Systolic Blood Pressure and Objective Hearing Thresholds Among Japanese Middle-Aged Adults: A Facility-Based Retrospective Cohort Study

Short running head: Systolic Blood Pressure and Hearing Thresholds

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Conflicts of Interest and Source of Funding

The authors declare that they have no conflicts of interest with respect to this research study and paper.

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgments

We thank Hiromi Rakugi, M.D., Ph.D. (Department of Geriatric and General Medicine, Osaka University Graduate School of Medicine, Suita, Osaka, Japan) and Hidenori Inohara, M.D., Ph.D. (Department of Otorhinolaryngology-Head and Neck Surgery, Osaka University Graduate School of Medicine) for their valuable advice, and our colleagues from Osaka University Center of Medical Data Science, Advanced Clinical Epidemiology Investigator's Research Project for providing their insight and expertise for our research. We are grateful to all the staff, particularly to Hirokazu Takeda, health information manager (Keiju Health Management Center) in Keiju Medical Center, Nanao, Ishikawa, Japan.

Word Counts

Abstract: 186 words

Articles excluding references: 1,628 words

Numbers of Tables, Figures, and Supplemental Digital Content

Tables: 2

Figures: 1

Supplemental Digital Content: 1

ABSTRACT

Introduction: Very few studies have compared the magnitude of the changes in the hearing thresholds at 1 kHz and 4 kHz according to the systolic blood pressure (SBP). We investigated the effects of SBP on repeated measures of hearing threshold using pure-tone audiometry.

Methods: This retrospective cohort study included 5,479 (for the analysis at 1 kHz) and 2,045 (for 4 kHz) individuals aged 50–59 years who underwent facility-based health checkups. A multivariable generalized linear mixed model was constructed for the analysis at 1 kHz and 4 kHz.

Results: The mean follow-up durations were 30,262 and 7,454 person-years, respectively. The interaction of SBP and year was significantly associated with the change in hearing threshold in both analyses at 1 kHz (with estimated slope, 0.00080; 95% confidence interval [CI], 0.00049–0.00110) and 4 kHz (with estimated slope, 0.0042; 95% CI, 0.0028–0.0057). The 10-year changes in hearing threshold with baseline SBP of 110 and 140 mmHg were 0.4 and 0.6 dB at 1 kHz and 1.0 and 2.3 dB at 4 kHz, respectively.

Conclusions: Higher SBP was associated with an increased hearing threshold at both 1 and 4 kHz among middle-aged individuals.

Keywords: Epidemiology; Hearing loss; Hypertension; Japanese population; Longitudinal study; Middle-aged

INTRODUCTION

In 2019, the Global Burden of Disease Study showed that 1.6 billion individuals experienced hearing impairment (HI) (1), and a global economic cost exceeding 981 billion USD (2). Furthermore, the disability-adjusted life-years (DALYs) for HI was the ninth and tenth top cause of DALY counts for individuals aged 50–74 years and ≥75 years, respectively (3).

Hypertension-related hearing impairment (HI) has the same audiometric characteristics as age-related HI (4), which is more pronounced at higher frequencies with a gradual and symmetric progression (4,5). The previous study, which utilized measured systolic blood pressure (SBP) and audiometry evaluation results, reported that higher SBP was associated with HI at 1 kHz among individuals aged 20–59 years who received health checkups at a facility in Japan (6). However, that study did not focus on the change in hearing threshold and could not estimate the effect of higher SBP on HI because the analytic model was constructed to examine the hazard ratios of HI (6). Additionally, that study treated young- and old-onset HI together (6), despite the difference in etiology. Moreover, no clear association was observed at 4 kHz as of yet (6).

In this study, we hypothesized that higher SBP levels were associated with a higher hearing threshold and HI was more pronounced at higher frequency among middle-aged adults, who had higher prevalence of HI. Therefore, we investigated the association between SBP and measured hearing thresholds by pure-tone audiometry at 1 kHz and 4 kHz in individuals aged 50–59 years using facility-based health checkup data.

MATERIALS AND METHODS

Study Design and Participants

This facility-based retrospective cohort study was conducted using data from medical records at the health checkup department of [Author's institution]. The participants were aged 50–59 years and underwent audiometry evaluation two times or more during health checkups at [Author's institution] between April 2007 and March 2020. For the analysis at 1 kHz and 4 kHz, 5,479 and 2,045 individuals, respectively, without HI at baseline were included. The details are shown in the Supplemental Digital Content.

The study protocol and use of existing data were approved by the ethics committee of [Author's institution] (Approval Number: @@@). It was performed in accordance with the ethical standards of the 1964 Declaration of Helsinki and its later amendments. The participants were allowed to drop out of the study via the hospital's website.

Variables

We collected information about SBP, the left and right hearing thresholds, age, sex, and the variables based on the risk factors of HI reported before (5). No information regarding ear diseases or noise exposure was available. The precise method can be found in the Supplemental Digital Content.

There were missing values for serum glucose levels, serum low-density lipoprotein cholesterol levels, current smoking and drinking status, regular exercise, and antihypertensive medication use. The percentage of missing values across the six variables varied between 34.0 to 35.3% (out of 5,479 records), and 9.5 to 11.4% (out of 2,045 records) in the analysis at 1 and 4 kHz, respectively. A total of 1,992 (36.4%) and 247 (12.1%) records were incomplete, respectively. A compact display of patterns of missingness with covariates is presented in Tables S1 and S2 in Supplemental Digital Content for the analysis at 1 kHz and 4 kHz, respectively.

Statistical Analysis

The baseline characteristics of the participants according to their SBP were presented as the mean values of continuous variables and proportions of categorical variables. A multivariable generalized linear mixed model was constructed to evaluate the effects of SBP on repeated measures of hearing threshold with first-order autoregressive modeling. The missing values of the covariates at baseline were processed using multiple imputation methods. The precise method for statistical analysis is shown in the Supplemental Digital Content.

RESULTS

The baseline characteristics of the study population according to the tertile levels of SBP are shown in Table 1. Among the participants for the analysis at 1 kHz and 4 kHz, there were 2,807 (51.2%) and 866 (42.3%) men, and the mean age was 52.7 (3.0 standard deviation [SD]) and 51.8 (2.6 SD) years, respectively. The SBP was positively correlated with age, sex (male), body mass index, antihypertensive medications, diabetes, hyperlipidemia, alcohol intake, and exercise habits.

The effects of the variables in the generalized linear mixed model are presented in Table 2. The mean follow-up durations were 30,262 and 7,454 person-years at 1 kHz and 4 kHz, respectively. In both analyses, the interaction between SBP levels and year was significantly associated with the change in hearing threshold. The parameter estimate of the interaction at 4 kHz was higher than that at 1 kHz. Compared with the results under fully conditional specification (FCS) to impute missing variables, the results under Markov chain Monte Carlo (MCMC) were consistent (Table S3 in Supplemental Digital Content).

According to the multivariable model, the slope of the hearing threshold of participants with an SBP of 140 mmHg was higher than participants with an SBP of 110 mmHg, for both the 1 kHz and 4 kHz analyses (Fig. 1). The 10-year changes in hearing threshold among participants with baseline SBP of 110 and 140 mmHg were 0.4 and 0.6 dB at 1 kHz (p <0.001) and 1.0 and 2.3 dB at 4 kHz (p <0.001), respectively.

DISCUSSION

This retrospective cohort study focused on the change value of hearing thresholds among middle-aged participants from a single health facility, comparing the magnitudes between the changes in hearing thresholds at 1 kHz and 4 kHz according to SBP levels. In this study, a higher SBP level was associated with an increased hearing threshold at both 1 kHz and 4 kHz for middle-aged people. There was a higher difference between the model-predicted change in the hearing threshold at 4 kHz than at 1 kHz according to SBP levels. Our results suggested that hypertension-related HI was more pronounced at 4 kHz than 1 kHz, which was in line with the prior findings (4).

To the best of our knowledge, twelve longitudinal studies on this topic have been conducted (6-17); however, only four studies utilized pure-tone hearing threshold as the continuous variable (7-10). Moreover, there were two longitudinal studies that utilized speech-in-noise performance (7,11). The Atherosclerosis Risk in Communities (ARIC) Study, a population-based cohort study in the USA, published two investigations (7,8). The first report revealed a positive association between the slope of pure-tone average levels at four frequencies (0.5, 1, 2, and 4 kHz) in the better-hearing ear and an increment of SBP among individuals aged 41–65 years (8). This result corroborates our result. The other report of the ARIC Study with individuals aged 44–65 years revealed that hypertension at either midlife or late life, and its change was not associated with hearing threshold measured by pure-tone audiometry based on the average levels at four frequencies (0.5, 1, 2, and 4 kHz) in the better-hearing ear (7). Meanwhile, individuals with hypertension at both midlife and late life had a higher risk of low speech-in-noise performance (7). That study investigated the association between midlife to late life change patterns in blood pressure and HI measured by pure-tone audiometry; however, no obvious difference was observed. A Brazilian cohort study yielded consistent results with ours (9). A web-based Dutch study revealed that hypertension was associated with a higher speech reception threshold among individuals aged 18–70 years (11). Another Dutch cohort study assessing showed no association between measured hypertension and HI (10). We did not fully investigate the association between blood pressure trajectory and development of HI. We also did not look into the effect of antihypertensive treatments on the prevention of HI; hence, further investigations are warranted.

Understanding the potential underlying mechanisms of hypertension in the development of HI is important. Hypertension may reduce the capillary blood flow to the cochlea and auditory nerve (4). Higher natriuretic peptide levels associated with hypertension may also inhibit the potassium pump within the stria vascularis of the cochlea, which disrupt ionic homeostasis in the inner ear fluids and depolarization of hair cells (4). Although these mechanisms are not yet fully elucidated, these processes could lead to cochlear damage and eventual sensorineural HI (4).

This study had some limitations. First, the blood pressure and hearing threshold measurement protocols were not standardized because the tests were performed during routine clinical practice, which is not designed for research. Second, the one-time blood pressure measurement at checkup may not be representative of the true blood pressure and we cannot rule out the possibility that this value may have been accidentally high or low. Third, since the lower limit of the hearing threshold was 30 dB, the floor effect should be considered. The difference in the true estimated slope may be smaller, especially if more floor effect occurred among participants with low SBP at baseline. Fourth, we could not obtain information on subjective hearing symptoms, which are important for assessing clinical significance. Fifth, determination of the underlying hypertension mechanisms is not possible since we did not assess the types of HI (e.g., conductive, sensorineural, or mixed) due to the lack of detailed history, including the onset of HI. Sixth, unmeasured factors, especially possible confounders (e.g., ear diseases and noise exposure), might have biased the estimated effects (4,5,18). Seventh, the information on adjusted variables was incomplete especially for the analysis at 1 kHz, which could have decreased the precision for the multiple imputation analysis. Although the two methods of multiple imputation revealed similar results, our findings should be interpreted with caution. Eighth, this study was conducted using data from a single facility, leading to inadequate external validity. Thus, further studies, particularly multicenter or population-based prospective studies are warranted.

In conclusion, higher SBP levels were associated with a higher hearing threshold at both 1 kHz and 4 kHz among middle-aged individuals. HI due to higher SBP was more pronounced at 4 kHz than 1 kHz. Further studies with repeated blood pressure and hearing threshold measurements are necessary to confirm the effects of blood pressure trajectory and hypertension treatment for HI.

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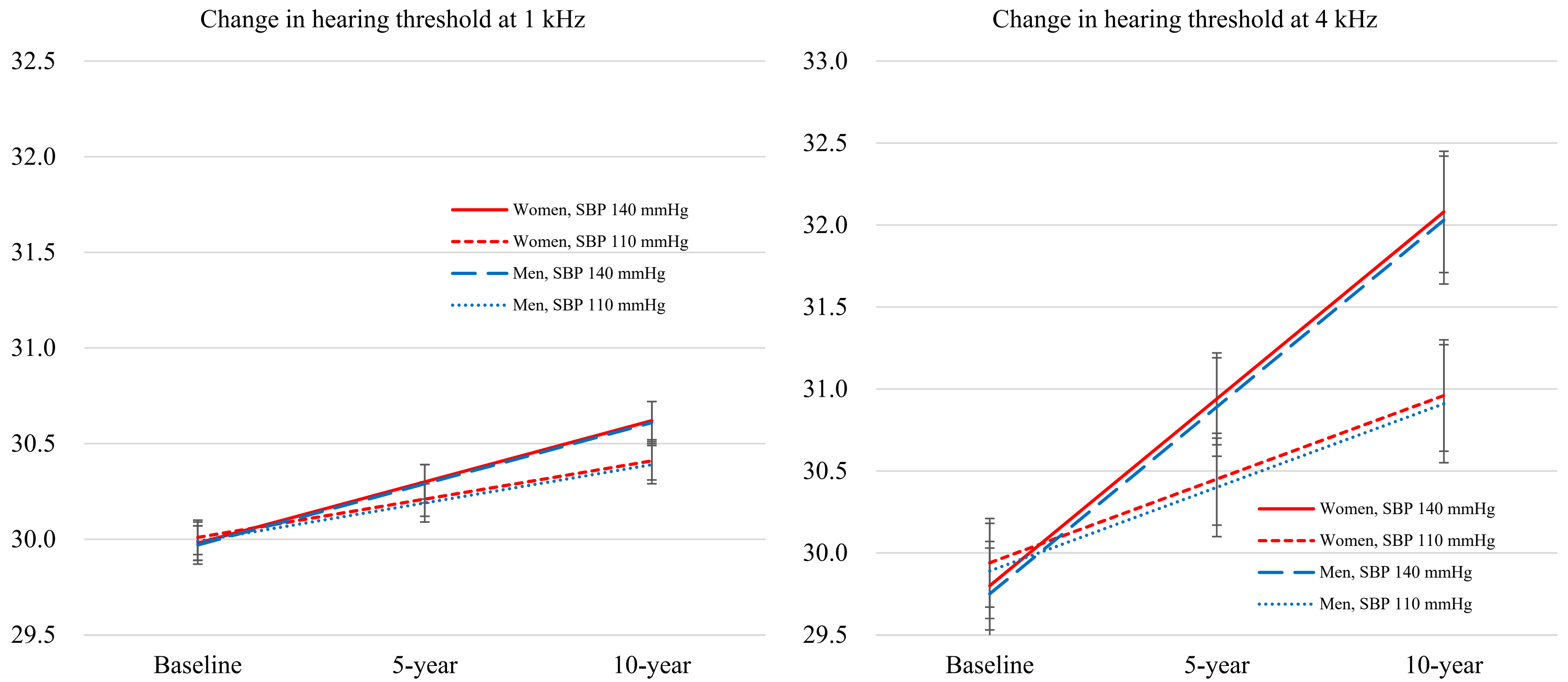
Figure Legends

FIG. 1 Multivariable model-predicted 5- and 10-year change in hearing thresholds at 1 kHz and 4 kHz according to the baseline systolic blood pressure (SBP) level. Figures in table represents estimates and standard deviations of hearing threshold in case of aged 50–54 years, body mass index of 21.0–22.9 kg/m^2, and without antihypertensive medications, diabetes mellitus, hyperlipidemia, current smoking habits, alcohol intake, and exercise habits. Error bars represent 95% confidence intervals for estimates.

List of Supplemental Digital Content

SBP_and_HI_SDC_blinded_20221227.docx



Model	Analysis at 1 kHz			Analysis at 4 kHz		
	Baseline	5-year	10-year	Baseline	5-year	10-year
Women, SBP 140 mmHg	29.98 (0.05)	30.30 (0.05)	30.62 (0.05)	29.80 (0.14)	30.94 (0.14)	32.08 (0.19)
Women, SBP 110 mmHg	30.01 (0.05)	30.21 (0.05)	30.41 (0.05)	29.94 (0.14)	30.45 (0.14)	30.96 (0.17)
Men, SBP 140 mmHg	29.97 (0.05)	30.29 (0.05)	30.61 (0.05)	29.75 (0.14)	30.89 (0.15)	32.03 (0.20)
Men, SBP 110 mmHg	29.99 (0.05)	30.19 (0.05)	30.39 (0.05)	29.89 (0.15)	30.40 (0.15)	30.91 (0.18)

TABLE 1. *Baseline characteristics according to the tertile systolic blood pressure levels*

Characteristics	Participants in the analysis at 1 kHz (*N*=5,479) Systolic blood pressure (mmHg)				Participants in the analysis at 4 kHz (*N*=2,045) Systolic blood pressure (mmHg)			
	Tertile 1; 79–116 (*N*=1,879)	Tertile 2; 117–128 (*N*=1,727)	Tertile 3; 129–208 (*N*=1,873)	*p* for trend	Tertile 1; 81–115 (*N*=684)	Tertile 2; 116–128 (*N*=663)	Tertile 3; 129–208 (*N*=698)	*p* for trend
Age (year)	52.4 (2.9)	52.7 (3.0)	53.1 (3.1)	<.001	51.4 (2.4)	51.7 (2.7)	52.1 (2.8)	<.001
Men (%)	39.9	51.2	62.6	<.001	29.2	42.7	54.9	<.001
Body mass index (kg/m^2)	22.1 (3.0)	23.3 (3.3)	24.5 (3.6)	<.001	21.8 (3.1)	23.2 (3.4)	25.0 (4.0)	<.001
Antihypertensive medications (%)	6.7	15.7	26.5	<.001	5.6	15.2	24.9	<.001
Diabetes[a] (%)	4.4	6.7	11.8	<.001	3.6	6.5	11.8	<.001
Hyperlipidemia[b] (%)	38.7	46.9	45.3	<.001	31.7	38.6	42.1	<.001
Current smoking habits (%)	24.7	27.0	25.8	0.35	20.9	22.2	21.9	0.45
Alcohol intake								
No (%)	52.6	41.8	36.9	<.001	56.2	47.0	41.4	<.001
Occasional (%)	23.0	26.2	24.8	0.40	24.1	28.5	27.4	0.19
Everyday (%)	24.5	32.0	38.3	<.001	19.7	24.5	31.2	<.001
Exercise habits[c] (%)	13.1	17.4	18.3	0.01	14.0	16.7	18.8	0.05

Figures represent mean (standard deviation) or proportion

[a] Serum glucose level ≥126 mg/dL or the use of antidiabetic medications

[b] Serum low-density lipoprotein cholesterol level ≥140 mg/dL or the use of antihyperlipidemic medications

[c] Once or more per week

TABLE 2. *Effects of variables in the generalized linear mixed model on hearing threshold at 1 kHz and 4 kHz*

Frequency	Analysis at 1 kHz (*N*=5,479)				Analysis at 4 kHz (*N*=2,045)			
	Parameter estimates (95% CI)		Standard error	*p*-value	Parameter estimates (95% CI)		Standard error	*p*-value
Age- and sex-adjusted model								
Intercept	30.0	(29.9 to 30.2)	0.1	<.001	30.6	(30.0 to 31.2)	0.3	<.001
SBP (mmHg)	-0.0005	(-0.0020 to 0.0010)	0.0007	0.50	-0.0039	(-0.0084 to 0.0007)	0.0023	0.09
Year	-0.046	(-0.084 to -0.008)	0.019	0.02	-0.39	(-0.57 to -0.21)	0.09	<.001
SBP (mmHg) * Year	0.00078	(0.00047 to 0.00108)	0.00016	<.001	0.0045	(0.0030 to 0.0059)	0.0007	<.001
Multivariable model[a,b]								
Intercept	30.1	(29.9 to 30.3)	0.1	<.001	30.4	(29.8 to 31.0)	0.3	<.001
SBP (mmHg)	-0.0009	(-0.0024 to 0.0007)	0.0008	0.28	-0.0045	(-0.0093 to 0.0003)	0.0024	0.06
Year	-0.047	(-0.085 to -0.009)	0.019	0.02	-0.37	(-0.55 to -0.19)	0.09	<.001
SBP (mmHg) * Year	0.00080	(0.00049 to 0.00110)	0.00016	<.001	0.0042	(0.0028 to 0.0057)	0.0007	<.001

CI, confidence interval; SBP, systolic blood pressure

[a] Adjusted for age, sex, body mass index, antihypertensive medications, diabetes mellitus, hyperlipidemia, current smoking habits, alcohol intake, and exercise habits

[b] Average number of all imputed datasets under fully conditional specifications

Supplemental Digital Content

Article Title

Systolic Blood Pressure and Objective Hearing Thresholds Among Japanese Middle-Aged Adults: A Facility-Based Retrospective Cohort Study

Journal Name

Otology & Neurotology

Authors

Blinded

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METHODS

Study Design

This facility-based retrospective cohort study was conducted using data from medical records at the health checkup department of [Author's institution]. This facility performs health screening for noncommunicable diseases among contractual company workers (86%), staff from [Author's institution] and affiliated nursing facilities (11%), and private individuals (3%) based on Japanese law and individual preference. Health screenings for hearing impairment (HI) is common in Japan even for individuals without a history of noise exposure.

The study protocol and use of existing data were approved by the ethics committee of [Author's institution] (Approval Number: 2019-5-2). It was performed in accordance with the ethical standards of the 1964 Declaration of Helsinki and its later amendments. The participants were allowed to drop out of the study via the hospital's website.

Participants

The participants were aged 50–59 years and underwent audiometry evaluation two times or more during health checkups at [Author's institution] between April 2007 and March 2020. Baseline was defined as the first examination for each participant. A total of 5,895 individuals were included in the target age group. For the analysis, 5,479 and 2,045 individuals were finally included after excluding individuals with a hearing threshold of >30 dB at 1 kHz (N=416) and 4 kHz (N=3,850) at the baseline, respectively.

Variables

We collected information about age, sex, medications for hypertension, diabetes, and hyperlipidemia, current smoking habits, alcohol intake frequency, and exercise habits once or more times per week using the baseline questionnaire standardized according to the Japanese Ministry of Health, Labour and Welfare. No information regarding ear diseases or noise exposure was available. The body mass index (BMI) was calculated as the weight in kilograms divided by height in meters squared (kg/m^2) at baseline. The participants were classified into two groups according to age (50–54 and 55–59 years) and seven groups according to BMI (<18.5, 18.5–20.9, 21.0–22.9, 23.0–24.9, 25.0–26.9, 27.0–29.9, and ≥30.0 kg/m^2).

The primary blood pressure measurements were performed with automatic sphygmomanometers

(TM-2655P; A&D Company Ltd., Toshima, Tokyo, Japan before January 27, 2016, and Kentaro HBP-9020; Omron Healthcare Co., Ltd., Muko, Kyoto, Japan after January 28, 2016) placed on the arm of the participants while in a sitting position. If the blood pressure level was high (systolic blood pressure [SBP] ≥129 mm Hg or diastolic blood pressure ≥85 mm Hg) or unreliable, the measurement was repeated or manual equipment was used, and the reading with the lowest SBP level was selected.

The hearing test was performed by well-trained nurses using pure-tone audiometry with circumaural headphones (AA-56; Rion Co., Ltd., Kokubunji, Tokyo, Japan before June 30, 2009, and AA-57; Rion Co., Ltd. after July 1, 2009) in a quiet isolated room. The hearing thresholds of the participants were evaluated at 5 dB intervals between 30 and 80 dB at 1 and 4 kHz, respectively. We used the average value of the left and right hearing thresholds. Blood pressure and hearing thresholds were measured in separate rooms, with a time difference of a few minutes.

We used the data on serum glucose and low-density lipoprotein cholesterol (LDL-C) levels at baseline. Diabetes mellitus was defined as the serum glucose level of ≥126 mg/dL and/or the use of antidiabetic medications according to the standard diagnostic criteria (1). The participants were instructed to fast before undergoing the health checkup. The HbA1c value was not used because it was not assessed during the health checkups prior to March 2012. Hyperlipidemia was defined as the serum LDL-C level of ≥140 mg/dL and/or the use of antihyperlipidemic medications according to the American guidelines (2).

There were missing values for serum glucose levels, serum low-density lipoprotein cholesterol levels, current smoking and drinking status, regular exercise, and antihypertensive medication use. The percentage of missing values across the six variables varied between 34.0 to 35.3% (out of 5,479 records), and 9.5 to 11.4% (out of 2,045 records) in the analysis at 1 and 4 kHz, respectively. A total of 1,992 (36.4%) and 247 (12.1%) records were incomplete, respectively. A compact display of patterns of missingness with covariates is presented in Tables S1 and S2 for the analysis at 1 kHz and 4 kHz, respectively.

Statistical Analysis

The baseline characteristics of the participants according to their SBP were presented as the mean values of continuous variables and proportions of categorical variables. A trend test using general linear and logistic regression analysis was performed to compare the baseline variables and proportions according to SBP.

A multivariable generalized linear mixed model was constructed to evaluate the effects of SBP on repeated measures of hearing threshold with first-order autoregressive modeling. We constructed an age- and sex-adjusted and a multivariable model to adjust for the variables based on the risk factors of HI reported before (3). The multivariable model was adjusted for age (50–54 and 55–59 years), sex, BMI (<18.5, 18.5–20.9, 21.0–22.9, 23.0–24.9, 25.0–26.9, 27.0–29.9, and ≥30.0 kg/m^2), antihypertensive medications (no, yes), diabetes (no, yes), hyperlipidemia (no, yes), current smoking habits (no, yes), alcohol intake (no, occasional, everyday), and exercise habits once or more times per week (no, yes).

The missing values of the covariates at baseline were processed using multiple imputation methods. Incomplete variables were imputed under fully conditional specification (FCS) that could handle missing categorical data (4). Multiple regression model included parameters of exposure (SBP), adjusted variables, and auxiliary variables (cohort enrollment year and type of participants [contractual workers of companies, staff of [Author's institution] and the affiliated facilities, and private individuals]). There were more missing data among participants who enrolled earlier and were staff of [Author's institution] (including the affiliated nursing facilities); therefore, we added these variables to the regression models for multiple imputation. The results across 100 imputed datasets were combined by taking the average (5), and standard errors were adjusted to reflect both within-imputation variability and between-imputation variability, according to Rubin's rule (6).

In addition, an alternative modeling strategy, Markov chain Monte Carlo (MCMC), was conducted (7), and the results were compared with those obtained from the FCS method. When using the MCMC method, we rounded the continuous imputations to the nearest allowed integer values.

Two-tailed *p*-values were obtained from the statistical analysis, with a *p*-value <0.05 considered as statistically significant. All analyses were conducted using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

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TABLE S1. *A compact display of patterns of missingness with covariates among participants in the analysis at 1 kHz*

Number of participants (*N*=5,479)	Antihypertensive medications	Diabetes	Hyperlipidemia	Current smoking habits	Alcohol intake	Exercise habits
3,487	X	X	X	X	X	X
10	X	X	X	X	X	
60	X	X	X	X		X
4	X	X	X	X		
1	X	X	X		X	X
1	X	X		X	X	X
6	X		X	X	X	X
38	X			X	X	X
10	X					
1			X			
2				X	X	
1,859						

An "X" indicates the presence of data, and a blank indicates missing data.

TABLE S2. *A compact display of patterns of missingness with covariates among participants in the analysis at 4 kHz*

Number of participants (*N*=2,045)	Antihypertensive medications	Diabetes	Hyperlipidemia	Current smoking habits	Alcohol intake	Exercise habits
1,798	X	X	X	X	X	X
4	X	X	X	X	X	
9	X	X	X	X		X
1	X	X		X	X	X
2	X		X	X	X	X
28	X			X	X	X
9	X					
2				X	X	
192						

An "X" indicates the presence of data, and a blank indicates missing data.

TABLE S3. *Effects of variables in the generalized linear mixed model on hearing threshold at 1 kHz and 4 kHz under fully conditional specification (FCS) and Markov chain Monte Carlo (MCMC) to impute missing variables*

Frequency	Analysis at 1 kHz (*N*=5,479)				Analysis at 4 kHz (*N*=2,045)			
	Parameter estimates (95% CI)		Standard error	*p*-value	Parameter estimates (95% CI)		Standard error	*p*-value
Age- and sex-adjusted model								
Intercept	30.0	(29.9 to 30.2)	0.1	<.001	30.6	(30.0 to 31.2)	0.3	<.001
SBP (mmHg)	-0.0005	(-0.0020 to 0.0010)	0.0007	0.50	-0.0039	(-0.0084 to 0.0007)	0.0023	0.09
Year	-0.046	(-0.084 to -0.008)	0.019	0.02	-0.39	(-0.57 to -0.21)	0.09	<.001
SBP (mmHg) * Year	0.00078	(0.00047 to 0.00108)	0.00016	<.001	0.0045	(0.0030 to 0.0059)	0.0007	<.001
Multivariable model under FCS[a]								
Intercept	30.1	(29.9 to 30.3)	0.1	<.001	30.4	(29.8 to 31.0)	0.3	<.001
SBP (mmHg)	-0.0009	(-0.0024 to 0.0007)	0.0008	0.28	-0.0045	(-0.0093 to 0.0003)	0.0024	0.06
Year	-0.047	(-0.085 to -0.009)	0.019	0.02	-0.37	(-0.55 to -0.19)	0.09	<.001
SBP (mmHg) * Year	0.00080	(0.00049 to 0.00110)	0.00016	<.001	0.0042	(0.0028 to 0.0057)	0.0007	<.001
Multivariable model under MCMC[a]								
Intercept	30.1	(29.9 to 30.3)	0.1	<.001	30.4	(29.8 to 31.0)	0.3	<.001
SBP (mmHg)	-0.0008	(-0.0024 to 0.0007)	0.0008	0.28	-0.0043	(-0.0091 to 0.0005)	0.0024	0.08
Year	-0.047	(-0.085 to -0.009)	0.019	0.02	-0.38	(-0.56 to -0.20)	0.09	<.001
SBP (mmHg) * Year	0.00080	(0.00049 to 0.00110)	0.00016	<.001	0.0044	(0.0029 to 0.0058)	0.0007	<.001

CI, confidence interval; FCS, fully conditional specification; MCMC, Markov chain Monte Carlo; SBP, systolic blood pressure

[a] Adjusted for age, sex, body mass index, antihypertensive medications, diabetes mellitus, hyperlipidemia, current smoking habits, alcohol intake, and exercise habits