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Analysis of Predisposing Factors for Hearing Loss in Adults

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We aimed to estimate the effects of various risk factors on hearing level in Korean adults, using data from the Korea National Health and Nutrition Examination Survey. We examined data from 13,369 participants collected between 2009 and 2011. Average hearing thresholds at low (0.5, 1, and 2 kHz) and high frequencies (3, 4, and 6 kHz), were investigated in accordance with various known risk factors via multiple regression analysis featuring complex sampling. We additionally evaluated data from 4,810 participants who completed a questionnaire concerned with different types of noise exposure. Low body mass index, absence of hyperlipidemia, history of diabetes mellitus, low incomes, low educational status, and smoking were associated with elevated low frequency hearing thresholds. In addition, male sex, low body mass index, absence of hyperlipidemia, low income, low educational status, smoking, and heavy alcohol consumption were associated with elevated high frequency hearing thresholds. Participants with a history of earphone use in noisy circumstances demonstrated hearing thresholds which were 1.024 dB (95% CI: 0.176 to 1.871; $P = 0.018$) higher, at low-frequencies, compared to participants without a history of earphone use. Our study suggests that low BMI, absence of hyperlipidemia, low household income, and low educational status are related with hearing loss in Korean adults. Male sex, smoking, and heavy alcohol use are related with high frequency hearing loss. A history of earphone use in noisy circumstances is also related with hearing loss.

Keywords: Hearing Loss; Sensorineural; Noise; Epidemiology

INTRODUCTION

Hearing loss is one of the most common problems facing older adults (1). Furthermore, the prevalence of hearing loss is expected to increase commensurate with the increasing age of the general population (2). Hearing loss represents a frustrating condition, characterized by communication difficulties that impair cognitive and emotional well-being and general life quality (3). Delays to medical access for hearing loss may also result in possible adverse consequences for health and longevity (4-6). In these respects, hearing loss can be viewed as a societal problem.

Various predisposing factors and pathophysiologic conditions appear to contribute to hearing loss. Several studies have reported that cardiovascular risks factors, including smoking, diabetes, and a history of cardiovascular disease, are also related to hearing loss (5, 7-10). In addition, the relevance of socioeconomic status (including education status, household incomes, and occupations), history of noise exposure, alcohol consumption, and obesity have also been documented (1, 8, 11, 12). However, there are still controversies regarding the precise impacts of these factors.

In this study, we used data from the Korea National Health and Nutrition Examination Survey (KNHANES), collected between 2009 and 2011, to further investigate associations between various risk factors and hearing loss. This study is the largest to analyze hearing loss in an Asian population to date, and it employed targeted sampling and weighting adjustment.

We investigated the relationship between hearing loss and various socioeconomic, demographic, cardiovascular, and other miscellaneous risk factors in Korean adults. We also evaluated the relationship between hearing loss and different types of noise exposure encountered in daily life via experiential questionnaires.

MATERIALS AND METHODS

Study population and data collection

Data from the fourth and fifth KNHANES, which were collected between 2009 and 2011, were analyzed. These data were collected by the Centers for Disease Control and Prevention of Korea. Each year, 192 enumeration districts were selected by a panel, and 20 households were selected in each district. These data represent the statistics of the civilian, non-institutionalized Korean population, based on stratified, multistage clustered sampling, which in turn was based on National Census Data. The sample was weighted by adjusting for the post-stratification non-response rate and extreme values.

Data from a total of 26,265 participants were analyzed. We

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excluded the following participants from this analysis: participants under 20 yr old (6,676 participants); participants who did not perform the audiometric test or physical examination (4,512 participants); participants with an abnormal tympanic membrane (1,518 participants); participants who had incomplete BMI, educational level, income, smoking, or alcohol data; and participants with a history of hypertension, hyperlipidemia, myocardial infarction or angina, and diabetes mellitus (190 participants). A total of 13,369 participants (5,710 male; 7,659 female) were included in the final analysis. Of the 13,369 participants who finished the audiometric test, 4,810 participants also completed the noise exposure analysis. The tympanic membranes of all participants were examined thoroughly by trained otolaryngologists. After applying the recommended weighted values for the KNHANES, frequencies were analyzed in a total of 22,593,776 participants (11,190,118 male [49.5%] and 11,403,658 female [50.5%]).

Survey

Pure tone audiometry was performed in a soundproof booth by trained technicians at 0.5, 1, 2, 3, 4, and 6 kHz in both ears via an automated diagnostic audiometer (SA 203, Entomed, Sweden). The mean threshold values of both ears were used. Low-frequency hearing was defined as average thresholds of 0.5, 1, and 2 kHz. High-frequency hearing was defined as average thresholds of 3, 4, and 6 kHz.

Age, sex, and body mass index (BMI, kg/cm^2) data were collected from each participant. Medical history questionnaires, which asked about hypertension, diabetes mellitus, hyperlipidemia, angina, and myocardial infarction, were also collected.

Socioeconomic data pertaining to monthly income and educational level also were obtained. Participants were divided into three categories according to their monthly household income: less than 2,000 dollars, between 2,000 and 4,000 dollars, and more than 4,000 dollars. For educational level, uneducated, elementary school-educated, and middle school-educated participants were defined as one group, because the prevalence of each of these levels of education was too low to analyze separately.

The smoking history of each participant was obtained. Participants were divided into three categories: never smoked, smoked less than five packs of cigarettes during their lifetime, and smoked more than five packs of cigarettes during their lifetime.

Alcohol consumption also was quantified in each participant. Participants were divided into six categories: never consumed, consumed less than once per month, consumed once per month, consumed 2-4 times per month, consumed 2-3 times per week, and consumed more than 4 times per week.

Noise exposure via earphone use, in the workplace (for more than 3 months), at other place (for more than 5 hr per week), and of a momentary nature, was measured. Noise exposure data were gathered from 4,810 individuals out of the 13,369 total participants included in this analysis.

Statistical analysis

Multiple regression analysis by complex sampling was used. The estimated values and 95% confidence intervals (CIs) for hearing loss were calculated. All results were presented as weighted values. The results were analyzed using SPSS for Windows (Ver. 20, SPSS, Inc., Armonk, NY, USA). A P value of 0.02 was considered statistically significant.

Ethics statement

This study protocol was approved by the institutional review board of Korea Centers for Disease Control and Prevention (IRB No.2009-01CON-03-2C, 2010-02CON-21-C, 2011-02CON-06-C), and the study was performed according to the Declaration of Helsinki. All subjects provided their written informed consent before participation.

RESULTS

Factors influencing low-frequency hearing loss

There was no sex difference for low-frequency hearing loss. A difference in 1 yr was associated with a 0.397 dB (95% CI: 0.373, 0.421, P < 0.001) higher threshold (Table 1).

The uneducated group, which included elementary school- and middle school-educated individuals, and the junior college group, had 3.498 dB (95% CI: 2.384, 4.611, P < 0.001), and 1.006 dB (95% CI: 0.259, 1.753, P = 0.008) higher thresholds, respectively, for low-frequency sounds compared to the graduate college group.

Participants with a low monthly income (≤ US$2,000) had a 1.970 dB (95% CI: 1.396, 2.545, P < 0.001) higher threshold for low-frequency sounds compared to those with a high monthly income (≥ US$4,000).

Participants with hyperlipidemia had -1.879 dB (95% CI: -0.995, -2.763, P < 0.001) differences in low-frequency thresholds compared to those without hyperlipidemia. Participants with diabetes had 1.711 dB (95% CI: 0.548, 2.874, P = 0.004) higher thresholds compared to those without diabetes.

Participants with a low BMI (< 18.5) had 1.695 dB (95% CI: 0.605, 2.785, P = 0.002) higher thresholds compared to high BMI (≥ 25) participants. Participants who had smoked less than five packs of cigarettes during their lifetime had 1.114 dB (95% CI: 0.426, 1.802, P = 0.002) higher thresholds compared to nonsmokers.

Factors influencing high-frequency hearing loss

Males had higher high-frequency thresholds than did females, with estimated values of 6.858 dB (95% CI: 5.982, 7.734, P < 0.001).

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A difference in 1 yr was associated with 0.815 dB (95% CI: 0.785, 0.846, $P < 0.001$) higher thresholds, annually (Table 1).

The uneducated group (which included elementary school- and middle school-educated individuals) and the high school-educated group had estimated threshold values 4.466 dB (95% CI: 2.967, 5.965, $P < 0.001$) and 1.489 dB (95% CI: 0.314, 2.663, $P = 0.013$) higher, respectively, compared to the graduate college group.

Participants with a low monthly income (≤ US$2,000) had estimated threshold values that were 1.611 dB (95% CI: 0.782, 2.441, $P < 0.001$) higher compared to the high monthly income (≥ US$4,000) group.

The participants with hyperlipidemia had thresholds that were -3.028 dB (95% CI: -4.173, -1.883, $P < 0.001$) higher compared to participants without hyperlipidemia. The low BMI (< 18.5) group had 3.319 dB (95% CI: 1.630, 4.649, $P < 0.001$) higher thresholds compared to the high BMI group.

Participants who had smoked less than five packs of cigarettes and those who had smoked more than five packs during their lifetime had 1.998 dB (95% CI: 1.088, 2.907, $P < 0.001$) and 2.210 dB (95% CI: 1.171, 3.248, $P < 0.001$) higher thresholds, respectively, than did non-smokers.

Table 1. Analysis of various factors related to hearing loss (n = 13,369)

Factors	AR (%)	Low-frequency hearing loss			High-frequency hearing loss		
		EV, dB	95% CI	*P* value	EV, dB	95% CI	*P* value
Sex							
Male	49.5	0.307	(-0.280, 0.894)	0.305	6.858	(5.982, 7.734)	< 0.001*
Female	50.5	0.000			0.000		
Age		0.397	(0.373, 0.421)	< 0.001*	0.815	(0.785, 0.846)	< 0.001*
Education							
≤ Middle school†	24.1	3.498	(2.384, 4.611)	< 0.001*	4.466	(2.967, 5.965)	< 0.001*
High school	27.0	0.693	(-0.105, 1.491)	0.089	1.489	(0.314, 2.663)	0.013*
Junior college	18.3	1.006	(0.259, 1.753)	0.008*	1.339	(0.209, 2.470)	0.020
College	23.0	0.424	(-0.302, 1.151)	0.252	0.325	(-0.654, 1.304)	0.515
Graduate college	7.6	0.000			0.000		
Monthly income							
≤ $2,000	32.0	1.970	(1.396, 2.545)	< 0.001*	1.611	(0.782, 2.441)	< 0.001*
$2,001-4,000	36.0	0.453	(-0.054, 0.960)	0.080	0.639	(0.101, 1.380)	0.090
≥ $4,001	32.0	0.000			0.000		
Hypertension							
No	83.3	0.000			0.000		
Yes	16.7	0.712	(-0.009, 1.434)	0.053	0.736	(-0.271, 1.742)	0.152
Hyperlipidemia							
No	91.6	0.000			0.000		
Yes	8.4	-1.879	(-0.995, -2.763)	< 0.001*	-3.028	(-4.173, -1.883)	< 0.001*
MI/Angina							
No	98.1	0.000			0.000		
Yes	1.9	0.088	(-1.570, 1.746)	0.917	0.128	(-2.289, 2.545)	0.917
Diabetes mellitus							
No	93.8	0.000			0.000		
Yes	6.2	1.711	(0.548, 2.874)	0.004*	1.587	(0.140, 3.034)	0.032
BMI							
< 18.5	4.8	1.695	(0.605, 2.785)	0.002*	3.319	(1.630, 4.649)	< 0.001*
18.5-25	62.8	0.172	(-0.252, 0.595)	0.426	0.494	(-0.158, 1.147)	0.137
≥ 25	32.3	0.000			0.000		
Smoking							
< 5 packs	31.0	1.114	(0.426, 1.802)	0.002*	1.998	(1.088, 2.907)	< 0.001*
≥ 5 packs	16.0	-0.157	(-0.815, 0.501)	0.640	2.210	(1.171, 3.248)	< 0.001*
Never	53.0	0.000			0.000		
Alcohol							
Never	22.1	0.753	(-0.307, 1.813)	0.163	-1.029	(-2.461, 0.404)	0.159
< 1 time/month	18.4	-0.578	(-1.541, 0.385)	0.239	-1.900	(-3.332, -0.467)	0.009*
1 time a month	10.7	0.437	(-0.695, 1.569)	0.448	-1.087	(-2.719, 0.545)	0.191
2-4 times a month	25.0	-0.067	(-0.977, 0.843)	0.885	-1.982	(-3.318, -0.645)	0.004*
2-3 times a week	16.0	-0.453	(-1.329, 0.423)	0.310	-1.424	(-2.814, -0.033)	0.045
≥ 4 times a week	7.7	0.000			0.000		

AR indicates "Adjusted Rate". EV indicates "Estimated Value". *Indicates a $P < 0.02$; †The below middle school group includes uneducated participants and elementary school graduates. MI, myocardial infarction.

Compared to the heavy drinking group (more than 4 times per week), the estimated threshold values of participants who drank less than once a month and those who drank 2-4 times a month were -1.900 dB (95% CI: -3.332, -0.467, $P = 0.009$) and -1.982 dB (95% CI: -3.318, -0.645, $P = 0.004$), respectively.

Frequency specific analysis for diabetes mellitus, smoking history, household income, and body mass index

We also evaluated several related factors, such as diabetes mellitus, smoking status, household income, and BMI, in a frequency-specific manner. Using these related factors, we compared average hearing thresholds at all frequencies.

Participants with diabetes mellitus demonstrated significantly worse hearing outcomes at 0.5, 1, and 6 kHz (0.5 kHz, $P = 0.002$; 1 kHz, $P = 0.002$; 6 kHz, $P < 0.001$) (Fig. 1A). The non-smokers demonstrated significantly better hearing outcomes at all frequencies (0.5 kHz, $P = 0.006$; 1 kHz, $P = 0.006$; 2 kHz, $P = 0.002$; 3 kHz, $P < 0.001$; 4 kHz, $P < 0.001$; 6 kHz, $P = 0.004$) compared to smokers who had smoked less than five packs of cigarettes during their lifetime. Smokers who had smoked more than 5 packs during their lifetime had significantly inferior hearing at 3, 4, and 6 kHz (3 kHz, $P < 0.001$; 4 kHz, $P < 0.001$; 6 kHz, $P = 0.001$) compared to non-smokers (Fig. 1B).

Mean audiometry showed that the low BMI group (< 18.5) had inferior hearing thresholds compared to the high BMI (≥ 25) group, at all frequencies (0.5 kHz, $P < 0.001$; 2 kHz, $P < 0.001$; 3 kHz, $P < 0.001$; 4 kHz, $P = 0.001$; 6 kHz, $P = 0.001$) except 1 kHz (Fig. 1C).

Participants with low incomes (≤ US$2,000) had inferior hearing outcomes, compared to participants with high incomes (≥ US$4,000), at all frequencies (0.5 kHz, $P < 0.001$; 1 kHz, $P < 0.001$; 2 kHz, $P < 0.001$; 3 kHz, $P = 0.005$; 4 kHz, $P = 0.01$; 6 kHz, $P < 0.001$) (Fig. 1D). The low education level (uneducated, elementary school, and middle school) group was associated with

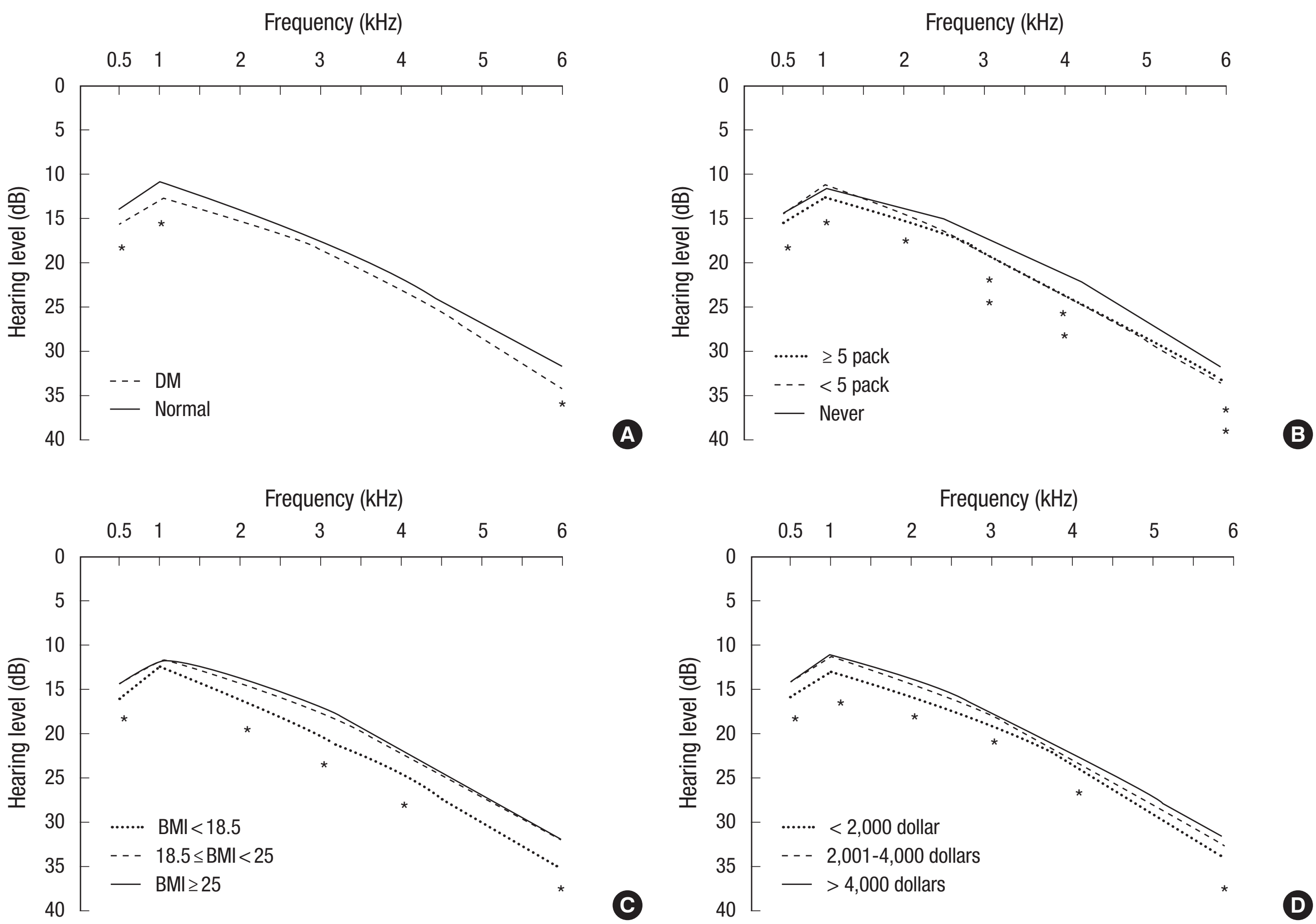

Fig. 1. Mean pure-tone thresholds among Korean adults, according to various factors. (**A**) Mean pure-tone thresholds among Korean adults, according to history of diabetes mellitus (DM). (**B**) Mean pure-tone thresholds among Korean adults, according to smoking history. Participants who smoked less than 5 packs of cigarettes during their lifetime demonstrated significantly inferior hearing thresholds, at all frequencies, compared to non-smokers. Participants who smoked more than 5 packs of cigarettes during their lifetime demonstrated significantly inferior hearing thresholds at high frequencies compared to non-smokers. (**C**) Mean pure-tone thresholds among Korean adults, according to body mass index (BMI). Participants with a low BMI (<18.5) had significantly inferior hearing thresholds at all frequencies compared to those with a high BMI (≥ 25), except at 1 kHz. (**D**) Mean pure-tone thresholds among Korean adults, according to household income. Participants with low household incomes (≤ 2,000 dollars) demonstrated inferior hearing thresholds at all frequencies compared to participants with high household incomes (≥ 4,000 dollars). *$P < 0.02$.

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Table 2. Types of noise exposure associated with hearing loss (n = 4,810)

Exposure types	Adjusted rate (%)	Estimated value (dB)	95% CI	*P* value
Low-Frequencies				
Earphone use†				
No	89.3	0.00		
Yes	10.7	1.024	(0.176, 1.871)	0.018*
Workplace noise‡				
No	88.3	0.00		
Yes	11.7	0.654	(-0.518, 1.826)	0.272
Other place noise§				
No	98.0	0.00		
Yes	2.0	0.253	(-1.758, 2.263)	0.804
Sudden loud noise‖				
No	78.5	0.00		
Yes	21.5	-0.816	(-1.591, -0.040)	0.039
High-Frequencies				
Earphone use†				
No	89.3	0.00		
Yes	10.7	1.146	(-0.467, 2.760)	0.163
Workplace noise‡				
No	88.3	0.00		
Yes	11.7	2.077	(0.269, 3.885)	0.025
Other place noise§				
No	98.0	0.00		
Yes	2.0	-2.190	(-5.686, 1.307)	0.218
Sudden loud noise‖				
No	78.5	0.00		
Yes	21.5	-1.130	(-2.581, 0.322)	0.126

*Indicates $P < 0.02$; †Participants with a history of earphone use in noisy environment; ‡Participants with a history of workplace noise exposure (≥ 3 months); §Participants with a history of noise exposure other than in the workplace (≥ 5 hr per week); ‖Participants with a history of exposure to acute explosive noise (e.g. gunshot, explosion).

inferior hearing compared to the high education level group (graduate college), at all frequencies (0.5 kHz, $P < 0.001$; 1 kHz, $P < 0.001$; 2 kHz, $P < 0.001$; 3 kHz, $P < 0.001$; 4 kHz, $P < 0.001$; 6 kHz, $P < 0.001$).

Noise exposure

Concerning noise exposure history, we only observed significant differences for earphone use. Participants with earphone-induced noise exposure had 1.024 dB (95% CI: 0.176, 1.871, $P = 0.018$) higher thresholds at low frequencies compared to the non-earphone-induced noise exposure group. Other noise exposure measures were not associated with noise exposure and non-noise exposure group differences (Table 2).

DISCUSSION

Men had inferior hearing to women at high-frequencies, a result which is consistent with previous cross-sectional studies (1, 13). In general, males believed that hearing loss occurred due to noise exposure related to their occupation. However, other studies have reported that male hearing loss is more prevalent even after adjusting for the influence of occupation, history of noise exposure, and education, which may reflect sex differences in exposure to other risk factors, such as smoking and atherosclerosis (14, 15). An exact explanation for greater levels of male hearing loss remains elusive; as such, further studies are required.

Participants with low incomes and low educational levels demonstrated significantly higher thresholds at all frequencies. In accordance with a previous study (1), educational level and income were inversely related to hearing loss. It appears that low income and educational levels may be associated with unhealthy lifestyles, which may in turn contribute to the risk of hearing loss.

We found that hypertension and cardiovascular diseases, such as myocardial infarction and angina, were not associated with hearing loss in this study. In contrast to this result, a previous study reported associations between cardiovascular events and low-frequency hearing loss (5). Moreover, it has been postulated that common cardiovascular risk factors might play a crucial role in the pathogenesis of hearing loss, via damage to the cochlear microvasculature. However, a recent prospective study reported that a history of hypertension was not associated with an increased risk of hearing loss (16). Thus, it appears that a history of cardiovascular diseases is not always associated with hearing loss.

A history of hyperlipidemia is associated with more favorable hearing outcomes at both high and low frequencies. Several studies have demonstrated a relationship between hyperlipidemia and hearing disturbance (17, 18). Although, some studies have reported that levels of triglycerides and cholesterol are not consistently related to hearing disturbance, these studies nevertheless attested to the relevance of low- versus high-density lipoprotein (5, 19). Other researchers have suggested that disturbances in microcirculation engendered by hyperlipidemia might represent a possible mechanism underlying hearing loss (20, 21). Because we did not arrive at a precise explanation for our result, additional studies would likely be instructive.

We observed that low BMI was associated with inferior hearing; a previous study has reported that a high BMI is correlated with hearing loss (8). However, a large cross-sectional study demonstrated no significant association between BMI and hearing-loss risk (22). In our study, low BMI (< 18.5) was associated with low- and high- frequency hearing loss. Low body weight might be associated with an elevated risk of hearing loss via an insufficient intake of dietary nutrients, such as vitamin B12 and antioxidants (23, 24). Additional studies might be required to corroborate these findings.

We also observed that alcohol consumption was associated with hearing thresholds. Participants who consumed alcohol less than once per month and those consuming alcohol 2-4 times per month had approximately 2 dB lower thresholds at 3 kHz, and 4 kHz compared with participants who consumed alcohol 4 times per week. However, the hearing thresholds of participants who never consumed alcohol were not statistically different from participants who consumed alcohol more than 4 times per week. Therefore, it appears that alcohol may have a protective effect on hearing. Generally, it has been accepted that chronic alcohol abuse is associated with hearing loss (25). However, a previous study has suggested that the ingestion of a moderate amount of alcohol might have a protective effect (8). The cardioprotective effects of alcohol consumption, which are mediated by high levels of high-density lipoprotein and antithrombotic activity, extend to a reduced risk of hearing loss, by protecting against a disturbance in cochlear blood flow. This study supports the hypothesis that some degree of drinking might have a protective effect on hearing.

A previous study has demonstrated that hearing loss is associated with the degree of glycemic control and disease duration (26). Specifically, it is accepted that diabetes-related hearing loss is progressive, with sensorineural disturbances affecting audiometric thresholds between 0.5 and 8 kHz (27, 28). Our study suggested that hearing thresholds of 0.5, 1, and 6 kHz are significantly elevated in individuals with diabetes. A previous study has reported that diabetes-related hearing loss occurs mainly at high frequencies (26). However, another study has reported that diabetic patients have inferior hearing thresholds at low and mid frequencies (29). The exact mechanism underlying hearing disturbances in diabetic persons remains unclear. Several studies have reported that diabetes mellitus is associated with microangiopathy of the cochlear and endolymphatic sac, and degeneration of the stria vascularis and outer hair cells (30, 31). Further study of the mechanisms underlying hearing loss at certain audiometric frequencies is required.

In contrast to diabetic retinopathy, hearing impairment is not a well-documented complication of diabetes mellitus. Therefore, it would be preferable to perform audiometry, as a part of the routine annual evaluations of glycemic control undertaken by all diabetic patients.

We also observed negative associations between smoking and hearing, a result that is consistent with the findings from another study (32). Our data indicated that high-frequency was particularly vulnerable in previous heavy and current smokers. One study indicated that the low-frequency hearing of heavy smokers working in noisy workplaces also was affected (32), although the high-frequencies appear to be more vulnerable in general (8, 33). The mechanism underlying hearing loss is not fully understood. However, free radicals are well known to be abundant in cigarettes (34). The direct delivery of reactive oxygen species (ROS) and the indirect delivery of ROS endogenously induced by smoking, may affect the cochlea. Smoking also may increase blood viscosity (35), which in turn may lead to reduced blood flow to the cochlea. Our study confirmed that smoking was associated with high-frequency hearing loss.

We found that hearing threshold levels, at low frequencies, were significantly higher in participants who reported a history of earphone use in noisy circumstances. One study reported that 490 students (13-18 yr old) who used a portable music player for more than 5 yr had significantly elevated audiometric thresholds at 4 kHz (36). It is accepted that acoustic trauma in early phase affects high-frequency hearing (10-20 kHz) (37). The reasons for the impairment of low-frequency hearing observed in this study are unclear.

Although exposure to loud noise is usually involuntary, some individuals, especially young adults, are voluntarily exposed to earphone use. We suggest that recommendations for earphone use should be emphasized for individuals who frequently use personal music players. For example, setting volume intensities to less than 50% of the maximal volume, and selecting in-ear and supra-aural varieties of earphones, might be prudent (38).

In terms of study limitations, we used nationally representative data (from KNHANES) to investigate the role of possible risk factors for hearing loss in the Korean population. Although this dataset is widely used and has a significant statistical power, it represents a cross-sectional study only. Because the studies that using NHANES (National Health and Nutrition Examination Survey) and KNHANES data are cross-sectional studies, causal inferences cannot be made, and careful interpretation of the data is required. However, there are several strong points in this study compared with other studies (39, 40) used the NHANES data. First, in this study, the ages of participants were more widely distributed: 20-97 yr old (KNHANES, Korea) vs. 20-69 yr old (NHANES, US). Therefore, this study represents all adults, including older adults. Second, the number of participants included in this analysis was larger than NHANES. Most studies (39, 40) using NHANES data analyzed no more than 5,000 participants. However, this study included the hearing results from 13,000 participants. The study population in this report was larger compared with a previous report (39), and may provide a substantial amount of additional information pertaining to hearing loss.

In conclusion, it is demonstrated that low BMI, the absence of hyperlipidemia, low household income, low educational status, and smoking are associated with low-frequency hearing loss. In addition, male sex, low BMI, the absence of hyperlipidemia, low household income, low educational status, smoking, and heavy alcohol use are all associated with high-frequency hearing loss. Participants who use earphones in noisy circumstances demonstrate elevated hearing thresholds at low-frequencies. This population-based study may provide reliable information pertaining to risk factors associated with hearing loss in adults. Although the exact mechanisms underlying our results remain unclear, a greater understanding of the possible risk factors may help prevent hearing loss.

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DISCLOSURE

The authors have no potential conflicts of interest to disclose.

AUTHOR CONTRIBUTION

Study design and literature review: Lee JS, Choi HG, Hong SK, Park B, Jang JH. Data management and analysis: Choi HG, Sim S. Interpretation of the findings and preparation of the manuscript: Lee JS, Choi HG, Hong SK, Lee HJ, Kim HJ.

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