Age and gender differences in loneliness during the COVID-19: Analyses on large cross-sectional surveys and emotion diaries

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Abstract

The recent COVID-19 outbreak changed how age and gender affect loneliness and had a severe impact on the mental health of susceptible groups. This study investigated the joint influence of age and gender on loneliness, along with other psychological variables during the COVID-19 pandemic in South Korea.

We utilized large public data containing more than 4,000 self-reports and 20,000 emotion diaries from October 2020 to March 2021. Hierarchical regression, t-test, and analysis of variance were used to examine the effect of age, as a continuous or categorical variable, and gender on loneliness. We also utilized N-gram frequency analyses and topic modeling to analyze the differences in expressions used by the age-gender groups in the diaries.

Analyses of surveys indicated that loneliness increased with age and that women were lonelier than men. However, age and gender interacted to predict loneliness: younger women and older men experience higher levels of loneliness. Age and age-gender interactions remained significant even after considering demographic and personality risk factors. Moreover, there were significant gender differences within the 20s and 30s. Furthermore, text analyses revealed that all age-gender groups, except women in their 60s to 70s, frequently expressed anxiety and depression. Also, women in their 20s expressed work experiences and difficulties in searching for a job, while women in their 30s highlighted childcare challenges and a lack of social connections. Lastly, spirituality was one of the major things expressed by women in their 50s to 70s, but not by the other groups.

This study confirmed the global trend of loneliness during COVID-19, while also illustrating cultural differences in loneliness trends that reflect social and psychological challenges in South Korea during the pandemic. Moreover, Text analyses provided potential explanations for the differences in loneliness by age and gender groups. Interventions targeting younger women and older men should be established.

1 Introduction

Loneliness arises when an individual's level of social connection does not reach the desired level (1). It is the idiosyncratic feelings of isolation, not necessarily caused by objective social isolation, meaning that one can feel "lonely in the crowd" (1). Research on loneliness indicates that loneliness can cause serious psychological and physical health problems that needs to be addressed. Lonely individuals experience mental health problems, such as anxiety, depression, and low life satisfaction (2-5), as well as physiological problems, such as high blood pressure, coronary heart disease, and strokes (6, 7). Additionally, loneliness is associated with a 32% increase in the likelihood of mortality (8), which is comparable to the risk of heavy smoking (9). Risk factors that affect loneliness include marital status, physical health, socioeconomic status, quantity and quality of social relationship, and personality traits such as neuroticism and extraversion (10-13).

Prevalence and severity of loneliness may have been exacerbated during COVID-19 due to the decline of in-person social contact. Research on residents of the United States indicated elevated levels of loneliness during the last week of stay-at-home measures in April, 2020 (14), and during the first six months of lockdown (15). Moreover, nation-wide lockdowns increasingly led people to feel lonely in Europe (16, 17). However, a different stream of research suggested no significant increase in loneliness during the pandemic. During the two occasions in the U.S. where the social restriction measures were strictly enforced, there was no significant loneliness surge than before the pandemic (18). In addition, the prevalence of loneliness among adults in the UK remained the same before and during the pandemic (19, 20). Given that researchers raised concerns regarding loneliness reaching the level of an epidemic even before the coronavirus outbreak, loneliness levels may have remained stable during COVID-19 due to loneliness being already high before the pandemic (18, 21). Another possible explanation is that loneliness levels may have stabilized after the introduction of lockdown measures, considering that the general mental health during COVID-19 followed such paths.(22). However, it has been reported that older adults, quarantined individuals, and emergency workers were lonelier during the "stay-at-home" measures, indicating vulnerability of certain groups (18, 23). Moreover, a recent study reported that gender differences in loneliness have widened during the pandemic (17). This underlines the need to examine loneliness trends during the pandemic in more specific populations and compare these among groups parceled by risk factors influencing loneliness during the pandemic.

Age is an important risk factor for loneliness. A nonlinear U-shape has been reported in the relationship between age and loneliness (11, 20). The youngest and the oldest age groups generally showed a higher prevalence and intensity of loneliness than the middle age group (12, 24, 25). In particular, a previous study revealed that adults under 25 years and above 80 years were the loneliest (11). The moderating effect of age on the impact of loneliness risk factors, such as employment status, relationship status, and household size can explain such differences (11). Recent studies conducted during COVID-19 have presented different age-loneliness relationship patterns. A general decreasing trend was identified, with the younger generation exhibiting the highest levels of loneliness (19, 26-28). However, when aggregated across age groups, middle-aged individuals were the loneliest (29). Similarly, a larger population of older adults aged over 70 years experienced increased loneliness (30), while adults in their 50s experienced even higher levels of loneliness (31).

It is important to consider gender differences in loneliness during the COVID-19 pandemic. It has been reported that the epidemic increased gender disparities in loneliness (17). Also, the patterns of these disparities have changed over time. On the one hand, earlier studies showed mixed findings, with some studies indicating no significant differences between gender and loneliness, while others

reported that males were lonelier than females (32, 33). However, a few recent studies, including those conducted during the pandemic, have reported that women are more vulnerable to loneliness (11, 20, 26, 28, 34).

Few studies have examined the joint effect of age and gender on loneliness, especially in the context of COVID-19. However, the interaction effect between age and gender on loneliness should also be carefully examined. According to the 2021 Happiness report, a decline in mental health was evident for young and female adults, which were the groups at high mental health risk before the pandemic (22). It has also been reported that women aged between 16 and 34 years had the worst general mental health in the United Kingdom during COVID-19 (22). This approach will assist in revealing a detailed trend in loneliness during the pandemic and identify groups that are more afflicted by the virus.

Additionally, previous studies on loneliness have focused on Western countries. Research describing the trends of loneliness in Asia was limited except for studies carried out in China using cross-sectional and longitudinal data from both before and during the pandemic (35-41). Acknowledging the severity of loneliness during the pandemic, a few studies have recently investigated loneliness trends in South Korea during the COVID-19 pandemic. For example, a study conducted in South Korea examined the trends and impact of loneliness during COVID-19, but this study mainly examined the impact of social relationship status, such as resident type or marital status, on loneliness and the impact of loneliness on general mental health (42). Another study examined the risk factors of loneliness during COVID-19 in South Korea, but the sample was limited to individuals over 40 years of age (43). Results from Western countries may not apply to Eastern cultures with different sociocultural backgrounds, which underscore the need to examine loneliness trends in Eastern cultures, especially in South Korea. Such research will help investigate whether the loneliness trends in Korea reflect the global loneliness trends during COVID-19.

Finally, the rising trend in emotion research used text analyses on diaries, interviews, or speeches reported a strong correlation between emotion-related linguistic markers and negative emotion measures (44-47). Naturalistic language containing individual writers' emotional experiences convey detailed information not fully captured by structural questionnaires. Word frequencies reveal attentional focus on oneself and the surrounding environment (48-50). Moreover, recent development in computerized intelligence to analyze narratives in an automated manner enables automatic topic extraction and classification from texts. Therefore, despite their limitations of being descriptive (50, 51), analyses of emotional narratives during COVID-19 offer insightful information on the varying attentional focus of life experiences, along with diverse emotional information, by demographic groups based on the influential risk factors of loneliness.

The present study aimed to investigate the joint influence of age and gender on loneliness during COVID-19 in South Korea. By utilizing text analyses in addition to scale-based response measures, we were able to gain rich information regarding culture and lifestyle factors that are related to age and gender in South Korea. This study hypothesized that gender would moderate the relationship between age and loneliness in both conditions, where age is a categorical and continuous variable. Specifying age as a categorical variable enables statistical tests across age groups and compares the results with those of other studies (20). Age as a continuous variable, without the scores being aggregated across age groups, is needed to uncover a general trend in age-loneliness relationships (11).

2 Materials and Methods

2.1 Dataset

This study used the “COVID-19 Emotion Diary with Empathy and Theory-of-Mind Ground Truths Dataset” (52). It is a public dataset funded by the Korea Data Agency and managed by a psychology laboratory at Seoul National University as part of the Data Voucher Project. The dataset was created to construct empathetic artificial intelligence (AI) models to enhance the mental well-being of people during the pandemic. It contains self-reported demographic and psychological variables that may have been impacted by the pandemic, which includes loneliness. It also has 5 written emotional diaries per participant that contain emotions and thoughts regarding their experiences during the COVID-19. The dataset was collected via online crowdsourcing. Response qualities were controlled via twofold inspection, first by the quality control workers at the crowdsourcing platform and then by the psychology experts (52). Therefore, we concluded that this dataset is a valid, high-quality source for research on the characteristics of loneliness experiences during the pandemic. The list of variables used in this study is in **Table 1**.

The researchers obtained written consent from the participants, and the participants were informed that their responses will be part of an open dataset (52). The responses were collected anonymously, and the participants were asked not to include any personally identifiable information about themselves or others. The posterior twofold inspection process ensured that all diaries did not contain any such information. Lastly, the collection process did not include any experiments that inflicted direct manipulation on the human mind or body. Therefore, utilizing the dataset for our research is subject to exemption from institutional Review Board (IRB) approval, under the declaration of Helsinki (53). It also complies with the approval exempt condition stated in Article 15 Paragraph 2 of the Bioethics And Safety Act and Article 13 of its Enforcement Rules in Korea (54).

2.2 Measures

In this study, we used the following variables from the dataset: loneliness, extraversion, neuroticism, ‘remote working or schooling,’ and ‘social distancing’ measures.

2.2.1 Loneliness

Six-item version of Revised UCLA loneliness scale (ULS-6) was used to measure loneliness (55, 56). It uses a 4-point Likert scale from 1(‘never’) to 4(‘often’) to indicate how often each item is descriptive of oneself (33). It measures unidimensional loneliness that captures the essential characteristics of subjectively experienced loneliness, which are the feeling of isolation and withdrawal. Measures used in the dataset were based on the translated version of the full-scale Revised UCLA Loneliness Scale (33, 57). The reliability of the scale was 0.83 in the current study.

2.2.2 Extraversion and Neuroticism

Newcastle Personality Assessor (NPA) was used to measure extraversion and neuroticism among Big 5 Personalities (58). NPA is a brief personality measure consisting of 12 items that exhibited the highest correlations with the aggregated scores of the five-factor measure from the International Personality Item Pool. It uses a 5-point Likert scale from 1(‘strongly disagree’) to 5(‘strongly agree’) to indicate how much each item is descriptive of oneself. There were 2 items for both extraversion and neuroticism. Cronbach’s alpha score is sensitive to the number of items and

relies upon strict assumptions that are more susceptible for short scales to violate (59, 60). Therefore, some researchers advise adopting the Spearman-Brown corrected coefficients instead of Cronbach's alpha for two-item scales (60). In this study, we calculated both Cronbach's alpha and Spearman-Brown coefficients. Cronbach's alpha scores were 0.48 for extraversion, and 0.74 for neuroticism, and Spearman-Brown coefficients were 0.65 for extraversion and 0.85 for neuroticism in this study.

2.2.3 Remote Working or Schooling, and Social Distancing

A single-item scale was used to assess whether participants work remotely or receive non-contact education, and whether the participants are restricting social contacts to less than twice a week (52). Participants responded as either 'yes' or 'no'.

2.3 Analysis

We grouped the participants into 5 age ranges: 20s, 30s, 40s, 50s, and 60s-70s. Education and income levels were defined as continuous variables. The impact of living alone on loneliness was compared to the impact of other household types. Twelve responses of the 'other' household type were re-assigned into either 'living with immediate family,' or 'living with people other than immediate family' household types based on how the participants' additional descriptions of their specific situations. We relocated 10 responses to household 'living with immediate family,' and 2 responses to 'living with people other than immediate family.'

2.3.1 Statistical Analysis

Four thousand, three hundred fifty original responses were collected for five months (from October 2020 to March 2021). Among them, we removed missing data points and excluded responses from participants who reported their education level as 'other'. Also, individuals who wrote the number of people living together as 20 people or more without valid reasons (i.e. who were in the military service; all South Korean men should serve in the military and live in barracks while serving) were excluded. We finalized 4,017 responses in total eligible for analyses.

For analyses involving age as a categorical variable, we calculated mean loneliness ratings for each age-gender group, as well as 95 percent confidence intervals. We performed Welch two-sample t-test to test the statistical significance of gender differences within some age groups. To prevent the increased risk of type 3 error, we chose a planned comparison for additional analysis on the analysis of variance (ANOVA) results over post-hoc analysis. R 4.1.0 was used to conduct all statistical analyses.

For analyses on age as a continuous variable, we expected that a linear model would be appropriate for modeling loneliness, considering that participants' age ranges were from the 20s to 70s and that the dataset was collected during the COVID-19 pandemic (11, 19, 20, 26). We conducted two hierarchical regression analyses: first to examine the influence of gender and age interaction on predicting loneliness, and then to test the final model obtained from the first regression analysis against the other risk factor for loneliness. Since the regression models contained interaction terms, we standardized all continuous variables to control Variance Inflation Factors (VIF) and increase the interpretability of coefficients in all models. To improve readability, we used the unstandardized version of the model for plotting graphs. Statistical significance was tested against $p < 0.05$ as a two-tailed test.

2.3.2 Text Analysis

To gain more insight into the gender differences in the relationship between age and loneliness, we conducted N-gram frequency analyses and topic modeling with diary texts and compared the results by gender within the same age groups. We utilized texts from participants whose responses did not contain any null values to increase the size of text input as much as possible. We finalized 20,730 diaries as input for text mining models. We conducted all the analyses using python 3.8.

For N-gram frequency analyses, we calculated unigram and bigram frequencies as main analyses and calculated trigram frequencies when a deeper understanding of the contexts of target words was needed. N-gram is a unit consisting of N number(s) of words that appear subsequently in a sentence. Unigram is a single word ($N=1$), and bigram is a continuous 2 words in a sentence ($N=2$). For example, in a sentence “Coronavirus made me stay home all day”, “stay” and “home” are unigrams, and “stay home” and “home all” are bigrams.

To create N-grams, we split the body texts of each diary into multiple sentences and each sentence into words. Then, we removed all punctuations, selected words with part-of speech (POS) tagging corresponding to nouns, and formed N-grams. N-grams that contained 'stop words' were not used. Stop words are words that commonly appear in a corpus but do not contain any meaningful information regarding the purpose of analyses. Finally, counts and frequencies on unigrams and bigrams that appear most frequently were calculated, mostly up to rank 30.

We used Latent Dirichlet Allocation (LDA) for topic modeling. Topic modeling is a machine learning technique that derives latent topics from a large corpus consisting of multiple documents. One of the most popular topic models, Latent Dirichlet Allocation (LDA), models the distribution of latent topics in documents using Dirichlet distribution to determine the best topic sets (61). The model implementation was based on Collapsed Gibbs Sampling method (62, 63). The text pre-processing procedure was similar to that used when constructing N-grams, with the exception that the stop words were removed before modeling. The vectorized token was created from the final form of processed tokens and used as input for modeling.

We ran coherence tests for each gender-age group model, altering two hyperparameters: the number of topics to be extracted, and the number of most frequent tokens to be deleted, to find the best model. We ran 300 iterations for each model. We chose the final model with the highest inter-topic discriminability and topic interpretability among the three models with the highest coherence scores.

3 Results

3.1 Sample Characteristics

The participants' average age was 34.87 ($SD=12.85$), with a range of 20 to 79. There were 3,053 female workers, accounting for 76% of all participants. The average income level was 3.73 ($SD=2.510$), and the average education level was 3.44 ($SD=0.97$). The average loneliness score was 2.27 ($SD=0.71$). Full sample characteristics by the age groups and gender are presented in **Supplementary Tables 1 and 2**.

3.2 Loneliness by Age and Gender: Age As a Continuous Variable

We tested the hypothesis of gender moderating the relationship between age and loneliness in the context of age as a continuous variable (**Table 2**). Model 1 ($F(1,4015)=13.12, p<0.001$) and model 2 ($F(2,4013)=15.13, p<0.001$) were both significant. Model 2 showed that age ($t(4013)=2.03, p=0.043$) and gender ($t(4013)=-5.24, p<0.001$) were both significant, with women and older people being lonelier. The interaction effect between gender and age ($t(4013)=2.92, p=0.004$) was also significant, with male participants showing greater variation to age in loneliness than female participants. Visualization of the effect of age on loneliness by gender group revealed that males were lonelier than females after reaching the age of 60 (**Figure 1**). According to hierarchical regression on models 1 and 2, gender and its interaction with age significantly increased the model's explanatory power ($F(2,4013)=17.33, p<0.001$).

We conducted another hierarchical regression analysis with the final model from Table 2 as the baseline model (**Table 3**). We investigated whether gender and age remained as a significant predictor of loneliness in the presence of other risk factors for loneliness. In the first step, we added the following demographic variables to model 1 as control variables: income, family type, remote working or schooling, and social distancing. The resulting model (model 2) was statistically significant ($F(10,4006)=15.02, p<0.001$), and the age, gender, and their interaction effect remained significant after demographic variables were included. The influence of age grew stronger, while the influence of gender weakened. Then, in the second step, we added the personality variables to form model 3.

With personality risk factors being added, model 3 was statistically significant ($F(12,4004)=116.60, p<0.001$). The effect of age as well as the interaction between age and gender remained significant, whereas the effect of gender did not. However, we discovered that the correlation between age and neuroticism was stronger than the correlations between the other two variables, which may influence the significance of age and age-gender coefficients. We conducted an additional regression analysis of age, neuroticism, and age-neuroticism interaction (**Supplementary Table 3**). In predicting loneliness, neuroticism had a significant interaction effect with age as a continuous variable ($t(4013)=2.06, p=0.039$). Age had a greater impact on predicting loneliness in participants with higher neuroticism scores. We, therefore, added age-neuroticism interaction term to model 3 to create model 4, and model 4 was chosen as the final model. The model was statistically significant ($F(13,4003)=108.10, p<0.001$), and explained 25.74% of loneliness variance overall. Age was a significant predictor of loneliness ($p<0.001$), with males having larger age prediction coefficients in loneliness than females ($p=0.030$). Lower income ($p=0.002$), social distancing ($p<0.001$), living alone compared to living with other people ($p=0.016$), lower extraversion ($p<0.001$), and higher neuroticism ($p<0.001$) were also significant predictors of loneliness.

3.3 Loneliness by the Age Groups and Gender: Age As a Categorical Variable

We visualized the aggregated loneliness scores across age groups and gender. The general trend was that participants in their 40s, regardless of gender, reported a high level of loneliness. Among all age-gender groups, females in their 30s and 40s were the loneliest. We conducted Welch two-sample t-test on age groups with high gender differences (**Figure 2**). Female participants in 20s ($M: 2.23, 95\% CI: [2.20, 2.26]$) and 30s ($M: 2.45, 95\% CI: [2.390, 2.499]$) were lonelier on average than male participants in 20s ($M: 2.06, 95\% CI: [1.99, 2.13]$) and 30s ($M: 2.16, 95\% CI: [2.07, 2.25]$) each. Such gender differences in 20s ($t(531)=4.13, p<0.001$) and 30s ($t(423.59)=5.32, p<0.001$) were both

statistically significant. Although male participants in 60s-70s ($M: 2.39, CI: [2.25, 2.53]$) were lonelier on average than females in the same age group ($M: 2.25, 95\% CI: [2.11, 2.38]$), such differences were not statistically significant.

We used ANOVA to evaluate the moderation effect of gender on the link between age as a continuous variable and loneliness. The main effect of gender ($F(1,4007)=2.70, p=0.019$), age group ($F(4,4007)=23.20, p<0.001$), and the interaction between gender and age groups ($F(4,4007)=10.20, p<0.001$) were all statistically significant (**Table 4**).

We also conducted a planned comparison to further test our assumptions about the loneliness levels in certain gender and age groups. Contrasts were constructed based on previous literature. We predicted that females would be lonelier than males. For contrasts within age and gender group levels, we predicted that individuals in their 20s to 30s would be lonelier than those in their 40s to 70s, and individuals in their 60s-70s would be lonelier than those in their 30s to 50s. Also, we speculated that respondents in their 20s would be lonelier than those in their 30s, and respondents in their 40s would be lonelier than those in their 50s.

Results showed that females were lonelier than males ($t(4007)=2.35, p=0.019$). Also, participants in their 20s to 30s were significantly less lonely than those in 40s to 70s ($t(4007)=-3.83, p<0.001$). Respondents in their 20s were lonelier than those in their 30s ($t(4007)=-4.69, p<0.001$), and respondents in their 40s were lonelier than those in their 50s ($t(4007)=2.66, p=0.008$). However, interaction effects revealed that female participants in their 20s to 30s were significantly lonelier than those in 40s to 70s while male participants in their 20s to 30s were significantly less lonely ($t(4007)=4.19, p<0.001$). The full results for planned comparison are in **Table 5**.

3.4 Frequent N-grams Used Within the Age-Gender Groups

We investigated gender differences in the N-gram usage among participants in their 20s to 30s (**Tables 6 and 7**). ‘Child’ was the 14th most frequent unigram for female participants with 0.48 word frequency, while the same word was 56th most frequent word for male participants with 0.00 word frequency. ‘Delivery food’ was the 24th most frequent bigram for females while it was 33rd for males, with bigram frequencies of 0.07 and 0.00, respectively. The findings showed that females in their 20s-30s were more concerned with child care and food provision than males in their 20s-30s during the COVID-19.

Another major gender difference in N-gram usage among participants in their 20s to 30s was the frequency using the word ‘confirmation’. ‘Confirmation’ was the 16th most frequent unigram used among females while being the 24th most frequent word among males, with word frequencies being 0.46 and 0.34 respectively. Moreover, ‘All day long’ was the 16th most frequently used bigram among females, with 0.09 bigram frequencies while it was the 29th among males, with 0.06 bigram frequencies. The results revealed that females in their 20-30s were more concerned about the virus and talked more about their experiences that lasted all day.

Another significant gender difference in N-gram usage among participants in their 20s to 30s was the use of ‘traveling’. It was the 23rd common bigrams used by females, while it was the 44th common unigram used by males, with word frequencies being 0.46 and 0.34 respectively. We examined trigrams containing the word ‘traveling’ used by females in their 20s and 30s to reveal the context of the word being used. Frequent trigrams were ‘traveling, because of, COVID-19’, ‘foreign,

domestic, traveling', 'trip, planning, traveling', 'traveling, domestic, trip', 'COVID-19, situation, traveling', 'domestic, traveling, people', 'friend, planning, traveling', 'wedding, honeymoon, traveling', and 'honeymoon, traveling, canceled', 'eventually, traveling, canceled'. This revealed that 'traveling' was used in relation to their plans on traveling, people traveling during the COVID-19, and canceling traveling. We also looked at gender differences in the word usage among participants in their 60s-70s, but no major differences were found.

3.5 Frequent Topics Discussed Within the Age-Gender Groups

To further investigate the differences among age-gender groups, we used topic modeling on 10 specific age-gender groups and extracted the topics that are mainly discussed within each group (**Supplementary Table 4**). First, all females except in their 30s showed topics related to their pets (i.e., 'dog' or 'cat'), but no males did (**Table 8**). Moreover, all females had mother-related topics in each age group (i.e., 'mom') (**Table 9**). Specifically, females in their 30s frequently talked about one's domestic role (i.e. as a mom or wife) or about other mothers, whereas males in their 30s did not. We conducted additional bigram and trigram frequency analyses that contained 'mom' in the sequence of two or three words to examine context of the word in diary texts. We used token '<name>' to collectively replace unigrams representing the names of other people. The results revealed that females over 30s used 'mom' to refer to their mother (i.e., 'think, mom' 'my, mom, father', and 'distance, parent's home, mom'), other people (i.e., 'child, friend, mom', 'friend, mom', and '<name>, mom'), or themselves (i.e., 'child, mom, child', 'son, child, mom', 'mask, child, mom', and 'child, kindergarten, mom'). However, all males across age groups did not show topics with the word 'father' as a topic word, and the word 'wife' was used to refer to their marriage partner.

With topic modeling, we also discovered patterns in diaries written by females in their 20s and over 50. Females in their 20s wrote more about jobs and working than males in their 20s, and this pattern did not occur in the other age groups (**Table 10**). Two of the three work-related topics of females in their 20s were about thoughts and feelings about acquiring jobs. They included topic words describing internal states. The other was about non-contact interview or working experience, and it featured topic words that described situational elements. Meanwhile, females in their 50s and 60s-70s had topics regarding their spiritual life, as indicated by the topic words 'church' and 'worship' (**Table 11**), while males did not. Lastly, all age-gender groups, with the exception of females in their 60s-70s showed topics related to negative affect state, which included topic words like 'depression', 'stress', and 'annoyance'.

4 Discussion

4.1 Analyses on the Effect of Age, Gender, and Other Variables on Loneliness Confirmed the Global Loneliness Trend While Suggesting Cultural Differences

The regression model found a positive correlation between age and loneliness, which remained significant even after adding other risk factors. This finding contradicts recent studies conducted during the pandemic (19, 26), which revealed that age, as a continuous variable, had a negative association with loneliness. Considering that similar large-scale loneliness studies were conducted within Western contexts, the novelty may be due to cultural differences. Meanwhile, ANOVA results revealed that South Koreans in their 20s and 30s were lonelier, on average, than

those in their 40-70s. The disparity in the age-loneliness relationship between the two analyses results indicates that the age-loneliness relationship can vary greatly depending on how the age variable is defined. Additionally, participants in their 40s reported higher levels of loneliness than those in the other age groups. This result corresponds with previous research, which indicated that the middle-aged group was the loneliest in the United Kingdom (29). In terms of the effect of gender on loneliness, women were generally lonelier than men, which is consistent with a recent study (11, 20, 26, 34).

However, the characteristics of the prevalence of loneliness could not be fully captured when age or gender was considered alone or separately. Regression analysis of the influence of age and gender on loneliness revealed that while women were lonelier than men on average, they exhibited a gradual increase in loneliness by age than men. Women were lonelier than men until 60 years, but men were lonelier than women after 60. The age-gender interaction remained significant even when other risk factors were included. The ANOVA results indicated that while women in their 20s and 30s were lonelier than those in their 40s, male participants showed the opposite trend. This suggests the importance of age and gender interaction in determining the severity of loneliness and that the interplay should thus be considered when identifying high loneliness groups.

4.2 Text Analyses Results Provided Potential Explanations for the Differences in Loneliness by Age and Gender

In South Korea, participants in their 20s and 30s showed the greatest gender differences in loneliness, with women being lonelier than men. Women in their 20s wrote more about their work experience than men and expressed a depressed state toward getting jobs. According to Statistics Korea, (64) the employment rate of Koreans in their 20s decreased by 4.2pp (percentage points) in January 2021 compared to the previous year, the steepest decrease among all age groups. It is likely that women suffered more from job loss in Korea during the pandemic, given that the increase in the number of unemployed women, 48.4pp, were higher than those of men, 25.9pp, after a year-long COVID-19 outbreak. The previous finding—employment status is a strong predictor of loneliness for adults under the age of 30—strengthens the argument that job difficulties may be a possible reason for younger women’s increased levels of loneliness in South Korea (11).

South Korean women in their 30s wrote more about their domestic role (i.e. as a mother or wife) of caring for their families or about other mothers, while males in their 30s did not. A closer examination of diaries containing “child” or “mom” written by women in their 30s indicated that women who were married and had children faced difficulties in supporting their children’s non-contact education while also feeding their families (**Table 12**). Remote work, remote education, and reduced one-on-one meetups prompted by COVID-19 exacerbated loneliness and depression in mothers. This result is consistent with earlier studies: women were burdened with more household duties and parenting responsibilities during the COVID-19 pandemic (65, 66). Additionally, women who were pregnant or in the perinatal period experienced worsening mental health after the COVID-19 outbreak (67, 68).

The impact of motherhood on the mental health of South Korean women may not be limited to married women with children. Some diary inputs written by women in their 30s suggested they were prone to feeling lonely due to COVID-19 that prohibited physical contact with friends (**Table 12**). The majority of research on women's psychological well-being during the COVID-19 pandemic focused

on married women about to or already raising their children. Younger women need to be given broader attention when designing interventions to address loneliness during COVID-19.

Some research conducted prior to COVID-19 identified the female gender as a risk factor, irrespective of age (20, 34). This contradicts this study's findings, which revealed that older women were less lonely than older men. Given that loneliness is associated with depression (2, 69) and lonely individuals demonstrated linguistic markers of depression and anxiety in self-written texts (70), this inclination is supported by the linguistic markers of emotions associated with loneliness – depression and anxiety – being less prevalent in diaries written by older women. Moreover, text analyses on diaries revealed that women in their 50s to 70s had spirituality-related interests. Older age and female gender have been reported to positively predict spirituality; and spirituality is positively correlated with subjective well-being in older adults (71-74). Such findings may provide an indirect explanation for why South Korean women are less lonely than men after the age of 60.

4.3 Contributions and Limitations

This study utilized large-sized survey data collected using the validated measures of loneliness along with diaries collected from South Korean samples during COVID-19. No research on Korean people's loneliness levels has been conducted in this size, specifically during the COVID-19 pandemic. Gender-age groups in South Korea suffering from elevated levels of loneliness during the pandemic were identified by examining loneliness trends using the interaction between gender and age during the pandemic. Based on the text analyses, further explanations for gender differences in loneliness levels within age groups were provided. Based on this study's findings, possible interventions targeting loneliness-suffering populations in South Korea can be designed.

The sample size varied greatly across age groups and genders; more than half the participants were women in their 20s. Owing to the nature of online crowdsourcing, the characteristics of individuals who actively participated on such platforms may have affected the results (75). Future studies should expand their sample to include more information from older age groups and male gender groups. Furthermore, possible results of recruiting participants online should be considered. Moreover, future studies should investigate cultural differences in loneliness trends with cross-cultural results. Finally, future research should explore the differences in loneliness levels before and after the pandemic and address changes in individual levels of loneliness over time.

5 Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

6 Author Contributions

All authors contributed to the conception and design of the study. YJ performed the statistical analysis and wrote the first draft of the manuscript. All authors contributed to the manuscript revision, and read and approved the final manuscript.

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462 (76).

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464 **9 Data Availability Statements**

465 A sample of “COVID-19 Emotion Diary with Empathy and Theory-of-Mind Ground Truths Dataset”
466 used for this study can be found at [https://github.com/humanfactorspsych/covid19-tom-empathy-](https://github.com/humanfactorspsych/covid19-tom-empathy-diary)
467 [diary](https://github.com/humanfactorspsych/covid19-tom-empathy-diary). Due to privacy concerns (e.g., mental health and personal history), researchers from verified
468 institutions could email the managing institution to get access to the full data (52, 77).

Table 1. The List of Self-Reported Measures in “COVID-19 Emotion Diary with Empathy and Theory-of-Mind Ground Truths Dataset” Used in This Study.

Variable Names	Number of Items	Item Scales
Loneliness	6 items	1 to 4
Extraversion	2 items	1 to 5
Neuroticism	2 items	1 to 5
Age	1 item	1 to 100
Gender	1 item	Male=1, Female=0
Income Level	1 item	1 to 9
Education Level	1 item	1 to 7
Household Type	1 item	1 to 4
Remote Working or Schooling	1 item	Yes=1 or No=0
Social distancing	1 item	Yes=1 or No=0

Income level: 1(less than 20k) to 9(90k to 100k). Education level: 1(middle school) to 6(doctorate degree), and 7(others). Household type: 1(living alone), 2(living with immediate family), 3(living with people other than immediate family), and 4(others).

Table 2. Hierarchical Regression Results on Age and Gender as a Predictor for Loneliness.

	Model 1			Model 2		
	β	<i>CI</i>	<i>p</i>	β	<i>CI</i>	<i>p</i>
Intercept	>-0.001	-0.031, 0.031	1.000	0.041	0.005, 0.076	0.024*
Age	0.057	0.026, 0.088	<0.001*	0.038	0.001, 0.075	0.043*
Gender(1=female)				-0.197	-0.270, -0.123	<0.001*
Age – Gender(1=female) Interaction				0.102	0.033, 0.170	0.004*

Age is standardized. Adjusted R^2 values for model 1 and model 2 are 0.003 ($F(1,4015)=13.12$, $p<0.001$) and 0.012 ($F(3,4013)=15.13$, $p<0.001$) respectively. The hypothesis test result for the change in adjusted R^2 values between the two models is $F(2,4013)=16.09$, $p<0.001$. Coefficients(β), p-values(p), and adjusted R^2 values are rounded to three decimal places. F-values are rounded to two decimal places. *CI*= 95% Confidence Intervals of coefficients(β). *= statistically significant at 95% confidence level.

484 **Table 3. Hierarchical Regression Results on Loneliness with Multiple Risk Factors.**

	Model 1			Model 2			Model 3			Model4		
	β	CI	p	β	CI	p	β	CI	p	β	CI	p
Intercept	0.041	0.005, 0.076	0.024*	-0.049	-0.136, 0.038	0.269	-0.033	-0.109, 0.043	0.396	-0.026	-0.102, 0.050	0.505
Age	0.038	0.001, 0.075	0.043*	0.043	0.006, 0.080	0.024*	0.128	0.095, 0.162	<0.001*	0.132	0.098, 0.166	<0.001*
Gender(1=female)	-0.197	-0.270, -0.123	<0.001*	-0.175	-0.248, -0.101	<0.001*	-0.012	-0.077, 0.053	0.721	-0.016	-0.081, 0.049	0.629
Age – Gender(1=female) Interaction	0.102	0.033, 0.170	0.004*	0.100	0.032, 0.167	0.004*	0.057	-0.003, 0.116	0.061	0.066	0.006, 0.126	0.030*
Income				-0.094	-0.127, -0.061	<0.001*	-0.046	-0.075, -0.017	0.002*	-0.047	-0.076, -0.017	0.002*
Education Level				0.008	-0.023, 0.039	0.629	0.016	-0.012, 0.043	0.260	0.014	-0.014, 0.041	0.331
Remote Working or Schooling(1=yes)				-0.031	-0.095, 0.034	0.352	0.020	-0.037, 0.077	0.486	0.021	-0.036, 0.078	0.464
Social Distancing(1=yes)				0.248	0.180, 0.315	<0.001*	0.161	0.102, 0.220	<0.001*	0.160	0.101, 0.219	<0.001*
Household Type2				-0.127	-0.250, -0.003	0.044*	-0.134	-0.242, -0.026	0.015*	-0.132	-0.240, -0.024	0.016*
Household Type3				-0.070	-0.155, 0.015	0.107	-0.096	-0.171, -0.021	0.012	-0.096	-0.171, -0.021	0.012*
Household Type4				0.068	-0.288, 0.424	0.708	-0.049	-0.361, 0.263	0.758	-0.047	-0.359, 0.265	0.767
Extraversion							-0.182	-0.209, -0.155	<0.001*	-0.182	-0.209, -0.155	<0.001*
Neuroticism							0.057	0.415, 0.471	<0.001*	0.442	0.414, 0.470	<0.001*
Age – Neuroticism Interaction										0.029	0.002, 0.056	0.036*

485 Household Type: 1(living alone), 2(living with immediate family), 3(living with people other than immediate family), and 4(others). All
 486 continuous variables are standardized. Adjusted R^2 values for model 1, model 2, model 3, and model 4 are 0.011, 0.036, 0.259, and 0.257

487 respectively. The hypothesis tests results for the change in adjusted R^2 values between the two models are $F(7,4006)=14.81$, $p<0.001$ for
488 model 1 and model 2, $F(2,4004)=601.96$, $p<0.001$ for model 2 and model 3, and $F(3,4003)=403.11$, $p<0.001$ for model 2 and model 4.
489 Coefficients(β), p-values(p), and adjusted R^2 values are rounded to three decimal places. F-values are rounded to two decimal places. CI=
490 95% Confidence Intervals of coefficients(β). *= statistically significant at 95% confidence level.

Table 4. ANOVA Results for Differences in Loneliness by the Age Groups and Gender.

	<i>df</i>	Type III <i>SS</i>	<i>F</i>	<i>p</i>	Partial η^2
Intercept	1	9824.00	19741.60	<0.001*	
Gender	1	2.70	5.50	0.019*	0.001
Age Group	4	23.20	11.60	<0.001*	0.012
Gender- Age Group Interaction	4	10.20	5.10	<0.001*	0.005
Residuals	4007	1994.10			

Sum of squares(*SS*) values and F-values(*F*) are rounded to two decimal places. P-values(*p*) and partial eta-squared(η^2) values are rounded to three decimal places. *= statistically significant at 95% confidence level.

Table 5. Planned Comparison Results for the Effect of the Age Groups and Gender on Loneliness.

	β	<i>SE</i>	<i>t</i>	<i>p</i>
Intercept	2.293	0.016	140.50	<0.001*
Gender	0.038	0.016	2.35	0.019*
Age Group1	-0.023	0.006	-3.83	<0.001*
Age Group2	0.010	0.019	0.52	0.601
Age Group3	-0.074	0.017	-4.69	<0.001*
Age Group4	0.074	0.028	2.66	0.008*
Gender – Age Group1 Interaction	0.025	0.006	4.19	<0.001*
Gender – Age Group2 Interaction	-0.028	0.017	-1.68	0.094
Gender – Age Group3 Interaction	0.031	0.019	1.68	0.102
Gender – Age Group4 Interaction	0.007	0.028	0.24	0.814

Gender(women compared to men), age group1(individuals in their 20s to 30s compared to those in their 40s to 70s), age group2(individuals in their 60s-70s compared to those in their 30s to 50s), age group3(individuals in their 20s compared to those in their 30s), and age group4(individuals in their 40s compared to those in their 50s) are contrasts of gender and age groups. The model was statistically significant: $F(9,4007)=11.11$, $p<0.001$. *= statistically significant at 95% confidence level.

Table 6. Unigrams that Greatly Varied in Frequencies by Gender among Participants in Their 20s and 30s.

	‘child’		‘confirmation’		‘traveling’	
	%	Ranks	%	Ranks	%	Ranks
Female	0.4756	14	0.4596	16	0.3742	23
Male	0.0023	56	0.3404	24	0.0025	44

Frequencies (%) and ranks are calculated within the same gender-age group.

Table 7. Bigrams that that Greatly Varied in Frequencies by Gender among Participants in Their 20s and 30s.

	‘delivery food’		‘all day long’		‘boyfriend’ or ‘girlfriend’	
	%	Ranks	%	Ranks	%	Ranks
Female	0.0679	24	0.0861	16	0.1953	3
Male	0.0005	33	0.0565	29	0.3015	1

Frequencies (%) and ranks are calculated within the same gender-age group.

Table 8. Topics Related to Pets across the Female Age Groups.

Age Groups	Topics
20s	mom, sound, dad, dog , call, grandfather, cat , grandmother
40s	this time, trouble, cat , fact, one, study, event, moving
50s	workout, stroll, dog , stress, movie, a day, mood, start
60s-70s	workout, mood, thought, stroll, dog , arrangement, park, apartment

Table 9. Topics Related to Mother across the Female Age Groups.

Age Groups	Topics
20s	mom , sound, dad, dog, call, grandfather, cat, grandmother
30s	mom , workout, husband, a day, baby, start, mood, morning
40s	mom , mind, happiness, parents, travel, thought, husband, family
50s	mom , hospital, mind, family, parents, test, worry, father
60s-70s	mind, thought, mom , alone, going to work, supermarket, extent, today

517 **Table 10. Topics Related to Jobs and Working across the Age-Gender Groups.**

Age Groups	Gender	Topics
20s	Female	thought, emotion, mind, self/confidence, finding a position , depression, happiness, situation company, working from home, going to work, working , thought, work, workplace , hospital progress, interview , thought, non-contact, face, online, first, meeting
	Male	work, part-time job , store, employee, going to work, boss , problem, working
30s	Female	class, company, working from home, work , start, study, progress, preparation
	Male	company, going to work, working, working from home, work, workplace, employee, colleague work, working from home , delivery, problem, situation, extent, occasion, emotion
40s	Female	company, working from home , situation, call, work , husband, hobby, workplace
	Male	company, work, working from home , progress, going to work , one, colleague, meeting employee , annoyance, travel, office , eating, most, dinner, happiness
50s	Male	work , problem, visit, apartment, occasion, employee, progress, management

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519 **Table 11. Topics Related to Spirituality among the Female Age Groups.**

Age Groups	Topics
50s	class, school, study, online, progress, church , student, situation
60s-70s	worship , preventative measure, church , last year, thought, vaccine, human, government

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525 **Table 12. Examples of Diaries Written by Females in Their 30s.**

Topics	Texts from the Diaries
Being a mother	Due to the coronavirus, the daycare centers are temporarily closed as social distancing measures have become stricter. I have to take care of my newborn baby and a three-year-old child alone.
	As a full-time stay-at-home mom, I had to help my daughter take an online class when she couldn't go to school in person, and I had to prepare three meals every day. One of the most painful things to do with the COVID-19 is to prepare a meal for your family.
Losing contact with friends who have their kids	She was a colleague I relied upon a lot, but I was very depressed to hear her having to quit the job. It was because she had difficulties raising her children due to coronavirus. I felt like I was left alone in the company.
	My best friend is a mom raising a 5-year-old child. After the outbreak of coronavirus, I can't go because I'm afraid that I might spread the virus to them. Even if only one of the parents is infected with the virus, the whole family will be quarantined, tested, and may become infected, so I can't visit them anymore.

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528 **Figure 1. Moderation Effect of Gender on the Relationship between Age and Loneliness.**

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530 The blue line indicates the regression line of women, and the grey line indicates the regression line of
 531 men. Colored areas around the lines represent 95% prediction intervals.

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533

534 **Figure 2. Average Loneliness Scores by the Age Groups and Gender.**

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536 The blue bars indicate loneliness scores of women by age groups, and the grey bars indicate
 537 loneliness scores of men by age groups. Error bars represent 95% confidence interval.

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