



# Age-Specific Changes in the Effects of Social Connectedness and Loneliness on Depressive Symptoms: Evidence From the Korean Longitudinal Study of Ageing Before and During the COVID-19 Pandemic

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**Objective** This study investigates the longitudinal effects of changes in the associations between two distinct aspects of social connections—i.e., social connectedness and loneliness—on depressive symptoms among community-dwelling Korean adults. This study also examines whether these associations vary across three age groups (45–64, 65–74, and 75 or above).

**Methods** Using data from the Korean Longitudinal Study of Ageing collected between 2014 and 2020 (n=3,642 individuals), fixed effects models were used to examine the age-specific associations between the two distinct aspects of social connections and depressive symptoms (Center for Epidemiologic Studies-Depression Scale) while, accounting for time-invariant individual heterogeneity. Social connectedness is measured by asking the frequency of interactions with friends, relatives, or neighbors.

**Results** The findings indicate that the impact of loneliness on depressive symptoms outweighs that of social disconnectedness. Notably, this study unveils age-specific patterns concerning the impact of the coronavirus disease-2019 pandemic on depressive symptoms and changes in the association between loneliness and depressive symptoms. Specifically, middle-aged individuals reported higher levels of depressive symptoms and loneliness along with a heightened impact of loneliness on depressive symptoms, despite maintaining stable social connections. Conversely, the oldest adults experienced reductions in both depressive symptoms and loneliness, despite a significant decrease in socializing.

**Conclusion** These findings shed light on the differential effects of loneliness on depressive symptoms within distinct age groups before and during the pandemic. The implications of these findings are discussed with a focus on informing the development of targeted policy interventions tailored to the specific needs of different age groups.

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**Keywords** Depressive symptoms; Social isolation; Loneliness; COVID-19; Social distancing.

## INTRODUCTION

Depression is a common and debilitating mental health issue that can significantly affect individual well-being, such as through changes in mood, physical symptoms (e.g., fatigue, headaches, digestive problems, and chronic pain), suicidal behavior, and cognitive function.<sup>1</sup> According to the World Health

Organization,<sup>2</sup> approximately 4.4% of individuals experience depression worldwide, with the prevalence of depression being notably higher among women, as 5.1% of women experience the disorder compared to 3.6% of men.<sup>2</sup> Depression is also more prevalent among older adults, affecting approximately 7.5% of women aged 55–74 and 5.5% of men in the same age group.<sup>2</sup> In South Korea, which is one of the fastest aging countries in the world, a significant proportion of adults aged 60 and older have reported depressive symptoms (11%–13%),<sup>3</sup> experiencing loneliness (19.6%–23.4%),<sup>4</sup> and a lack of social support (28.4%–31.1%).<sup>4</sup> The increased societal consequences resulting from depression, such as suicidal behavior, has already come to the forefront of public health concerns, thus underscoring the need to understand factors that may protect against the development or continuation of depressive

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symptoms.

Social isolation has been identified as a crucial risk factor for depressive symptoms.<sup>5-9</sup> Research has consistently documented the effect of social isolation on depressive symptoms, and studies have proposed behavioral (e.g., reduced physical activity), psychosocial (e.g., lacking a feeling of belongingness), and physiological (e.g., inflammation) mechanisms to explain these associations.<sup>7,10</sup> Prior research has also distinguished between two components of social isolation, namely, social disconnectedness and perceived isolation (i.e., objective isolation and subjective isolation), which have separate and distinct associations with mental health.<sup>5,11</sup> Whereas social disconnectedness refers to the degree of physical separation from other people and society as measured by social network size, frequency of interactions, and social participation, perceived social isolation refers to an individual's subjective experience with and feelings in their relationships with others, such as loneliness or a lack of perceived social support, regardless of physical separation.<sup>5,11-13</sup> These two components of social isolation may operate together in their association with mental health outcome, or they may stand alone and have fully separate patterns of association. Individuals that are physically connected through socializing with others and participating in social organizations may still feel lonely and a lack of social support, which can then have a deleterious effect on their mental health. By contrast, other individuals who are socially disconnected but not lonely may still maintain good mental health. Indeed, some previous studies have found that socially disconnected older adults have worse mental health only to the extent that they perceive themselves to be isolated.<sup>5,11</sup> However, less is known about the extent to which social disconnectedness and loneliness change differently and consequently have separate patterns of change in their association with depressive symptoms.

Although previous studies distinguished between the two components of social isolation and also shown that they have distinct associations with mental health, the majority of research in this area focused predominantly on older adults,<sup>5,11,14</sup> thus leaving a significant gap in the empirical literature regarding the varying associations across different age groups. This gap is particularly concerning considering the differential impact of the coronavirus disease-2019 (COVID-19) pandemic on social connectedness and loneliness across age groups.<sup>4,15</sup> Examining the pre-pandemic levels of social connectedness and loneliness is expected to provide valuable insights into the varying degrees of social isolation experienced across different age groups during the pandemic, and the subsequent impact of this isolation on mental health outcomes. Given the mandatory stay-at-home measures and restrictions on face-to-face interactions, understanding these relative differences

is crucial for addressing social isolation and its associated mental health consequences.

Social connectedness among Korean middle to older adults exhibits distinct features that are seldom observed in other countries which should be noted. For instance, while older adults aged 75 and above in the United States mainly socialize with relatives, neighbors, old friends, and members from social organizations,<sup>16,17</sup> their Korean counterparts predominantly socialize with members from senior community centers or social welfare centers for seniors in addition to their relatives, neighbors, and friends.<sup>18</sup> Senior community centers represent a unique aspect of old age in Korea, as approximately 30 to 40 percent of older adults utilize these facilities. These centers serve as multifunctional spaces that provide various amenities for accommodation, meals, and leisure activities.<sup>19</sup> To capture the unique context of Korea, specific response categories such as “no-in-jung” or “kyung-ro-dang” in Korean for senior centers and “no-in-bokji-kwan” for social welfare centers are incorporated into representative panel surveys involving older adults, such as the Korean Longitudinal Study on Ageing (KLoSA).<sup>20</sup> Notably, these senior centers and social service centers were frequently selected by older adults responding to the KLoSA survey.<sup>18</sup> In the context of the COVID-19 pandemic, where minimal activities and interactions were allowed in places like workplaces, it is expected that older adults whose primary interactions revolved around locations that were forced to close (e.g., senior centers, daycare centers, leisure clubs, and religious organizations) experienced an inevitable increase in social disconnectedness. Therefore, the impact of social distancing measures after the outbreak of the COVID-19 pandemic may be more severe among older adults compared to middle-aged adults.

The purpose of this study is to examine the impact of COVID-19 on the associations between social isolation and depressive symptoms of adults aged 45 or older using four waves of data from the KLoSA (2014–2020). The primary focus of our study is to investigate potential variations in the relationships between the two dimensions of social isolation and depressive symptoms across three distinct age groups (specially, 45–64, 65–74, and 75 or over) both before and during the COVID-19 pandemic. We will use longitudinal panel data to apply fixed-effect (FE) method to control for time-invariant unobserved characteristics that could bias the estimation in ordinary least square regression. To our knowledge, this study is the first to estimate the longitudinal effects of social connectedness and perceived isolation on depressive symptoms among middle-aged to older adults in Korea, using data collected both before and during the COVID-19 period.

## METHODS

### Data and sample

We used data from the KLoSA survey to obtain comprehensive information on social connectedness, loneliness, and depressive symptoms.<sup>20</sup> The KLoSA survey has been conducted biennially between August and December since 2006, and it covers a wide range of topics, including basic demographics, health, economic status, and inquiries pertaining to expectations and life satisfaction among Korean individuals aged 45 years or older. This survey was designed based on established panel surveys conducted in the United States (the Health and Retirement Study [HRS] [<https://hrs.isr.umich.edu>]), United Kingdom (the English Longitudinal Study of Ageing [ELSA] [<https://www.elsa-project.ac.uk>]) and Europe (Survey of Health, Ageing and Retirement in Europe [SHARE] [<https://share-eric.eu>]), thus enabling comparative analysis on ageing across different countries. To assess the influence of social connectedness and loneliness on depressive symptoms, we used a condensed version of the Center for Epidemiologic Studies-Depression Scale (CES-D) as a measuring instrument for depression. However, different shortened versions of CES-D have been used throughout different waves of the KLoSA survey. For example, the Anderson Form<sup>21</sup> was used from the first wave (2006) to the fourth wave (2012). The Boston Form<sup>22</sup> was then adopted from 2014 onwards. Given the distinct item structure and response formats related to these two different forms,<sup>23</sup> we limited our analysis to the periods from 2014 to 2020 in an attempt to ensure a consistent measure of depressive symptoms.

Moreover, the sample in this study was further constrained to specific regions, such as Seoul city, Daegu city, Gyeonggi province and Gyeongbuk province. Seoul and its adjacent Gyeonggi province, both of which are characterized by high population density, experienced large numbers of daily or cumulative confirmed COVID-19 cases per 1,000 individuals compared to other cities or provinces during 2020. Further, Daegu and its neighboring Gyeongbuk province notably experienced an initial significant outbreak of COVID-19, which was largely attributed to worship gathering in churches. Therefore, we focused our study exclusively on these four regions. As a result, in terms of sample size, there were 3,642 respondents, and the total number of observations was 12,562. This study was approved by the Institutional Review Board of University of Seoul (IRB number: 2022-10-004).

### Measures

#### Social connectedness

Social connectedness was measured using the following

question: “How often do you meet with friends, relatives, or neighbors?” The respondents could choose from the following answers: 1) almost every day, 2) once a week, 3) two to three times a week, 4) once a month, 5) twice a month, 6) once or twice a year, 7) three or four times a year, 8) six times a year, and 9) almost never. To standardize the responses, they were converted into a monthly frequency scale for the purposes of answering the question. The average frequency of social interaction among the sample respondents was 5.86. This indicates that individuals aged 45 or older interacted with people—including friends, relatives, and neighbors—an average of 5.86 times per month.

#### Loneliness

Perceived social isolation is measured using emotional loneliness. Emotional loneliness was measured using the following survey question: “How many days do you feel lonely during the past week?” The response options were as follows: 1) never, 2) one or two days per week, 3) three or four days per week, and 4) always. The average value for “loneliness” was 1.528. The average values of loneliness varied across age groups. The average value of loneliness experienced in the past week was highest among individuals aged 75 or older, while the lowest average value was observed among individuals aged 45 to 64.

#### Depressive symptoms

The KLoSA includes the Korean version of the CES-D as a measure of depressive symptoms. The dependent variable for depressive symptoms in this study is CES-D, which assesses the severity of depressive symptoms. The presence or absence of depressive symptoms was evaluated using the Korean version of the CES-D survey.<sup>20</sup> Specifically, the CES-D10 (Boston form) was used, which is an adapted and abbreviated version of the original CES-D20 questionnaire developed for older adults and individuals with chronic illnesses in the United States. The CES-D10 (Boston form) has been used since the fifth survey conducted in 2014. Scores on the CES-D range from 0 to 10, with higher scores indicating a greater severity of depressive symptoms. However, in this particular study, the CES-D was modified to exclude one question related to loneliness, thus resulting in a nine-item questionnaire.

#### Covariates

The various explanatory variables were controlled for, with the main variables measuring loneliness and social connectedness. First, demographic characteristics such as age, gender (male=0, female=1), marital status (others=0, married=1), education level (dropout=0, high school or less education=1, high school grad=2, some college=3, bachelor's degree or

more=4), household size, and residential area (metropolitan=0, city and town=1) were all controlled for. Further, the income variable, which represented current economic status, was log-transformed and controlled for. A number of other variables that directly or indirectly measure health status were also controlled for, including the presence of chronic conditions, functional or instrumental limitations in physical health, self-rated health, and health-related lifestyle factors such as smoking and alcohol consumption.

**Analysis**

To investigate the impacts of social connectedness and loneliness on depressive symptoms, we employed the regression specification at the individual (i) and year (t) with region-fixed effects. However, to estimate the effect of social isolation and loneliness on depressive symptoms can be empirically challenging. Individuals with moderate or severe depressive symptoms are more likely to experience social disconnectedness and loneliness. This association may be influenced by many confounding factors, such as unobserved personality traits and lifestyle choices. These confounding factors could lead to biased estimators in the regression models. To address these concerns, we utilize panel FE models to control for unobserved individual characteristics. Since the Hausman test suggests that the coefficients between the random-effect (RE) and FE models are statistically different, the FE model should also be preferred in all models.

First, we use the COVID-19 pandemic period as an exogenous shock that influences depressive symptoms. We examine the heterogenous effects of the COVID-19 pandemic on depressive symptoms across different age-groups: individuals aged 45 to 64, aged 65 to 74, and those aged 75 or above. We also explore how the COVID-19 pandemic influences social connectedness or loneliness in different age groups using the following equation:

$$Y_{it} = \beta_0 + \beta_1 \text{Age}_{\text{Group } it} + \beta_2 \text{Year}_t + \beta_3 \text{Age}_{\text{Group } it} \text{Year}_t + X'_{it} \alpha + c_i + \mu_t + \sigma_{\text{region}} + \epsilon_{1it} \tag{1}$$

which includes indicator variables regarding age groups (Age\_Group<sub>it</sub>). We construct indicator variables for the three distinct age groups of individuals aged 45 to 64, individuals aged 65 to 74, and individuals aged 75 or above. If an individual (i) in year (t) falls into the age group of 45 to 64, the indicator variable for this specific age group is assigned a value of 1, while the indicator variables for the other age groups are assigned a value of 0. Year<sub>t</sub> is also an indicator variable for each year. Therefore, the coefficients (β<sub>3s</sub>) on interaction terms between Age\_Group<sub>it</sub> and Year<sub>t</sub> show the changes in outcome variables across different age groups and years. To account for

potential confounding factors, several demographic characteristics were included as covariates, denoted as X'<sub>it</sub>. These covariates include marital status, education level, household size, household income, employment status, residential area, smoking and drinking status, and self-rated health. c<sub>i</sub> is an individual FE term and μ<sub>t</sub> is a time-FE term. We also added the region FE term for explaining different non-linear trend of social isolation or loneliness in four regions.

If social connectedness and loneliness influence depressive symptoms, we investigate which dimension of isolation is a main reason causing depressive symptoms across age groups and periods. If age groups respond differently to the COVID-19 pandemic, then their social isolation and depressive symptoms will show different association patterns during the pandemic period. For each age group, we estimate the following specification before and during COVID-19.

$$Y_{it} = \beta_0 + \beta_1 \text{Social Connectedness}_{it} + \beta_2 \text{Loneliness}_{it} + X'_{it} \alpha + c_i + \mu_t + \sigma_{\text{region}} + \epsilon_{1it} \tag{2}$$

**RESULTS**

Table 1 lists the summary statistics for the sample of individuals aged 45 to 64, 65 to 74, and 75 or above. The data shows that, compared to younger individuals in the sample, older adults are more likely to be female and less likely to be married due to divorce and bereavement. Individuals aged 75 or above are also more likely to have lower educational attainment and less likely to be actively working, thus resulting in a lower average income compared to younger individuals. Older adults aged 75 or above with lower socioeconomic status also exhibit lower rates of smoking and alcohol consumption. However, due to their higher age, they are still more vulnerable to health shocks. Therefore, they face a higher prevalence of chronic diseases, and their self-rated health is poorer compared to that of any of the other older age groups. In terms of the outcome variables, the level of loneliness is found to increase with age and is highest among individuals aged 75 or above. However, older adults aged 75 or above, who benefit from the unique community center (No-in-jung) system for older adults in Korea, have a higher frequency of interactions. Despite having higher levels of objective connectedness, the proportion of individuals experiencing loneliness and the degree of associated depression symptoms are both significantly higher in the 75 and above age group compared to any other of the older age groups.

Difference p-value in Table 1 displays the F-statistics and related p-values used to test the equality of each variable between age groups. Different age groups exhibit distinct characteristics across all variables, including control and outcome

variables. The results of a test of joint significance across all variables are shown to reject the null hypothesis of equality between age groups. Considering that all age groups have different characteristics across all observed variables, they might

also possess distinct unobserved characteristics that can influence outcome variables. Therefore, we use the panel fixed model to control for unobserved time-invariant characteristics.

Table 2 presents the results of estimating equation (1), which

**Table 1.** Basic statistics (KLoSA 2014–2020, N=3,642, n=12,562)

	Aged 45 to 64	Aged 65 to 74	Aged 75 or above	Difference p
Controls				
Gender				
Male	0.439	0.437	0.394	11.3***
Female	0.561	0.563	0.606	
Age (yr)	58.5	69.5	81.1	36,808.0***
Marital status				
Married	0.897	0.793	0.543	859.7***
Not married, divorced	0.103	0.208	0.457	
Education level				
Middle school grad	0.270	0.590	0.766	1089.8***
High school grad	0.508	0.302	0.161	
College grad or above	0.222	0.108	0.073	
Employment				
Yes	0.648	0.329	0.107	1767.0***
No	0.352	0.671	0.893	
Household income (1,000 won)	4,808	2,746	2,105	736.4***
Household size	3.02	2.51	2.46	274.2***
Area				
Metropolitan	0.458	0.444	0.434	28.4***
Mid to small city	0.423	0.370	0.358	
Town	0.119	0.186	0.208	
Drinking status	0.483	0.315	0.172	519.1***
Smoking status	0.304	0.318	0.252	22.7***
Chronic diseases	0.867	0.895	0.950	86.4***
Self-rated health				
Very good	0.020	0.008	0.003	
Good	0.400	0.192	0.073	
Normal	0.476	0.535	0.412	1405.6***
Bad	0.090	0.218	0.385	
Very bad	0.015	0.047	0.127	
ADL	0.03	0.11	0.52	264.9***
IADL	0.11	0.31	1.52	636.1***
Dependent variables				
Frequency of socializing (per month)	4.87	5.77	6.28	61.5***
Feel Lonely (during last week)	1.37	1.48	1.75	280.4***
Depression (CES-D)	1.64	1.82	2.20	132.0***
Observation	4,801	3,783	3,981	12,565

All statistics are based on a dataset created by the KLSA for 2014–2020. As a result, in terms of sample size, there were 3,642 respondents (N=3,642), and the total number of observations was 12,562 (n=12,562). Difference p-value reports the p-value for the test of equality between age groups. The joint test F statistics and p-value correspond to the null of equality between age groups for all reported characteristic. \*\*\*p<0.001. KLoSA, Korean Longitudinal Study on Ageing; ADL, Activities of Daily Living; IADL, Instrumental Activities of Daily Living; CES-D, Center for Epidemiologic Studies-Depression Scale

focuses on the interaction term between aged groups and years. We demonstrate how each age group responds differently to the COVID-19 pandemic. Table 2 presents RE and FE estimates of the effect of sample period and age on depressive symptom (CES-D). The results of the FE model (RE model)

are as follows: first, throughout the sample period, individuals aged 75 or above show higher depressive symptoms scores compared to those in the 45 to 64 age group by 0.36 (0.28). Second, when examining the impact of time, it becomes evident that the year 2020 showed a significant 0.48 (0.49) in-

**Table 2.** Effects of COVID-19 on depression (CES-D) (N=3,642, n=12,562)

	CES-D	
	Random-effect	Fixed-effect
Age (reference: 45–64)		
65–74	0.0897 (0.0607)	0.1270 (0.0826)
≥75	0.2771 (0.0694)***	0.3596 (0.1086)***
Year (reference: 2014)		
2016	0.2391 (0.0452)***	0.2224 (0.0461)***
2018	0.1291 (0.0485)**	0.1076 (0.0504)*
2020	0.4857 (0.0531)***	0.4819 (0.0560)***
Age×year (reference: 45–64×2014)		
65–74×2016	-0.0435 (0.0715)	-0.0179 (0.0734)
65–74×2018	0.0057 (0.0760)	-0.0103 (0.0803)
65–74×2020	-0.1222 (0.0808)	-0.1578 (0.0878)*
≥75×2016	-0.1277 (0.0724)	-0.1269 (0.0748)
≥75×2018	-0.0842 (0.0746)	-0.0897 (0.0795)
≥75×2020	-0.4141 (0.0787)***	-0.4440 (0.0859)***
Gender	-0.0093 (0.0145)	-
Married	-0.1248 (0.0474)**	-0.4358 (0.1000)***
Education (reference: middle school grad)		
High school grad	-0.0032 (0.0486)	0.1910 (0.2302)
College grad or above	-0.0641 (0.0658)	-0.0047 (0.3970)
Unemployed	0.0112 (0.0373)	0.0443 (0.0492)
Log (household income)	-0.0010 (0.0146)	0.0095 (0.0181)
Household size	-0.0141 (0.0134)	-0.0082 (0.0181)
Region (reference: metropolitan)		
City	0.5028 (0.1378)***	0.1185 (0.1947)
Town	0.1123 (0.1346)	0.2008 (0.1982)
Drinking status	-0.0764 (0.0412)*	-0.1348 (0.0656)*
Smoking status	0.0011 (0.0561)	0.3307 (0.1858)
Self-rated health (reference: very good)		
Good	-0.1060 (0.1182)	-0.1083 (0.1271)
Normal	-0.0909 (0.1188)	-0.1634 (0.1288)
Bad	0.1997 (0.1223)	0.0299 (0.1331)
Very bad	1.1201 (0.1363)***	0.7035 (0.1505)***
Existence of chronic disease	0.1338 (0.0636)**	0.1937 (0.1093)
ADL	0.0477 (0.0203)*	-0.0006 (0.0241)
IADL	0.0549 (0.0116)***	0.0817 (0.0137)***

All statistics are based on a dataset created by the KLoSA for 2014–2020. As a result, in terms of sample size, there were 3,642 respondents (N=3,642), and the total number of observations was 12,562 (n=12,562). Standard errors in parentheses. \*p<0.05; \*\*p<0.01; \*\*\*p<0.001. COVID-19, coronavirus disease-2019; CES-D, Center for Epidemiologic Studies-Depression Scale; ADL, Activities of Daily Living; IADL, Instrumental Activities of Daily Living; KLoSA, Korean Longitudinal Study on Ageing

crease in depression symptoms (CES-D) compared to the data from 2014, thus indicating a substantial impact of the pandemic across all age group. While some fluctuations were observed between 2014 and 2020, it is noteworthy that the substantial surge in scores observed specifically in 2020 surpasses the increases noted in other years. However, older adults aged 75 or above are less likely to be negatively influenced by the COVID-19 pandemic in terms of depressive symptoms. Individuals aged 75 or above had lower depressive symptom scores compared to other age groups. Specifically, their CES-D score is lower than the corresponding score for those aged 45 to 64 in 2014 by 0.4440 (0.4141) points.

Figure 1 depicts the trends over time and by age groups for depressive symptoms (CES-D), which aligns with the FE results presented in Table 2. Individuals aged 45 to 64 and those aged 65 to 74 experienced a worsening of depressive symptoms in 2020. However, the group aged 75 and older did not experience higher depressive symptoms during the COVID-19 period compared to other periods.

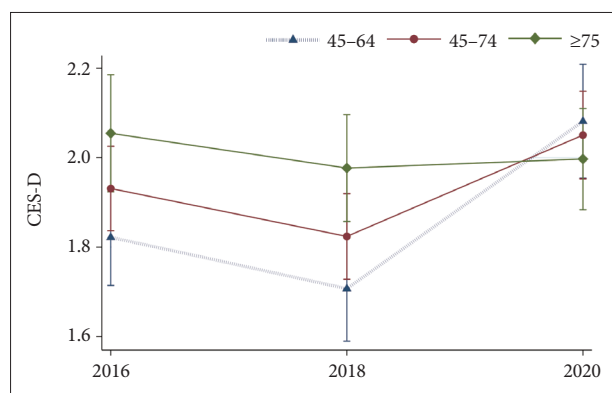
To understand what dimension of social isolation affects depressive symptoms more before and during the COVID-19 pandemic, Table 3 presents the effects of social connectedness and perceived isolation on depressive symptoms. The frequencies of socializing and loneliness are the main explanatory variables in model (1) and model (2), respectively. Perceived isolation (loneliness) is associated with higher depressive symptom (0.6613,  $p < 0.001$ ), while social connectedness (frequency of social interactions) does not have a statistically significant relationship with depressive symptoms due to its small magnitude. Model (3) examines the effects of both frequency of social interaction and loneliness on CES-D. The relationship between frequency of social interaction and depressive symptom remains weak (0.0051,  $p < 0.05$ ), but the relationship between perceived isolation (loneliness) and depressive symp-

toms is strongly negative (0.6630,  $p < 0.001$ ).

Each age group has data from two sample periods: before and during the COVID-19 pandemic. Table 4 presents separate results for each age group and sample period regarding the effect of social connectedness and loneliness on depressive symptom. To understand how different age groups differentially respond to the COVID-19 pandemic, the results indicate the effect of frequency of socializing and loneliness on depressive symptoms for each age group. There are two details related to the results that are worth mentioning. First, perceived isolation shows a stronger link with depressive symptoms than it does with social connectedness for all age groups. Second, the strength of that link has changed before and during the COVID-19 pandemic for each age group. While the effect of loneliness became larger during the pandemic for individuals aged 45 to 64, perceived isolation (loneliness) in older age groups had a similar or even reduced impact on depressive symptoms. The coefficients of Loneliness decreased from 0.8651 to 0.7774 for older adults aged 75 or above. Coefficients for older adults aged 65 to 74 have slightly decreased from 0.6332 to 0.6074 between the periods before and during COVID-19.

We expected that the COVID-19 pandemic would have the most significant impact on the social disconnectedness of individuals aged 75 or above, thus leading to an increase in loneliness. We therefore expected that this heightened loneliness would intensify the association between loneliness and depressive symptoms. To explore these unexpected findings and how COVID-19 affects social disconnectedness and loneliness across age groups, we also conducted a supplementary analysis of the effects of COVID-19 on social connectedness and loneliness across the time. Supplementary Table 1 (in the online-only Data Supplement) illustrates how the frequency of social interaction and loneliness changed in response to the COVID-19 pandemic among different age groups. Note that individuals aged 75 or above exhibit a higher frequency of social interactions than individuals aged 45 to 64 by 1.32. However, individuals aged 75 or above experienced the most significant reduction in the number of social interactions in the year 2020 (-1.70,  $p < 0.001$ ). Surprisingly, despite this decrease, they also experienced the largest reduction in the level of loneliness (-0.1381,  $p < 0.001$ ). Although the COVID-19 pandemic affected individuals aged 75 or above by decreasing their frequency of social interaction, this did not result in an increase in their experience of loneliness.

Consistent with Supplementary Table 1 and Supplementary Figure 1 (in the online-only Data Supplement) presents the predicted value of frequency of social interaction by age group. The trend from 2016 to 2020 is characterized by a sharp decrease in the frequency of social interaction for those aged 65



**Figure 1.** Predicted value of depressive symptoms measure (CES-D) before and during COVID-19 by age groups and year (KLoSA, 2016–2020). CES-D, Center for Epidemiologic Studies-Depression Scale; COVID-19, coronavirus disease-2019; KLoSA, Korean Longitudinal Study on Ageing.

**Table 3.** Effects of social connectedness and loneliness on depression (CES-D) (N=3,642, n=12,562)

	CES-D Fixed-effect		
	Model (1)	Model (2)	Model (3)
Frequency of socializing	0.0014 (0.0027)	-	0.0051 (0.0026)*
Loneliness	-	0.6613 (0.0202)***	0.6630 (0.0202)***
Age (reference: 45–64)			
65–74	0.1310 (0.0612)*	0.1278 (0.0578)*	0.1271 (0.0578)*
≥75	0.1785 (0.0919)	0.1696 (0.0868)*	0.1666 (0.0868)
Year (reference: 2014)			
2016	0.1915 (0.0305)***	0.2166 (0.0288)***	0.2147 (0.0289)***
2018	0.0998 (0.0335)**	0.1176 (0.0317)***	0.1180 (0.0317)***
2020	0.3012 (0.0383)***	0.3318 (0.0361)***	0.3364 (0.0362)***
Gender	-	-	-
Married	-0.3887 (0.0996)***	-0.2156 (0.0942)*	-0.2132 (0.0942)*
Education (reference: middle school grad)			
High school grad	0.1383 (0.2302)	0.1469 (0.2174)	0.1468 (0.2174)
College grad or above	-0.0565 (0.3969)	-0.1881 (0.3749)	-0.1812 (0.3749)
Unemployed	0.0506 (0.0492)	0.0358 (0.0465)	0.0360 (0.0465)
Log (household income)	0.0016 (0.0181)	0.0026 (0.0171)	0.0027 (0.0171)
Household size	-0.0060 (0.0181)	-0.0061 (0.0171)	-0.0064 (0.0171)
Region (reference: metropolitan)			
City	0.1402 (0.1949)	0.0429 (0.1840)	0.0328 (0.1841)
Town	0.2264 (0.1984)	0.1625 (0.1873)	0.1540 (0.1874)
Drinking status	-0.1295 (0.0656)*	-0.0756 (0.0620)	-0.0774 (0.0620)
Smoking status	0.3471 (0.1859)	0.2329 (0.1757)	0.2300 (0.1756)
Self-rated health (reference: very good)			
Good	-0.1116 (0.1272)	-0.1437 (0.1202)	-0.1423 (0.1202)
Normal	-0.1520 (0.1289)	-0.2294 (0.1218)	-0.2273 (0.1218)
Bad	0.0401 (0.1333)	-0.1464 (0.1261)	-0.1429 (0.1261)
Very bad	0.7236 (0.1507)***	0.3949 (0.1427)**	0.4013 (0.1427)**
Existence of chronic disease	0.1916 (0.1094)	0.1906 (0.1034)	0.1908 (0.1034)
ADL	0.0039 (0.0241)	-0.0035 (0.0227)	-0.0024 (0.0227)
IADL	0.0713 (0.0136)***	0.0509 (0.0128)***	0.0523 (0.0128)***

All statistics are based on a dataset created by the KLoSA for 2014–2020. As a result, in terms of sample size, there were 3,642 respondents (N=3,642), and the total number of observations was 12,562 (n=12,562). Standard errors in parentheses. \*p<0.05; \*\*p<0.01; \*\*\*p<0.001. CES-D, Center for Epidemiologic Studies-Depression Scale; ADL, Activities of Daily Living; IADL, Instrumental Activities of Daily Living; KLoSA, Korean Longitudinal Study on Ageing

to 74 as well as those aged 75 or above during COVID-19. On the other hand, individuals aged 45 to 65 maintained their level of social interaction compared to 2018. Therefore, the group that was most affected by social distancing measures was older adults aged 75 or over. On the other hand, Supplementary Figure 2 (in the online-only Data Supplement) shows the level of loneliness over time and by age group. Notably, although individuals aged 45 to 64 maintained their social interactions during 2020, the extent to which they felt lonely in-

creased in this age group. However, individuals aged 65 and older (aged 65 to 74 and aged 75 or older) experienced a decrease in the level of loneliness during the COVID-19 period.

## DISCUSSION

Social isolation and depressive symptom are both growing concerns in many countries. While previous studies have found that the two distinct forms of social isolation—i.e., social dis-



**Table 4.** Effects of social connectedness and loneliness on depression (CES-D) by age groups (N=3,642)

	Aged 45 to 64			Aged 65 to 74			Aged 75 or above		
	Before	During	After	Before	During	After	Before	During	After
Frequency of socializing	0.0042 (0.0046)	-0.0088 (0.0068)	0.0107 (0.0060)	-0.0037 (0.0061)	0.0037 (0.0070)	0.0037 (0.0070)	0.0037 (0.0070)	-0.0002 (0.0067)	-0.0002 (0.0067)
Loneliness	0.4092 (0.0396)***	0.7054 (0.1000)***	0.6332 (0.0503)***	0.6074 (0.0882)***	0.8651 (0.0480)***	0.8651 (0.0480)***	0.8651 (0.0480)***	0.7774 (0.0692)***	0.7774 (0.0692)***
Year (reference: 2014)									
2016	0.2365 (0.0380)***	-	0.2439 (0.0575)***	-	0.1443 (0.0689)*	0.1443 (0.0689)*	0.1443 (0.0689)*	-	-
2018	0.1570 (0.0427)***	-	0.1041 (0.0661)	-	0.0341 (0.0775)	0.0341 (0.0775)	0.0341 (0.0775)	-	-
Married	-0.0870 (0.2402)	0.0097 (0.1429)	-0.6568 (0.2531)**	-0.0222 (0.1180)	-0.2379 (0.2338)	-0.2379 (0.2338)	-0.2379 (0.2338)	0.2287 (0.1049)*	0.2287 (0.1049)*
Education (reference: middle school grad)									
High school grad	0.5073 (0.5212)	-0.1202 (0.0977)	1.1137 (1.3712)	-0.0778 (0.0976)	0.0313 (0.1140)	0.0313 (0.1140)	0.0313 (0.1140)	0.0313 (0.1140)	0.0313 (0.1140)
College grad or above	1.3322 (1.2788)	-0.3169 (0.1316)**	-1.2240 (1.9417)	-0.1247 (0.1310)	0.0180 (0.1590)	0.0180 (0.1590)	0.0180 (0.1590)	0.0180 (0.1590)	0.0180 (0.1590)
Unemployed	-0.0098 (0.0743)	-0.0222 (0.0949)	0.1235 (0.1239)	-0.1393 (0.0822)	0.1032 (0.1823)	0.1032 (0.1823)	0.1032 (0.1823)	0.0487 (0.1081)	0.0487 (0.1081)
Log (household income)	0.1379 (0.0367)***	-0.0309 (0.0703)	0.0511 (0.0531)	-0.1176 (0.0819)	-0.0199 (0.0348)	-0.0199 (0.0348)	-0.0199 (0.0348)	-0.0843 (0.0568)	-0.0843 (0.0568)
Household size	-0.0212 (0.0308)	0.0322 (0.0371)	0.0241 (0.0439)	0.0343 (0.0354)	0.0144 (0.0539)	0.0144 (0.0539)	0.0144 (0.0539)	0.0274 (0.0318)	0.0274 (0.0318)
Region (reference: metropolitan)									
City	0.3066 (0.2771)	0.6729 (0.2807)*	0.3422 (0.5824)	0.3126 (0.3010)	-0.0551 (0.5352)	-0.0551 (0.5352)	-0.0551 (0.5352)	0.5025 (0.5385)	0.5025 (0.5385)
Town	0.2490 (0.3381)	0.6337 (0.2361)**	1.0234 (0.5736)	0.1496 (0.2742)	0.3013 (0.5616)	0.3013 (0.5616)	0.3013 (0.5616)	0.1012 (0.5252)	0.1012 (0.5252)
Drinking status	0.2353 (0.1137)*	0.0732 (0.0927)	-0.3755 (0.1671)*	0.0654 (0.0905)	-0.3345 (0.1819)*	-0.3345 (0.1819)*	-0.3345 (0.1819)*	0.0056 (0.1025)	0.0056 (0.1025)
Smoking status	0.0517 (0.2125)	-0.1984 (0.1312)	-0.2471 (0.6062)	-0.0583 (0.1227)	1.5408 (0.5882)**	1.5408 (0.5882)**	1.5408 (0.5882)**	-0.0334 (0.1160)	-0.0334 (0.1160)
Self-rated health (reference: very good)									
Good	-0.2813 (0.1520)	0.0202 (0.2696)	0.0551 (0.3534)	0.0423 (0.5137)	-0.4339 (0.8236)	-0.4339 (0.8236)	-0.4339 (0.8236)	0.2037 (0.5409)	0.2037 (0.5409)
Normal	-0.3787 (0.1575)*	0.1289 (0.2695)	-0.0545 (0.3508)	0.2778 (0.5121)	-0.3131 (0.8233)	-0.3131 (0.8233)	-0.3131 (0.8233)	0.3194 (0.5239)	0.3194 (0.5239)
Bad	-0.3337 (0.1763)	0.2127 (0.2998)	0.0697 (0.3593)	0.3348 (0.5184)	-0.1248 (0.8266)	-0.1248 (0.8266)	-0.1248 (0.8266)	0.2761 (0.5281)	0.2761 (0.5281)
Very bad	0.4140 (0.2621)	-0.0514 (0.5243)	0.5041 (0.3970)	1.1306 (0.6135)	0.4180 (0.8367)	0.4180 (0.8367)	0.4180 (0.8367)	0.8320 (0.5756)	0.8320 (0.5756)
Existence of chronic disease	-0.1713 (0.1968)	0.0617 (0.1422)	0.5190 (0.2944)	0.0324 (0.1560)	0.0717 (0.3184)	0.0717 (0.3184)	0.0717 (0.3184)	0.0292 (0.2131)	0.0292 (0.2131)
ADL	-0.0695 (0.0827)	0.6415 (0.3151)*	-0.1023 (0.0737)	0.1066 (0.1722)	-0.0211 (0.0409)	-0.0211 (0.0409)	-0.0211 (0.0409)	0.0610 (0.0568)	0.0610 (0.0568)
IADL	0.0495 (0.0533)	-0.2353 (0.1131)*	0.0870 (0.0414)*	-0.0913 (0.0771)	0.0631 (0.0247)*	0.0631 (0.0247)*	0.0631 (0.0247)*	-0.0036 (0.0239)	-0.0036 (0.0239)
Observation	3,939	860	2,887	896	2,920	2,920	2,920	1,060	1,060

All statistics are based on a dataset created by the KLoSA for 2014–2020. Standard errors in parentheses. \*p<0.05; \*\*p<0.01; \*\*\*p<0.001. CES-D, Center for Epidemiologic Studies-Depression Scale; ADL, Activities of Daily Living; IADL, Instrumental Activities of Daily Living; KLoSA, Korean Longitudinal Study on Ageing

connectedness and loneliness—have profound effects on depressive symptoms,<sup>11,14</sup> less is known the extent to which these associations change differently across age groups. Moreover, in a context where individuals are compelled to adhere to shelter-in-place orders and minimize in-person interactions during the pandemic, namely, when everyone was forced to undergo enforced physical separation from others, the pre-existing variations in social connectedness and loneliness among different age groups can significantly contribute to the emergence of social isolation during the pandemic and therefore impact mental health outcomes. To investigate this issue, we employed the FE models using four waves (2014–2020) of the KLoSA, a nationally representative sample of individuals age 45 and over collected before and during the pandemic. The FE estimates reveals that loneliness, and not social disconnectedness, is associated with depressive symptoms. This finding is generally consistent with recent research using the longitudinal representative data of older adults in the United States that disentangle the impact of perceived isolation and social connectedness on mental health.<sup>11,14</sup> However, our research findings uncover distinct age-specific patterns regarding the impact of COVID-19 on depressive symptoms, and they also help elucidate the relationship between social isolation and depressive symptoms. These findings sharply contrast with recent findings from other countries using similarly designed longitudinal data (e.g., HRS; Canadian Longitudinal Study; and the SHARE) and therefore represent a significant contribution to the existing body of knowledge and offer novel insights into the subject matter.

First, our findings provide strong evidence that depressive symptoms increased during the pandemic, but only for middle-aged (age 45–64) and young older adults (age 65–74). In fact, the level of depressive symptoms of the oldest group (age 75 or over) remained at a relatively stable level before and during the pandemic. These findings are consistent with the results of a number of studies that have reported slightly lower levels of depressive symptoms among older adults after the COVID-19 outbreak. However, it should be noted that these studies often had limitations such as small sample sizes,<sup>24</sup> cross-sectional designs,<sup>25</sup> or a lack of differentiation between distinct age groups.<sup>26,27</sup> Consequently, these studies were unable to thoroughly investigate age-specific changes in psychological responses—such as loneliness—to the pandemic and their subsequent impact on mental health.

Our findings also indicate that the impact of loneliness on depressive symptoms outweighs that of social disconnectedness, with particular emphasis on the age-specific variations in the changes observed in the association between loneliness and depressive symptoms both before and during the pandemic. Specifically, we observed an intensified impact of lone-

liness on depressive symptom among individuals aged 45 to 64 during the pandemic. By contrast, the influence of loneliness on depressive symptoms among older age groups remained either consistent (age 65–74) or even reduced (age 75 or above). Two other studies using longitudinal representative data collected before and during the pandemic reveal inconclusive findings: whereas Canadian older adults aged 65 or older exhibit an attenuated association between loneliness and depressive symptoms,<sup>27</sup> Irish older adults aged 54 or older demonstrate amplified associations.<sup>28</sup> This inconclusive finding could be partially attributed to unspecified age groups. In other words, contrary to the concern raised by public health experts and other relevant researchers regarding the potential increase in loneliness and subsequent impact on mental health, particularly among older adults as a result of mandated physical separation, our findings reveal that it is in fact middle-aged adults who are most likely to feel lonely and depressed as well as experience the greatest impact of loneliness on depressive symptoms.

These findings may be attributable to age-specific challenges within the context of aging in Korea and hold significant policy implications. Notably, a substantial portion of social connections among older adults is dependent on interactions within senior centers.<sup>19</sup> The significant decline in socializing among older adults can be attributed to the mandatory closure of these centers along with the suspension of related activities in response to social distancing policies. Further, the observed decrease in loneliness and its impact on depressive symptoms among individuals aged 75 or above, despite their reduced socializing following the onset of COVID-19, raises concerns about the adequacy of social relationships within these settings in terms of the social needs of bonding and attachment. It is plausible that older adults aged 75 or above may visit senior centers primarily for purposes of casual socialization, engaging in informal conversations, dining, and passing time. However, the quality of these relationships warrants further examination. Recent findings from studies involving Dutch older adults suggest that interventions that effectively combine physical distancing and well-being are closely tied to the quality of social contacts, including interactions with societal institutions.<sup>26</sup> Therefore, there is a need for additional research to thoroughly explore the quality of social relationships among Korean older adults whose primary social interactions revolve around senior centers.

The finding that young older adults (age 65–74) exhibited higher levels of depressive symptoms during the pandemic, despite a decline in loneliness, along with the sustained strength of the association between loneliness and depressive symptoms, suggests that senior centers or senior welfare centers may hold significance beyond mere socialization for this par-

ticular group. This observation may be linked to their relatively higher labor force participation, as young older adults often engage in employment to supplement their post-retirement living expenses.<sup>3</sup> Notably, the closure of social welfare centers, which are frequented by young older adults and offer elderly employment programs, has been found to heighten concerns regarding income and employment security, thus reflecting the need for economic support in this age group.<sup>29</sup>

On the other hand, in the case of middle-aged adults (age 45–64), our findings indicate an increase in both depressive symptoms and the intensity of the association between loneliness and depressive symptoms, despite the observed consistency in their level of social interactions prior to and during the pandemic. For individuals in this particular group, they may maintain minimum level of social interactions based on their worksite (as an example), but the abrupt restriction in personal social interactions may amplify feelings of loneliness and its correlation with depressive symptoms. Further investigations are warranted to determine whether the heightened levels of loneliness and depressive symptoms that are currently observed are of a transient, acute nature or if they have evolved into chronic conditions.

This study has some limitations. First, the measure of loneliness was based on a single item. Although a single-item measure of loneliness is widely used in the literature, the multiple items can capture different dimensions of loneliness (e.g., intimate, relational, and collective)<sup>6</sup> that match different dimensions of social connectedness and thus have different association with health outcomes. Second, the data is based on community-dwelling adults. Residents in nursing homes were completely cut off from visitors due to pandemic-related restrictions, and they may have witnessed fellow residents dying more frequently.<sup>30</sup> Therefore, feelings of loneliness and depression can be more severe among that population compared to the population in this study.

Despite these limitations, our study is one of the first studies to examine changes in the relationship between social isolation and depressive symptoms before and during the COVID-19 pandemic, by using a nationally representative sample of older adults in Korea (KLoSA). This study also offers valuable insights into whether different age groups, including middle-aged individuals (45–64), young older adults (65–74), and the oldest adults (75 or more), exhibited distinct responses to the COVID-19 pandemic, thus resulting in varying associations with mental health outcomes. Moreover, the data utilized in this study are structured in a manner similar to those used in well-established studies such as HRS, ELSA, and SHARE. This design choice allows for meaningful comparisons of COVID-19 responses among older adults across various countries. Consequently, this study not only offers valu-

able policy implications during the global pandemic, but it also contributes to a comprehensive understanding of the unprecedented aging challenges faced by Korea within a global context.

### Supplementary Materials

The online-only Data Supplement is available with this article at <https://doi.org/10.30773/pi.2023.0268>.

### Availability of Data and Material

The datasets generated or analyzed during the current study are available in the Korea Employment Information Service repository, <https://survey.keis.or.kr/eng/klosa/klosa01.jsp>.

### Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

### Author Contributions

Conceptualization: Juyeon Kim, Jungtaek Lee. Data curation: Jungtaek Lee. Formal analysis: Jungtaek Lee. Methodology: Jungtaek Lee, Juyeon Kim. Project administration: Juyeon Kim, Jungtaek Lee. Writing—original draft: Juyeon Kim, Jungtaek Lee. Writing—review & editing: Juyeon Kim, Jungtaek Lee.

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