (11.0)	17 (20.7)	44 (53.6)	12 (14.6)	
70–79 years (n=86)	2 (2.3)	23 (26.7)	45 (52.3)	16 (18.6)	
≥80 years (n=130)	0 (0.0)	32 (24.6)	58 (44.6)	40 (30.8)	
Hypertension (n=68)	1 (1.5)	7 (10.3)	38 (55.9)	22 (32.4)	0.006*†
Diabetes mellitus (n=18)	2 (11.1)	3 (16.7)	8 (44.4)	5 (27.8)	0.263**
Smoking (n=50)	7 (14.0)	14 (28.0)	15 (30.0)	14 (28.0)	<0.0001*†
Noise exposure (n=58)	0 (0.0)	20 (34.5)	26 (44.8)	12 (20.7)	0.099*

Data are presented as n (%). Grade 1: n=11, Grade 2: n=72, Grade 3: n=147, Grade 4: n=68. *chi-squared tests; **Fisher's Exact tests; † $p<0.05$

Table 3. Correlation between hearing loss severity and family history of hearing impairment

	Grade 1	Grade 2	Grade 3	Grade 4	p value
Family history of hearing loss (n=86)	4 (4.7)	20 (23.3)	32 (37.2)	30 (34.9)	0.009*†
Female with maternal family history of hearing loss (n=34)	0 (0.0)	6 (17.6)	22 (64.7)	6 (17.6)	0.029*†
Male with paternal family history of hearing loss (n=32)	1 (3.1)	8 (25.0)	20 (62.5)	3 (9.4)	0.070**
Male with maternal family history of hearing loss (n=6)	0 (0.0)	3 (50.0)	2 (33.3)	1 (16.7)	0.580**
Female with paternal family history of hearing loss (n=4)	1 (25.0)	2 (50.0)	1 (25.0)	0 (0.0)	0.145**

Data are presented as n (%). Grade 1: n=6, Grade 2: n=39, Grade 3: n=77, Grade 4: n=40. *chi-squared tests; **Fisher's Exact tests; † $p<0.05$

tance. A statistically significant association was observed in female patients with a maternal history of hearing loss, who exhibited a progressive increase in hearing loss severity from mild to profound levels ($\chi^2=9.058$, $p=0.029$). In contrast, no significant correlation was identified between paternal inheritance and hearing loss severity in male patients, as determined by Fisher's Exact Test ($p=0.070$). Similarly, no statistically significant association was found in female patients with a paternal family history ($p=0.145$) or in male patients with a maternal family history of hearing loss ($p=0.580$).

Discussion

Our study highlights the predominance of sensorineural hearing loss within the population examined, constituting approximately 77% of all cases. This outcome aligns with the well-documented characteristics of presbycusis, a condition typically bilateral and symmetric. Approximately 23% of cases involved mixed hearing loss, with these cases commonly associated with chronic otitis media. This finding is consistent with age-related hearing loss accompanied by chronic middle ear inflammation. Grade 3 hearing loss emerged as the most prevalent severity, impacting 47.0% of right ears and 51.7% of left ears. The progression of presbycusis is closely associated with age-related histological changes affecting the entire auditory system, from cochlear hair cells to the auditory cortex in the temporal lobe. Specifically, presbycusis involves epithelial atrophy and the loss of sensory and supporting cells in the organ of Corti, with degeneration initiating at the cochlear base and gradually advancing toward the apex. Schuknecht and Gacek's⁴⁾ estimation of 2100 cochlear neurons lost per decade out of a total of 35000 underscores the progressive nature of this condition. In terms of audiogram shapes, our study results presented similarities between the right and the left ears where audiogram with flat configuration predominates (56% for the right ear, 53% for the left ear). Our findings corroborate these patterns, further supported by Demeester, et al.,³⁾ who observed similar symmetric sensorineural audiogram patterns, predominantly flat or sloping.

The degenerative nature of presbycusis was evident in its significant correlation with age. Mild hearing loss (Grade 1) was predominantly found in the 60–69 age group, whereas moderate to severe cases (Grades 2 and 3) were most prevalent in the 70–79 age group. Profound hearing loss (Grade 4) was concentrated in individuals aged 80 years and above. This trend underscores the progressive decline in auditory function

as a natural consequence of aging, mirroring the systemic degeneration of other organ systems. Early detection and timely intervention are imperative to mitigate the impacts of age-related auditory decline and improve the quality of life for affected individuals.

Gender-specific variations in hearing loss patterns were prominently observed. Females exhibited higher rates of mild (Grade 1) and profound (Grade 4) hearing loss, whereas males displayed greater rates of moderate (Grade 2) and severe (Grade 3) hearing loss. A statistically significant correlation between gender and hearing loss severity ($\chi^2=9.318$, $p=0.025$) was observed. Supporting evidence from Jerger and Hall (1980)⁵⁾ and Pearson, et al. (1995)⁶⁾ suggests that men often experience earlier onset and greater severity of hearing loss due to higher occupational and recreational exposure to high-frequency noise. Although the role of estrogen as a protective factor against auditory aging remains debated, studies indicate that postmenopausal women undergoing hormone replacement therapy exhibit improved auditory outcomes. Conversely, individuals with Turner syndrome, characterized by estrogen deficiency, display earlier onset and greater severity of presbycusis, further substantiating the hormonal hypothesis.

A significant association was identified between hypertension and hearing loss severity ($\chi^2=12.466$, $p=0.006$). Accordingly, patients with hypertension tend to suffer from severe hearing loss than patients without hypertension. This finding aligns with Nawaz, et al.,⁷⁾ who reported a positive correlation between hypertension duration and hearing loss severity. The vascular and neurological effects of hypertension, including reduced cochlear blood flow, likely contribute to these outcomes. However, no statistically significant association was observed between diabetes mellitus and hearing loss severity in our study ($p=0.263$). This contrasts with Meneses-Barriviera, et al.'s⁸⁾ findings, which linked diabetes to increased prevalence of hearing loss among older adults. Some study findings suggest the existence of damage to the nerves and blood vessels of the inner ear in patients with diabetes. Studies by Fowler and Jones⁹⁾ and Dorit Samocha-Bonet, et al.¹⁰⁾ concluded that the severity extent of hearing loss increases with higher blood glucose levels, a hypothesis agreed upon by many authors. This is deemed a neurological complication of diabetes, leading to widespread microvascular damage in many central nervous system centers. The auditory nerve center is also impacted, resulting in sensorineural hearing loss. The differences between our study and those of previous authors may be attributed to variations in sample char-

acteristics. In our investigation, patients with a history of diabetes mellitus were found to have good treatment adherence and well-controlled blood glucose levels, thereby reducing the likelihood of neurological and vascular complications. Additionally, the Biomedical Research Institute is located in an area predominantly inhabited by working-age immigrants. As a result, the number of individuals aged 60 years and older presenting with hearing loss was limited, leading to a small sample size—this is also a limitation of our study.

Smoking history emerged as a significant risk factor for hearing loss severity ($\chi^2=22.921$, $p<0.001$). Our study result is consistent with the research of Cruickshanks, et al,¹¹⁾ which found that smokers have a 1.69 times higher risk of hearing loss compared to non-smokers. Smokers were markedly more likely to experience severe hearing loss, with passive smokers also at elevated risk. Nicotine's ototoxic effects, including oxidative stress and cochlear damage, are well-documented. Nicotine-induced vasoconstriction and atherosclerosis impair blood flow to the auditory system, compounding the effects of hearing loss. Additionally, harmful chemicals in tobacco may damage antioxidant mechanisms and auditory vasculature. Despite these findings, no significant association was noted between environmental noise exposure and hearing loss severity ($\chi^2=2.748$, $p=0.099$). However, studies like those by Feng, et al.¹²⁾ suggest that prolonged exposure to environmental noise exacerbates auditory decline, necessitating further research in this area.

Genetic predisposition significantly influenced the onset and severity of presbycusis. Among our sample, 28.9% of patients reported a family history of hearing loss, with higher severity levels strongly correlated with a familial predisposition ($\chi^2=34.878$, $p<0.001$). All of these cases were identified as sensorineural hearing loss. In addition, when evaluating the influence of sex-linked hereditary factors on the severity of presbycusis, we only found a statistically significant association between a maternal history of hearing loss and increasing severity of hearing impairment among female patients ($p<0.05$). These findings align with McMahon, et al.'s work,¹³⁾ suggesting stronger maternal genetic influence, potentially linked to mitochondrial DNA mutations and X-linked genetic factors. Hutchin and Cortopassi¹⁴⁾ estimated that mitochondrial mutations contribute to approximately 15% of post-lingual hearing loss cases with familial components. These insights emphasize the importance of genetic counseling and early screening in managing presbycusis among genetically

predisposed populations.

In conclusion, age remains the most critical determinant in the progression of hearing loss, with severity increasing significantly over time. Modifiable risk factors such as hypertension and smoking were identified as major contributors to worsening auditory outcomes. Additionally, a family history of hearing loss, particularly maternal inheritance, was strongly associated with increased risk, especially among female patients. These findings highlight the need for comprehensive strategies to address presbycusis, including mitigating modifiable risk factors, offering genetic counseling, and implementing targeted interventions. Proactive approaches tailored to high-risk populations can significantly reduce the burden of age-related hearing loss and enhance quality of life for affected individuals.

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