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Self-reported hearing and vision impairment and incident frailty in Japanese older people: A 3-year longitudinal analysis of the Japan Gerontological Evaluation Study

Kenjiro Kawaguchi [a,*], Noriyuki Abe [a], Yoshimune Hiratsuka [b], Kaori Kojima [c], Katsunori Kondo [a,d]

[a] Department of Social Preventive Medical Sciences, Center for Preventive Medical Sciences, Chiba University, 1-33 Yayoicho, Inage-ku, Chiba, Chiba 263–8522, Japan
[b] Department of Ophthalmology, Juntendo University Graduate School of Medicine, Tokyo 113–8431, Japan
[c] Medical Sciences Graduate School, Hamamatsu University School of Medicine, Shizuoka 431–3192, Japan
[d] Department of Geriatric Evaluation, Center for Gerontology and Social Science, National Center for Geriatrics and Gerontology, Aichi 474–8511, Japan

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ABSTRACT

Background: We examined the associations and interactions of hearing impairment (HI) and vision impairment (VI) with frailty.
Methods: We performed a 3-year longitudinal analysis of the Japan Gerontological Evaluation Study (JAGES), a nationwide prospective cohort study of functionally independent Japanese older people (age ≥ 65 years). Frailty status at baseline and follow-up was defined according to the Kihon Checklist. HI and VI at baseline were self-reported. Logistic regression models were used to examine the main and interaction effects of HI and VI on incident frailty during a 3-year follow-up period.
Results: Of the 7,852 participants (mean age 73.2 years, standard deviation 5.6; 50.7% women), 9.7%, 5.3%, and 1.9% reported HI, VI, and concurrent HI and VI, respectively. After adjusting for possible confounders and the other sensory impairment, VI (odds ratio [OR] 2.50, 95% confidence interval [CI] 1.62–3.85, $p < 0.001$), but not HI (OR 1.29, 95% CI 0.97–1.72, $p = 0.081$), was significantly associated with incident combined pre-frailty and frailty from a robust baseline. No interaction was observed between HI and VI (OR 0.83, 95% CI 0.38–1.81, $p = 0.636$). We observed no significant associations between sensory impairments and incident frailty from a pre-frail baseline (HI: OR 1.26, 95% CI 0.88–1.80, $p = 0.205$; VI: OR 1.44, 95% CI 0.90–2.31, $p = 0.127$; interaction between HI and VI: OR 1.16, 95% CI 0.53–2.53, $p = 0.718$).
Conclusions: VI, rather than HI, may be an independent risk factor for frailty, without any interaction between the two.

1. Introduction

Frailty is defined as a geriatric syndrome that is caused by a decline in physiological systems and results in an increased vulnerability to external stressors (Clegg et al., 2013; World Health Organization, 2015). Frail older people are at a higher risk for adverse health outcomes, such as falls, hospitalization, institutionalization, and mortality (Cheng & Chang, 2017; Chu et al., 2021; Kojima et al., 2018). Furthermore, frailty is recognized as an intermediate state between robustness and disability as well as a reversible state when effective interventions are undertaken (Apóstolo et al., 2018; Puts et al., 2017). Preventing and delaying the onset of frailty by interventions aimed at potentially modifiable risk factors is a key public health concern, as frailty imposes burdens on individuals and society (Shinkai et al., 2016).

With the increasing lifespan and population aging, a growing number of people have sensory impairments. Worldwide, more than 1.5 billion people have some type of hearing impairment (HI), and more than 65% of people aged ≥ 60 years have HI (World Health Organization, 2021). In contrast, at least 2.2 billion people suffer from near or distance vision impairment (VI), and people aged ≥ 50 years comprise

Abbreviations: ADL, activities of daily living; CI, confidence interval; ELSA, English Longitudinal Study of Ageing; HI, hearing impairment; JAGES, Japan Gerontological Evaluation Study; KCL, Kihon Checklist; OR, odds ratio; SE, standard error; VI, vision impairment.

* Corresponding author.
E-mail address: kawaguchikenjiro@chiba-u.jp (K. Kawaguchi).

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70–80% of individuals with VI (World Health Organization, 2019). Both HI and VI are increasingly recognized as crucial modifiable risk factors for frailty among older people. According to meta-analyses, HI (Tan et al., 2020; Tian et al., 2021) and VI (Tan et al., 2020) increase the odds of older people developing frailty.

Concurrent HI and VI are common among older people. More than 10% of adults aged $\geq$ 80 years have both HI and VI (Swenor et al., 2013), which are considered to comprise several common underlying pathways to frailty, such as depression (Cosh et al., 2018; Li et al., 2014), social isolation (Brunes et al., 2019; Shukla et al., 2020), and reduced physical activity (Martinez-Amezcua et al., 2022; Ong et al., 2018). Thus, concurrent HI and VI may be more strongly associated with incident frailty than either HI or VI alone. However, the few earlier studies conducted on this topic investigated the relationship between HI and VI cross-sectionally (Buttery et al., 2015; Eyigor et al., 2015; Herr et al., 2018; Ng et al., 2014). Furthermore, to our knowledge, no longitudinal studies have investigated concurrent HI and VI with regard to incident frailty. Therefore, it remains unclear whether individuals who have both HI and VI are at a greater risk of frailty than those who have either HI or VI alone, or whether concurrent HI and VI induce a synergistic effect on incident frailty. A clear understanding of the risks posed by sensory impairment for the development of frailty is crucial for the design of effective interventional strategies to reduce the frailty burden in older people.

This study examined the associations of HI and VI with incident frailty over 3 years. Specifically, we investigated whether: (1) HI and VI were independent risk factors after adjusting for one another and other possible confounders, and (2) a significant interaction of HI and VI on frailty was observable.

2. Material and methods

2.1. Data sources

This study involved a secondary analysis of data from the Japan Gerontological Evaluation Study (JAGES) (Kondo & Rosenberg, 2018), a longitudinal nationwide cohort study that aims to investigate health, social, and behavioral issues among noninstitutionalized Japanese older people. Approximately every three years since 2003, surveys on health behaviors, psychological factors, and a wide range of socioeconomic factors have been conducted of older people aged 65 years or older without any long-term care need certification under the Japanese Long-Term Care Insurance. In this study, we used data from the 2016 and 2019 waves for the baseline and outcome analyses, respectively.

2.2. Participants

The baseline survey was conducted between October 2016 and January 2017. Self-reported questionnaires were mailed to 279,661 functionally independent older people aged 65 years or older without a long-term care need certification, and 196,438 adults responded to the questionnaire (response rate: 70.2%). The survey questionnaire comprised the core questions and one of eight modules with various thematic questions based on the researchers' interests (Fig. A1) (Kondo & Rosenberg, 2018). The one module included the questions about eyesight and hearing and was randomly distributed to one-eighth of the target cohort (34,571 of 279,661 individuals), of whom 24,313 individuals answered the questionnaires (response rate: 70.3%). A follow-up survey was conducted between November 2019 and January 2020. Of the 24,313 respondents to the baseline survey, 9345 replied to the follow-up survey questionnaire. In our analysis, we included the baseline questionnaire respondents who were subsequently censored during the follow-up period because of death ($n = 577$) or certification of long-term care requirement ($n = 1206$). Thus, 10,752 individuals were eligible for our analysis (follow-up rate: 48.2%). We excluded individuals with invalid information on age ($n = 12$) as well as those with dependence for activities of daily living (ADL; $n = 537$) or frailty ($n = 2351$) at baseline. Consequently, 7852 of the 10,752 eligible participants were included in our analysis (Fig. 1).

2.3. Frailty status

We used the Kihon Checklist (KCL) to determine frailty status at baseline and at the 3-year follow-up. The KCL was originally designed by the Japanese Ministry of Health, Labour, and Welfare to identify community-dwelling older people at higher risk of becoming disabled (Arai & Satake, 2015). However, a systematic review reported that the KCL is also a reliable tool for assessment of the frailty risk among older people (Sewo Sampaio et al., 2016). The KCL consists of 25 items and assesses seven domains of daily living functions: instrumental activities of daily living, physical strength, nutritional condition, oral, social, and cognitive functions, and depressed mood, using simple dichotomous responses (yes = 1; no = 0; total score range: 0–25, with a higher score indicating worse functioning) (Arai & Satake, 2015). Each of the seven KCL domains is related to frailty status. A systematic review, for example, indicates that oral health is an important predictor of frailty because poor oral health leads to a decrease in oral intake and physical function (Hakeem et al., 2019). According to another systematic review, depression is associated with an increase in the prevalence of frailty as a result of physical inactivity (Soysal et al., 2017).

A previous study (Satake et al., 2016) validated whether or not the total KCL score could identify frailty status defined by Fried phenotype criteria (Fried et al., 2001), the most widely accepted criteria for assessment of frailty, which consists of five items: unintentional weight loss, self-reported exhaustion, low levels of activity, weak grip strength and slow walking speed. A KCL cut-off value of 7/8 had sensitivity of 89.5% and specificity of 80.7% for determining frailty, respectively. At a KCL cut-off value of 3/4 for pre-frailty, sensitivity and specificity were 70.3% and 78.3%, respectively. Based on this study, frailty status was classified into three categories: robust (0–3 points), pre-frail (4–7 points), and frail (8–25 points).

In our study, the incidences of pre-frailty and frailty were combined as "any frailty" as there were few new-onset frailty cases during the follow-up period among participants with HI or VI at the robust baseline ($n = 21$ for HI and $n = 15$ for VI).

2.4. Disability and all-cause mortality

We included the respondents at baseline who became disabled or deceased during the follow-up period in the analytic sample to reduce the risks of selection bias and underestimation of the effects of sensory impairments on incident frailty. Because frail status is a strong predictor for disability (Kojima, 2017) and death (Kojima et al., 2018), as a sensitivity analysis, we considered the transition from a robust baseline to any level of frailty, disability, or death at follow-up ("worsening frailty"), and the transition from a pre-frail baseline to frailty, disability, or death at follow-up ("worsening pre-frailty").

Disability was defined as the initial certification of long-term care need. An individual's level of long-term care need (seven levels: Preventative Support Level 1 or 2, or Long-term Care Levels 1 through 5) is assessed by a 74-item questionnaire about ADL. This information is reviewed and finalized by the Certification Committee of Needed Long-Term Care, which comprises experts from the health, medical care, and welfare domains (Tamiya et al., 2011). Information on all-cause mortality was obtained from the administrative records. Participants who died after being certified as requiring long-term care were grouped with the deceased.

2.5. Vision and hearing impairments

We assessed VI using a single item consistent with the one used in the English Longitudinal Study of Ageing (ELSA) (Marmot et al., 2003):

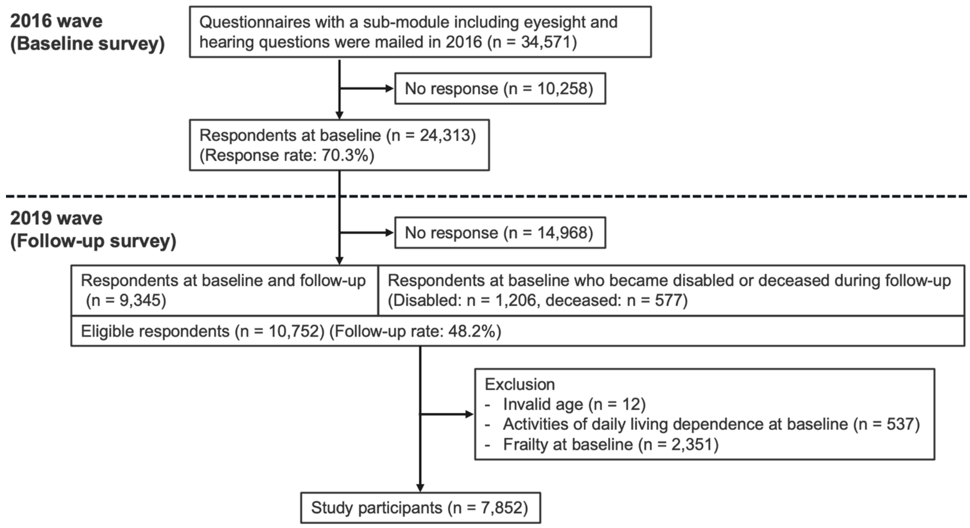

Fig. 1. Flowchart showing participation in the Japan Gerontological Evaluation Study surveys of 2016 and 2019.

"How is your eyesight? If you normally use eyeglasses, please describe your eyesight while wearing them." Moreover, HI was assessed using a single item consistent with the one used in the ELSA (Marmot et al., 2003): "How is your hearing? If you use a hearing aid, please describe your hearing ability while wearing it." Possible responses for both items were: excellent, very good, good, fair, or poor. These responses were dichotomized as indicating good vision or hearing (excellent, very good, or good) and poor vision or hearing (fair or poor). Self-reported HI and VI were previously validated by comparing functions based on objective measures (Ferrite et al., 2011; Zimdars et al., 2012).

2.6. Covariates

We considered the following 13 factors as possible confounders: age, sex, educational attainment, employment status, marital status, living arrangements, equivalized household income, drinking, smoking, and comorbidities (hypertension, stroke, heart disease, and diabetes). Participants were categorized into four subgroups, by age: 65–69, 70–74, 75–79, and $\geq$ 80 years; and three subgroups, by educational attainment: $\leq$ 9, 10–12, and $\geq$ 13 years. Employment status was dichotomized as employed or unemployed, marital status as married or single, and living arrangements as living alone or living with others. Equivalized household income was calculated by dividing the household's total income by the square root of the number of members in the household and was classified into three categories: $<$ USD20,000, USD20,000–39,999, and $\geq$ USD40,000 per year (1 USD equals 100 yen) (Mochida et al., 2018). Drinking and smoking were classified as currently smoking/drinking or not. Comorbidities were ascertained from the following self-reported medical conditions (Liljas et al., 2017): hypertension, stroke, heart disease, and diabetes.

2.7. Statistical analysis

We initially described the baseline characteristics of the participants. Next, we presented the distributions of frailty status at follow-up in robust and pre-frail participants by sensory impairments. Then, logistic regression models were used to examine associations between sensory impairments and the incidence of any frailty among robust participants and of frailty among pre-frail participants during the 3-year follow-up period. We first calculated crude odds ratios (ORs) and 95% confidence intervals (95% CIs). We then estimated ORs with 95% CIs after adjusting for all possible confounders. We used four models to systematically examine the associations between sensory impairments and frailty. We examined associations between HI and incident pre-frailty and/or frailty without considering VI (Model 1), and vice versa (Model 2). In Model 3, we considered the HI and VI variables simultaneously to test whether each sensory impairment was independently associated with frailty. Additionally, we added a product term of HI and VI in Model 3 to test whether associations between one sensory impairment and frailty were modified by another (Model 4).

In a sensitivity analysis, we examined the associations between sensory impairments and frailty using "worsening robustness" and "worsening pre-frailty" as outcome measures.

The proportions of missing values across all variables varied from 0% to 15.1% (household income). A total of 1868 (23.8%) participants were missing data. We performed multiple imputation by chained equations to impute incomplete variables and created 20 imputed datasets. We obtained the estimates and standard errors (SEs) in each imputed dataset separately using logistic regression analyses and combined them by applying Rubin's rules (Rubin, 1996).

Statistical analysis was performed using Stata/SE 16.0 (StataCorp, College Station, TX, USA). All p-values were two-sided, and a 0.05 threshold of statistical significance was used.

This study was approved by the Ethics Committee of the National Center for Geriatrics and Gerontology (No. 992) and the Ethics Committee of Chiba University (No. 2493). Informed consent was obtained by requiring all respondents to select an acceptance checkbox on the questionnaire before returning it.

3. Results

Table 1 shows the baseline characteristics of the participants, with a mean age of 73.2 years (standard deviation 5.6); 50.7% were women. Among 7852 participants, 5464 (69.6%) were robust and 2388 (30.4%) were pre-frail at baseline. The prevalences of HI, VI, and the concurrence of HI and VI were 9.7% ($n = 730$), 5.3% ($n = 400$), and 1.9% ($n = 146$), respectively. Regarding a sample of the respondents excluded owing to their frail status at baseline ($n = 2351$), the prevalences of HI, VI, and the concurrence of HI and VI were 18.6% ($n = 437$), 13.8% ($n = 325$), and 6.6% ($n = 155$), respectively.

Participants with HI and/or VI were more likely than those without HI and/or VI to develop any frailty from robustness (HI: 30.8% vs. 21.5%, VI: 40.5% vs. 21.4%, HI and VI: 44.2% vs. 21.8%) and frailty from pre-frailty (HI: 23.6% vs. 17.4%, VI: 24.2% vs. 17.7%, HI and VI: 27.4% vs. 18.0%; Fig. 2A, 2B).

Figs. 3 and 4 depict the results of logistic regression analyses of the associations between sensory impairments and incident pre-frailty and/or frailty. Compared with participants who reported no HI or VI, those

Table 1
Characteristics of the study participants who were robust or pre-frail at baseline ($N = 7852$).

Variable	Category	Total, n (%)
Age (years)	65–69	2586 (32.9)
	70–74	2321 (29.6)
	75–79	1776 (22.6)
	≥80	1169 (14.9)
Sex	Female	3983 (50.7)
Educational attainment (years)	≤9	1903 (24.3)
	10–12	3486 (44.5)
	≥13	2451 (31.3)
Employment status	Unemployed	5434 (71.5)
	Employed	2162 (28.5)
Marital status	Single	1812 (23.1)
	Married	6040 (76.9)
Living arrangement	Living alone	1070 (13.6)
	Living with others	6782 (86.4)
Equivalized income (USD per year)	<20,000	2849 (42.8)
	20,000–39,999	2977 (44.7)
	≥40,000	838 (12.6)
Drinking	Yes	3245 (41.9)
Smoking	Yes	768 (9.8)
Hypertension	Yes	3239 (43.1)
Stroke	Yes	166 (2.2)
Heart disease	Yes	671 (8.9)
Diabetes	Yes	977 (13.0)
Hearing impairment	Yes	730 (9.7)
Vision impairment	Yes	400 (5.3)
Hearing and vision impairments	Yes	146 (1.9)
Frailty status	Robust	5464 (69.6)
	Pre-frail	2388 (30.4)

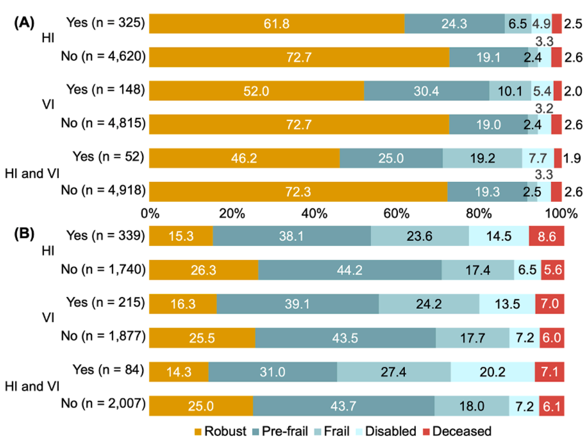

Fig. 2. Distribution of frailty status at follow-up by hearing impairment (HI) and vision impairment (VI) at the robust (A) and pre-frail (B) baseline.

who reported HI (crude: OR 1.70, 95% CI 1.32–2.18, $p < 0.001$; Model 1: OR 1.43, 95% CI 1.10–1.85, $p = 0.007$) and VI (crude: OR 2.65, 95% CI 1.88–3.74, $p < 0.001$; Model 2: OR 2.51, 95% CI 1.77–3.57, $p < 0.001$) were significantly associated with higher odds of incident any frailty from robustness. The associations of VI (Model 3: OR 2.36, 95% CI 1.65–3.39, $p < 0.001$; Model 4: OR 2.50, 95% CI 1.62–3.85, $p < 0.001$), but not HI (Model 3: OR 1.26, 95% CI 0.96–1.65, $p = 0.093$; Model 4: OR 1.29, 95% CI 0.97–1.72, $p = 0.081$), remained significant even after considering the effects of both HI and VI. We did not observe a significant interaction term between HI and VI (OR 0.83, 95% CI 0.38–1.81, $p = 0.636$).

Similar results were obtained for the relationships between sensory impairments and incident frailty from the pre-frail baseline (Fig. 4). After adjusting for confounders, the participants with HI (crude: OR 1.78, 95% CI 1.33–2.38, $p < 0.001$; Model 1: OR 1.39, 95% CI 1.02–1.89, $p = 0.037$) and VI (crude: OR 1.71, 95% CI 1.21–2.43, $p = 0.003$, Model 2: OR 1.61, 95% CI 1.11–2.33, $p = 0.011$), compared with

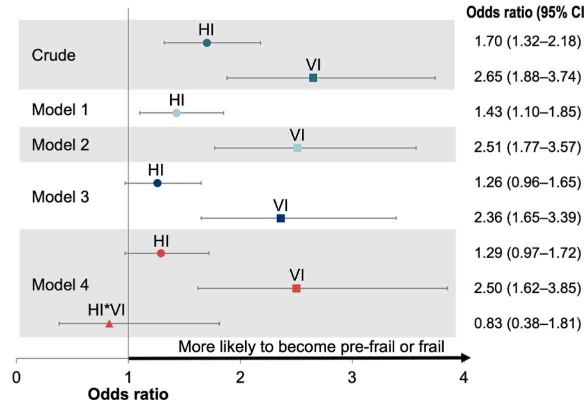

Fig. 3. Odds ratios and 95% confidence intervals (CIs) of logistic regression analysis for hearing impairment (HI) and vision impairment (VI) at the robust baseline and their interaction on the incidence of any frailty at follow-up. Models 1 and 2 included HI and VI alone, respectively. Model 3 included both HI and VI. Model 4 included HI, VI, and an interaction term between HI and VI (HI*VI). The models were adjusted for age, sex, educational attainment, employment status, marital status, living arrangement, equivalized income, drinking, smoking, hypertension, stroke, heart disease, and diabetes.

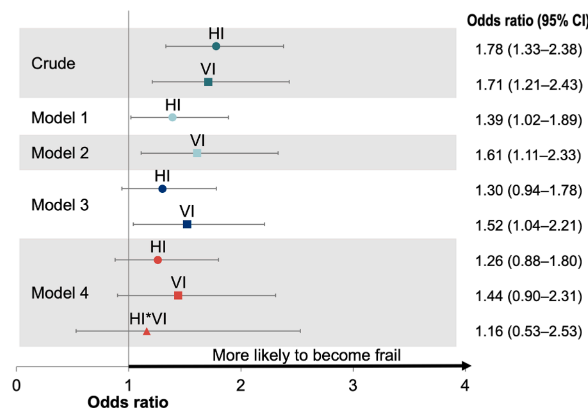

Fig. 4. Odds ratios and 95% confidence intervals (CIs) for logistic regression analysis of hearing impairment (HI) and vision impairment (VI) at the prefrail baseline and their interaction with the incidence of frailty at follow-up. Models 1 and 2 included HI and VI alone, respectively. Model 3 included both HI and VI. Model 4 included HI, VI, and an interaction term between HI and VI (HI*VI). The models were adjusted for age, sex, educational attainment, employment status, marital status, living arrangement, equivalized income, drinking, smoking, hypertension, stroke, heart disease, and diabetes.

those reporting no HI or VI, were more likely to develop frailty from a pre-frail baseline. When considering both HI and VI, the odds of incident frailty were significantly higher among the participants who reported VI (OR 1.52, 95% CI 1.04–2.21, $p = 0.031$), but not HI (OR 1.30, 95% CI 0.94–1.78, $p = 0.109$), than among those who did not report either HI or VI (Model 3). However, the relationship between frailty and VI did not remain significant in Model 4, which included the product term of HI and VI in Model 3 (HI: OR 1.26, 95% CI 0.88–1.80, $p = 0.205$; VI: OR 1.44, 95% CI 0.90–2.31, $p = 0.127$; HI*VI: OR 1.16, 95% CI 0.53–2.53, $p = 0.718$).

The results from the sensitivity analysis using worsening robustness and pre-frailty indicated the same directions as the results of the primary analysis (Tables A1 and A2). There was one notable exception: we found statistically significant association of HI with worsening pre-frailty in Model 3 (OR 1.28, 95% CI 1.01–1.72, $p = 0.043$).

4. Discussion

In this study, we examined the associations between self-reported HI and VI and the incidences of pre-frailty and frailty. To the best of our knowledge, this is the first longitudinal study to examine the associations and interactions of HI and VI with frailty and to investigate the cumulative risk of frailty in older people with concurrent HI and VI. After adjusting for possible confounders, our findings revealed that older people with VI or HI were more likely to become pre-frail and frail than those without VI or HI. However, when adjusting for another sensory impairment and possible confounders, we found a statistically significant association between VI and frailty, but not between HI and frailty. Additionally, no significant interactions between HI and VI were consistently identified, which means that there was no excess risk for frailty, even when HI was present.

According to the findings of the present study, VI was an independent risk factor for pre-frailty or frailty in robust participants at baseline. Previous studies of the association between VI and frailty have reported similar results. Several longitudinal studies (Liljas et al., 2017; Trevisan et al., 2017) demonstrated that self-reported VI was related to an increased risk of frailty. Similarly, other longitudinal studies using objective measurements of visual acuity (Kamil et al., 2016; Lorenzo-Lopez et al., 2019; Swenor et al., 2020) reported significant effects of VI on frailty. However, these studies did not take the effects of HI into account. Therefore, we believe that the findings of the present study provide new insight into the relationship between VI and frailty.

In contrast, on controlling for VI along with the potential confounders, the associations between HI and frailty did not remain statistically significant. A systematic review and meta-analysis (Tian et al., 2021) revealed that older people with HI had a 1.5-fold greater risk of incident frailty, which is similar to the results that we obtained in Model 1. However, no longitudinal studies included in the meta-analysis analyzed the effects of concurrent HI and VI on incident frailty, which indicates that those studies probably did not exclude the confounding effect of VI on the relationship between HI and frailty. In other words, previously reported associations between HI and frailty might have been confounded by VI. Our findings suggest that VI could be a relevant confounder in the relationship between HI and frailty. Future research on sensory impairments should investigate the effects of HI and VI together, rather than individually, to obtain a better understanding of the links between sensory impairments and frailty.

Hearing and vision are both important for effective functioning. However, the two may function differently, depending on the circumstances. According to an earlier study, vision is more necessary for engagement with the physical and spatial environment, whereas hearing is more immediately required for interaction with the social environment (Saunders & Echt, 2007). Thus, VI may be more likely than HI to disrupt interaction with the physical and spatial environment and decrease physical activity in daily life. Accordingly, VI may lead more directly to a decline in physical function (Enoch et al., 2019; Scott et al., 2016). There is a paucity of information on the different influences of HI and VI on incident frailty. Further research is required to better understand the underlying mechanisms of incident frailty caused by HI and VI, with a particular emphasis on their interactions.

Both HI and VI are widespread among older people but often remain overlooked (Crews & Campbell, 2004). The findings of this study suggest that effective management of VI might prevent and delay the incidence and progression of frailty. VI screening in the healthcare setting may facilitate the early identification of VI among older people, which could facilitate early intervention, such as the use of glasses, cataract surgery, or sensory rehabilitation. Accordingly, these may mitigate the detrimental effects of VI and delay the occurrence of frailty. In particular, cataract surgery seems to be a promising intervention to reduce the incidence of frailty. Worldwide, cataracts are one of the leading causes of VI. According to estimates, 15.2 million people aged $\geq$50 years are blind, and 78.8 million have mild to severe VI due to cataracts (Steinmetz et al., 2021). However, few studies have examined the effects of interventions for VI on incident frailty. A longitudinal study (Graue-Hernandez et al., 2017) found that approximately 70% and 20% of adults who were frail and pre-frail at baseline reversed to pre-frailty and robustness, respectively, 1 month after cataract surgery. Moreover, cataract surgery is reportedly related to a reduction in the incidence of dementia, depression, and falls (Ishii et al., 2008; Scott, 2005), which may prevent incident frailty. Further interventional studies are needed to examine whether treatments for VI could prevent the incidence of frailty.

Our study has several strengths, including the large sample of older people and the follow-up of censored cases in the sensitivity analysis to more accurately estimate the risks of HI and VI on incident frailty and obtain robust results. Nonetheless, our study has several limitations. First, frailty was not assessed based on clinical diagnostic criteria, which might result in the misclassification of frailty status despite using a highly validated frailty assessment tool. For instance, such misclassification may partially account for the finding that 15%–25% of the pre-frail participants at baseline became robust at the follow-up (Fig. 2). Second, assessments of HI and VI depended on self-reporting by the participants, implying that we may have underestimated the prevalence of sensory impairments compared with objectively measured impairments. Nonetheless, these self-reported data provided significant findings. Third, we did not consider some relevant clinical features of sensory impairments, such as the duration of the impairments, use of hearing or vision aids, changes in the impairments over time, and causes and characteristics of the impairments (e.g., refractive error or eye disease, near or distance VI), which might have led to biases in our estimates. Fourth, we might have underestimated the effects of sensory impairments on incident frailty owing to the low follow-up rate (48.2%). In general, individuals at risk for developing frailty are less likely to respond to follow-up surveys. This could induce a selection bias that decreases the percentages of frail participants at the follow-up, even though we sought to lower the dropout rate by including the participants who became disabled or deceased during the follow-up period in the final sample.

5. Conclusions

In conclusion, we found that VI, but not HI, was independently associated with the incidence of frailty from a robust and pre-frail baseline in a nationwide sample of independent older people in Japan. In comparison to having VI alone, having both HI and VI did not increase the risk of developing frailty. The prevention and treatment of VI in later life may help delay the onset of frailty. Further research is required to explore preventive interventions for VI that may provide a substantial benefit in reducing the risk of frailty.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.archger.2022.104834.

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