

# Combined Vision and Hearing Impairment is Associated with Frailty in Older Adults: Results from the West China Health and Aging Trend Study

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**Objective:** Hearing and vision loss have been independently associated with frailty in older adults, but the relationship between concurrent hearing and visual impairment (dual sensory impairment) and frailty is not well understood. Therefore, we aimed to examine whether dual sensory impairment is associated with frailty in older adults.

**Methods:** This cross-sectional study was based on the data from the West China Health and Aging Trend (WCHAT) study of community-dwelling individuals aged 60 years and older. Frailty status was evaluated by the FRAIL scale and categorized as robust, prefrail and frail. Hearing and vision functions were based on self-report. We used multinomial regression models to explore the association between dual sensory impairment and frailty.

**Results:** Of 3985 participants, 1655 (41.5%) were male and the median age was 66 years (interquartile range: 61–68). Overall, 7.6% of participants reported hearing impairment only, 32.7% reported vision impairment only, and 28.6% reported dual sensory impairment. The prevalence of prefrailty and frailty was 60.7% and 6.1%, respectively. After adjustment for confounding variables, results from the multinomial regression analysis showed that dual sensory impairment was significantly associated with greater odds of becoming frail (OR = 2.17, 95% CI = 1.40–3.38) compared with no impairment. When stratified by gender, dual sensory impairment was significantly associated with frailty in women (OR = 2.42, 95% CI = 1.40–4.20) but not in men (OR = 1.30, 95% CI = 0.58–2.91).

**Conclusion:** Older adults with dual sensory impairment are more likely to be frail than those with no impairment, suggesting that interventions to improve sensory function may potentially help reduce the risk of frailty in older adults.

**Keywords:** frailty, sensory impairment, vision impairment, hearing impairment

## Introduction

Hearing and vision impairments are common age-related conditions in older people and often occur concurrently.<sup>1</sup> The prevalence of concurrent hearing and vision loss, defined as dual sensory impairment, estimates ranging from 10% to 34% among older adults of long-term care facilities, and 13–25% in home care, respectively.<sup>2</sup> With the rapid population aging, the prevalence of age-related sensory impairment is gradually increasing, which becomes an important public health concern.<sup>1</sup> Dual sensory impairment limits the ability to obtain information, communication, daily activities, and social interactions.<sup>3,4</sup> Evidence has shown that dual sensory impairment is significantly associated with cognitive impairment, function decline, anxiety, depression, and mortality.<sup>5–7</sup>

Frailty is another age-related clinical condition in older adults that is associated with an increased risk of mortality, hospitalization, falls, and disability.<sup>8</sup> It is defined as a syndrome of increased vulnerability to stressors due to multisystem impairments and decreased physiologic reserve.<sup>9</sup> Sensory impairments have been postulated as a potential marker for frailty because of their sharing of some common risk factors, such as cognitive impairment, depression, poor physical

function, and disability.<sup>10</sup> To date, a number of studies have only focused on the impact of a single sensory impairment (eg, hearing or vision impairment) on frailty. Previous cross-sectional studies found an association between self-reported hearing/vision impairment and frailty in older adults.<sup>11,12</sup> Longitudinal analyses of community-dwelling older adults have also showed an association between hearing/vision impairment and incident frailty.<sup>13–16</sup> However, the association between dual sensory impairment and frailty in older adults has not been examined.

In the present study, we aimed to explore the relationship between dual sensory impairment and frailty in a large cohort of community-dwelling older adults. We hypothesized that dual sensory impairment would be associated with greater odds of being frail compared with no sensory impairment.

## Methods

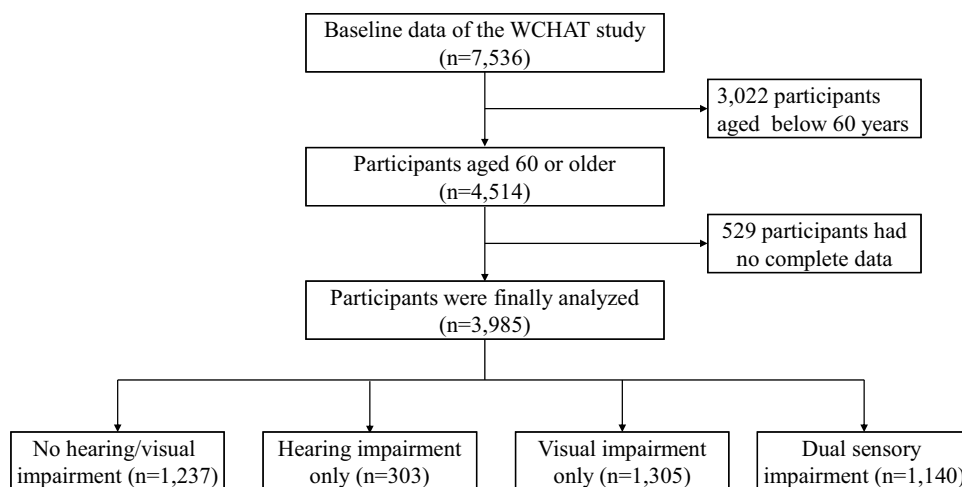
### Study Design and Population

The cross-sectional study used data from the baseline survey of the West China Health and Aging Trend (WCHAT), a population-based longitudinal study conducted in western China.<sup>17</sup> The study aimed to explore the determinants of healthy aging among community-dwelling adults aged 50 years and older from 18 ethnic groups in Sichuan, Yunnan, Guizhou and Xinjiang province. All the baseline data were collected from July 2018 to November 2018. The study was approved by the Ethics Committee of West China Hospital, Sichuan University and was performed according to the Declaration of Helsinki. All participants (or legal proxies) gave written informed consent.

For the purpose of the present study, we limited our study population to older adults aged 60 and older ( $n = 4514$ ). Participants with missing data on frailty, vision function or hearing function ( $n = 529$ ) were excluded, resulting in an analytic sample of 3985 (Figure 1).

### Data Collection

Data were collected through face-to-face interviews with trained interviewers. Information regarding age, sex, education level, ethnicity (Han, Qiang, Tibetan, Yi, others), marital status, smoking status, and drinking status were collected. A number of chronic diseases were collected based on self-report diagnosis of hypertension, diabetes, heart diseases, cerebrovascular diseases, lung diseases, digestive diseases, osteoarthritis and tumor. Sleep disturbance was defined as having trouble falling asleep or staying asleep in the past month. Cognitive function was measured using the Short Portable Mental Status Questionnaire (SPMSQ), which is composed of 10 items and adjusts for education level.<sup>18</sup> Higher SPMSQ scores indicate weaker cognitive function. Depression was considered when the score of the 15-item Geriatric Depression Scale (GDS-15) was 5 or more.<sup>19</sup> The basic activities of daily living (ADL) were determined by the Barthel Index score,<sup>20</sup> in which a total score of 95 or less indicated functional impairment. Nutritional status was measured by the



**Figure 1** Flow chart of study inclusion.

short form of the Mini Nutritional Assessment (MNA-SF),<sup>21</sup> and participants were categorized as malnourished (0–7 points), at risk of malnutrition (8–11 points), and well-nourished (12–14 points).

## Assessment of Vision and Hearing Impairment

Vision and hearing functions were assessed based on self-report at baseline. Participants were categorized into four groups: no sensory impairment, vision impairment only, hearing impairment only, and dual sensory impairment (presence of both vision and hearing impairment).

Vision function was measured by asking participants whether their eyesight was good, fair, poor, very poor or blind despite wearing corrective lenses. Vision impairment was defined as reporting fair, poor, very poor or blind eyesight. Hearing function was evaluated by asking participants to rate their hearing as good, fair, poor, or deaf despite using a hearing aid. Reporting fair, poor, or deaf was classified as having hearing impairment. Self-reported vision and hearing impairment is a valid method, which has been widely used in previous studies.<sup>14,16</sup> There is evidence suggesting good agreement between self-reported vision and hearing impairment and objective measurements.<sup>22</sup>

## Assessment of Frailty

Frailty was evaluated with the FRAIL scale,<sup>23</sup> which has been validated for the assessment of frailty status in older community-dwellers. The scale consists of five items: fatigue (feeling tired all or most of the time in the past month), resistance (inability to climb a flight of stairs without rest and aids), ambulation (inability to walk 100 meters alone without aids), illness (having  $\geq 5$  of the following illnesses: hypertension, diabetes, cancer, chronic lung disease, heart attack, congestive heart failure, angina, asthma, arthritis, stroke, kidney disease), and loss of weight (unintentional weight loss of  $\geq 5\%$  over the past year). One point is attributed to each item and the total score ranges from 0 to 5 points. The individuals were divided into the following three groups based on the cut-offs: robust (0 points), prefrail (1–2 points), and frail (3–5 points).

## Statistical Analysis

All categorical variables were presented as count and percentage, and the non-normally distributed continuous variables as medians and interquartile range (IQR). Comparisons of differences among groups were tested by Kruskal–Wallis for non-normally distributed continuous variables, and chi-square test for categorical variables. Multinomial logistic regression models were used to determine the association between sensory impairment as compared to no sensory impairment with frailty. Four sets of models were conducted: Model 1 was unadjusted; Model 2 adjusted for age, sex, education, ethnicity and marital status; Model 3 adjusted for smoker, alcohol abuse, number of chronic diseases, cognitive impairment, and variables included in Model 2; Model 4 adjusted for depression, ADL impairment, sleep condition, malnutrition status, and variables included in Model 3. In addition, we analyzed the association of sensory impairment with frailty by gender. All statistical analyses were conducted using SPSS version 21.0 (IBM Corp., Armonk, NY).  $P < 0.05$  was considered statistically significant.

## Results

A total of 3985 participants were enrolled in our studies. The median age of the participants was 66 years (interquartile range: 63–72) and 1655 (41.5%) were male. Among these participants, 2417 (60.7%) were prefrail and 245 (6.1%) were frail. A total of 303 (7.6%) reported hearing impairment, 1305 (32.7%) reported vision impairment, and 1140 (28.6%) reported dual sensory impairment. In addition, the prevalence of malignancy, chronic obstructive pulmonary disease and congestive heart failure were 0.6%, 1.8% and 3.9%, respectively.

Table 1 presents the characteristics of all participants according to type of sensory impairment. There were significant differences in age, gender, education level, ethnicity, marital status, alcohol use, cognitive impairment, ADL impairment, depression, malnutrition, and frailty status among different sensory impairment groups. Table 2 shows the characteristics of all participants stratified by the degree of frailty status. Significant differences were found among different frailty status groups with regard to age, gender, education level, ethnicity, marital status, smoking, alcohol use, number of chronic diseases, cognitive impairment, ADL impairment, depression, sleep disturbance, and malnutrition.

**Table 1** Characteristics of Participants According to Sensory Impairment Status

Characteristic	Overall (n = 3985)	No Sensory Impairment (n = 1237)	Hearing Impairment Only (n = 303)	Visual Impairment Only (n = 1305)	Dual Sensory Impairment (n=1140)	P-value <sup>a</sup>
Age (years), median (IQR)	66 (63–72)	64 (61–68)	69 (65–74)	66 (64–71)	70 (65–75)	<0.001
Male gender, n (%)	1655 (41.5)	537 (43.4)	159 (52.5)	491 (37.6)	468 (41.1)	<0.001
Education level, n (%)						<0.001
Illiterate	1366 (34.3)	373 (30.2)	97 (32.0)	396 (30.3)	500 (43.9)	
Primary school	1505 (37.8)	418 (33.8)	137 (45.2)	535 (41.0)	415 (36.4)	
Secondary school and above	1114 (28.0)	446 (36.1)	69 (22.8)	374 (28.7)	225 (19.7)	
Ethnicity, n (%)						<0.001
Han	1450 (36.4)	416 (33.6)	98 (32.3)	483 (37.0)	453 (39.7)	
Qiang	867 (21.8)	289 (23.4)	110 (36.3)	208 (15.9)	260 (22.8)	
Tibetan	668 (16.8)	213 (17.2)	31 (10.2)	243 (18.6)	181 (15.9)	
Yi	370 (9.3)	129 (10.4)	26 (8.6)	138 (10.6)	77 (6.8)	
Uighur	306 (7.7)	99 (8.0)	17 (5.6)	103 (7.9)	87 (7.6)	
Others	324 (8.1)	91 (7.4)	21 (6.9)	130 (10.0)	82 (7.2)	
Marital status, n (%)						<0.001
Married	3130 (78.5)	1020 (82.5)	243 (80.2)	1039 (79.6)	828 (72.6)	
Unmarried/widowed/divorced	855 (21.5)	217 (17.5)	60 (19.8)	266 (20.4)	312 (27.4)	
Smoker, n (%)	833 (20.9)	276 (22.3)	76 (25.1)	261 (20.0)	220 (19.3)	0.069
Alcohol abuse, n (%)	1079 (27.1)	363 (29.3)	106 (35.0)	335 (25.7)	275 (24.1)	<0.001
Number of chronic diseases, n (%)						0.431
<5	3883 (97.4)	1211 (97.9)	296 (97.7)	1272 (97.5)	1104 (96.8)	
≥5	102 (2.6)	26 (2.1)	7 (2.3)	33 (2.5)	36 (3.2)	
Cognitive impairment, n (%)	711 (17.8)	172 (13.9)	56 (18.5)	188 (14.4)	295 (25.9)	<0.001
ADL impairment, n (%)	517 (13.0)	121 (9.8)	50 (16.5)	140 (10.7)	206 (18.1)	<0.001
Depression, n (%)	226 (5.7)	46 (3.7)	17 (5.6)	69 (5.3)	94 (8.2)	<0.001
Sleep disturbance, n (%)	987 (24.8)	287 (23.2)	76 (25.1)	335 (25.7)	289 (25.4)	0.489
Malnutrition, n (%)						<0.001
Normal	2433 (61.1)	814 (65.8)	183 (60.4)	816 (62.5)	620 (54.4)	
Risk of malnutrition	1490 (37.4)	407 (32.9)	117 (38.6)	474 (36.3)	492 (43.2)	
Malnutrition	62 (1.6)	16 (1.3)	3 (1.0)	15 (1.1)	28 (2.5)	
Status of frailty, n (%)						<0.001
Robust	1323 (33.2)	515 (41.6%)	110 (36.3)	429 (32.9)	269 (23.6)	
Prefrail	2417 (60.7)	671 (54.2)	180 (59.4)	800 (61.3)	766 (67.2)	
Frail	245 (6.1)	51 (4.1)	13 (4.3)	76 (5.8)	105 (9.2)	

**Note:** <sup>a</sup>P values according to Kruskal–Wallis or Pearson chi-square tests.

**Abbreviation:** IQR, interquartile range; ADL, activities of daily living.

**Table 3** displays the results of the multinomial logistic regression analysis on the association between sensory impairment and frailty. Compared with participants with no sensory impairment, higher odds of being prefrail and frail were found in those with vision impairment only and dual sensory impairment but not in hearing impairment only in the unadjusted model. After adjustment for age, sex, education, ethnicity, marital status, smoking, alcohol abuse, number of chronic diseases, cognitive impairment, depression, ADL impairment, sleep condition and malnutrition status, the association of dual sensory and vision impairment with prefrailty and frailty remained statistically significant. When stratified by gender, vision impairment only and dual sensory impairment were significantly associated with prefrailty in both genders. Moreover, women with dual sensory impairment had higher odds of being frail than those with no sensory impairment, but no significant association was observed in men (**Table 4**).

## Discussion

Results from the present study showed that dual sensory impairment was significantly associated with higher odds of being frail in a large sample of older adults (aged ≥60 years). The association remained unchanged after adjustment for

**Table 2** Characteristics of Participants According to Frailty Status

Characteristic	Robust (n = 1323)	Prefrail (n = 2417)	Frail (n = 245)	P-value <sup>a</sup>
Age (years), median (IQR)	66 (63–70)	67 (63–72)	70 (65–75)	<0.001
Male gender, n (%)	634 (47.9)	951 (39.3)	70 (28.6)	<0.001
Education level, n (%)				<0.001
Illiterate	377 (28.5)	887 (36.7)	102 (41.6)	
Primary school	517 (39.1)	911 (37.7)	77 (31.4)	
Secondary school and above	429 (32.4)	619 (25.6)	66 (26.9)	
Ethnicity, n (%)				<0.001
Han	552 (41.7)	830 (34.3)	68 (27.8)	
Qiang	270 (20.4)	569 (23.5)	28 (11.4)	
Tibetan	220 (16.6)	393 (16.3)	55 (22.4)	
Yi	121 (9.1)	231 (9.6)	18 (7.3)	
Uighur	32 (2.4)	217 (9.0)	57 (23.3)	
Others	128 (9.7)	177 (7.3)	19 (7.8)	
Marital status, n (%)				<0.001
Married	1094 (82.7)	1881 (77.8)	155 (63.3)	
Unmarried/widowed/divorced	229 (17.3)	536 (22.2)	90 (36.7)	
Smoker, n (%)	315 (23.8)	487 (20.1)	31 (12.7)	<0.001
Alcohol abuse, n (%)	391 (29.6)	647 (26.8)	41 (16.7)	<0.001
Number of chronic diseases, n (%)				<0.001
<5	1316 (99.5)	2344 (97.0)	223 (91.0)	
≥5	7 (0.5)	73 (3.0)	22 (9.0)	
Cognitive impairment, n (%)	144 (10.9)	468 (19.4)	99 (40.4)	<0.001
ADL impairment, n (%)	54 (4.1)	346 (14.3)	117 (47.8)	<0.001
Depression, n (%)	20 (1.5)	162 (6.7)	44 (18.0)	<0.001
Sleep disturbance, n (%)	233 (17.6)	663 (27.4)	91 (37.1)	<0.001
Malnutrition, n (%)				<0.001
Normal	958 (72.4)	1378 (57.0)	97 (39.6)	
Risk of malnutrition	362 (27.4)	999 (41.3)	129 (52.7)	
Malnutrition	3 (0.2)	40 (1.7)	19 (7.8)	

**Note:** <sup>a</sup>P values according to Kruskal–Wallis or Pearson chi-square tests.

**Abbreviation:** IQR, interquartile range; ADL, activities of daily living.

potential confounding covariates. Moreover, we particularly found that dual sensory impairment was significantly associated with frailty only in women, but not among men. Together, our results suggest that frailty in older adults with dual sensory impairment, especially among women, warrants greater attention by clinicians.

In the present study, the prevalence of frailty among community-dwelling older adults was 6.1%. The result was in line with previous study conducted in China, where the prevalence of frailty evaluated by the FRAIL scale in community-dwelling older adults was 6.6%.<sup>24</sup> The prevalence of vision impairment in this study was 32.7%, which was in consistent with the prevalence of vision loss reported for adults aged 60 years and older in the United States (16.1–50%).<sup>25</sup> However, our study showed a considerably lower prevalence of hearing impairment than the high estimate of >45% reported by Cruickshanks et al.<sup>26</sup> One explanation is the difference in the definitions and measures of hearing impairment. Ours defined hearing impairment based on self-report, but Cruickshanks et al used objective measures. Another potential explanation is that older adults are more likely to report better than the fact, leading to a lower identification of participants with hearing impairment.

Existing studies have demonstrated an independent association of hearing impairment with frailty. A population-based cohort study of older adults based on the English Longitudinal Study of Ageing identified that hearing loss was associated with greater odds of frailty.<sup>14</sup> A cross-sectional study by Kamil et al<sup>11</sup> demonstrated that self-reported hearing impairment was associated with frailty in women but not in men. Meanwhile, their subsequent longitudinal study using objective hearing assessment reported a higher risk of frailty in both men and women with hearing impairment.<sup>13</sup> In contrast, our study failed to observe any association between hearing impairment and frailty after adjusting for potential confounders. The fact might potentially be due to the fact that a relatively small number of participants with hearing impairment could diminish their statistical power to detect significant associations.

**Table 3** Association Between Sensory Impairment and Frailty According to Multinomial Logistic Regression Analyses

		Prefrail vs Robust		Frail vs Robust	
		OR (95% CI)	P-value	OR (95% CI)	P-value
<b>Model 1</b>	No sensory impairment	Reference		Reference	
	Hearing impairment only	1.26 (0.97–1.64)	0.09	1.19 (0.63–2.27)	0.59
	Visual impairment only	1.43 (1.22–1.69)	<0.001	1.79 (1.23–2.61)	0.003
	Dual sensory impairment	2.19 (1.83–2.62)	<0.001	3.94 (2.74–5.68)	<0.001
<b>Model 2</b>	No sensory impairment	Reference		Reference	
	Hearing impairment only	1.16 (0.88–1.52)	0.309	1.03 (0.53–2.03)	0.924
	Visual impairment only	1.38 (1.16–1.64)	<0.001	1.42 (0.96–2.11)	0.082
	Dual sensory impairment	1.94 (1.59–2.36)	<0.001	2.74 (1.83–4.10)	<0.001
<b>Model 3</b>	No sensory impairment	Reference		Reference	
	Hearing impairment only	1.13 (0.86–1.50)	0.376	0.99 (0.50–1.97)	0.981
	Visual impairment only	1.39 (1.17–1.65)	<0.001	1.51 (1.01–2.25)	0.046
	Dual sensory impairment	1.89 (1.55–2.31)	<0.001	2.45 (1.62–3.69)	<0.001
<b>Model 4</b>	No sensory impairment	Reference		Reference	
	Hearing impairment only	1.07 (0.80–1.42)	0.664	0.82 (0.40–1.68)	0.583
	Visual impairment only	1.41 (1.18–1.68)	<0.001	1.54 (1.00–2.36)	0.048
	Dual sensory impairment	1.81 (1.47–2.21)	<0.001	2.17 (1.40–3.38)	0.001

**Notes:** Model 1 unadjusted; Model 2 adjusted for age, sex, education, ethnicity and marital status; Model 3 adjusted for age, sex, education, ethnicity, marital status, smoker, alcohol abuse, number of chronic diseases, and cognitive impairment; Model 4 adjusted for age, sex, education, ethnicity, marital status, smoker, alcohol abuse, number of chronic diseases, cognitive impairment, depression, ADL impairment, sleep condition and malnutrition status.

**Abbreviation:** OR, odds ratio; CI, confidence interval.

**Table 4** Sex Differences in the Association Between Sensory Impairment and Frailty According to Adjusted Multinomial Logistic Regression Models

	Female				Male			
	Prefrail		Frail		Prefrail		Frail	
	OR <sup>a</sup> (95% CI)	P-value	OR <sup>a</sup> (95% CI)	P-value	OR <sup>a</sup> (95% CI)	P-value	OR <sup>a</sup> (95% CI)	P-value
No sensory impairment	Reference		Reference		Reference		Reference	
Hearing impairment only	1.44 (0.93–2.12)	0.102	1.39 (0.55–3.46)	0.486	0.88 (0.59–1.32)	0.539	0.40 (0.11–1.43)	0.157
Visual impairment only	1.34 (1.05–1.69)	0.017	1.49 (0.87–2.52)	0.144	1.61 (1.23–2.12)	0.001	1.56 (0.73–3.32)	0.248
Dual sensory impairment	1.69 (1.28–2.23)	<0.001	2.42 (1.40–4.20)	0.002	2.09 (1.54–2.82)	<0.001	1.30 (0.58–2.91)	0.525

**Note:** <sup>a</sup>Adjusted for age, education, ethnicity, marital status, smoker, alcohol abuse, number of chronic diseases, cognitive impairment, depression, ADL impairment, sleep condition and malnutrition status.

**Abbreviation:** OR, odds ratio; CI, confidence interval.

There are several studies showing that vision impairment has an effect on frailty. For example, a cross-sectional study of US older adults from the National Health and Nutrition Examination Survey observed that individuals with near vision impairment were more likely to be frail than those without sensory impairment.<sup>12</sup> Liljas et al,<sup>16</sup> using data from the English Longitudinal Study of Ageing, also reported that poor vision was associated with an increased risk of being frail over 4 years. Additionally, a longitudinal study found that individuals with vision impairment had greater odds of frailty.<sup>15</sup> However, in our study, the result of the association between vision impairment and frailty was not significant. This observation may be explained by the fact that we were not adequately powered to detect meaningful differences due to the imbalance in the groups based on degree of frailty status. Furthermore, vision loss is not considered as a component of the FRAIL scale, which mainly includes functional and biological factors. Different results might be observed if our study uses the Frailty Risk Index, which incorporates vision impairment, illness, nutritional parameters, and biochemical indexes.<sup>27</sup>



The primary finding of this study showed that dual sensory impairment was associated with frailty, which is inconsistent with research conducted in Brazil that failed to find a significant association between dual sensory impairment and frailty.<sup>28</sup> The discrepancy may be partly due to differences in the definition of frailty and sensory impairment. Additionally, the sample size in their study is relatively small (107 subjects). There are several plausible explanations for the association of dual sensory impairment with frailty. First, dual sensory impairment has been revealed to be independently associated with slow walking speed,<sup>29,30</sup> which may have an important impact on resistance and ambulation, the components of the FRAIL scale. Second, compared to single sensory impairment, dual sensory loss leads to greater risk of worse health-related outcomes including depression, cognitive impairment, functional limitation, social isolation, and falls,<sup>6,7,31,32</sup> which are known as risk factors for frailty. Third, there are shared comorbidities such as cardiovascular disease and diabetes, which could contribute to both dual sensory impairment and frailty.<sup>33–35</sup> Finally, sensory impairment and frailty may share a similar pathological pathway such as systemic inflammation.<sup>36–38</sup> Our findings extend the discussion in the literature on the relationship between sensory impairment and frailty in older adults.

Interestingly, we also found that dual sensory impairment was significantly associated with frailty only among older women but not men. This may be because a higher rate of frailty among older women can be identified by the FRAIL scale, with a good known-group divergent validity.<sup>24</sup> And there is evidence that frailty is more common in older women compared to men.<sup>9</sup> In addition, differences in social, cultural, and economic may increase the risk of illnesses and limit access to services for women.<sup>39</sup> Finally, lower muscle mass, strength and androgen may expose women to a greater risk of frailty.<sup>40</sup> Thus, it is not surprising that dual impairment has a significant relationship with frailty among women.

Moreover, we also found that sensory impairment was associated with cognitive impairment and depression. This association can be explained by several hypotheses. The first is the sensory deprivation hypothesis: sensory impairment can result in neuroplastic changes, depression and social isolation, consequently leading to cognitive decline.<sup>41</sup> The second is the common cause hypothesis: sensory impairment as well as cognitive decline and depression may share common pathological processes, such as vascular disease or inflammation.<sup>42</sup>

Strengths of the present study include a large sample of older adults, and a comprehensive baseline survey, which enabled us to adjust for numerous relevant confounders. However, our study has several limitations. First, frail was based on self-report, which may be subject to recall bias. Likewise, sensory impairment was also assessed by self-report rather than objective measures, and hence participants may under- or over-report their impairment. Second, cognitive impairment and depression may effect the self-reported assessment of sensory function. However, we excluded individuals who were unable to complete hearing or vision assessment because of severe depression or severe cognitive impairment. Third, we did not investigate the role of assistive devices (eg, hearing aids or glasses) in sensory-impaired participants because the use of assistive devices was included in the definition of sensory impairment. Fourth, the cross-sectional design limits the ability to explore the causal relationship between sensory impairment and frailty among older adults. Longitudinal studies with objective measures of sensory impairment are needed to further prospectively examine this relationship.

## Conclusion

In conclusion, our results showed that older adults with dual sensory impairment, particularly in women, were more likely to be frail than those without sensory impairment. Thus, assessment of sensory function in older adults should be as a part of routine assessments to help identify older adults at increased risk of frailty. As the population of sensory impaired older adults increases, future studies are needed to determine whether prevention and treatment strategies could reduce the progression of frailty among sensory impaired older adults.

## Abbreviations

ADL, activities of daily living; SPMSQ, Short Portable Mental Status Questionnaire; GDS-15, 15-item Geriatric Depression Scale; MNA-SF, short form of the Mini Nutritional Assessment.

## Data Sharing Statement

There are no linked research data sets for this paper. The data are confidential, and the authors do not have permission to share the data.

## Ethical Approval and Informed Consent

This study was performed according to the Helsinki Declaration and was approved by the Ethics Committee of West China Hospital, Sichuan University (reference: 2017-445). Each participant provided written informed consent. In participants with cognitive impairment, written informed consent was also obtained from a valid surrogate.

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## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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## Disclosure

The authors declare that they have no conflicts of interest.

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