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Association of Household Income and Education With Prevalence of Hearing Impairment in Japan

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Objectives/Hypothesis: Epidemiological information regarding the relationship between household income and education and hearing impairment (HI) is limited. The present cross-sectional study investigated this issue in Japan.

Study Design: Cross-sectional investigation.

Methods: Study subjects were 371 men and 639 women aged 36 to 84 years. A self-administered questionnaire was used. Audiological assessment was performed by pure-tone audiometry. HI was defined as present in subjects who did not respond to a pure-tone average of >25 dB HL in the better hearing ear according to the World Health Organization standard. Adjustment was made for age, smoking status, alcohol consumption, hypertension, dyslipidemia, diabetes mellitus, and body mass index.

Results: The prevalence of HI was 31.5% in 371 men and 20.8% in 639 women. In men, a slight inverted J-shaped association was observed between household income and HI, compared with a household income of <3 million yen per year. A household income of 3 to 5 million yen, but not of 5 million yen or more, was independently inversely associated with the prevalence of HI; the prevalence ratio for 3 to 5 million yen was 0.73 (95% confidence interval: 0.54-0.999). After adjustment for confounding factors, no relationship was found between household income and the prevalence of HI in women. There were no associations between educational level and the prevalence of HI in either men or women in the multivariate model.

Conclusions: Our results suggest that medium, but not high, household income may be associated with a lower prevalence of HI only in men.

Key Words: Education, hearing loss, household income, Japanese.

Level of Evidence: 2b

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INTRODUCTION

Hearing is one of the most important communication tools but is well known to deteriorate gradually with aging. Age-related hearing loss, also known as presbycusis, is a common problem facing middle-aged and older adults, affecting tens of millions of people worldwide.1 With the aging of the world’s population, the prevalence of hearing impairment (HI) is likely to increase. HI can have negative effects on quality of life by impairing communication and can cause social isolation.2–4 Prevention of HI is an important element of public health, and accordingly, it is essential to identify risk and preventive factors for HI.

Epidemiological evidence regarding the relationship between household income and HI has been reported5–11; however, few of these studies were conducted in Asian countries.10,11 Epidemiological evidence regarding the relationship between educational level and HI has been limited, and studies have yielded inconsistent findings.5–15 No previous study has examined such relationships in Japan. Here, we cross-sectionally investigated the associations of household income and educational level with HI in a Japanese population using baseline data from the Aidai Cohort Study (AICOS) conducted in Yawatahama and Uchiko, Japan.

MATERIALS AND METHODS

Study Population

The baseline survey of the AICOS was initiated in the city of Yawatahama, Japan in 2015, and in the town of Uchiko, Japan in...
2016, and is still ongoing; the present study is restricted to data collected in Yawatahama and Uchiko. Yawatahama and Uchiko, with total populations of nearly 36,000 and 17,000, respectively, are two of the 20 municipalities in Ehime Prefecture on Shikoku Island, which is located south of Japan’s main island. There were 616 and 266 participants who received health checkups conducted by the city of Yawatahama in 2015 and town of Uchiko in 2016, respectively. After being recruited through one of several alternate recruiting processes, 182 and 81 additional individuals participated in the baseline survey conducted in Yawatahama in 2015 and Uchiko in 2016, respectively. In total, 1145 participants aged 36 to 84 years (419 men aged 36−84 years and 726 women aged 37−79 years) in 2015 and 2016 gave their written informed consent and completed a baseline questionnaire. Missing or incomplete data on the variables under study or the audiometric hearing assessment caused the exclusion of 118 participants. Also, 17 participants with an asymmetrical hearing threshold defined as a between-ear difference of pure-tone average (PTA) >20 dB HL were excluded to exclude subjects with otologic disease as much as possible. There were, therefore, 371 men and 639 women eligible for analysis. The AICOS was approved by the ethics committee of the Ehime University Graduate School of Medicine.

**Measurements**

A self-administered questionnaire elicited information on smoking habits; drinking habits; current use of antihypertensive, cholesterol-lowering, and diabetic medications; household income, and education. Blood pressure was measured twice with a cuff in the sitting position after a rest period of greater than 5 minutes; the value recorded in the second measurement was adopted for the present study. Hypertension was defined as systolic blood pressure ≥140 mm Hg, diastolic blood pressure ≥90 mm Hg, or current use of antihypertensive medication. Blood samples were collected from an antecubital vein after an overnight fast ≥12 hours. Serum low-density cholesterol; high-density lipoprotein cholesterol; triglyceride and plasma glucose concentrations; and hemoglobin A1C levels were determined at an external laboratory (Shikoku Chuken, Matsuyama, Japan). Dyslipidemia was defined as a serum low-density lipoprotein cholesterol concentration ≥140 mg/dL, high-density lipoprotein (HDL) cholesterol concentration < 40 mg/dL, triglyceride concentration ≥150 mg/dL, or current use of cholesterol-lowering medication. Diabetes mellitus was defined as a fasting plasma glucose level ≥126 mg/dL, hemoglobin A1C level ≥6.5%, or current use of diabetic medication. Height and weight were measured with the subject in light clothes without

<table>
<thead>
<tr>
<th>TABLE I.</th>
<th>Characteristics According to Household Income and Education.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Household Income (Million Japanese Yen/Year)*</td>
</tr>
<tr>
<td>Overall</td>
<td>&lt;3</td>
</tr>
<tr>
<td>Men, n = 371</td>
<td></td>
</tr>
<tr>
<td>Age, yr, mean</td>
<td>61.4</td>
</tr>
<tr>
<td>Smoking status, %</td>
<td>33</td>
</tr>
<tr>
<td>Never</td>
<td>30.5</td>
</tr>
<tr>
<td>Former</td>
<td>54.2</td>
</tr>
<tr>
<td>Current</td>
<td>15.4</td>
</tr>
<tr>
<td>Alcohol consumption, %</td>
<td>.01</td>
</tr>
<tr>
<td>Never</td>
<td>15.1</td>
</tr>
<tr>
<td>Former</td>
<td>7.6</td>
</tr>
<tr>
<td>Current</td>
<td>77.4</td>
</tr>
<tr>
<td>Hypertension</td>
<td>56.6</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>51.8</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>8.9</td>
</tr>
<tr>
<td>Body mass index, kg/m², mean</td>
<td>24.0</td>
</tr>
<tr>
<td>Women, n = 639</td>
<td></td>
</tr>
<tr>
<td>Age, yr, mean</td>
<td>60.5</td>
</tr>
<tr>
<td>Smoking status, %</td>
<td>.19</td>
</tr>
<tr>
<td>Never</td>
<td>91.2</td>
</tr>
<tr>
<td>Former</td>
<td>6.1</td>
</tr>
<tr>
<td>Current</td>
<td>2.7</td>
</tr>
<tr>
<td>Alcohol consumption, %</td>
<td>.03</td>
</tr>
<tr>
<td>Never</td>
<td>55.6</td>
</tr>
<tr>
<td>Former</td>
<td>5.6</td>
</tr>
<tr>
<td>Current</td>
<td>38.8</td>
</tr>
<tr>
<td>Hypertension</td>
<td>37.4</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>57.4</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>5.5</td>
</tr>
<tr>
<td>Body mass index, kg/m², mean</td>
<td>22.6</td>
</tr>
</tbody>
</table>

*US $1 = 112 yen.
† Low: junior high school; medium: high school; high: junior college, vocational technical school or university.
‡ For continuous variables, a linear trend test was used; for categorical variables, a Mantel-Haenszel χ² test was used.

shoes. Body mass index (BMI) was calculated by dividing body weight (in kilograms) by the square of height (in meters).

Assessment of HI

Audiometric hearing assessment was performed in the form of air-conduction threshold testing with a pure-tone audiometer (AA-75; Rion, Tokyo, Japan) calibrated according to Japanese Industrial Standards T 1201. Air conduction thresholds were obtained at octave frequencies from 0.125 to 8 kHz using a manual testing protocol. Testing was performed in a quiet office using headphones. We used the audiometric definition of hearing loss adopted by the World Health Organization, which identifies the speech-frequency PTA hearing thresholds at 0.5, 1, 2, and 4 kHz tones. HI was defined as present when PTA was >25 dB HL in the better-hearing ear.

Statistical Analysis

Age, smoking status, alcohol consumption, hypertension, dyslipidemia, diabetes mellitus, and BMI were selected a priori as potential confounding factors. Household income was classified into three categories (<3, 3–5, and >5 million yen per year), education into three categories (low [junior high school], medium [high school], and high [junior college, vocational technical school, or university]), smoking into three categories (never, former, and current), and alcohol consumption into three categories (never, former, and current). Age and BMI were adjusted for as continuous variables. Poisson regression with a robust variance was used to calculate crude and BMI were adjusted for as continuous variables. Poisson regression with a robust variance was used to calculate crude

RESULTS

The prevalence of HI was 31.5% in 371 men and 20.8% in 639 women. Table I shows the distribution of selected factors among the 371 men and 639 women. Mean age was 61.4 years in men and 60.5 in women. Among the 371 men, household income was positively associated with alcohol consumption and inversely with age, hypertension, and diabetes mellitus. Educational level was inversely related to age and hypertension. Among the 639 women, household income and educational level were positively associated with alcohol consumption and inversely with age, hypertension, and dyslipidemia. There was also an inverse relationship between education and BMI.

Table II shows crude and adjusted PRs and 95% CIs for HI in relation to household income and education. Compared with household income <3 million yen per year, both household income of 3 to 5 and household income >5 million yen were significantly associated with a lower prevalence of HI in men. After adjustment for age, smoking status, alcohol consumption, hypertension, dyslipidemia, diabetes mellitus, and BMI, we found a slight inverted J-shaped association between household income and HI in men, although the quadratic trend fell just short of the significance level ($P = .08$ for quadratic trend). Household income of 3 to 5 million yen was independently inversely associated with the prevalence of HI, although the inverse relationship between a household income of >5 million yen and the prevalence of HI was not statistically significant: the adjusted PR was 0.73 (95% CI: 0.54-0.999) for 3 to 5 million yen and 0.91 (95% CI: 0.64-1.30) for >5 million yen. In women, a significant inverse association was found between a household income of >5 million yen, but not 3 to 5 million yen, and the prevalence of HI in crude analysis; however, this inverse association completely disappeared after adjustment for confounding factors. Likewise, after allowance for confounding factors, there were no associations between educational level and the prevalence of HI in either men or women, although significant associations were found in crude analysis.

DISCUSSION

To our knowledge, this is the first study to report that, compared with low household income, medium, but not high, household income was independently related to

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HI only in men. This is also the first study in a Japanese population to examine the association between educational level, household income, and HI.

In a Chinese cross-sectional study of 25,860 working-aged adults (12,804 men and 13,056 women) aged 25 to 59 years, lower education was associated with a higher prevalence of HI; however, income was not associated with HI. Both income and education were inversely associated with the prevalence of HI in a South Korean cross-sectional study of 7,434 subjects (3,214 men and 4,220 women) aged ≥40 years. In a cross-sectional study in England among 3,292 subjects (1,485 men and 1,807 women) aged ≥45 years, both lower income and lower education were associated with a higher prevalence of HI in men, but not in women. Similar associations were seen in a US cross-sectional study of 3,379 subjects (1,585 men and 1,794 women) aged 20 to 69 years, in a cross-sectional study conducted in Canada among 2,972 subjects (1,483 men and 1,489 women) aged 20 to 79 years, in a Brazilian cross-sectional study of 2,254 subjects (1,216 men and 1,038 women) aged ≥4 years, and in a US cross-sectional study of 16,415 Hispanics/Latinos (6,301 men and 9,415 women) aged 18 to 74 years. In a US prospective cohort study, significant inverse associations were observed between education and the risk of HI both among 3,753 adults aged 48 to 92 years at baseline using 10 years of follow-up data and among 1,925 subjects aged 43 to 84 years at baseline using 15 years of follow-up data. In an Australian prospective cohort study of 3,526 subjects (1,633 men and 1,893 women) aged ≥50 years, low education was cross-sectionally positively associated with baseline levels of hearing but was not longitudinally related to change in hearing thresholds. Education was significantly inversely associated with low-frequency HI only in women and with high-frequency HI only in men in a Dutch cross-sectional study of 3,135 subjects (1,376 men and 1,759 women) aged 52 to 99 years. Our results are at variance with these findings.

We have no immediate explanation for the observed inverse association between middle household income and HI in the present study. The relationship between household income and education level and health outcomes observed in Japan may differ from that observed in Western countries. For example, a positive association was found between household income and BMI in a study based on 19 years of longitudinal data from a national sample of 4,869 Japanese aged 60 years and older. On the other hand, there was a significant inverse relationship between income and current smoking in a cross-sectional study in Japan using a nationally representative sample (20,206 men and 21,093 women aged 18 to 54 years). Given the positive associations of both BMI and current smoking with HI in Western studies, the present results regarding the inverse relationship between middle household income and HI might be reasonable. A prospective study of 20,543 Japanese women aged 40 to 59 years found U-shaped associations between educational level and the risk of total stroke, subarachnoid hemorrhage, and ischemic stroke, whereas no association was shown between educational level and the risk of coronary heart disease or intraparenchymal hemorrhage. Alternatively, the current results might be simply a chance phenomenon.

The present study had methodological advantages in that participants were homogeneous regarding their residential area, and that the definition of HI adopted by the World Health Organization was used. However, there are several limitations in the present study; among these is the fact that the nature of cross-sectional studies prevents conclusions from being drawn about causality. In addition, the participation rate could not be calculated because the exact number of eligible subjects was not available; however, the participation rate must have been low. Our subjects were probably not representative of the Japanese general population. The educational levels of our subjects were higher than those of the general population. According to a population census conducted in 2010 in Ehime Prefecture, the proportions of men aged 60 to 69 years with low, medium, and high educational levels and an unknown educational level were 28.2%, 48.5%, 19.9%, and 4.2%, respectively. The corresponding figures among men aged 60 to 69 years in the present study were 10.8%, 54.5%, 34.7%, and 0.0%, respectively. The proportions of women aged 60 to 69 years in 2010 in Ehime Prefecture with low, medium, and high educational levels and an unknown educational level were 26.7%, 56.4%, 12.9%, and 4.0%, respectively. The corresponding figures among women aged 60 to 69 years in the present study were 10.0%, 58.2%, 31.8%, and 0.0%, respectively. The present population, therefore, might have had a greater awareness regarding health issues than did the general population.

The present study did not involve the observation of the tympanic membrane or ear canal, and there was also no assessment of conductive hearing loss. The possibility thus remains that the subjects included individuals with conductive hearing loss such as that caused by bilateral otitis media. In addition, this study did not assess the effect of noise exposure that might cause noise-related hearing loss. The possibility of nondifferential outcome misclassification might have biased the magnitude of the observed associations toward the null.

The number of study subjects was rather small, especially in men; however, a significant association was detected. The nonsignificant association between high household income and HI, as well as the lack of the relationship between education and HI, might be attributable to insufficient statistical power. Although we adjusted for several confounding factors, residual confounding effects could not be ruled out.

**CONCLUSION**

The current cross-sectional study in Japan suggests that medium, but not high, household income is independently associated with the prevalence of HI in men. In women, no association was found between household income and HI. There was no association between education and HI regardless of sex. Further research on the relationship between socioeconomic status and HI, especially in Asian countries, is needed to confirm the present findings.
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