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ARTICLE

Widowhood and functional impairment: gender-specific trajectories of sensory and masticatory functions

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Abstract

Despite a large body of research on the effects of widowhood on health, little is known about whether spousal loss is related to functional impairment in widowed persons. This study examines the trajectories of functional impairment (sensory and masticatory functions) before and after spousal loss. This study also investigates whether the temporal changes in functional impairment of widowed people are gendered. Using data from the Korean Longitudinal Study of Ageing over seven waves (42,967 person-observations), this study estimated fixed effects regression models to account for unobserved individual-level heterogeneity. Gender-stratified fixed effects regression models were used to determine whether changes in functional impairment associated with spousal loss differ by gender. The results of this study indicated that the vision of widowed people began to decrease within the first year following spousal loss and persisted through the fourth and subsequent years. By contrast, mastication deterioration occurred only among widowers. Masticatory impairment began during the first year of spousal loss and lasted the entire survey period. No statistically significant reduction in hearing loss was found for both widowers and widows. The results of this study suggest that spousal loss has a long-term effect on functional impairment, particularly in vision and masticatory functions. This study also documents gender heterogeneity in the trajectories of functional impairment before and after spousal loss. Vision impairment was found to be universal among widowers and widows, whereas masticatory impairment was significant only among widows. To address the physical and psychological vulnerability of widowed people, policies should be developed early in the process of adjusting to widowhood.

Keywords: widowhood; gender; functional impairment; sensory function; mastication

Introduction

Spousal loss is one of the most stressful life events that married couples can experience. It affects multiple aspects of the surviving partner's life, including psychosocial

and physical health (Kung, 2020). The consequences of spousal loss are not transient and may persist for an extended period of time. Additionally, widowhood may invoke anticipation effects, as the anticipated impending loss of a spouse can provoke adverse psychological reactions (Infurna *et al.*, 2017; Yoon *et al.*, 2022). As widowed individuals progress through the grieving process, they must also adjust to the subsequent changes in lifestyles previously shared with their spouse (Utz *et al.*, 2004). During the process of bereavement and thereafter, widowed individuals continue to report poor mental health such as depression, loneliness and sadness (Yang and Gu, 2021). A number of previous studies have also found that widowed people have a higher risk of the development of chronic diseases, such as cardiovascular disease and diabetes (Stahl *et al.*, 2016), as well as mortality (Stroebe *et al.*, 2007).

While most previous research has focused on health outcomes, little is known about whether spousal loss affects physical functions in widowed people. Spousal loss may aggravate declines in sensory and masticatory functions among widowed individuals, both of which are representative degenerative symptoms (Okamoto *et al.*, 2015). Diminished sensory capacity becomes a major impediment to avoiding communication (Swenor *et al.*, 2019), curtailing the frequency of social interactions and activities (Park *et al.*, 2022). Meanwhile, impaired masticatory function leads to a decrease in nutrition intake, a major cause of health deterioration (Tanaka *et al.*, 2018). Furthermore, sensory and masticatory impairments are a good predictor of overall quality of life because they are closely linked to physical, mental and cognitive declines (Ehrlich *et al.*, 2021). Thus, determining whether spousal loss has an effect on sensory and masticatory functions is critical for enhancing the health and wellbeing of widowed persons.

There are both direct and indirect ways in which spousal loss affects sensory and masticatory functions in widowed people. First, spousal loss is a source of acute and chronic stress that can impair one's physical function (Lee and Carr, 2007). The biological responses to stress associated with spousal loss (*e.g.* high levels of catecholamine or cortisol) may impair the sensory function of widowed individuals via an imbalanced autonomous nervous system and problems with brain processing (Wettstein *et al.*, 2022). A failure of autoregulation in the ocular blood vessels caused by repeated stress would result in an inability to regulate intraocular pressure, the only modifiable factor in glaucoma (Sabel *et al.*, 2018). Exaggerated sympathetic innervation of the cochlea due to constant stress may increase the risk of hearing loss (Pérez-Valenzuela *et al.*, 2019). Spousal loss may also impair masticatory function because stress-induced inflammatory diseases such as periodontal disease would be detrimental to oral health (Lamster, 2004). Furthermore, emotional tension in overloaded muscles may cause myofascial pain and its sequels, as well as involuntary motor activities such as bruxism and subsequent dental attrition (Anna *et al.*, 2015).

Second, spousal loss may affect sensory and masticatory functions through indirect channels. Functional impairment in widowed persons may be exacerbated by a decrease in social capital and social connections following spousal loss (Kung, 2020). Marriage has been shown to protect one's health by promoting health-related behaviours and increasing access to resources (Perkins *et al.*, 2016). Thus, spousal loss means the loss of a vital source of social support as

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well as social health regulation for a surviving counterpart. Spousal loss may increase risky behaviours such as smoking and drinking as a stress control device (Nystedt, 2006). Cigarettes, as a mixture of thousands of hazardous toxic chemicals, exacerbate oxidative stress, which damages the lens and retina directly and indirectly, eventually resulting in age-related macular degeneration (Han *et al*., 2021). Nicotine also impairs hearing by causing anaemia in the cochlea through vasoconstriction (Nomura *et al*., 2005). Excessive alcohol consumption may also damage the performance of visually guided movements and the processing of auditory information (Upile *et al*., 2007). Furthermore, widowed people may exhibit reduced health-care utilisation following the death of a spouse (Jin and Chrisatakis, 2009). This lack of regular medical check-ups may delay opportunities for early detection and treatment of physical impairments, which can be particularly concerning for those who use assistive devices like dentures or hearing aids. Without regular check-ups, it can be difficult to monitor the fit of these devices, potentially leading to long-term complications associated with ill-fitting ones (Cockerill, 1987; Manoharan *et al*., 2014).

Spousal loss may lead to a range of behavioural transitions in daily lives as surviving counterparts should adjust to living alone. For example, dietary behaviour, a long-shared life routine, could be altered, thereby weakening masticatory functions. Loss of appetite and irregular meals following spousal loss may result in nutritional deficiencies (Shahar *et al*., 2001). Given that malnutrition is associated with the development of caries, periodontal disease and other oral maladies (Palmer, 2001), inadequate mineral intake due to limited eating would attenuate oral homeostasis, reducing the capacity of tissue healing (Sheetal *et al*., 2013). As meal planning and preparation becomes more difficult for widowed people (Shahar *et al*., 2001), they may develop an increased reliance on unfamiliar outside food, potentially increasing their risk of dental illness.

Functional impairment caused by spousal loss may be greater for men than women (Umberson, 1992). Widowers tend to struggle more with bereavement and household reconfiguration than widows (Utz *et al*., 2004). In marriage, wives are typically in charge of the emotional work of maintaining the couple's social network, and husbands rely on their wives for practical, emotional, health-regulating support throughout their lives (Umberson *et al*., 1992). Therefore, compared to their husbands, wives often enjoy stronger social bonds outside the family, and closer bonds with their children (Lee and Carr, 2007). As a result, widowers face a greater psychological burden and receive less emotional support than widows following the death of a spouse (Yoon *et al*., 2022). In addition, because marital benefits (such as regular check-ups and medical care, healthy diets, exercise and enjoying higher standards of living) are greater for men than women (Monin and Clark, 2011), the death of a spouse may have a greater impact on functional impairment for widowers than widows. Similarly, given that women's typical domestic work such as meal preparation is a daily duty compared to men's typical domestic work such as house maintenance (Cerrato and Cifre, 2018), widowers are more likely than widows to experience changes in daily routines following spousal loss, which can be a significant source of psychological stress for them (Förster *et al*., 2019). Based on this, we anticipate that men will suffer more functional impairment due to spousal loss than women.

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In South Korea (hereafter Korea), the gendered impact of widowhood on health may be particularly pronounced due to the prevalence of the female care-giver ideology (Brinton and Oh, 2019). Women are often responsible for providing instrumental assistance, especially among older adults, within households. Traditionally, care-giving has been the responsibility of female family members in Korea, and it is taken for granted that wives are responsible for caring for their spouses in old age (Choi, 1993; Kim, 2016). In this regard, older widowers are three times more likely than widows to desire remarriage, suggesting that their spouse's networks are their primary source of social support (Jeon *et al.*, 2013). Given Korea's unique social context, examining how widowhood is associated with functional ability in older adults is expected to improve our understanding of the role of family dynamics in the health of the older population in Korea.

Using seven waves of the Korean Longitudinal Study of Ageing (KLoSA) spanning 12 years between 2006 and 2018, this study examines trajectories of functional impairment among bereaved participants. Specifically, this study evaluates the temporal changes in sensory (vision and hearing) and masticatory function at multiple points in time before and after spousal loss. To account for unobserved individual-level heterogeneity, fixed effects models are estimated. This study adds nuance to our understanding of the impact of spousal loss on the health of widowed individuals by documenting changes in physical function trajectories beyond the immediate transition in marital status. Gender-stratified fixed effects models are used to investigate potential gender heterogeneity in the trajectories of functional impairment before and after spousal loss. A statistical test for gender differences is conducted by fitting a joint model in which gender is interacted with time since spousal loss, as well as all other independent variables included in the estimation model. This gender analysis adds to the existing literature by considering gender differences in the extent of loss of marital benefits following spousal loss and coping strategies in widowhood.

Data and methods

Data

Data were drawn from KLoSA, a nationally representative longitudinal study of adults aged 45 or higher in Korea (Jang, 2016). Starting from 2006, the survey has been conducted every two years. The survey was designed to collect socio-economic, psychological and health-related information among middle- and old-aged people in Korea. The sampling frame was constructed based on enumeration districts from the Population and Housing Census of Korea Statistics. Survey participants were sampled through multi-stage stratification by geographic region (urban or rural) and housing type (apartment or ordinary housing).

The present study relied on the 12-year longitudinal data from Wave 1 (2006) to Wave 7 (2018) in KLoSA. Among 10,254 respondents who were surveyed in Wave 1, the number of respondents married was 8,340. Not included in the analyses were respondents whose marital status at baseline was divorced or widowed (N = 369). Four respondents who had missing values on the variables used in this study were also dropped. For technical reasons, those with missing information on the

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variable measuring time to spousal loss (19 respondents) had to be excluded. Listwise deletion was used because excluding a small number of cases is less likely to bias the results or reduce the statistical power (Allison, 2002). In addition to the 7,948 remaining respondents at Wave 1, an additional 54 respondents who met the inclusion criteria during subsequent waves were included. The resulting analytical sample consisted of 42,967 person-observations from 8,002 respondents, 685 of whom experienced spousal loss during the observed period. All the enrolled participants completed and submitted an informed consent form. Data were de-identified before being uploaded to a publicly available database. This study was exempted from institutional review as it utilised publicly available data without any identification information.

Measures

Dependent variable

Two sensory (vision and hearing) and masticatory functions were used as dependent variables in this study. Vision function was measured by the respondent's response to the following question (National Eye Institute Visual Functioning Questionnaire-25 (NEI VFQ-25) Question 2): 'At the present time, would you say your eyesight using both eyes (with glasses or contact lenses, if you wear them) is very poor (1), poor (2), moderate (3), good (4) or very good (5)?' For hearing function, the respondent's response to the following question was used: 'At the present time, would you say your hearing is very poor (1), poor (2), moderate (3), good (4) or very good (5)? (If you are using a hearing aid, please indicate the condition in which you are wearing the hearing aid.)' Masticatory function was measured based on the following question: 'Do you normally chew hard things like meat and apples without wearing dentures?' For those who wear dentures, we used the answer to the following question instead: 'With dentures, can you chew hard foods like apples and meat without difficulty?' The possible responses included: 1 = unable to chew at all, 2 = don't chew well, 3 = moderate, 4 = chew well and 5 = chew very well. Previous studies have commonly employed these subjective measures as they capture physical sensations and symptoms associated with health deterioration (Benyamini, 2011).

Independent variable

The key independent variable was time to spousal loss (in years). In the survey, if participants lost their spouse, they were asked to indicate the year and month when their spouse died. We created the measure of the time to spousal loss by subtracting the date of spousal loss from the interview date. For example, '0' indicates that the interview took place in the month in which the respondent lost his or her spouse. Then, we divided the measure into the following eight categories: the first year (months 0 to 11), second year (months 12 to 23), third year (months 24 to 35), and fourth and subsequent years (months $\geq$36) after spousal loss and the last year (months -12 to -1), second year (months -13 to -24), third year (months -25 to -36), and fourth and previous years (months ≤ -37) before spousal loss. For those who did not lose their spouse during the observed period, this variable was set to a constant.

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Control variables

A number of time-varying control variables were included in the empirical models (Kim and Park, 2023). To account for age-related changes in functional impairment, age and age squared were controlled for. Age was grand mean-centred to reduce collinearity when estimating effects of squared age. Marital status was measured by whether the respondent was married or not (single, widowed, divorced or separated). The household size was determined by calculating the total number of members in the household (ranging from 1 to 13). Household income was divided into quartiles. Homeownership was determined based on whether the respondent was an owner-occupier or not. Economic activity refers to whether or not the respondent was engaged in any form of paid employment. The region of residence was categorised into a large city, a small city and a rural area. The number of chronic diseases was measured by the sum of doctor-diagnosed chronic diseases (ranging from 0 to 7), including hypertension, diabetes mellitus, cancer or a malignant tumour, chronic lung disease, cerebrovascular disease, arthritis or rheumatoid arthritis, psychological disease, liver disease and/or prostatic disease. Activities of daily living (ADLs) were measured by respondents' report on whether they needed assistance when performing the following seven daily activities: dressing oneself, washing one's face, bathing oneself, eating, going out of the room, using a toilet, and regulating urine and bowel movements. The number of daily activities for which respondents reported needing assistance was summed (ranging from 0 to 7).

Statistical analysis

This study estimated fixed effects regression models to examine whether time to spousal loss is associated with temporal changes in sensory and masticatory functions. The key feature of fixed effects models is to leverage within-person variation to account for observed and unobserved time-constant heterogeneity at the individual level. To identify trajectories of sensory and masticatory functions before and after spousal loss, we modelled changes in the outcomes across multiple time-points in reference to spousal loss. The following equation represents the fixed effects model:

$$\begin{aligned} y_{it} = \alpha &+ \beta_1(-3\text{rd year})_{it} + \beta_2(-2\text{nd year})_{it} \\ &+ \beta_3(-1\text{st year})_{it} + \beta_4(1\text{st year})_{it} + \beta_4(2\text{nd year})_{it} \\ &+ \beta_5(3\text{rd year})_{it} + \beta_6(4\text{th} + \text{years}) + \boldsymbol{Z_{it}}\delta + \nu_i + \varepsilon_{it} \end{aligned} \quad (1)$$

where y_{it} is the dependent variable, sensory and masticatory function of individual i at time t. The variables with β coefficients indicate time to spousal loss. The reference category is the fourth and previous years before spousal loss (months ≤ -37). The vector $\boldsymbol{Z_{it}}$ includes a set of time-varying control variables (linear and squared age, marital status, household size, household income, homeownership, economic activity, region of residence, number of chronic diseases and ADLs). ν_i is the individual-specific, time-invariant error term, and in fixed effects models, ν_i is treated as a fixed constant (Vaisey and Miles, 2017). ε_{it} is the

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idiosyncratic error term that varies with people and time. In all analyses, robust standard errors were used.

The ordinal variable of functional performance was treated as continuous in the fixed effects models. The rationale for this approach is to increase statistical power and precision of the estimated coefficients. Treating the ordinal variable as continuous enables us to use the full range of values and capture more variation in the outcome variable. Additionally, treating the ordinal variable as continuous allows for a simpler interpretation of the coefficients, as the effect of the variable is assumed to be linear and constant across its range. Consequently, the resulting regression coefficients can be interpreted as the change in the outcome variable associated with a one-unit increase in the predictor variable. To investigate gender differences in trajectories of sensory and masticatory functions associated with spousal loss, we first stratified analyses by gender. Then, we tested whether gender differences are statistically significant by fitting a joint model in which all independent variables are interacted with gender (full interaction models).

Results

The summary statistics (the entire sample, the sample of individuals who did and did not experience spousal loss, and the sample of individuals who experienced spousal loss by gender) are shown in Table 1. For the analytic sample, the average respondent age was about 59.5 years old, and 48.6 per cent of respondents were women. The average vision, hearing and masticatory functions were 3.145, 3.775 and 3.423, respectively. On average, observations for not losing spouse showed better functional outcomes than those for losing spouse (column 2 *versus* column 3). The functional outcomes of widowed people (including vision and hearing) also differed greatly depending on their gender (column 4 *versus* column 5). Furthermore, there were gender differences in a number of covariates, including household income, homeownership, economic activity, place of residence and the number of chronic diseases.

Table 2 shows the distribution of time to spousal loss by gender. There were 551 women and 134 men among the 685 respondents who had lost a spouse. Among the total 42,967 observations in the analytic sample, 685 respondents contributed to 4,279 observations with the variable of time to spousal loss.

Table 3 presents results from fixed effects models that assess the association between time to spousal loss and sensory and masticatory functions among the total sample. The variable time to spousal loss indicates the difference between sensory and masticatory functions in the reference period (*i.e.* the fourth year and previous years before spousal loss) and sensory and masticatory functions of the period under consideration, while age-related changes as well as potential time-varying confounders are accounted for. Column 1 shows that vision function decreased one year after spousal loss ($b = -0.323$). In the years that followed, vision function remained low ($b = -0.317$ for the second year, $b = -0.251$ for the third year, $b = -0.275$ for the fourth and subsequent years). Although hearing and masticatory functions seemed to decrease in response to spousal loss, the declines were not large enough to be statistically significant (columns 2 and 3).

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Table 1. Descriptive statistics

	(1) Entire sample	(2) Not losing spouse	(3) Losing spouse (total)		(4) Losing spouse (women)		(5) Losing spouse (men)	
	Mean or %	Mean or %	Mean or %	SD	Mean or %	SD	Mean or %	SD
Dependent variables:								
Vision[1,2]	3.145	3.168	2.891	0.829	2.867	0.822	2.993	0.854
Hearing[1,2]	3.775	3.793	3.590	0.800	3.628	0.749	3.433	0.969
Mastication[1]	3.423	3.451	3.128	0.904	3.138	0.896	3.090	0.938
Demographics:								
Age[1,2]	59.592	58.986	66.070	9.190	65.265	8.881	69.381	9.718
Women (%)[1]	48.6	45.6	80.4					
Time-varying controls:								
Married (%)[1]	99.6	99.5	99.6		99.5		100.0	
Household size[1]	3.111	3.133	2.883	1.312	2.877	1.310	2.910	1.323
Household income (%):[1,2]								
Quartile 1	20.8	20.2	28.0		27.6		29.9	
Quartile 2	24.2	23.4	32.6		33.9		26.9	
Quartile 3	28.8	29.3	22.9		23.0		22.4	
Quartile 4	19.1	20.1	9.1		8.3		11.9	
Missing	7.1	7.0	7.4		7.1		9.0	
Homeownership (%)[1,2]	79.7	79.8	78.4		79.7		73.1	

(*Continued*)

Table 1. (*Continued.*)

	(1) Entire sample	(2) Not losing spouse	(3) Losing spouse (total)		(4) Losing spouse (women)		(5) Losing spouse (men)	
	Mean or %	Mean or %	Mean or %	SD	Mean or %	SD	Mean or %	SD
Economic activity (%)[1,2]	44.3	46.2	23.4		20.7		34.3	
Place of residence (%):[1,2]								
Large city	44.4	44.9	38.7		39.7		34.3	
Small city	33.0	33.4	29.3		28.3		33.6	
Rural	22.6	21.7	32.0		31.9		32.1	
Number of chronic diseases[1,2]	0.675	0.651	0.934	1.025	0.967	1.030	0.799	0.995
ADLs[1]	0.138	0.138	0.128	0.773	0.122	0.759	0.157	0.830
N (observations)	8,002	7,317	685		551		134	

Notes: Summary statistics are based on 2006 data from the Korean Longitudinal Study of Ageing. Chi-squared tests for categorical variables and *t*-tests for continuous variables were performed. SD: standard deviation. ADLs: activities of daily living. 1. Differences between never widowed (column 2) and widowed (column 3) are statistically significant, $p < 0.05$. 2. Differences between women (column 4) and men (column 5) are statistically significant, $p < 0.05$.

Table 2. Time to spousal loss, by gender

	Total		Women		Men	
Time to spousal loss	N	%	N	%	N	%
≤− 4th year	1,386	32.4	1,122	32.1	264	33.7
− 3rd year	267	6.2	223	6.4	44	5.6
− 2nd year	346	8.1	270	7.7	76	9.7
− 1st year	307	7.2	253	7.2	54	6.9
+ 1st year	353	8.2	277	7.9	76	9.7
+ 2nd year	316	7.4	265	7.6	51	6.5
+ 3rd year	252	5.9	199	5.7	53	6.8
≥+ 4th year	1,052	24.6	886	25.4	166	21.2
N (observations)	4,279	100.0	3,495	100.0	784	100.0

Note: In total 685 respondents lost their spouse (551 women and 134 men).

To assess the influence of attrition-related selection bias on the estimated association between widowhood and functional impairment, a sensitivity analysis was performed using the inverse of the estimated probability of attrition (inverse probability weighting). The results obtained from the models using inverse probability weighting for the purpose of adjusting for attrition bias were substantially similar to the ones reported in this paper (*see* Tables S1–S3 in the online supplementary material).

Table 4 presents results from gender-stratified analyses (columns 1 and 2 for vision function; columns 3 and 4 for hearing function; columns 5 and 6 for masticatory function). Columns 1 and 2 show that the trajectories of vision function associated with spousal loss are similar for women and men. For both women and men, vision function decreased one year after spousal loss and remained low. Although the declines in vision function seemed to be greater for men than women, these differences were not statistically significant according to the interaction term in the joint model (*see* Table S4 in the online supplementary material). In columns 3 and 4, similar to the total sample, a decrease in hearing function associated with spousal loss was not statistically significant for both women and men.

Columns 5 and 6 show that the relationship between time to spousal loss and masticatory function is different on the basis of gender. In column 5, masticatory function among women was relatively stable before and after spousal loss compared to the reference point. In contrast, as shown in column 6, declines in masticatory function associated with time to spousal loss were dramatic for men. Masticatory function began to decrease in the first year after spousal loss ($b = -0.379$) and persisted even after the fourth year and subsequent years ($b = -0.379$). This decrease may be considered as substantial given that a within-person standard deviation for masticatory function for men is 0.593. In the interaction model, these gender differences were statistically significant (*see* Table S4 in the online supplementary material).

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Table 3. Effect of time to spousal loss on sensory and masticatory functions

	(1) Vision	(2) Hearing	(3) Mastication
Sample	Total	Total	Total
Estimation model	FE	FE	FE
Time-varying controls	Yes	Yes	Yes
	B (95% confidence intervals)		
Age	−0.007*** (−0.009, −0.004)	−0.032*** (−0.034, −0.030)	−0.013*** (−0.015, −0.011)
Age^2	0.000 (−0.000, 0.000)	−0.000*** (−0.001, −0.000)	0.000 (−0.000, 0.000)
Time to spousal loss (Ref. ≤− 4th year):			
− 3rd year	0.002 (−0.088, 0.092)	−0.010 (−0.098, 0.077)	−0.027 (−0.124, 0.070)
− 2nd year	−0.022 (−0.099, 0.056)	−0.030 (−0.106, 0.047)	−0.001 (−0.082, 0.080)
− 1st year	0.052 (−0.036, 0.141)	−0.067 (−0.156, 0.022)	−0.070 (−0.166, 0.027)
+ 1st year	−0.323** (−0.551, −0.096)	−0.001 (−0.294, 0.291)	−0.044 (−0.297, 0.209)
+ 2nd year	−0.317** (−0.556, −0.079)	−0.042 (−0.338, 0.254)	−0.095 (−0.362, 0.173)
+ 3rd year	−0.251* (−0.485, −0.016)	−0.092 (−0.382, 0.199)	−0.032 (−0.298, 0.234)
≥+ 4th year	−0.275* (−0.505, −0.045)	−0.071 (−0.365, 0.224)	−0.114 (−0.373, 0.145)
N (observations)	42,967	42,967	42,967
N (individuals)	8,002	8,002	8,002

Notes: Robust standard errors were used. Time-varying controls include age (linear and squared age), marital status, household size, household income, homeownership, economic activity, region of residence, number of chronic diseases and activities of daily living. FE: fixed effect. Ref.: reference category.
Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Figure 1 plots the gendered trajectories by presenting predicted values of sensory and masticatory functions depending on time to spousal loss (panel A for vision function, panel B for hearing function and panel C for masticatory function). In panel A, the temporal patterns of declines in vision function are similar for women and men. In panel B, hearing function appears not to respond to time to spousal loss for both women and men, despite some decreasing pattern for men. In panel C, masticatory function for men dropped in the first year and remained low thereafter. As shown in the same plot, no such patterns were found among women.

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Table 4. Effect of time to spousal loss on sensory and masticatory functions, by gender

	(1) Vision	(2) Vision	(3) Hearing	(4) Hearing	(5) Mastication	(6) Mastication
Sample	Women	Men	Women	Men	Women	Men
Estimation model	FE	FE	FE	FE	FE	FE
Time-varying controls	Yes	Yes	Yes	Yes	Yes	Yes
			B (95% confidence intervals)			
Age	−0.002 (−0.005, 0.001)	−0.011*** (−0.014, −0.008)	−0.031*** (−0.034, −0.028)	−0.033*** (−0.036, −0.029)	−0.012*** (−0.015, −0.009)	−0.013*** (−0.016, −0.010)
Age^2	0.000* (0.000, 0.000)	0.000 (−0.000, 0.000)	−0.000*** (−0.000, −0.000)	−0.000*** (−0.001, −0.000)	0.000 (−0.000, 0.000)	0.000 (−0.000, 0.000)
Time to spousal loss (Ref. ≤− 4th year):						
− 3rd year	−0.014 (−0.109, 0.080)	0.013 (−0.254, 0.281)	−0.001 (−0.096, 0.093)	−0.082 (−0.311, 0.146)	−0.004 (−0.111, 0.102)	−0.176 (−0.404, 0.052)
− 2nd year	−0.019 (−0.107, 0.068)	−0.093 (−0.263, 0.077)	−0.003 (−0.084, 0.078)	−0.143 (−0.340, 0.055)	−0.006 (−0.099, 0.087)	−0.012 (−0.184, 0.161)
− 1st year	−0.014 (−0.113, 0.086)	0.257** (0.063, 0.451)	−0.103* (−0.202, −0.004)	0.070 (−0.129, 0.270)	−0.097† (−0.204, 0.010)	0.008 (−0.221, 0.237)
+ 1st year	−0.314* (−0.622, −0.006)	−0.446** (−0.716, −0.176)	0.013 (−0.400, 0.425)	−0.001 (−0.291, 0.289)	0.096 (−0.210, 0.401)	−0.379* (−0.696, −0.063)
+ 2nd year	−0.366* (−0.690, −0.042)	−0.224 (−0.511, 0.063)	−0.014 (−0.436, 0.408)	−0.106 (−0.403, 0.190)	0.068 (−0.256, 0.392)	−0.565** (−0.915, −0.215)
+ 3rd year	−0.273† (−0.590, 0.044)	−0.285† (−0.576, 0.007)	−0.051 (−0.461, 0.359)	−0.198 (−0.532, 0.136)	0.091 (−0.235, 0.416)	−0.302† (−0.639, 0.034)
≥+ 4th year	−0.331* (−0.645, −0.018)	−0.248† (−0.526, 0.030)	−0.062 (−0.483, 0.358)	−0.071 (−0.344, 0.202)	0.002 (−0.316, 0.320)	−0.379* (−0.689, −0.069)
N (observations)	21,641	21,326	21,641	21,326	21,641	21,326
N (individuals)	3,891	4,111	3,891	4,111	3,891	4,111

Notes: Robust standard errors were used. Time-varying controls include age (linear and squared age), marital status, household size, household income, homeownership, economic activity, region of residence, number of chronic diseases and activities of daily living. FE: fixed effect. Ref.: reference category.
Significance levels: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

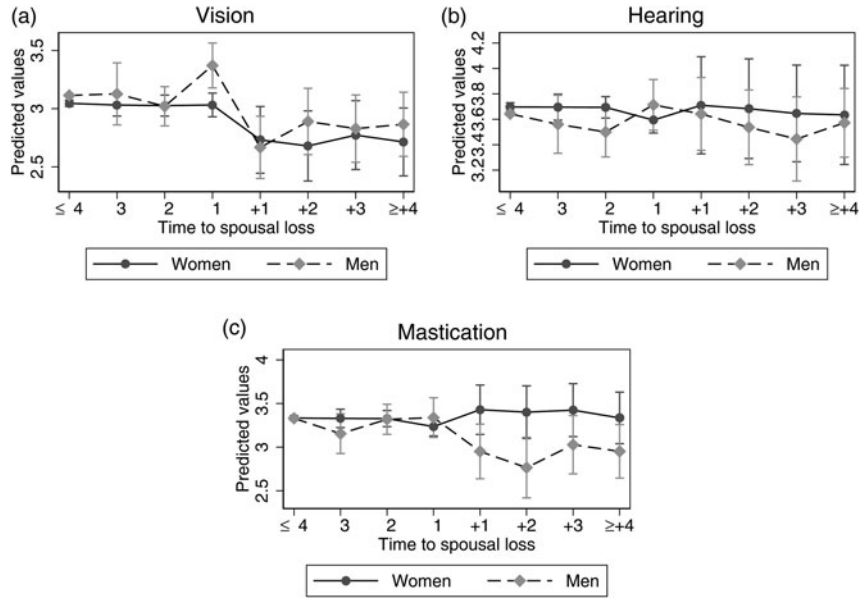

Figure 1. Trajectories of sensory and masticatory functions over time relative to spousal loss, by gender. *Note*: Ninety-five per cent confidence intervals are shown.

Discussion

Despite a growing body of research on the impact of spousal loss on the physical and psychological health of widowed individuals, little is known about its impact on physical functions. Furthermore, to the best of the authors' knowledge, no study has been conducted to investigate gender differences in temporal changes of physical functions in response to spousal loss. To fill these knowledge gaps in the literature, this study estimated gender-stratified fixed effects models using seven waves of a nationally representative longitudinal study spanning 12 years.

The findings of this study indicate that widowed individuals experience a decline in self-reported visual functions following spousal loss, and this impairment persists over time (until the fourth and subsequent years after spousal loss). There was no evidence of such impairment in the hearing or masticatory functions. The stress and emotional turmoil associated with the loss of a spouse can cause an increase in cortisol levels, which can contribute to the development of age-related macular degeneration and other vision-related issues (Dougherty *et al*., 2017). In addition, visual impairments are thought to be particularly susceptible to social environment changes. The social activities of widowed people tend to be limited, as they are averse to social interaction and may lack the confidence to appear in public alone (Naef *et al*., 2013). Widowed individuals also engage in less physical activity (Engberg *et al*., 2012). Due to limited social and physical activities, it is likely that widowed individuals engage in more indoor activities, with television watching being a common form of entertainment and a way to alleviate loneliness for older adults in Korea (Lee and Shin, 2018). However, increased screen

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time has been associated with ocular symptoms such as dryness, redness and blurred vision (Kim *et al*., 2020), which may result in discomfort with visual function for widowed individuals.

The findings of gender-stratified models suggest that changes in self-reported masticatory functions among individuals who have lost a spouse are markedly gendered. Spousal loss was associated with a reduction in masticatory malfunctions in widowers but not in widows. The loss of masticatory function in widowers was not temporary at the time of spousal loss, but lasted for a prolonged period. These findings are generally consistent with previous empirical studies that show men often have more oral and masticatory problems than women (Leles *et al*., 2019). This gendered distinction can be partially elucidated by the decline of health reminders. A decline in health reminders and assistance from others have been addressed as a predominant factor in compromised health status among widowed individuals (Williams, 2004), and men have been found to gain more marital benefits than women in the forms of health regulation by their spouses (Umberson, 1987). Widowhood, which signifies the loss of the primary source of health regulation, may therefore have more pronounced impact on widowers, leading to a series of adverse health outcomes. Moreover, the connection between social exclusion and pain sensitivity could explain such gender differences. Recent neuroimaging studies showed that social and physical pain share a common neurological basis, and that social exclusion can result in both physical and social pain (Bernstein and Claypool, 2012). Given that widowers are more likely than widows to confront social isolation and experience a disruption in social engagement following spousal loss (Yoon *et al*., 2022), emotional distress may manifest physically as masticatory dysfunctions in widowers to a greater extent than in widows.

This study contributes to existing scholarship in a number of ways. First, this study sheds light on the long-term physical dysfunctions associated with spousal loss. This is the first study to examine whether spousal loss results in various physical dysfunctions such as sensory (vision and hearing) and masticatory dysfunctions. We also broaden the view that, unlike some aspects of physical wellbeing, declines in sensory and masticatory functions can last a long time. Second, this study adds to our understanding of gender differences in physical functional trajectories among people who have experienced spousal loss. This study can serve as a foundation for gender-based approaches to assisting individuals in better adjusting to widowhood. Third, this study used fixed effects regression models that account for both observed and unobserved time-constant confounders. This allowed us to estimate within-person changes in physical functional outcomes related to spousal loss, yielding a more credible estimate of the influence of spousal loss.

This study has some limitations that should be considered. First, this study was unable to examine directly the detailed mechanisms that link spousal loss to functional impairment in widowed individuals. Future research could explore potential mechanisms underlying the association between widowhood and functional performance, such as the loss of social support or regulation of health, family reconfiguration and the stress of grief, which have been well-documented as influencing widowed people's health (Williams, 2004; Jin and Chrisatakis, 2009). Second, the sample attrition problem inherent in longitudinal studies may introduce bias into our estimates. Our findings, in particular, may be underestimated if the likelihood of panel attrition

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is greater for those who experience a greater impact of spousal loss on physical functional declines. Third, we were unable to take into account the context of spousal death. The consequences of spousal loss may be mitigated if the death occurs in anticipated circumstances (*e.g.* in hospice care) (Christakis and Iwashyna, 2003). Future research should consider the characteristics of a spouse's death and the context surrounding the death to gain a better understanding of physical function impairment caused by spousal loss. For example, investigating whether and how the relationship between time since spousal loss and functional outcomes differs depending on the spouse's health or care-giving burden prior to their death would provide valuable insight into the nuances of the impact of spousal loss on functional impairment. Fourth, the sensory and masticatory dysfunction measures in KLoSA were based on self-reports, which may lead to measurement error. Future studies may benefit from using objective assessment (performance-based) of sensory and masticatory functions to produce accurate and reliable data (Hu *et al.*, 2021).

The study's findings have policy implications. Our findings on long-term vision damage as a result of spousal loss highlight the need for multifaceted interventions to assist widowed people in managing the physical and psychosocial crisis caused by their spouse's death. Because vision impairment is associated with a variety of daily limitations, the primary feature of older adults with low vision is a loss of independence in their lives. Given that it is difficult for those with vision impairment to maintain social relationships and engagement (Mick *et al.*, 2018), the psychological pain associated with the loss of a spouse may be exacerbated in widowed persons with vision impairment. This creates a vicious cycle of physical and psychosocial vulnerability in widowed people. Thus, interventions that aid in the early stages of adjustment to widowhood can have a positive effect on the widowed person's overall wellbeing. In addition, our findings regarding gender differences in trajectories of masticatory dysfunction should be considered when developing measures designed to mitigate the negative effects of spousal loss. Interventions that can reduce the risk of masticatory dysfunction (*e.g.* assisting with dietary practices and improving oral health) are required for widowers.

To conclude, the current study extends previous research by exploring whether time since spousal loss is associated with trajectories of physical functional outcomes such as vision, hearing and mastication. The most common physical dysfunction for both widows and widowers was vision impairment. Vision impairment began in the first year of spousal loss and persisted through the fourth and subsequent years. In contrast, masticatory functional changes were gendered: only for widowers, masticatory function deterioration began within the first year of spousal loss and continued throughout the survey period. These findings suggest that spousal loss-related changes in physical functions occur over time and that their effects on masticatory function vary by gender. They also hold implications for research and practice aimed at enhancing widowed people's health and wellbeing.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0144686X23000557.

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