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Decreasing patterns of depression in living alone across middle-aged and older men and women using a longitudinal mixed-effects model

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ABSTRACT

There is little evidence regarding the association between living arrangement and depression, and no studies have examined the age- and gender-specific differences in this association. The present study sought to examine the longitudinal changes in depression patterns between isolative living versus living in company among middle-aged and older men and women by obtaining data from waves 1–7 of the Korean Longitudinal Study of Aging (KloSA), which comprises a sample of persons at least 45 years of age in the Republic of Korea (2273 middle-aged and 1387 older men, 2805 middle aged and 1862 older women). Depression scores were based on the self-reported Center for Epidemiologic Studies Depression Scale (CES-D-10) short forms. Using mixed-effect linear regression models, we estimated depression patterns by living arrangement across age- and gender groups. Our findings from the mixed-effects model revealed that over a 14-year follow-up period, there were significant decreasing patterns of depression were among middle-aged men and women, and older men living alone compared to living with a spouse and living with others. However, living alone still had the highest depression compared to other living arrangement types. On the other hand, the depression of older women living alone changed to a level similar to those living with others during the follow-up period. In conclusion, these findings indicate that living alone significantly increases the risk of depression, but the risk decreases over time. Additionally, depression patterns by living arrangement proved to differ across age and gender groups.

1. Introduction

Depression is a significant and growing problem worldwide. According to the 2021 Korea National Mental Health Survey, 1.7% of adults suffer from depression annually, accordingly with the following age categories: 1.5% of those aged 40–49, 1.8% of those aged 50–59, 1.8% of those aged 60–69, and 3.1% of those aged 70–79 (Ministry of Health and Welfare, 2021). The risk of depression increases with age (Mojtabai and Olfson, 2004), and depression in later life reduces quality of life in terms of physical and cognitive health (Hu et al., 2019) and increases mortality (Keyes and Simoes, 2012). Therefore, it is important to prevent depression for successful aging and health.

In the aspect of social integration, people living alone are more likely to have depression than those living with a spouse or family members (Cacioppo and Hawkley, 2003). A meta-analysis of 25 studies by Xiu-Ying et al. (2012) found that older people living alone had a 1.44 times higher risk of depression than those not living alone. Another study using the 2014 and 2016 Korea National Health and Nutrition Examination Survey reports that people living alone had the highest risk of clinically relevant depression compared to those not living alone (Hong et al., 2021). People living alone may have limited social connection and support from family members and friends (Jennifer Yeh and Lo, 2004), leading to poor mental health (Russell and Taylor, 2009) and high risk for mortality (Ng et al., 2015). Although several studies point to other social network factors, such as social isolation, social support, and social disengagements (Schwarzbach et al., 2014), living alone is still an important risk factor for increased depression (Stahl et al., 2017).

The observation of the association between living alone and depression deserves attention over a long period of time for the following two reasons: Firstly, the risk of depression from living alone may decrease over time (Oshio and Kan, 2019; Stone et al., 2013). In a

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longitudinal study with 6 years of follow-up, the prevalence of depression increased immediately after switching to living alone, but the risk fell to a level similar to not living alone (Stone et al., 2013). Oshio and Kan (2019) also found that the initial change in mental health at the onset increased in people living alone and then declined over 5 years of follow-up. This process can be explained by adapting to a life alone (Kirkevold et al., 2013). Secondly, depression should be repeatedly measured over the time period because self-reported depression can be underestimated and unrecognized. Self-reporting measures of depression are widely used in geropsychiatric practice to screen older adults with depression and are known to be valid measures for older adults used in clinics, hospitals, and communities (Park and Lee, 2021). However, self-reporting presents reliability issues as self-reporting bias may be introduced due to social stigma or ageism. Mental health issues were considered a personal weakness, family stigma, and cultural taboo in some Asian countries (Zhang et al., 2020). Asians also tend to perceive depressive symptoms as a normal part of the aging processes and pay less attention to mental health issues compared to physical or functional problems (Ludvigsson et al., 2015). Therefore, in order to represent the risk of depression in living alone, it is necessary to repeatedly measure depression and identify the depression pattern among individuals who live alone over a long-term period.

The significance of living alone for depression has not been fully examined according to the life cycle of middle-aged and older adults. Most of the previous longitudinal studies on older adults (Honjo et al., 2018; Nakagomi et al., 2020; Stone et al., 2013), and a few studies on middle-aged adults have indicated a negative association between living alone and mental health (Oshio and Kan, 2019). Regarding age-related changes in social relationships, older adults living alone are more likely to have deficient social interactions compared with middle-aged adults living alone. For example, a meta-analysis of 277 studies revealed that global, personal, and friendship networks, excluding family networks, decreased after 65 years old (Wrzus et al., 2013). Similar results also indicated that social network size increased until middle age, but decreased gradually throughout old age in 10-year follow-up study (English and Carstensen, 2014). This study examines depression in middle-aged adults and focuses on difference in patterns of depression in middle-aged and older adults over a 14-year follow-up period.

In addition, the impact of living alone on depression could differ by gender. Women are consistently more vulnerable to depression in most age groups. According to the 2021 Korea National Mental Health Survey, the prevalence of depression over the past year has been 2.2 times higher in women than in men: 40–49 years old, 0.7% men and 2.3% women; 50–59 years old, 1.3% men and 2.4% women; 60–69 years old, 1.9% men and 1.6% women; and 70–79 years old, 0.3% men and 5.4% women (Ministry of Health and Welfare, 2021). However, in the association between living alone and mental health, men were at higher risk compared with women (Honjo et al., 2018). For example, a cross-sectional health study in South Korea found that men and women living alone were most likely to have depression, and this association was stronger for men than women (Oh et al., 2015). This difference could be interpreted as a result of men's apparent dependency on their spouses for healthy diets, health habits, or social supports. Furthermore, living alone seemed more detrimental to older men than older women (Jeon et al., 2007; Oh et al., 2015). Older men are less likely to maintain social relationships than older women, and this risk was particularly high for older men living alone (Ajrouch et al., 2005). On the other hand, older women living alone are not socially isolated and maintain more active social ties with friends and relatives, regardless of their marital status. Also, it is important to focus on gender-specific differences in the association between living alone and depression, especially in Asian societies with strong gender specific roles. Living with a family is not entirely positive for women compared to men, as women primarily play a role in providing social support to family members at home (Floridi et al., 2022; Honjo et al., 2018). Thus, the depression patterns would be different by gender.

The aim of this study was to examine the longitudinal course of depression according to the living arrangement of Korean middle-aged and older men and women over a 14-year follow-up period. We hypothesized that the risk of depression was more prevalent in living alone compared to the other living arrangement types, including living with a spouse and living with others. In addition, we hypothesized that these depression patterns differed across age and gender groups as follows: 1) Among middle-aged adults, both men and women living alone have the highest level of depression than other living arrangement types across 14-year follow-up period. 2) Among older adults, men living alone have the highest level of depression; women living alone have a similar level of depression compared to other arrangement types across the 14-year follow-up period.

2. Methods

2.1. Primary data source

The data were obtained from the Korean Longitudinal Study of Aging (KLoSA) from 2006 to 2018. Similar to the Health and Retirement Study in the United States and the English Longitudinal Study of Ageing in England, KLoSA is a nationally representative longitudinal study of the middle and old-age population (aged 45 or more). The survey was conducted in a stratified multistage and probability proportional sampling method based on geographical area. The baseline survey in 2006 collected 10,254 adults in 6171 households, and the seventh wave in 2018 followed 6136 participants out of 8058 available follow-up participants (response rate: 76.1%). All participants were interviewed face-to-face using a computer-assisted personal interviewing method. KLoSA provides details on socio-demographics, health status, family support, social engagement, and life satisfaction, and the data are publicly available on its website (https://survey.keis.or.kr/klosa/klosa01.jsp).

2.2. Sample of the secondary data analysis

A total of 8327 participants (3660 men and 4667 women) were included in this secondary data analysis; 3596 men and 4571 women at baseline in 2006; 3434 men and 4393 women at second wave in 2008; 3055 men and 3950 women at third wave in 2010; 2887 men and 3766 women at fourth wave in 2012; 2654 men and 3525 women at fifth wave in 2014; 2490 men and 3377 women at sixth wave in 2016, and 2309 men and 3156 women at seventh wave in 2018. Individuals who only participated in the baseline (n = 1261) or had a diagnosed of psychiatric disorders (n = 558) were excluded. In addition, we excluded 142 participants with incomplete data or only one wave of completed data. The final sample comprised 8327 participants.

3. Measures

3.1. Self-reported depression: CES-D-10 scale

Self-reported depression was measured with the short version of the Center for Epidemiologic Studies Depression Scale, CES-D-10 (Andresen et al., 1994; Kohout et al., 1993). The two versions of CES-D-10 were used in KLoSA; Andresen form (Andresen et al., 1994) and Boston form (Kohout et al., 1993). After the fourth wave, the version of CES-D-10 was changed from the Andresen form to the Boston form, with three items of the CES-D-10 different between the two assessments. Using the KLoSA data, the previous study revealed the difference between the two measurements from confirmatory factor analysis (Bae et al., 2020). Andresen's form indicated two factor-positive and negative affect-, and Boston's form measured four factor-depressed, positive, somatic, and interpersonal. These results were identical to what the initial developers showed (Andresen et al., 1994; Kohout et al., 1993). Even though the Anderson and Boston forms do not consist of the same factors, both

assessments are remarkably consistent with the original CES-D-20 scale. Additionally, both Andresen and Boston's forms were validated with good internal consistency (Boey, 1999; Zhang et al., 2012) and measurement invariance across age, gender, and cultural differences (Bae et al., 2020).

In this study, both Andresen's and Boston's forms of CES-D-10 were assessed with a four-point scale ranging from 0 to 3 for each item (0 = rarely or none of the time, 1 = some or little of the time, 2 = moderately or much of the time, 3 = most or almost all the time). The total score ranged from 0 to 30, with high scores indicating greater depression. The time frame for assessing depression was seven days prior to the interview. In our sample, the internal consistency of CES-D-10 was good as following; 0.83 in the overall Cronbach α of CES-D-10; 0.83 in Andresen form (Wave 1 - Wave 4); and 0.84 in Boston form (Wave 5 - Wave 7).

3.2. Living arrangements

The type of living arrangement was categorized as living alone, living with spouse only, and living with others. Living alone included being single, divorced, widowed, and separated. Living with a spouse included a person who lived only with a spouse. Living with others indicated that participants lived with their children or grandchildren, and their spouse, if any (Lee et al., 2011; Park, 2014).

3.3. Age group

Age was categorized into two groups: middle-aged (45–64 years) and old-aged (65 years and older) (Kaplan et al., 2012). Age classification refers to prior research focusing on the age-specific effects and this classification can capture various life stages and the entire life cycles of middle-age and older adults.

3.4. Control variables

As sociodemographic variables are important factors for depressive symptoms (Lorant et al., 2007; Milner et al., 2016), we adjusted for annual household income quartiles and employment status (employed and unemployed). Previous studies have revealed that less social relationships and social isolation were associated with poor mental health (Cornwell and Waite, 2009; Teo et al., 2013). Based on the concept of social embeddedness, lacking a confidant to share personal feelings and emotions was a strong predictor of distress (Taylor et al., 2018). Social relationships were measured with the frequency of contact with familiar friends. The responses were assigned to one of three subcategories: daily or 1–3 times per week, 1–2 times per month, and 1–6 times per year or none. Depressive symptoms also related to alcohol consumption (Boden and Fergusson, 2011), and health status including self-rated health (Ambresin et al., 2014), comorbidities (Boima et al., 2020; Holt et al., 2014; Kales et al., 2005), and cognitive function (Kang et al., 2014; Shin, 2021). Alcohol consumption was categorized as current drinker, former drinker, or never; three categories were collapsed into two (current drinker vs. former drinker or never). Although further research should investigate the mechanisms of alcohol use and depression, a potential mechanism is that neurophysiological and metabolic changes are results of alcohol exposure. (Boden and Fergusson, 2011). Self-rated health was categorized into three groups: very good/good, fair, poor/very poor. The total number of comorbidities was calculated to include hypertension, diabetes, cancer, chronic pulmonary disease, liver disease, cardiovascular disease, heart disease, cerebrovascular disease, and arthritis or rheumatism, a continuous variable ranging from 0 to 7. The MMSE, a Korean version of the Mini-Mental State Examination, was used to assess general cognitive function (Kang et al., 1997). The total score ranged from 0 to 30 and, in this study, they were classified as normal (>23), mild (18–23), and severe (<18). This cutoff is the most widely used and accepted for the MMSE (Tombaugh and McIntyre, 1992).

3.5. Data analysis

The primary aim of the study was to evaluate whether the longitudinal course of depression according to living arrangement differed from the baseline to the 14-year follow-up. The longitudinal data of depressive symptoms were analysed using the linear mixed-effect model, which is advantageous because the procedure accounts for the correlations among repeated assessments within an individual (Liu et al., 2012). Fundamentally, the mixed-effects regression approach model changes across time at both the population and individual level. Ability to model person-specific trends is extremely useful in a mental health study where response to treatment is quite individualized (Gibbons, 2000). Another important feature of this model is that it permits unbalanced data. Thus, participants who had missing data at a follow-up wave are not excluded from the analyses. The assumption of the model is that the data that are available for participants are representative of that individual's deviation from the average trend lines that are observed for the whole sample. The model estimates a subject's trend over time based of whatever data that subject has, augmented by the time-trend that is estimated for the sample as a whole and effects of all covariates in the model (Gibbons, 2000).

In the mixed-effects regression model (StataCorp, 2013), let i denote the level-2 units (subjects in the longitudinal data), and j denote the level-1 units (repeated observations). Assume that there are $i = 1, \ldots, N$ level-2 units and $j = 1, \ldots, n_i$ level-1 units nested within the i-th level-2 unit. The model for the $n_i \times 1$ response vector $\mathbf{y}$ for the i-th level-2 unit can be written:

$$y_i = W_i\alpha + X_i\beta_i + \varepsilon_i, i = 1, \ldots, N$$

W_i is a $n_i \times p$ design matrix for the fixed effect, X_i is a $n_i \times r$ design matrix for the random effects. α and β_i are a vector of unknown fixed and random effects, respectively. ε_i is the unknown random error. The covariance matrix of y is made up:

$$\mathrm{V} = \mathrm{var}(\mathrm{y}) = ZGZ^{'} + R$$

This matrix structure of R can include the within-group heteroscedasticity and spatial correlation, thus allowing the structure of R to be modelled as an autoregressive structure (AR (1)).

$$\mathrm{AR}(1) = \sigma^2 \begin{bmatrix} 1 & \rho & \rho^2 \\ \rho & 1 & \rho \\ \rho^2 & \rho & 1 \end{bmatrix}$$

The AR (1) structure has homogeneous variance and correlations that decline exponentially with distance. ρ is an autoregressive parameter, and correlation between measurements immediately next to each other in time depends on the value of ρ (Cnaan et al., 1997; Gibbons, 2000; StataCorp, 2013).

We used a t-test or chi-square test to compare differences in CE-SD-10 scores, gender, living arrangement, education level, household income, employment status, frequency of contact with familiar friends, health-related behaviours, self-rated health, number of chronic diseases, and cognitive function by age group based on the first assessment (Table 1). The linear mixed-effects regression models were performed first for all participants (Table 2) and second for age and gender subgroups: middle-aged men; middle-aged women; older men; and older women (Table 3). The linear mixed-effects regression models were examined with and without adjustment variables (age, household income, employment status, frequency of contact with familiar friends, alcohol consumption, self-rated health, number of chronic diseases, and cognitive function). To estimate the pattern of self-reported depression scores over 14 years, the interaction term between living arrangement and wave includes the linear mixed-effects regression models. This variable indicates whether the negative association between depression and living arrangement significantly increases across time (Gibbons et al., 2010). To describe the interaction effects between living arrangement and wave on depression,

Table 1
Descriptive statistics for all study variables by age group at first assessment (N = 8327).

Variables	Middle-aged adults		Older adults		*p*
	N = 5093		N = 3234		
Wave	5.95	(1.59)	5.21	(1.8)	<0.001
CES-D-10, M±SD	5.46	(4.1)	7.68	(5.3)	<0.001
Number of chronic diseases, M ±SD	0.5	(0.8)	1.0	(1.0)	<0.001
Gender					
Men	2279	(44.7%)	1381	(42.7%)	0.070
Women	2814	(55.3%)	1853	(57.3%)	
Living arrangement					
Living alone	210	(4.1%)	485	(15.0%)	<0.001
Living with spouse	1520	(29.8%)	1423	(44.0%)	
Living with others	3363	(66.0%)	1326	(41.0%)	
Household income					
1Q Lowest	1537	(30.2%)	1954	(60.4%)	<0.001
2Q	1068	(21.0%)	597	(18.5%)	
3Q	1565	(30.7%)	489	(15.1%)	
4Q Highest	923	(18.1%)	194	(6.0%)	
Employment status					
Employed	2798	(54.9%)	628	(19.4%)	<0.001
Not employed	2295	(45.1%)	2606	(80.6%)	
Frequency of contact with familiar friends					
Daily or 1–3 times/week	3292	(64.6%)	2210	(68.3%)	<0.001
1–2 times/month	1029	(20.2%)	440	(13.6%)	
No contact or 1–6 times/year	772	(15.2%)	584	(18.1%)	
Alcohol consumption					
No	2805	(55.1%)	2289	(70.8%)	<0.001
Yes	2288	(44.9%)	945	(29.2%)	
Self-rated health					
Very good/good	2598	(51.0%)	682	(21.1%)	<0.001
Fair	1595	(31.3%)	1093	(33.8%)	
Poor/very poor	900	(17.7%)	1459	(45.1%)	
Cognitive function (MMSE)					
<18	87	(1.7%)	568	(17.6%)	<0.001
18-23	412	(8.1%)	848	(26.2%)	
>23	4594	(90.2%)	1818	(56.2%)	

Data are presented as mean ± standard deviation for continuous variables or n (%) for categorical variables.

the mean values of estimated CES-D-10 were calculated from the adjusted longitudinal linear mixed-effect models and shown in Fig. 1. Education level and smoking were excluded from the control variables due to time invariant and low rates, respectively. The summary of categorical variables over time are shown in Supplementary Table 1. The level of significance was set to $p < .05$, two-tailed. Statistical analyses were carried out using Stata 15.0.

4. Results

4.1. Sample characteristics by age group

The differences by age group in all the study variables from the first assessment are presented in Table 1. The average number of waves was 5.95 for middle-aged adults and 5.21 for older adults. The mean ± standard deviation of CES-D-10 scores were 5.46 ± 4.1 for middle-aged adults and 7.68 ± 5.3 for women. This difference between age groups was significant. Grouped by gender, 44.7% of men and 55.3% of women were middle-aged, and 42.7% of men and 57.3% of women were older adults. Regarding living arrangements among middle-aged adults, only 4.1% lived alone; 29.8% lived with a spouse, and 66.0% lived with others at the first assessment. In the case of older adults, 15.0% lived alone, 44.0% lived with a spouse, and 41.0% lived with others. There were significant differences between middle-aged and older adults in all variables except for gender.

Table 2
Results from longitudinal linear mixed effect models among total participants (N = 8327).

Variables	Unadjusted		Adjusted	
	β	*p*-value	β	*p*-value
[a] Living arrangement (ref: living alone)				
Living with spouse	−2.80	<0.001	−2.03	<0.001
Living with others	−3.06	<0.001	−1.98	<0.001
[b] Wave	−0.27	<0.001	−0.34	<0.001
[a]*[b]				
Living with spouse × wave	0.22	<0.001	0.22	<0.001
Living with others × wave	0.33	<0.001	0.30	<0.001
Older adults			0.25	<0.001
Women			−0.004	0.832
Household income (ref: 1Q)				
2Q			0.02	0.809
3Q			−0.25	0.001
4Q (Highest)			−0.39	<0.001
Employment status, not employed			0.65	<0.001
Frequency of contact with familiar friends (ref: Daily or 1–3 times/week)				
1–2 times/month			0.59	<0.001
No contact or 1–6 times/year			1.97	<0.001
Alcohol consumption, yes			−0.24	<0.001
Self-rated health (ref: very good/good)				
Fair			0.70	<0.001
Poor/very poor			2.77	<0.001
Number of chronic diseases			0.23	<0.001
Cognitive function (MMSE) (ref: <18)				
18-23			−1.36	<0.001
>23			−2.47	<0.001

4.2. Patterns of CES-D-10 scores by living arrangement among total participants

Table 2 shows the longitudinal linear mixed effect of living arrangement and of the interaction association between living arrangement and wave among total participants. The main effects of wave, living arrangement, and interaction term between them were significant both in unadjusted and adjusted models. In the adjusted model of Table 2, CES-D-10 scores in participants living with spouse and living with others changed over time compared to living alone, increasing by 0.22 and 0.30 units per wave, respectively.

4.3. Patterns of CES-D-10 scores by living arrangement in middle-aged and older men and women

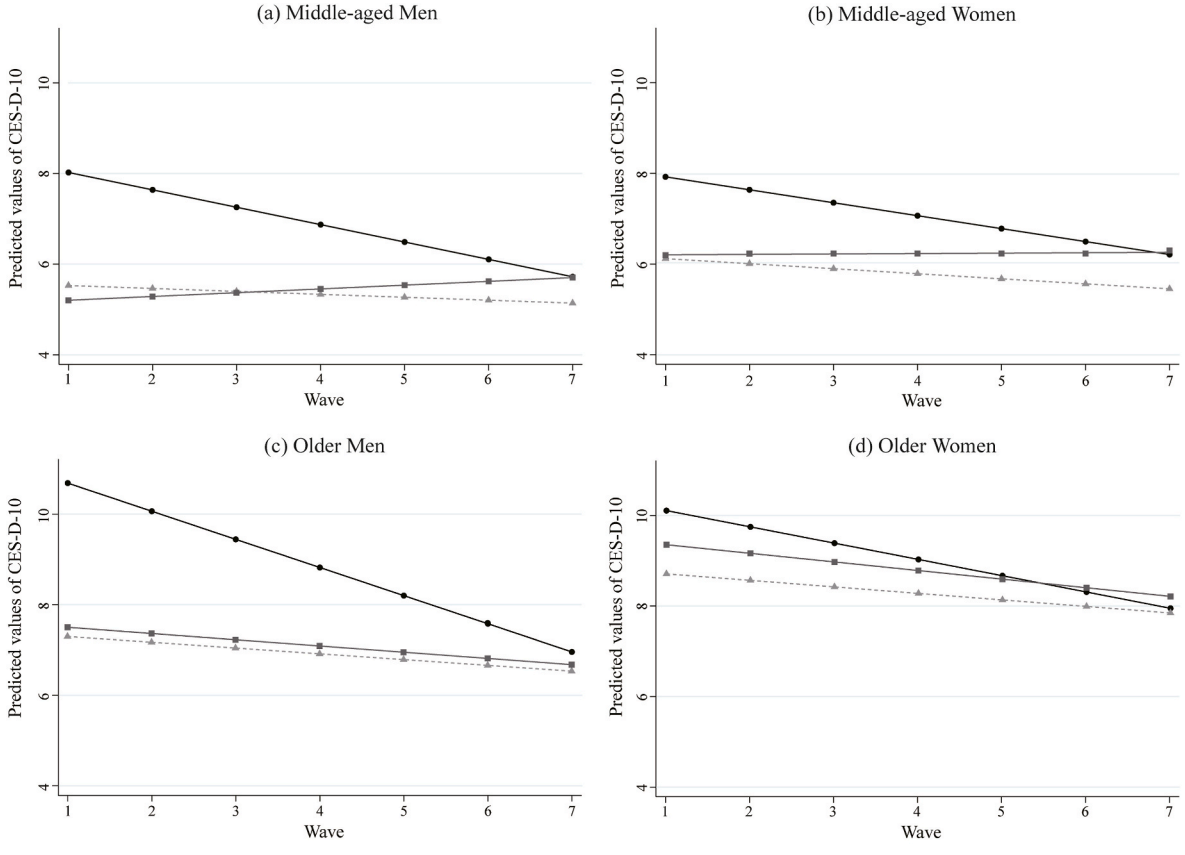
Table 3 shows the results of the main variables, including living arrangement, wave, and interaction term from the longitudinal linear mixed-effect models in middle-aged and older men and women. The four subgroups had the identical patterns of CES-D-10 scores by living arrangement. In the adjusted models of Table 3, CES-D-10 scores in those living with spouse and living with others increased over time compared to living alone by 0.32 ($p = .003$) and 0.47 ($p < .001$) among middle-aged men, 0.19 ($p < .005$) and 0.30 ($p < .001$) among middle-aged women, 0.47 ($p < .001$) and 0.46 ($p < .001$) among older men, and 0.22 ($p = .005$) and 0.17 ($p = .016$) among older women, respectively. Participants living alone were more likely to have higher CES-D-10 scores than those living with a spouse and/or living others; however, the differences in CES-D-10 scores between them decreased over the follow-up period, respectively. Supplementary Tables 2 and 3 shows the full results.

Fig. 1 shows the 14-year changes in the mean scores of predicted values of CES-D-10 score by living arrangement from the results of longitudinal mixed-effect models by middle-aged and older men and women. As the common patterns of CES-D-10 scores among four groups became apparent, living alone had the highest values at Wave 1, and then decreased over the follow-up periods. The degree of decline in the

Table 3
Results from the longitudinal linear mixed effect models by middle-aged and older men and women.

Variables	Middle-aged adults				Older adults			
	Men (N = 2279)		Women (N = 2814)		Men (N = 1381)		Women (N = 1853)	
	β	*p*-value	*β*	*p*-value	*β*	*p*-value	*β*	*p*-value
Unadjusted model								
[a] Living arrangement (ref: living alone)								
Living with spouse	−3.15	<0.001	−2.16	<0.001	−4.29	<0.001	−1.99	<0.001
Living with others	−3.62	<0.001	−2.43	<0.001	−4.04	<0.001	−1.05	0.002
[b] Wave	−0.32	0.004	−0.22	0.001	−0.44	0.001	−0.20	0.001
[a]*[b]								
Living with spouse × wave	0.30	0.009	0.15	0.040	0.59	<0.001	0.23	0.007
Living with others × wave	0.42	<0.001	0.27	<0.001	0.61	<0.001	0.20	0.009
Adjusted model								
[a] Living arrangement (ref: living alone)								
Living with spouse	−2.81	<0.001	−2.02	<0.001	−3.70	<0.001	−1.61	<0.001
Living with others	−3.31	<0.001	−2.06	<0.001	−3.50	<0.001	−0.92	0.003
[b] Wave	−0.38	<0.001	−0.30	<0.001	−0.59	<0.001	−0.36	<0.001
[a]*[b]								
Living with spouse × wave	0.32	0.003	0.19	0.005	0.47	<0.001	0.22	0.005
Living with others × wave	0.47	<0.001	0.30	<0.001	0.46	<0.001	0.17	0.016

All models were adjusted by age, household income, employment status, frequency of contact with familiar friends, alcohol consumption, self-rated health, number of chronic diseases, and cognitive function (see Supplementary Table 2 and Table 3).



	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 6	Wave 7	Total
Middle-aged Men	2,760	2,637	2,418	2,370	2,285	2,270	2,195	16,935
Middle-aged Women	2,234	2,134	1,928	1,888	1,788	1,730	1,663	13,365
Older Men	1,362	1,300	1,127	999	866	760	646	7,060
Older Women	1,811	1,756	1,532	1,396	1,240	1,107	961	9,803

Fig. 1. The patterns of depression scores by living arrangement over a 14-year follow-up period among middle-aged and older men and women.

mean values of the predicted CES-D-10 scores was dependent on the living arrangement, age group, and gender. The differences in the mean values between living alone and living with spouse were 2.49 at Wave 1, and 0.60 at Wave 7 among middle-aged men; 1.84 and 0.73 among middle-aged women; 3.23 and 0.42 among older men, and 1.40 and 0.10 among older women, respectively. Between living alone and living with others, the differences were 2.84 at Wave 1 and 0 at Wave 7 among middle-aged men; 1.76 and −0.06 among middle-aged women, 3.03 and 0.28 among older men, and 0.75 and −0.26 among older women, respectively.

5. Discussion

In this population-based longitudinal study, we investigated whether patterns of depression scores differed by living arrangement over a 14-year follow-up period across age and gender groups. Our study showed that: (1) people living alone had higher depression scores than those in other living arrangements during all follow-up periods, with the exception of older women; (2) the level of self-reported depression scores was the highest for older men living alone compared to other age and gender groups; and (3) For older women, depression scores for living alone shifted to similar levels for living with others over a 14-year follow-up period.

Regarding living arrangements, the level of depression scores was highest in living alone for men and middle-aged women during the follow-up period. Living alone is a risk factor for depression in middle-aged and older adults (Russell and Taylor, 2009; Xiu-Ying et al., 2012). The association of living along and depression has been established in cross-sectional studies (Stahl et al., 2017) and a few longitudinal studies (Honjo et al., 2018; Nakagomi et al., 2020; Oshio and Kan, 2019). Consistent with these previous studies, we confirmed, using the linear mixed-effect analysis model, that living alone was associated with a high risk of depression scores for both middle-aged and older men and women based on longitudinal data.

We further suggested that older men were more vulnerable to living alone than older women: older men had the largest difference in the CES-D-10 scores among living alone, living with spouse, living with others. Several previous studies found gender differences in the association between living alone and depression, however, there are inconsistencies in the results, such as significant only for men (Honjo et al., 2018), significant only for women (Chou et al., 2006), or significant for both men and women (Hughes and Waite, 2002; Oh et al., 2015). Using longitudinal data from the Japan Gerontological Evaluation Study conducted in 2010 and 2013, one study reported that men aged 65–74 living alone had a greater risk of depression, but women did not (Honjo et al., 2018). Using the Japan Gerontological Evaluation from 2010 to 2016, Nakagomi et al. (2020) also found that widowhood while living alone was associated with a marked worsening of depressive symptoms only in men. Compared to these previous longitudinal studies in Asia, we support that living alone is particularly harmful for older men and living with only their spouse or others was beneficial for older men's depression.

These differences can be explained by the gender-specific social challenges that are faced by people living alone. Living alone is linked with social isolation and limits social bonds with close social network members (Lee et al., 2018). Men might be more vulnerable to social isolation when living alone because they tend to depend primarily on their spouses for social relationships and support, compared to women (Lee et al., 2001). Social relationships with family and friends are beneficial for depression; however, men are likely to have smaller social networks and less stable contact with children and relatives over the course of their lives (Cornwell, 2011), and they face the risk of social isolation after divorce or becoming widowers. Our results suggest that gender-specific interventions to buffer the risk of living alone might help to prevent depression in men.

Decreasing patterns of depression were found in middle-aged and older men living alone over a 14-year follow-up period. The difference in self-reported depression scores between men living alone and men living with only a spouse changed from 2.49 at baseline to 0.60 at Wave 7 for middle-aged men and from 3.23 to 0.42 for older men. This result might suggest the following implications: Men living alone are more vulnerable to recognizing depression; men are less likely to express their depressive moods, which makes diagnosing depression difficult (Seidler et al., 2016); for men with depression, their depressed mood is not as obvious as it is in women. Especially, when older adults consider their depression to be part of normal aging, it is difficult to recognize depression and receive timely treatment (Sözeri-Varma, 2012). In this study, the CES-D-10 self-report metric was used to measure depression. Therefore, along with self-reporting measures for men living alone, other measures may be considered such as complementary measures or biomarkers (Fanelli et al., 2020).

In addition, the possible explanation for decreasing patterns of depression was that men adapted to living alone over a long duration of living alone. In this study, the main reasons for men living alone were divorce (62.3%) in middle age and widowhood (82.5%) in old age. Men who are recently widowed or divorced may suffer serious consequences in the short term, which may be overcome in the long term (Nakagomi et al., 2020; Oshio and Kan, 2019). They might be able to do things on their own and find independent enjoyment of life despite having previously been looked after both emotionally and physically by a spouse and family (Bergland et al., 2016). As a result of this depression-reducing pattern, it is clear that much attention should be paid to those who are recently living alone.

The risk of living alone was different in older women; older women living with others had similar depression scores to those living alone and living with a spouse was the most beneficial factor. The results can be interpreted through the differences in the social roles of women. Under the traditional gender norms, women are expected to take care of and provide a range of social support to their family members. This gender norm might shape and maintain their identity within the family, and living with their parent/child/grandchild may enhance women's gender roles (Lee, 2011). Thus, older women living with families reported worse depression scores compared to those living alone (Jeon et al., 2007). For older women, living alone probably means having more availability to seeking self-determination, and more opportunity to maintain balance and find purpose in their own life.

Lastly, older women living with a spouse had a positive effect on depressive scores. Over a 14-year follow-up period, the depression levels for older women living with a spouse was 2 points lower than those living alone, and those living with others. We might interpret these results as being due to the benefits of a higher income and strong support within a marriage (Tumin and Zheng, 2018). Because of multiple factors, older women living with a spouse are less likely to experience financial hardship (Sasson and Umberson, 2014), one of the crucial risk factors of depressive symptoms. For example, under the traditional gender roles in South Korea and especially for older women, women's labour force participation rate was low, making them vulnerable to economic dependence. Also, older women tend to desire more intimate relationships with people than men do (Baek et al., 2021) and living together is one way to achieve an intimate relationship (Kim et al., 2000). Our results indicate that the marriage benefits of living with a spouse might help prevent depressive symptoms in older women compared to other types of living arrangements.

6. Limitations

Several limitations of this study should be discussed. First, the sample of men living alone was relatively small. In the KLoSA data, out of a total of 4451 men, only 148 (3.30%) were living alone in the baseline survey, and 417 (9.4%) were living alone throughout the panel survey. Therefore, men living alone were somewhat underrepresented in the sample. This limitation suggests that the effects of living alone on

depression in men needs to be examined further. Secondly, we could not control the impact of the widowhood effect on depression because we did not acquire enough participants who were married and living alone. Marital status is strongly associated with living arrangement and the effect of widowhood on depression should be linked with the association between living alone and depression. However, in our data across all waves, only 244 participants had a spouse and lived alone. Hence, further investigations using different data sets on Koreans are required to distinguish the effect of marriage and living arrangement on depression patterns. The third limitation relates to controlling for a sample with physician-diagnosed depression. In the KLoSA questionnaires, the subjects were not asked whether they had ever been diagnosed with depression by a physician. The questionnaires on whether to take an antidepressant were used only from the first to the fourth survey. In the data, a total of 172 participants took an antidepressant in the panel survey. Among 172 participants, only 3 took an antidepressant in all four surveys, and 143 (83%) took an antidepressant in one of the four surveys. Instead of controlling for samples diagnosed with depression or taking an antidepressant, a diagnosis of mental illness was included as a chronic health condition. For improved outcomes, studies using samples with a depression history to determine whether the same outcome was observed would be suitable and are proposed for the future. Fourthly, we used two version of the CES-D-10 measurement, Andresen's and Boston's forms. Even though several previous studies focused on depression used longitudinal data from KLoSA (Kim et al., 2021; Kim, 2022; Lee and Yeung, 2022), it is still cautious to use the different version of CES-D-10. Finally, attrition in longitudinal data can create a problem of interpreting the depression patterns among middle-aged and older men and women. KLoSA collected data from 10,254 adults at baseline, and failed to follow 4118 participants, including due to death (n = 676). If people with severe depression or other physical and social problems might have difficulty in completing follow-up surveys, this attrition may induce bias to observe longitudinal depression patterns if the excluded participants were systematically different from those included (Seaman and White, 2013). In further studies, additional analysis such as inverse probability weighting can be applied, which involves estimating the probability of response as a function of observed characteristics.

7. Conclusion

Decreasing patterns of depression were found in those living alone over a 14-year follow-up period in all of the age and gender groups. Both middle-aged and older men were at a higher risk of depression when they started living alone, but the association weakens over time. We propose additional measures regarding depression for men living alone because self-reported depression may be underestimated and unrecognized. The association between living arrangement and depression varied by age, gender, and time elapsed since follow-up. Our study findings will support the development of age and gender specific interventions, and policies regarding depression for the most vulnerable subgroups in later life.

Note: The mean values of estimated CES-D-10 were calculated from the longitudinal linear mixed-effect models in Table 3, and adjusted for age, household income, employment status, frequency of contact with familiar friends, alcohol consumption, self-rated health, number of chronic diseases, and cognitive function. The bottom of this Figure shows the numbers of participants at each Wave.

Credit author statement

H.K and **J.B** contribute in a substantial way to the conceptualization and design of the work. All authors write drafts of the document providing critical important intellectual content. Additionally, all authors will provide final approval of the version to be published and be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Declaration of competing interest

Declarations of interest: none.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

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