Research Article

Hoveyzeh Ear Cohort Study in Southwest Iran: A Pilot Study

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Highlights

- Hoveyzeh ear cohort evaluates auditory system disorders in the Arab ethnicity in Iran
- Hypertension and diabetes were the most important disorders leading to hearing loss
- Tinnitus and dizziness were prevalent symptoms in combination with hearing loss

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ABSTRACT

Background and Aim: The increasing trend of hearing loss is an important public health concern that needs coordinated and well-designed measures at the regional, global, and local levels. We determined the audiological profile of a province in Iran with unique socioeconomic, ethnic, and geographical characteristics and investigated the risk factors associated with hearing loss.

Methods: A total number of 1845 participants (35–70 years old) were recruited in the current prospective study. Pure tone audiometry and tympanometry tests were conducted to determine the type and severity of hearing loss in adults living in southwest Iran (Arab ethnicity). The hearing loss prevalence in individuals with a history of head trauma, cardiovascular disease, noise exposure, diabetes, and smoking status was compared with that of disease-free participants.

Results: The hearing loss prevalence was 51.3% (947/1845), which was significantly correlated with sociodemographic factors, including age, gender, marital status, educational level, skill levels, wealth status, Townsend deprivation index, and smoking habit ($p<0.001$). The hearing loss prevalence showed a significant association with a history of diabetes, cardiovascular disorders, smoking habits, head trauma, and noise exposure ($p<0.05$). Nonetheless, the prevalence of hearing loss and the type of residency, and the wealth index were not significantly associated.

Conclusion: Hearing loss causes the burden of chronic disability in southwest of Iran. Several socioeconomic, demographic, and medical parameters influence the consequences of hearing loss.

Keywords: Hearing loss; cohort study; Iran

Introduction

As the Global Burden of Disease (GBD) reported, hearing loss is currently the fourth reason for disability worldwide [1]. Recent estimates by the World Health Organization (WHO) report that more than 430 million individuals, 5% of the world's population, have disabling hearing loss [2], which will increase to 630 million by 2030 and 900 million people by 2050 because of the global aging population.

It has been estimated that unaddressed hearing loss has a substantial economic cost, at almost US$1 trillion annually, including health care, productivity loss, education, and societal costs [3,4]. The remarkable epidemiologic burden of hearing loss in adults may exert a profoundly negative effect on their health, psychosocial and economic conditions, leading to depression, social isolation, cognitive decline, and reduced quality of life [5-10]. At a societal level, adults with hearing impairment commonly exhibit lower education and employment levels compared to their normal people [11].

Age-Related Hearing Loss (ARHL) accounts for most cases of hearing loss in adults, which is typically induced by gradual, irreversible damage to the cochlea or auditory nerve structures [12]. Besides ARHL, the main factors leading to the increasing trend in hearing loss in adults are an increase in the rate of Non-Communicable Diseases (NCDs), using ototoxic drugs, and excessive noise exposure [13].

It has been shown that hearing loss in older adults is independently associated with an increase in NCD risk, including Cardiovascular Disorders (CVDs), Diabetes Mellitus (DM), chronic respiratory diseases as well as cognitive decline [14]. Of all NCD prevalence, about 75% are in low- and middle-income countries, and most of these countries lack definite strategies for reducing the incidence, prevalence, mortality, and burden associated with NCDs. A significant rate of hearing loss prevalence in adults is preventable through taking appropriate audiological assessment and management, including community-oriented health education [14, 15].

In a large cohort study in South Korea, the relationship between DM and the development of incident hearing loss was evaluated. Kim et al. [16] evaluated hearing acuity in 253301 adults (age>18 years) who took part in a regular health-screening assessment. The adjusted hazard ratios for incident hearing impairment in individuals with DM and pre-diabetes than people who had normal glucose levels were 1.36 and 1.04, respectively. The authors also estimated the hearing loss rate in patients with DM and pre-diabetes as 9.2 and 3.1 per 1000 person-years, respectively.

During a longitudinal cohort study of 5306 African Americans with a focus on cardiometabolic health (Jackson Heart Study Cohort), the prevalence of hearing loss and tinnitus/balance symptoms were measured. The authors reported that the prevalence of hearing loss was 38.1%. Furthermore, the prevalence of tinnitus and dizziness symptoms was 29.5% and 24.1%, respectively [17]. In a retrospective chart review, Baiduc et al. [18] investigated the association between hearing deficits and CVD risk factor burden in 6332 patients (mean age: 62.96 years) and reported a 64% rate of hearing loss in the studied population. They demonstrated an association between DM, smoking status, and ≥2 major CVD risk factors with hearing deficits. The strongest association was observed with current smoking, which was related to hearing deficits in both genders.

It has been suggested that the distribution of subjects with hearing loss is different across geographical areas. Geographical variation can be due to factors such as the prevalence of preventable NCDs, preventable occupational noise exposure, and healthcare access. The aims of the Hoveyzeh Ear Cohort (HEC) study were: *i)* to determine the prevalence of hearing loss in a province in Iran with unique socioeconomic, ethnic, and geographical characteristics and *ii)* to assess the risk factors associated with hearing loss in the study population.

Methods

Study design

The Persian cohort is a series of prospective, population-based projects developed to measure the health, nutritional, and functional status of the civilian non-institutionalized Iranian population. The HEC is a subcategory of the Persian cohort project, enrolled a cohort of 10,009 Iranian adults from southwest Iran

Figure 1. The geographic location of Hoveyzeh City in Iran

between the ages of 35 to 70 years [19]. The HEC study included enrolment and follow-up phases. At the pilot stage of HEC, 1845 participants (60.6% female) were enrolled in the study. On the first day of the visit, the demographic and health information of the participants was collected during a series of face-to-face interviews and audiological assessments (enrollment phase). Then, a specific code was assigned to each participant. The follow-up phase of HEC will be carried out for a minimum of 10 years following the first enrolment time. Every five years, participants will be assessed again for hearing assessment and risk factors.

The skill level classification of the participants was conducted based on the International Standard Classification of Occupations-8 (ISCO-8) [20]. The Townsend Deprivation Index (TDI) was also calculated as a socio-economic measure of deprivation derived from census data. The TDI incorporates four parameters, including non-home ownership, unemployment, household overcrowding, and non-car ownership [21].

Audiological assessment

All participants underwent an audiological examination and were given a detailed otologic case-history questionnaire. The questionnaire covered a wide range of topics, including the history of middle/external ear disorders, noise exposure, head trauma, ototoxic medications, and reported disorders that may result in hearing loss (e.g. NCDs).

The standard tympanometry was performed with a middle ear analyzer (Model AT235, Intracoustics, Denmark) using a 226-Hz probe tone. Tympanograms were classified as type An (normal admittance with normal ear canal volume), type C (negative admittance peak with normal ear canal volume; abnormal), type B (flattened graph with no admittance peak; abnormal), and type As (normal graph but with low middle ear compliance).

Pure tone audiometry was conducted using an AC40 audiometer (Intracoustics, Denmark). Bone conduction and air conduction hearing thresholds were established in octave intervals between 250 and 8000 Hz and between 250 Hz and 4000 Hz, respectively. The lowest level at which the participant responded to 50% of the stimuli was determined as the threshold level. The four-frequency (4000, 2000, 1000, and 500 Hz) Pure-Tone Average (PTA) was calculated as a clinical estimate of the degree of hearing loss. The hearing loss severity was categorized according to the WHO guideline: 26–40 dB HL as mild; 41–55 dB HL as moderate, 56–70 dB HL as severe, 71–90 dB HL as moderately severe, and >90 dB HL as profound hearing loss [22].

Audiological assessments were performed in a sound-attenuating acoustic chamber based on ISO 8253-1.50 protocols.

Statistical analysis

Demographic and clinical features were compared between participants with/without hearing loss using the χ^2 test. A $p<0.05$ was regarded as significant. Stata software (version 16) was applied for statistical analysis.

Results

The main subjects' socio-demographic characteristics are summarized in Table 1. Of the 1845 subjects,

1118 (60.6%) were women, and 1175 (63.4%) were living in urban areas. Most participants were married (87.2%), 12.8% had a diploma or higher level of education, and 64.1% were illiterate. A majority of participants reported being non-smokers (94.5%).

The prevalence of type 2 DM and cardiovascular

Table 1. Socio-demographic characteristics of the participants

Parameter		Hoveyzeh ear Cohort study (Pilot study) n=1845	Hoveyzeh Cohort study n=10,009
Age group	35–39 years	290(15.7)	1912(19.1)
	40–44 years	346(18.8)	2025(20.2)
	45–49 years	320(17.3)	1797(18)
	50–54 years	294(15.9)	1482(14.8)
	55–59 years	301(16.4)	1281(12.8)
	60≥ years	294(15.9)	1512(15.1)
Gender	Male	727(39.4)	4026(40.2)
	Female	1118(60.6)	5983(59.8)
Marital status	Single	52(2.8)	343(3.4)
	Married	1608(87.2)	8760(87.5)
	Widow	150(8.1)	737(7.4)
	Divorced	35(1.9)	169(1.7)
Education level	Illiterate	1182(64.1)	6209(62)
	Under diploma	427(23.1)	2338(23.4)
	Diploma or higher	236(12.8)	1462(14.6)
Skill level	Skill level 1	59 (11.1)	346(3.5)
	Skill level 2	419(78.9)	2377(72.8)
	Skill level 3	11(2.1)	126(1.3)
	Skill level 4	42(7.9)	417(4.2)
Wealth index	Poorest	349(18.9)	2000(20.0)
	Poor	384(20.8)	2033(22.3)
	Moderate	396(21.5)	1982(19.8)
	Rich	382(20.7)	2023(20.2)
	Richest	334(18.1)	1971(19.7)
Type of residency	Urban	1175(63.4)	6176(61.7)
	Rural	675(36.6)	3833(38.3)
Smoking habit	Yes	102(5.5)	197(2.0)
	No	1743(94.5)	9812(98.0)

disorder in the HEC was 24% and 16.4%, respectively (Table 2). The hypertension prevalence was relatively high (14.8%), and men (17.2%) were more affected than women (12.3%). The smoking prevalence was also greater in males (31.6%) than in females (8.9%).

Table 3 indicates the participants' audiological features in the pilot study. The hearing loss prevalence in our study population was 51.32% (947/1845). According to our data, the prevalence of tinnitus and dizziness symptoms was 17.7% (n=326) and 15.9% (n=295), respectively.

Table 2. Clinical features of the participants

Parameter		Hoveyzeh ear Cohort study (Pilot study) n=1845	Hoveyzeh Cohort study n=10,009
Cardiovascular disease history	Yes	302(16.4)	1483(14.8)
	No	1543(83.6)	8527(85.2)
Diabetes history	Yes	442(24.0)	2226(22.2)
	No	1403(76.0)	7783(78.8)
Head trauma history	Yes	273(14.8)	594(5.9)
	No	1572(85.2)	9415(94.1)
Smoking habit	Yes	374(20.3)	2098(20.9)
	No	1471(79.7)	7911(79.1)
Alcohol consumption	Yes	30(1.6)	197(2.0)
	No	1815(98.4)	9812(98.0)

Table 3. Audiological characteristics of the participants in Hoveyzeh ear cohort study (n=1845)

Parameter			Frequency
Right-left hearing symmetry; n (%)		Symmetrical	824(87.1)
		Asymmetrical	123(12.9)
Degree of hearing loss; n (%)	Right ear	Mild hearing loss	391(21.2)
		Moderate hearing loss	339(18.3)
		Severe hearing loss	217(11.8)
	Left ear	Mild hearing loss	346(18.7)
		Moderate hearing loss	398(21.6)
		Severe hearing loss	203(11.0)
Word recognition score; mean (range)		Right ear	78.61%(64–100)
		Left ear	82.24%(68–100)
Tympanograms; n (%)	Right ear	Type An	705(74.4)
		Type As	242(25.6)
	Left ear	Type An	743(78.5)
		Type As	204(21.5)

Table 4. The association between the socio-demographic characteristics and hearing loss at pilot study of the Hovyzeh ear cohort study (n=1845)

Parameter		Hearing loss		P
		No, n(%)	Yes, n(%)	
Age group	35–39 years	222(24.7)	68(7.2)	<0.001
	40–44 years	234(26.1)	112(11.8)	
	45–49 years	178(19.8)	142(15.0)	
	50–54 years	120(13.4)	174(18.4)	
	55–59 years	90(10.0)	211(22.3)	
	60≥years	54(6.0)	240(25.3)	
Gender	Male	267(29.7)	460(48.6)	<0.001
	Female	631(70.3)	487(51.4)	
Marital status	Single	39(4.3)	13(1.4)	<0.001
	Married	781(87.0)	827(87.3)	
	Widow	59(6.6)	91(9.6)	
	Divorced	19(2.1)	16(1.7)	
Education level	Illiterate	533(59.4)	649(68.5)	<0.001
	Under diploma	225(25)	202(21.4)	
	Diploma or higher	140(15.6)	96(10.1)	
Skilled levels	Skilled level 1	28(11.2)	31(11.0)	0.014
	Skilled level 2	186(74.4)	233(82.9)	
	Skilled level 3	7(2.8)	4(1.4)	
	Skilled level 4	29(11.6)	13(4.6)	
Wealth index	Poorest	152(16.9)	197(20.8)	0.199
	Poor	183(20.4)	201(21.2)	
	Moderate	206(22.9)	190(20.1)	
	Rich	191(21.3)	191(20.2)	
	Richest	166(18.5)	168(17.7)	
Type of residency	Urban	585(65.1)	585(61.8)	0.073
	Rural	313(34.9)	362(38.2)	

The hearing loss prevalence was significantly correlated with socio-demographic characteristics, like age, sex, educational level, skill level, marital status, TDI, and smoking habit ($p<0.001$). However, the hearing loss prevalence did not significantly associate with the type of residency and wealth index factors (Table 4). Also, the hearing loss prevalence was significantly higher in patients who had a history of cardiovascular disorders, respiratory diseases, DM, head trauma, and noise exposure ($p<0.001$) (Table 5).

Table 5. The association between the clinical features and hearing loss at pilot study of the Hovyzeh ear cohort study (n=1845)

Parameter		Hearing loss		p
		No, n(%)	Yes, n(%)	
Diabetes	Yes	156(17.4)	286(30.2)	<0.001
	No	742(82.6)	661(69.8)	
Cardiovascular diseases	Yes	206(18.1)	182(15.8)	<0.001
	No	934(81.9)	523(74.2)	
Noise exposure	Yes	81(7.0)	235(36.6)	<0.001
	No	1122(93.0)	407(63.4)	
Head trauma	Yes	107(10.3)	166(20.6)	<0.001
	No	932(89.7)	640(79.4)	
Smoking habit	Yes	115(12.8)	259(27.3)	<0.001
	No	783(87.2)	688(72.7)	
Alcohol consumption	Yes	12(1.1)	18(2.3)	0.056
	No	1070(98.9)	745(97.7)	

The result of trend analyses also demonstrated that hearing thresholds have been elevated with increasing participants' age for both females and males, with poorer hearing thresholds observed in males.

Discussion

According to the WHO report, hearing loss in adults is a health issue that deserves global recognition and prioritization. Nocini et al. [6] showed that hearing loss represents the primary cause of years lived with disability index (health loss) in all functional impairments provided by the Global Health Data Exchange (GHDx) database, making hearing loss an important public health issue, ahead of other more severely perceived functional deficits, such as intellectual disability, heart failure, and vision impairment. Also, the health burden of hearing loss has significantly raised in both genders recently, approximately 20%, particularly in its milder forms.

The prevalence of hearing loss increases progressively and proportionally with age which was more pronounced at the high frequencies. It seems that untreated hearing loss in adults has the potential to have significant impacts on many aspects of a person's life, such as their physical and mental health, socioeconomic status, and employment and educational opportunities [23-25].

According to our results, 15.8% of patients with CVDs experienced some degree of hearing loss. It has been suggested that CVDs cause hearing impairment because of compromised blood flow toward the cochlea. The labyrinthine artery provides blood for the cochlea, with no collateral circulation, then the damaged cochlear perfusion following cardiovascular diseases can decrease the oxygen level in the endolymph and enhance blood viscosity and thrombotic and/or embolic episodes, leading to hearing loss [26, 27].

DM as a systemic metabolic disease is increasing worldwide. Older adults are most affected by hearing loss; nonetheless, it is almost twice as common in adults with DM [28]. There is a high prevalence of hearing impairment in patients with DM, indicating that DM could be regarded as an important risk factor for hearing loss in adults and justifies hearing screening for diabetic patients. DM is known to be correlated with multiple micro- and macrovascular deficits, including thickening of the basal membrane of the stria vascularis capillaries on the lateral wall of the cochlea and other neuropathic and microvascular alternations leading to hearing loss

[28, 29]. Our results indicated that a significant number of individuals with DM (30.2%) had hearing loss. In a similar study, Li et al. [30] also reported a significantly larger number of DM patients (45.1%) were affected by hearing loss compared to pre-diabetic (23.6%) and control subjects. However, results from other large cohorts of older adults have also reported inconsistent results in terms of these risk factors. For example, DM was found to be positively correlated with hearing loss in the HealthABC study [31] but not in the Beaver Dam [32] and Framingham [33] studies.

There are inconsistent results about the relationship between smoking habit and hearing loss [34]. We demonstrated smoking as a risk factor for hearing loss, especially at high frequencies. Approximately 27 % of smoker patients showed some degree of hearing loss. The exact mechanism of smoking's adverse effects on the auditory system is not clearly understood. Smoking may affect cochlea hair cells by an ischemic mechanism – i.e. by decreasing blood flow toward the cochlea or by an increase in carboxyhaemogolobin [35]. Furthermore, nicotinic-like receptors can be seen in hair cells, suggesting direct nicotine ototoxic impacts on hair cell performance [36]. Li et al. [37] meta-analysis also indicated that current smokers have a higher risk of hearing loss than former smokers, and there is a positive dose-response association between smoking and occupational noise exposure.

Not only do head traumas cause mortality and morbidity, but they also have an important position in emergency care admission because of the annual incidence of up to 5% [38]. It has been postulated that individuals with traumatic head injuries show a 2.1 times greater risk of developing hearing loss [39]. Among patients with a history of head trauma, we estimated that about 20 % of patients had hearing loss. The commonest causes of hearing loss are motor vehicle accidents, crashing into a blunt object, and falling. In patients with head trauma, permanent sensory and physical disabilities, like hearing loss, enhance at a very high rate.

The main strengths of our research were: *i)* high participation rate; *ii)* persistent population because of low rates of immigration to and from the area; iii) robust quality control; *iv)* prolonged follow-up duration, up to ten years; *v)* high similarity in the lifestyle of the study population with Kuwait's and Iraq's Arab ethnicity. Thus, the HEC study results are generalizable to a wide geographical region.

Conclusion

The preliminary analysis of the present pilot study represents the high prevalence of hearing loss in southwest Iran. Such important evidence emphasizes broader recognition of this health issue, leading the way to reinforce health policies to prevent the occurrence of mild hearing loss or progression toward more severe problems. This aspect is particularly important if a hearing screening program is not routinely performed in the adult population.

Availability of data and materials

The data are held by the HEC research team at the Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran. We welcome collaboration with other researchers. Data from our cohort study is available for researchers who submit a research proposal to our scientific committee. More details about questionnaire contents, clinical assessments, and contract rules can be found on our website (https://cohort.ajums.ac.ir). A research proposal editable form can be downloaded and sent to hoveizeh.cs@ajums.ac.ir / ahvaz.ent@gmail.com.

Ethical Considerations

Compliance with ethical guidelines

This project was approved by the Local Ethics Committee (Ethical Code: IR.AJUMS.REC.1396. 353). All participants signed informed written consent forms for the interviews, audiological assessments, and access to administrative records.

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Authors' contributions

NS: Study design, acquisition of data, interpretation of the results, and drafting the manuscript; BC: Study design, statistical analysis, and drafting the manuscript; MMZ, Interpretation of the results and drafting the manuscript; SN: Interpretation of the results and drafting the manuscript; ZR: Study design, acquisition of data, statistical analysis, and drafting the manuscript; FR: Study design, interpretation of the results, and drafting the manuscript; HP: Study design, and drafting the manuscript; SS: contributed to the statistical analyses of this investigation; SN: Study design, acquisition of data, interpretation of the results, and drafting the manuscript; AB: Study design, acquisition of data, interpretation of the results, and drafting the manuscript.

Conflict of interest

The authors declare that they have no conflict of interest.

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