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Cardiovascular Risk Factors and Demographic Characteristics in Iranian Adults with Noise-Induced Hearing Impairment: A Cross-Sectional Study

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Abstract

Background: Hearing loss (HL), including noise-induced hearing loss (NIHL), is a prevalent health issue that affects millions of individuals worldwide and ranks as the third most common disability. This study examines the relationship between HL and cardiovascular risk factors (RFs) such as hypertension (HTN), diabetes mellitus (DM), and dyslipidemia (DLP) within the Iranian adult population.

Methods: This study was carried out at Iran University of Medical Sciences and involved 1,996 individuals undergoing routine health checks, including audiometry and lab tests.

Results: The study indicated that older age (per each additional year of age, aOR=1.14, 95%CI: 1.12-1.16, $P<0.001$) and male gender (aOR=3.08, 95%CI: 1.84-5.14, $P<0.001$) were significantly associated with HL, while a higher educational level served as a protective factor (tertiary education compared to a primary school degree, aOR=0.35, 95%CI: 0.24-0.5, $P<0.01$). Although initial analyses suggested associations between HL and cardiovascular RFs, these associations lost significance after adjusting for confounding variables. Notably, the presence of a single cardiovascular RF was significantly linked to HL in the total sample (aOR=1.37, 95%CI: 1.04–1.81, $P=0.02$) and in men (aOR=1.41, 95%CI: 1.05–1.90, $P=0.02$), but not in women.

Conclusion: This research emphasizes the significant association between hearing loss and demographic factors such as age, gender, and educational attainment in Iranian adults. These findings underscore the necessity for inclusive hearing health strategies that take these factors into account in both occupational and public health contexts.

Keywords: Noise-induced hearing loss, Hearing impairment, Cardiovascular risk factors, Hypertension, Diabetes mellitus, Dyslipidemia, Demographic characteristics, Cross-sectional study, Iranian adults

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Introduction

Hearing loss (HL), a significant health concern associated with aging as well as occupational and non-occupational noise exposure, ranks third among the most prevalent disabilities, following hypertension (HTN) and arthritis (1). The WHO reports that more than 5% of the global population approximately 430 million individuals require rehabilitation to address their disabling HL. It is projected that by 2050, more than 700 million people worldwide will experience disabling HL (2). HL increases the risk of falls, social communication difficulties, depression, and cognitive dysfunction (3, 4). Traditionally, HL is categorized into sensorineural hearing loss (SNHL), con-

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↑What is "already known" in this topic:
Hearing loss is a prevalent disabling condition for which no specific treatment exists, thereby underscoring the importance of prevention. Although some studies indicate a potential association between noise exposure and cardiovascular risk factors related to hearing loss, the findings remain controversial.

→What this article adds:
The study indicates a significant correlation between hearing loss, older age, and male gender. However, it found that cardiovascular risk factors, including hypertension, obesity, diabetes, and dyslipidemia, did not demonstrate a strong significant relationship with hearing loss. This suggests that strategies beyond the improvement of metabolic factors may be necessary to prevent hearing loss.

ductive hearing loss (CHL), and mixed types (5). CHL is typically associated with structural abnormalities of the auditory system, whereas SNHL may result from prolonged noise exposure, toxic agents, and metabolic disorders (6, 7). Noise-induced hearing loss (NIHL), the most prevalent occupational disease, ranks second in prevalence among the causes of SNHL, following presbycusis (3, 6). The distinction between CHL and SNHL can be established through audiometric evaluation, which reveals varying thresholds across different populations. However, a universally accepted definition of HL remains lacking (7).

Despite numerous studies aimed at treating SNHL in adults, no definitive treatment currently exists (8). The most effective approach to address this issue is prevention through an understanding of its risk factors (RFs), which include genetic, environmental, and occupational aspects (9). The most significant environmental factor identified is noise exposure, which contributes to NIHL (10). Previous studies have indicated that male gender, older age, and smoking are additional environmental RFs for hearing loss (HL) (11).

In addition, it has been recently hypothesized that certain cardiovascular RFs, such as diabetes mellitus (DM), dyslipidemia (DLP), and HTN, may also increase the risk of SNHL. These conditions can adversely affect blood flow in the auditory system, similar to their impact on the cardiovascular system, and contribute to arterial diseases that may compromise the arteries supplying the vestibulocochlear nerve, ultimately leading to SNHL (4, 12). However, the results of available studies remain inconclusive. Some studies indicate a correlation between cardiovascular RFs and SNHL, while others have not identified any significant relationship (13, 14). Furthermore, these studies have primarily been conducted in specific countries, including the United States, Canada, Korea, and Japan, with inconsistent findings in some instances (3, 15, 16). According to our literature review, only a limited number of studies from Iran have evaluated the effect of cardiovascular RFs, such as DM, DLP, and HTN, on HL among the adult population. Therefore, given the increasing incidence of SNHL and these conditions, it is essential to investigate modifiable RFs within the Iranian population. Consequently, we conducted this study.

Methods

Survey Population and Data Curation:

We utilized data stored in the clinical information system at the Iran University of Medical Sciences (IUMS) occupational medicine clinic. The data were obtained from individuals who attended the clinic for pre-employment or periodic health surveillance programs between June 2023 and April 2024. According to the Iranian national occupational health guidelines, these surveillance programs include assessments of general health, pre-existing conditions, potential occupational exposures, and risk factors during each individual's pre-employment and annual check-ups. Qualified IUMS personnel conducted audiometric and laboratory assessments in compliance with the standards set by the Iranian National Ministry of Health.

This cross-sectional study included all attendees who visited the clinics during the specified period. Data were collected retrospectively using a questionnaire based on attendees' information. Exclusion criteria comprised incomplete questionnaires, missing laboratory data, or absence of pure-tone audiometry (PTA) results. Furthermore, patients with a greater than 20 decibel (dB) difference between the average hearing levels in both ears, as measured by the PTA, were also excluded to ensure that individuals with otologic problems were omitted. Additionally, patients exhibiting a CHL pattern on the audiogram did not participate in the study.

Initial Evaluation

During the initial assessment, clinic staff and interns collected data on participants' occupations, academic degrees, past medical history, medication history, marital status, previous occupational noise exposure, and smoking history. The latter included whether participants had ever smoked, the number of cigarettes smoked, and the duration of smoking. This information was documented in our database. Subsequently, the clinic nurse or physician measured participants' height, weight, and blood pressure in the right arm under standardized conditions using automated sphygmomanometers. Measurements were taken after participants refrained from smoking, eating, or drinking for at least half an hour and had been seated calmly for more than five minutes with their feet on the ground. Individuals on antihypertensive medications or with a systolic blood pressure of 140 mmHg or higher and a diastolic blood pressure of 90 mmHg or higher were classified as hypertensive. Additionally, body mass index (BMI) was calculated by dividing weight in kilograms by the square of height in meters.

Audiometric data

The hearing threshold for each ear was determined using a calibrated Madsen audiometric device (model 100-2PS) employing an ascending procedure for PTA. Testing was conducted at frequencies of 0.5, 1, 2, 3, 4, 6, and 8 kilohertz (kHz). Participants wore headphones, with the red earbud placed in the right ear and the black earbud in the left ear. Each participant spent a minimum of 20 minutes in the examination room prior to the procedure. On average, the entire testing process lasted between 20 to 30 minutes per attendee, with ambient sound levels maintained below 40 dB, as conducted by experienced audiologists from IUMS.

Following the PTA evaluation, we excluded patients with CHL based on the current definition, which requires a minimum of 15 dB difference between air and bone conduction at a specified frequency. The remaining patients were subsequently categorized into two groups: the HL group and those with normal hearing. According to the latest World Health Organization (WHO) guidelines, an auditory threshold greater than 25 dB in the better ear indicates hearing impairment (17). Additionally, we excluded individuals with unilateral SNHL exhibiting a difference greater than 10 dB, as these cases necessitate referral to rule out specific diagnoses, such as tumors. Furthermore, individuals with asymmetrical SNHL showing a difference greater than 20 dB were also excluded due to the requirement for referral to exclude specific diagnoses.

Laboratory data

The laboratory measures assessed in this study included serum fasting blood sugar (FBS), triglycerides (TG), high-density lipoprotein (HDL), and low-density lipoprotein (LDL). Additionally, hemoglobin (Hb) and creatinine (Cr) levels were evaluated in a fasting blood sample. Recipients were classified into various health groups based on specific criteria. Individuals with FBS levels exceeding 126 mg/dL are classified as having impaired fasting glucose, which necessitates further evaluation for a DM diagnosis. In this article, however, we refer to this group as having DM, despite the fact that they do not entirely meet the diagnostic criteria for the condition, as the American Diabetes Association recommends repeating the test prior to establishing a diagnosis (18). Patients were categorized into the DLP group if they had TG levels higher than 200 mg/dL, LDL levels exceeding 150 mg/dL, HDL levels below 40 mg/dL, or if they were receiving lipid-lowering medications. Anemia was identified in individuals whose Hb levels were below 14 g/dL for men and 13 g/dL for women.

Study Outcomes and Analysis

The primary outcome of this study was to identify any relationship between various cardiovascular RFs, including HTN, DM, DLP, and SNHL. To achieve this objective, we utilized means and standard deviations for continuous variables, along with frequencies for categorical factors. The Chi-square test was employed for categorical variables, while the Mann-Whitney U test was selected for continuous variables to determine statistically significant differences.

Additionally, we conducted univariate and multivariate logistic regression analyses to determine the odds ratios (ORs) of each RF associated with SNHL, adjusting for variables such as age, body mass index (BMI), gender, marital status, education level, and smoking status. To further investigate the relationship between cardiovascular RFs and HL, we performed a binomial logistic regression analysis while controlling for additional covariates. This analysis was executed using generalized linear models with a logit link function and robust standard errors. To assess the robustness of the fully adjusted logistic regression model and to identify a more parsimonious set of predictors for HL, we conducted a stepwise logistic regression utilizing the Akaike information criterion (AIC) as the selection criterion. Beginning with a full model that included age, gender, BMI, marital status, education, smoking, noise exposure, diabetes, hypertension, and dyslipidemia, the stepwise procedure retained only three predictors: age, gender, and education.

The results were reported as ORs with 95% confidence intervals (CIs), and statistical significance was determined at $P < 0.05$. All statistical analyses were conducted using Stata 17 (Stata Corp, College Station, TX, USA) and SPSS version 27 (SPSS Statistics for Windows; IBM, Armonk, New York, USA).

Ethical approval

This study was conducted in accordance with the Helsinki Declaration of Ethical Principles, as revised in 2013. Ethical approval was obtained from the institutional research board at IUMS for study number IR.IUMS.REC.1403.181.

Results

The study included all attendees (2187 cases) who visited the clinics during the designated period. A total of 1,996 individuals met the criteria for inclusion in the study. Eight patients with CHL were excluded. Additionally, 164 patients did not complete the PTA and were therefore excluded from the research. Nineteen patients

Table 1. Participant demographics and clinical characteristics

Variable	Categories	Total (n = 1996)	Men (N=1524)	Women (N=472)	*P*-value*
		Mean± SD	Mean± SD	Mean± SD	
Age		34.91±9.7	35.86±10.11	31.86±7.78	<0.001
BMI		26.30±4.6	26.67±4.59	25.09±4.66	<0.001
		N (%)	N (%)	N (%)	
Marital status					<0.001
	Single	826(41.4)	565(37.1)	261(55.3)	
	Married	1170(58.6)	959(62.9)	211(44.7)	
Education					<0.001
	Primary education	403(20.2)	381(25.0)	22(4.7)	
	Secondary education	818(41.0)	687(45.1)	131(27.8)	
	Tertiary education	775(38.8)	456(29.9)	319(67.6)	
Smoking					<0.001
	Never	1583(79.3)	1115(73.2)	468(99.2)	
	Former	18(0.9)	18(1.2)	0(0.0)	
	Current	395(19.8)	391(25.7)	4(0.8)	
Noise exposure		871(43.64)	744(48.82)	127(26.91)	<0.001
Diabetes Mellitus		64(3.2)	60(3.9)	4(0.8)	<0.001
Hypertension		187(9.4)	168(11.0)	19(4.0)	<0.001
Dyslipidemia		852(42.7)	696(45.7)	156(33.1)	<0.001
Anemia		161(8.1)	49(3.2)	112(23.7)	<0.001

*Mann-Whitney U test or Chi-Square List of abbreviations: SD: standard deviation, BMI: body mass index.

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were excluded due to otologic complications.

Subsequently, 1,996 participants were included in the analysis, with a majority being male (76.4%) and a mean age of 34.91 years. Significant differences were observed between men and women in terms of age, BMI, marital status, educational level, and smoking status. Men were more likely to be married (62.9% versus 44.7%), had a higher BMI (26.67 versus 25.09), and reported current smoking at a rate of 25.7% compared to 0.8% in women. In contrast, women exhibited higher rates of anemia (23.7% versus 3.2%). Cardiovascular risk factors, including HTN (11.0% in men versus 4.0% in women), DLP (45.7% in men versus 33.1% in women), and DM (3.9% in men versus 0.8% in women), were significantly more prevalent in men than in women. Chi-square and Mann-Whitney U tests confirmed a *P*-value of < 0.001 for all the mentioned differences (Table 1).

Logistic regression analysis confirmed that age, gender, and specific cardiovascular RF were significantly associated with HL. SNHL exhibited a strong correlation with older age, with an adjusted odds ratio (aOR) of 1.14 (95% CI: 1.12–1.16). Furthermore, HL was approximately three times more prevalent in men than in women. A protective effect of higher educational attainment was also observed; individuals with secondary and tertiary education were significantly less likely to experience SNHL (aOR = 0.58 and 0.35, respectively) compared to those without primary school degrees (Table 2).

DM was significantly associated with HL in the initial model (Crude Odds Ratio(cOR): 2.97); however, this association was not observed in the multivariate model (aOR: 0.70, *p* = 0.274). Initially, HTN (cOR: 2.97, *P* < 0.001) and DLP (cOR: 1.40, *P* = 0.003) were also significantly related to HL. Nevertheless, after adjusting for potential confounding variables, both associations lost their significance. DLP, however, exhibited a tendency to increase the risk of HL (aOR: 1.28, *P* = 0.071).

The analysis of the association between the number of existing cardiovascular RF (HTN, DLP, and DM) in a person and HL revealed a significant relationship, particularly in the unadjusted model (Table 3). In the entire population (n =1996), individuals with one cardiovascular RF were 53% more likely to experience HL compared to those without RF (unadjusted OR: 1.53, 95% CI: 1.21–1.94, *P* = 0.0003). This association remained significant after adjusting for covariates, including age, gender, BMI, and smoking status (adjusted OR: 1.37, 95% CI: 1.04–1.81, *P* = 0.0245). However, among individuals with two or more RF, the unadjusted odds ratio was significantly elevated (OR: 3.83, 95% CI: 2.61–5.61, *P* < 0.0001), nevertheless, this association lost significance after adjustment (aOR: 1.08, 95% CI: 0.65–1.77, *P* = 0.3239).

The Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) for the full model were

Table 2. Variables in the logistic regression equation for hearing loss

Variable	Categories	Mean ± SD / (%)						
		Total (n = 1996)	Hearing loss (n = 408) (20.44%)	Normal (n = 1588) (79.56%)	cOR (95% CI)	*P* value	aOR (95% CI)	*P* value
age		34.91±9.7 (Range: 18-76)	44.38±9.7	32.48±8.1	1.15 (1.14-1.18)	<0.001	1.14 (1.12-1.16)	<0.001
BMI		26.30±4.6 (Range: 17.4-45.2)	27.13±4.3	26.08±4.7	1.05 (1.02-1.07)	<0.001	1.01 (0.98-1.04)	0.421
			N (%)	N (%)				
Gender	Female	472 (23.6)				<0.001		<0.001
	Male	1524 (76.4)	25 (5.30)	447 (94.70)	1		1	
			383 (25.13)	1141 (74.87)	6 (3.95-9.13)		2.74 (1.69-4.46)	
Marital status	SINGLE	826(41.4)				<0.001		0.433
	MARRIED	1170(58.6)	71(8.60)	755(91.40)	1		1	
			337(28.80)	833(71.20)	4.3 (3.27-5.66)		0.87 (0.61-1.24)	
Education	Primary education	403(20.2)				<0.001		<0.001
	Secondary education	818(41.0)	186(46.15)	217(53.85)	1		1	
	Tertiary education	775(38.8)	151(18.46)	667(81.54)	0.26 (0.20-0.34)		0.58 (0.42-0.80)	<0.001
			71(9.16)	704(90.84)	0.12 (0.09-0.16)		0.35 (0.24-0.51)	<0.001
Smoking	NEVER	1583(79.3)				<0.001		0.219
	FORMER	18(0.9)	277(17.50)	1306(82.50)	1		1	
	CURRENT	395(19.8)	10(55.56)	8(44.44)	5.89 (2.31-15.07)		2.16 (0.66-7.11)	0.204
		871(43.64)	121(30.63)	274(69.37)	2.08 (1.62-2.67)		1.22 (0.90-1.67)	0.200
Noise exposure		64(3.2)	220(53.92)	651(40.99)	1.68(1.35-2.10)	<0.001	1.03(0.79-1.35)	0.830
DM		187(9.4)	27(42.19)	37(57.81)	2.97 (1.79-4.94)	<0.001	0.70 (0.37-1.33)	0.274
Hypertension		852(42.7)	75(40.11)	112(59.89)	2.97 (2.16-4.07)	<0.001	1.11 (0.74-1.68)	0.612
Dyslipidemia		161(8.1)	201(23.59)	651(76.41)	1.40 (1.12-1.74)	0.003	1.28 (0.98-1.68)	0.071
Anemia			19(11.80)	142(88.20)	0.50 (0.30-0.81)	0.005	0.84 (0.45-1.56)	0.582

List of Abbreviations: BMI: Body Mass Index, DM: Diabetes Mellitus

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Table 3. Odds ratios (ORs) and 95% confidence intervals (CIs) for hearing impairment based on the total number of three cardiovascular risk factors: hypertension, dyslipidemia, and diabetes mellitus.

Number of Risk Factors	Prevalence (%)	Unadjusted OR* (95% CI)	Adjusted OR** (95% CI)
Total (N = 1996)			
0	165/1034 (15.96)	Reference	Reference
1	187/829 (22.56)	1.53 (1.21–1.94)	1.37 (1.04–1.81)
		P (1 VS 0) = 0.0003	*P* (1 VS 0) = 0.0245
≥2	56/133 (42.11)	3.83 (2.61–5.61)	1.08 (0.65–1.77)
		P (2 VS 1) <0.0001	*P* (2 VS 1) = 0.3239
P for trend		<0.0001	0.0722
Women (N = 472)			Adjusted OR*** (95% CI)
0	15/299 (5.02)	Reference	Reference
1	9/167 (5.39)	1.08 (0.46–2.52)	1.00 (0.42–2.41)
		P (1 VS 0) = 0.8617	*P* (1 VS 0) = 0.9916
≥2	1/6 (16.67)	3.79 (0.41–34.56)	3.06 (0.47–20.07)
		P (2 VS 1) = 0.2744	*P* (2 VS 1) = 0.2907
P for trend		0.4984	0.5081
Men (N = 1524)			
0	150/735 (20.41)	reference	Reference
1	178/662 (26.89)	1.43 (1.12–1.84)	1.41 (1.05–1.90)
		P (1 VS 0) = 0.0044	*P* (1 VS 0) =0.0235
≥2	55/127 (43.31)	2.98 (2.00–4.42)	1.02 (0.61–1.72)
		P (2 VS 1) = 0.0002	*P* (2 VS 1) = 0.2103
P for trend		<0.0001	0.0596

*Unadjusted Binomial Regression Analysis of Hearing Loss (HL) and Cardiovascular Risk (CVR).
** Adjusted binomial regression analysis includes covariates such as gender, age, BMI, marital status, education, smoking status, and noise exposure.
*** Adjusted binomial regression analysis incorporates covariates including age, marital status, education level, smoking status, and noise exposure.

1448.00 and 1509.57, respectively, whereas those for the stepwise model were lower (AIC = 1442.05; BIC = 1464.44), indicating a superior model fit. A likelihood-ratio test comparing the stepwise model to the full model yielded no statistically significant difference (χ^2 = 8.05, df = 7, *P* = 0.33), suggesting that the reduced model retained comparable explanatory power. These results confirm that the primary findings—specifically, the strong associations of hearing loss with older age, male gender, and lower educational attainment—are robust across different variable selection strategies.

We assessed multicollinearity among the cardiovascular RFs (DM, HTN, and DLP) included in our multivariable logistic regression model predicting HL. The Variance Inflation Factors (VIFs) for all three variables were low, with DM exhibiting a VIF of 1.016, HTN a VIF of 1.007, and DLP a VIF of 1.011. These values are well below the commonly accepted thresholds of 5 or 10, indicating that multicollinearity did not substantially affect the precision and stability of the coefficient estimates in our model.

The gender-stratified analysis provided enhanced insight into the differences in the association between cardiovascular RF and hearing impairment. In males (n = 1524), the presence of a single cardiovascular RF was significantly associated with hearing impairment in both unadjusted (OR: 1.43, 95% CI: 1.12–1.84, *P* = 0.0044) and adjusted models (OR: 1.41, 95% CI: 1.05–1.90, *P* = 0.0235). In contrast, women (n = 472) exhibited no significant association between the number of cardiovascular RF and hearing impairment, even in the unadjusted model (OR: 1.08, 95% CI: 0.46–2.52, *P* = 0.8617).

The analysis of the cumulative number of cardiovascular RFs (HTN, DLP, and DM) revealed a significant association between the presence of one RF and HL in the total sample after adjusting for covariates (aOR:–1.37, 95% CI: 1.04–1.81, *P* = 0.0245). This association was also significant among men (aOR: 1.41, 95% CI: 1.05–1.90, p=0.0235). However, the association did not remain statistically significant for individuals with two or more RFs compared to those with one RF in the adjusted model for the total sample (aOR: 1.08, 95% CI: 0.65–1.77, *P* = 0.3239). In the gender-stratified analysis, women (n = 472) exhibited no significant association between the number of cardiovascular RFs and HL in either the unadjusted or adjusted models.

Discussion

In this cross-sectional study, we aimed to determine whether associations exist between HL and various demographic variables and cardiovascular RFs, including a history of cardiovascular disease (CVD), DM, HTN, male sex, and older age, as hypothesized. This survey was conducted with 1,996 individuals who participated in the occupational health surveillance program at the IUMS occupational medicine clinics and met our inclusion criteria. According to the performed PTA, 20.44% of participants exhibited HL. The logistic regression analysis revealed that, after adjusting for other factors, the association between HL and male gender as well as older age remained significant, increasing the odds of HL by 3.08 and 1.14 for each additional year of age, respectively. Furthermore, a higher educational level was inversely associated with HL; specifically, among individuals with college degrees, HL was 65% less common. In contrast, other factors such as BMI, DLP, HTN, and DM lost statistical significance.

Badache et al. investigated the potential association between hearing loss (HL) and participants' age, sex, and

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educational status among Swedish adults (19). They reported that HL was significantly more prevalent among older individuals, those with lower educational levels, and males. Their findings were consistent with ours. However, the present study possesses several advantages over theirs; for instance, we utilized pure tone audiometry (PTA) instead of self-reporting, which is inherently subjective, and, unlike their study, which included only adults over 60, we did not impose an age limit. Similarly, research conducted on adults in the United States demonstrated a notable association between HL and lower education and socioeconomic status (23). According to their findings, Americans who had not completed their high school education were twice as likely to experience HL compared to those with tertiary education. Xu et al. provided comparable data regarding the protective effects of female gender, younger age, and higher education levels among the Chinese population aged over 45 years (11). They reported that the aOR of HL among women was 0.88. When considering individuals in their 40s as the reference group, those over 70 exhibited odds of HL approximately three times higher. Additionally, a national survey of 3,000 Ethiopian households demonstrated that HL was associated with older age and lower education, findings that align with our results (5). However, unlike our study, they did not identify a significant difference between the sexes, which may be attributed to their inclusion of individuals over 5 years old. In contrast, we excluded the pediatric population. One possible explanation for the higher prevalence of HL among individuals with lower education may be their exposure to louder noise levels in the workplace compared to those with academic degrees.

A survey conducted on Malaysian marine personnel revealed no significant association between educational degrees and HL (20). This discrepancy with our findings may be attributed to variations in demographics and job characteristics between the samples of the two studies. The Malaysian study also reported that while smoking and HL exhibited no significant relationship, older age was associated with HL, which aligns with our findings. Nash et al. investigated 3,285 individuals to identify risk factors associated with HL (21). The prevalence of HL in their sample was 14.22%. One underlying reason for the lower HL rates observed in their participants may be the gender distribution in their sample (1,795 females versus 1,490 males). In contrast, our sample comprised approximately 76% males, as men in Iran typically experience higher noise exposure in the workplace. Nash et al. found that the odds of HL were significantly higher among individuals of advanced age (aOR = 1.69 for each additional 5 years), male gender (aOR = 3.48), and lower educational levels, all of which are consistent with our results. Similar to our survey, they did not find any association between HL and a history of CVD, current smoking, HTN, DM, or obesity. They reported significantly increased odds of HL in individuals with lower HDL levels, while no association was identified between HL and serum cholesterol levels. However, we found no association between HL and DLP. One limitation of our study is the lack of documentation of lipid profile components. Additionally, similar to our findings, no significant association was observed between HL and anemia in their cohort. Nevertheless, a meta-analysis that included four studies found a significant association between iron deficiency anemia and HL, with an OR of 1.55 compared to non-anemic individuals (22).

Our analysis revealed no significant association between occupational noise exposure and NIHL. The absence of a definitive association between these two variables can be explained in several ways. Firstly, most of our cases were evaluated during pre-employment assessments; consequently, we lacked reliable data regarding their prior noise exposure. A major limitation of the Iranian occupational medicine system is the lack of a registration and data storage system for individuals. This deficiency hinders access to historical exposure information, which is essential for both research and treatment purposes. Secondly, we did not have objective measures to assess the actual noise levels at each participant's workplace; therefore, we had to estimate their exposure based on their work activities. It is important to note that noise exposure does not occur exclusively in occupational settings (6). Thus, non-occupational NIHL should not be disregarded. Additionally, the average age of our participants (34.91 years) is outside the typical range for presbycusis, suggesting that other factors, such as noise exposure, may have contributed to the observed outcomes.

In 2023, a study that retroactively reviewed clinical data from 7,069 individuals identified an association between HL and DM (aOR = 1.58) as well as current smoking (aOR = 2.02). However, similar to our study, no relationship was found between HL and DLP or HTN (23). Two significant differences between our study and theirs include the method of audiological data extraction; they manually extracted data from records, whereas we actively conducted PTA on the participants. Additionally, their sample size was nearly 3.5 times larger than ours. While our study found no association between BMI and HL, a national cohort of Chinese adults suggested a protective effect of obesity on hearing sensation, reporting a hazard ratio of 0.85 for obese individuals (24). Conversely, a meta-analysis has reiterated that obesity is a significant RF for HL (25), reporting an OR of 1.14 for each 5 kg/m^2 increase in BMI.

A meta-analysis of the factors associated with HL revealed numerous RF for HL (26). While some of these factors, such as lower educational levels, older age, and male sex, were consistent with our findings, others, including DM, CVD, HTN, and smoking, were not. This discrepancy may be attributed to the relatively small population size of our study, as well as the specific occupational group examined. In Iran, only a few original studies have investigated the factors associated with HL. One study involving 250 workers in the automobile industry demonstrated that smoking significantly increases the risk of NIHL (27). The difference in findings between this study and our research can be explained by the fact that nearly half of their participants were smokers, whereas only 19.8% of our population reported smoking. Another study identified a notable association between HL and age

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among steel industry workers, which aligns with our findings (28).

The relationship between the number of cardiovascular RF and HL has been investigated in a sample of 1,010 Japanese individuals. After adjusting for confounding variables, researchers found that an increased number of cardiovascular RFs is associated with HL in men and the overall sample, but not in women. Among men, the aOR for HL was 1.11 in those with two or more RFs, with a p-value for the trend of 0.02. In the total sample, the reported p-value for the trend was 0.045 (29). Similarly, our study found no association between the number of cardiovascular RFs and HL among women. However, among men and in the total sample, we observed a statistically significant increase in the adjusted ORs for HL in individuals with one RF, with an aOR of 1.37. Conversely, our model did not reveal a significant association for those with two or more RFs. This lack of significance may be attributed to diminished statistical power due to the smaller number of individuals in this subgroup; for instance, there were only six women in the group with two or more RFs, among whom one had HL, thereby limiting the statistical power for this subgroup. It is also pertinent to note the demographic characteristics of these risk groups: the mean age of participants was 33.94 years for those with no cardiovascular RFs, 34.70 years for those with one RF, and 43.81 years for those with two or more RFs, indicating a progressive increase in age with an increasing number of these RFs.

The current research presents several limitations. Firstly, as a cross-sectional study, it cannot establish causality between variables; it only reports the observed associations. Secondly, the sample size may not be sufficiently large to be representative of the entire population when compared to other nationwide surveys. Thirdly, our sample comprised university employees, thereby excluding certain segments of society, such as individuals with disabilities, the pediatric population, unemployed individuals, rural residents, homemakers, retirees, and those who are severely ill and unable to work. Finally, and perhaps most importantly, our study lacks a reliable, objective measurement of individuals' exposure to occupational noise. Conversely, our study is unique in that it focuses on the Iranian population, which possesses distinct personal and social characteristics and lifestyles that may differ from those in other countries. To the best of our knowledge, there is a scarcity of similar studies conducted in our region.

Conclusion

In conclusion, this cross-sectional analysis offers important insights into the determinants of hearing impairment among Iranian adults. Our findings indicate that older age and male gender are significant risk factors, while higher educational attainment is inversely associated with hearing loss. Although initial associations between cardiovascular risk factors and hearing impairment were observed, only the presence of a single cardiovascular risk factor remained significantly linked to hearing impairment, particularly in men, after adjusting for confounding variables. These results underscore the complex interplay between demographic characteristics, cardiovascular health, and auditory function. Further longitudinal research is warranted to elucidate causal relationships among these factors and to inform targeted prevention and intervention strategies aimed at reducing the burden of hearing loss in this region and beyond.

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Conflict of Interests

The authors declare that they have no competing interests.

Authors' Contributions

B.T. and M.C. conceived and designed the study topic. M.C. and H.N. collected the data. M.S. conducted the data analysis. M.S., A.S., L.N., and M.O. collaborated in drafting the manuscript. B.T. and Z.R. supervised the study, revised the manuscript, and provided expert commentary. All authors take full responsibility for their contributions to this study and have reviewed and approved the final manuscript.

Ethical Considerations

The research protocol received ethical approval from the institutional review board and Ethics Committee of Iran University of Medical Sciences (IR.IUMS.REC.1403.181). Participants provided informed consent after being thoroughly informed about the aims and objectives of the survey prior to completing the questionnaire.

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N/A.

Data Availability

The datasets analyzed during the current study are not publicly available due to concerns regarding participant privacy. However, these datasets can be obtained from the corresponding author upon reasonable request.

AI Use Statement

Artificial intelligence tools, including ChatGPT and Grammarly, were used solely to assist with language editing, grammar correction, and improvement of readability, as English is not the authors' first language. These tools did not contribute to the study design, data analysis, interpretation of results, or scientific content. All final content and interpretations are the responsibility of the authors.

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