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Brief Report

Living Alone and Depressive Symptoms among Older Adults in the COVID-19 Pandemic: Role of Non–Face-to-Face Social Interactions



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A B S T R A C T

Keywords:

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Objective: This study examined the association of living alone with changes in depressive symptom status and the moderating effect of non–face-to-face social interactions among older adults during the coronavirus disease (COVID-19) pandemic.

Design: A longitudinal study.

Setting and Participants: This study recruited individuals aged ≥ 65 years without long-term care in one semi-urban city in Japan, who completed mailed questionnaires in March (baseline) and October 2020 (follow-up).

Methods: Based on depressive symptoms assessed by the Two-Question Screening at baseline and follow-up, participants were classified as “non-case,” “onset,” “remission,” and “persistence.” Non–face-to-face social interactions during the pandemic, including phone calls or emails with separated families or friends, were dichotomized as “less than weekly interactions” and “weekly interactions.” A multinomial logistic regression analysis was conducted to examine the association of living arrangement (living alone or together) with changes in depressive symptoms status.

Results: Data of 1001 participants were analyzed (mean age = 79.9 years). Of them, 13.8% lived alone. Overall, 40.6% participants were grouped as “non-case,” 11.7% as “onset,” 11.0% as “remission,” and 27.1% as “persistence.” Living alone was significantly associated with depressive symptom onset (odds ratio: 1.92; 95% CI: 1.03–3.56; $P = .039$), and a negative interaction (protective effect) was found between living alone and weekly non–face-to-face social interactions for depressive symptom onset.

Conclusion and Implications: During the pandemic, older adults living alone had a higher depressive symptom risk, but non–face-to-face social interactions may have buffered this risk. Our findings suggest the importance of supporting older adults living alone in times of social restrictions such as the pandemic, and furthermore, maintaining social connections, including non–face-to-face relationships, is necessary to protect their mental health.

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The authors declare no conflicts of interest.

This study was reviewed and approved by the ethics committees of the National Center for Geriatrics and Gerontology (No. 20TB4) and Seijoh University (No. 2020C0013). The mailed questionnaire was accompanied by an explanation of the

study purpose, and participants were informed that there were no consequences to withdrawing from the study at any point. Informed consent was obtained when participants agreed to complete the questionnaire and returned the completed survey. All procedures conformed to the principles of the Declaration of Helsinki.

All datasets have ethical or legal restrictions for public deposition because of the inclusion of sensitive information about the human participants.

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With global aging, the number of older adults living alone increases.¹ In Japan, 1 in 8 older men and 1 in 5 older women live alone.² Living alone as an older adult is associated with various adverse health outcomes,^{3,4} including mental health.⁵ Past studies suggest that older adults living alone tend to be lonely,⁶ experience functional loss,⁷ be socioeconomically disadvantaged,⁸ and lack adequate support.^{9,10} Although protecting the health of older adults living alone is an important public health issue, recent knowledge indicates that those living alone are not necessarily socially vulnerable.¹¹

Living alone does not in itself indicate a lack of family and other sources of social support. Even living alone, individuals with rich social networks have good well-being.¹¹ Several studies suggest that extensive social networks and support, even when living alone, reduce adverse health risks.^{4,12} Social ties are a fundamental component of human life and play an important role in health,^{13,14} potentially contributing to the moderation of the health risks of living alone.

The recent infectious disease pandemic, the novel coronavirus infection (COVID-19),¹⁵ has restricted people's social behaviors because of its high transmissibility, reducing social interactions and leading to isolation.^{16,17} For older adults living alone, without social resources within the family, the pandemic's restriction of social relations outside the family may be a mental health crisis. In the United Kingdom, adults living alone felt highly lonely during pandemic lockdowns.¹⁸ In Japan, those living alone experienced persistent psychological distress, despite Japan not implementing a lockdown measure.¹⁹

With the restrictions, the importance of non-face-to-face social interactions, including phone calls, emails, and video chats, has increased. Recent studies in non-pandemic periods have reported the positive health effects of non-face-to-face social interactions.^{20–22} In the pandemic, the moderating effects of non-face-to-face social interactions on mental health decline have also been suggested, but only in cross-sectional studies.^{23,24} Hence, empirical evidence is insufficient during the pandemic. Identifying the effects of social resources, including non-face-to-face social connections, may help to increase the mental health resilience of community-dwelling older adults living alone in the pandemic.

We examined the association of living alone with depressive symptoms and the moderating role of non-face-to-face social interactions among older adults during the COVID-19 pandemic.

Methods

Study Participants

This longitudinal study recruited older adults aged ≥ 65 years in Minokamo City, Gifu, in Japan, who were not eligible for public long-term care insurance (LTCI) benefits or those with "support need levels" in the public LTCI system. Japan has introduced universal health coverage for long-term care, and under this system, eligible people (those aged ≥ 65 years and those aged 40 to 64 years with age-related diseases) can receive long-term care services as insurance benefits-in-kind.²⁵ The system classifies those eligible for the benefits into 7 levels: "support need levels" 1 and 2, and "care need levels" 1 to 5 (higher numbers indicate increased care need).²⁵

Mailed questionnaire surveys were conducted in the target municipality before and after 2 emergency declaration states for the early waves of the COVID-19 pandemic; Japan's emergency declarations mainly called for refraining from nonessential outings, maintaining physical distance, and self-restraining restaurants at night.^{26,27} The baseline survey was conducted from March 3 to 16, 2020, just before the nationwide emergency declaration state for the first wave of the pandemic in Japan,²⁶ and the follow-up survey was conducted from October 16 to 30, 2020, after the emergency state had ended at the local prefecture level in the target area.²⁸

We randomly selected 2000 eligible older adults, 1350 of whom responded to the baseline survey (response rate: 67.5%). Among them, 1106 individuals completed the follow-up survey (follow-up rate: 81.9%). Those with missing information for age and/or sex ($n = 3$) and those with a change in their living arrangement between the 2 time points ($n = 102$) were excluded. Finally, 1001 participants were included.

This study was reviewed and approved by the ethics committees of the National Center for Geriatrics and Gerontology (No. 20TB4) and Seijoh University (No. 2020C0013). All procedures conformed to the principles of the Declaration of Helsinki.

Depressive Symptoms

At baseline and follow-up, depressive symptoms were assessed by the Two-Question Screen, and those with either and both depressive mood and apathy in the past month were defined as having depressive symptoms.^{29,30} This measurement has been validated: for major depression, sensitivity = 100% and specificity = 60.5%.³⁰

Based on the depressive symptom status at baseline and follow-up, participants were classified into 4 groups: "non-case" (without depressive symptoms in both the surveys), "onset" (without depressive symptoms at baseline, with depressive symptoms at follow-up), "remission" (with depressive symptoms at baseline, without depressive symptoms at follow-up), and "persistence" (with depressive symptoms in both the surveys).

Living Arrangement

Participants were asked about their living arrangement at baseline and follow-up and were classified as "living together" (ie, living with 1 or more people) or "living alone." Participants living alone continuously at the 2 time points were grouped as "living alone," and those living together continuously were grouped as "living together." Those with living arrangements that changed between the 2 time points were excluded from the analysis.

Non-Face-to-Face Social Interactions

In the follow-up survey, non-face-to-face social interactions during the pandemic were assessed by the following question, "How often did you communicate by phone or email with your separated family members or friends during the COVID-19 pandemic (April–August 2020)?" (6 potential responses, from "none" to "4 or more times per week"). Participants were divided into "less than weekly interactions" and "weekly interactions."²⁸

Statistical Analysis

We conducted a multivariable multinomial logistic regression analysis and obtained odds ratios (ORs) and 95% CIs for changes in depressive symptom status of living arrangements. Model 1 was analyzed without adjusting for covariates. Model 2 included age, gender, educational attainment, subjective economic status, comorbidities, basic and instrumental activities of daily living performance, subjective health status, subjective memory complaints, motor function, frequency of going out and meeting with friends at baseline as covariates (Supplementary Table 1). Model 3 added the variable of non-face-to-face social interactions into Model 2. Model 4 added a product term of living arrangement and non-face-to-face social interactions into Model 3.

For missing information, we applied the multiple imputation approach under the missing at random assumption, then pooled the results of 20 generated imputed datasets.³¹

The significance level was set at $P < .05$. R software for Windows (Version 4.0.3; R Foundation) was used for all the statistical analyses.

Results

Data of 1001 older adults were analyzed. Table 1 shows the descriptive statistics of the participants' characteristics. The participants' mean age was 79.9 (SD = 4.9) years, 534 (53.3%) were women, and 138 (13.8%) lived alone.

Table 2 shows the distribution of changes in depressive symptoms at baseline and follow-up. Of the participants, 40.6% were "non-case," 11.7% were "onset," 11.0% were "remission," and 27.1% were "persistence." Those living alone were more likely to be "onset" or "persistence" as compared with those living together. Those who had more non-face-to-face social interactions during the pandemic were less likely to be "non-case" or "onset" and more likely to be "remission."

Table 3 shows the association of living alone with changes in depressive symptom status (Supplementary Table 2 shows full results). Living alone was significantly associated with depressive symptom onset during the pandemic, after adjusting for covariates (Model 2: OR: 1.89; 95% CI: 1.02–3.49; $P = .044$). This association remained significant after adding non-face-to-face social interactions during the pandemic into the analytical model (Model 3: OR: 1.92; 95% CI: 1.03–3.56; $P = .039$). Furthermore, the product term of living arrangement and non-face-to-face social interactions was negatively associated with depressive symptom onset (Model 4: OR: 0.23; 95% CI: 0.06–0.84; $P = .026$). Meanwhile, living arrangement was not associated with changes in depressive symptoms status. In the stratified analysis by non-face-to-face social interactions (Supplementary Table 3), among those without weekly interactions, the association between living alone and depressive symptom onset was particularly strong, whereas among those with weekly interactions, the association disappeared.

Discussion

This study demonstrated that older adults living alone had a higher risk of depressive symptom onset during the COVID-19 pandemic. In addition, we found a moderating effect of non-face-to-face social interactions during the pandemic on the risk of depressive symptom onset for older adults living alone.

Previous studies have reported that individuals living alone experienced poorer mental health than those in other living arrangements during the pandemic.^{18,19} Research on the general adult population in Japan showed that, in the earliest phase of the pandemic, psychological distress increased regardless of living arrangements, but individuals who lived with others returned to low-stress levels, whereas those living alone continued to experience high-stress levels.¹⁹ When social activities and interactions are suddenly limited by external factors like a pandemic, the social resources of those living alone can become threatened. In situations in which in-person interaction and contact with others outside the family is limited, older adults living alone may easily socially isolate, preventing their mental health recovery during the pandemic. Because the health impact of the pandemic may vary depending on people's social background, including their living arrangements, particular attention should be paid to supporting older adults living alone.

This study indicated that the risk of depressive symptom onset of living alone was moderated by non-face-to-face social interactions during the pandemic. Recently, the health benefits of non-face-to-face social interactions as well as face-to-face interactions have received attention.^{25–28} This study adds empirical evidence about the moderating effects of non-face-to-face social interactions on mental decline in the COVID-19 pandemic. Extensive social networks may mitigate adverse health risks, including poor mental health.^{4,12} Not

Table 1
Characteristics of Study Participants

| | Overall n = 1001 | Living Arrangement | |
|--|---------------------|----------------------------|-------------------------|
| | | Living Together n = 863 | Living Alone n = 138 |
| Age, y, mean (SD) | 79.9 (4.9) | 79.7 (4.9) | 81.5 (5.0) |
| Gender, n (%) | | | |
| Male | 467 (46.7) | 433 (50.2) | 34 (24.6) |
| Female | 534 (53.3) | 430 (49.8) | 104 (75.4) |
| Educational attainment, y, n (%) | | | |
| Low | 663 (66.2) | 578 (67.0) | 85 (61.6) |
| High | 322 (32.2) | 273 (31.6) | 49 (35.5) |
| Missing | 16 (1.6) | 12 (1.4) | 4 (2.9) |
| Subjective economic status, n (%) | | | |
| Severe | 751 (75.0) | 651 (75.4) | 100 (72.5) |
| Normal or rich | 230 (23.0) | 194 (22.5) | 36 (26.1) |
| Missing | 20 (2.0) | 18 (2.1) | 2 (1.4) |
| Comorbidities, n (%) | | | |
| None | 77 (7.7) | 68 (7.9) | 9 (6.5) |
| One | 512 (51.1) | 435 (50.4) | 77 (55.8) |
| Two or more | 410 (41.0) | 358 (41.5) | 52 (37.7) |
| Missing | 2 (0.2) | 2 (0.2) | 0 (0.0) |
| Basic activities of daily living performance, n (%) | | | |
| No difficulty | 866 (86.5) | 751 (87.0) | 115 (83.3) |
| Difficulty | 95 (9.5) | 78 (9.0) | 17 (12.3) |
| Missing | 40 (4.0) | 34 (3.9) | 6 (4.3) |
| Instrumental activities of daily living performance, n (%) | | | |
| No difficulty | 851 (85.0) | 727 (84.2) | 124 (89.9) |
| Difficulty | 108 (10.8) | 100 (11.6) | 8 (5.8) |
| Missing | 42 (4.2) | 36 (4.2) | 6 (4.3) |
| Subjective health status, n (%) | | | |
| Good | 765 (76.4) | 656 (76.0) | 109 (79.0) |
| Poor | 188 (18.8) | 163 (18.9) | 25 (18.1) |
| Missing | 48 (4.8) | 44 (5.1) | 4 (2.9) |
| Subjective memory complaints, n (%) | | | |
| No | 447 (44.7) | 387 (44.8) | 60 (43.5) |
| Yes | 525 (52.4) | 454 (52.6) | 71 (51.4) |
| Missing | 29 (2.9) | 22 (2.5) | 7 (5.1) |
| Motor function, n (%) | | | |
| Not impaired | 825 (82.4) | 713 (82.6) | 112 (81.2) |
| Impaired | 124 (12.4) | 102 (11.8) | 22 (15.9) |
| Missing | 52 (5.2) | 48 (5.6) | 4 (2.9) |
| Depressive symptoms, n (%) | | | |
| Without depressive symptoms | 551 (55.0) | 479 (55.5) | 72 (52.2) |
| With depressive symptoms | 392 (39.2) | 334 (38.7) | 58 (42.0) |
| Missing | 58 (5.8) | 50 (5.8) | 8 (5.8) |
| Frequency of going out, n (%) | | | |
| ≥5 d/wk | 361 (36.1) | 322 (37.3) | 39 (28.3) |
| Two to 4 d/wk | 434 (43.4) | 372 (43.1) | 62 (44.9) |
| ≤1 d/wk | 191 (19.1) | 157 (18.2) | 34 (24.6) |
| Missing | 15 (1.5) | 12 (1.4) | 3 (2.2) |
| Frequency of meeting with friends, n (%) | | | |
| ≥ once/week | 362 (36.2) | 306 (35.5) | 56 (40.6) |
| Once/mo to once/wk | 306 (30.6) | 263 (30.5) | 43 (31.2) |
| < once/month | 259 (25.9) | 229 (26.5) | 30 (21.7) |
| Missing | 74 (7.4) | 65 (7.5) | 9 (6.5) |
| Non-face-to-face social interactions during the pandemic,* n (%) | | | |
| Less than weekly | 452 (45.2) | 406 (47.0) | 46 (33.3) |
| Weekly | 423 (42.3) | 343 (39.7) | 80 (58.0) |
| Missing | 126 (12.6) | 114 (13.2) | 12 (8.7) |

*Evaluated at the follow-up survey.

only face-to-face interactions but also non-face-to-face interactions may have some benefits in alleviating the tendency of older adults living alone to become socially isolated. For those living alone who may experience a sudden shortage of available social resources due to

Table 2
Descriptive Statistics of Living Arrangement, Non-Face-to-Face Social Interactions and Changes in Depressive Symptom Status

| | n | Changes in Depressive Symptom Status, n (%) | | | |
|--|----------|---|------------|------------|-------------|
| | | Non-case | Onset | Remission | Persistence |
| Overall | n = 1001 | 406 (40.6) | 117 (11.7) | 110 (11.0) | 271 (27.1) |
| Living arrangement | | | | | |
| Living together | n = 863 | 362 (89.2) | 94 (80.3) | 97 (88.2) | 228 (84.1) |
| Living alone | n = 138 | 44 (10.8) | 23 (19.7) | 13 (11.8) | 43 (15.9) |
| Non-face-to-face social interactions during the pandemic | | | | | |
| Less than weekly | n = 452 | 194 (52.6) | 63 (60.0) | 49 (48.5) | 123 (50.6) |
| Weekly | n = 423 | 175 (47.4) | 42 (40.0) | 52 (51.5) | 120 (49.4) |

Missing data: n = 97 for changes in depressive symptom status; n = 126 for non-face-to-face social interactions.

the pandemic, having non-face-to-face social connectedness, including via phone and email, may have an important protective effect against depressive symptoms.

Meanwhile, even in the unstable social situation of the pandemic, the absence of non-face-to-face connections, despite living alone, might represent severe social isolation from non-pandemic periods. Although we tried to address this in part by analysis-adjusting for social factors such as frequency of going out and meeting with friends at the baseline, residual confounding might be possible. In addition, non-face-to-face interactions may only be a proxy for the individual's social resources, including their families and friends. Therefore, it should be noted that non-face-to-face social contacts with formal support may not have the same effect. Nevertheless, we believe that it is important to also focus attention on non-face-to-face social connections when evaluating the social networks of older adults living alone.

This study was conducted based on data during a relatively early stage of the COVID-19 pandemic. The situations of pandemic and the policies vary across countries; rather than a lockdown measure, people in Japan were only requested to refrain from nonessential activities and maintain physical distancing without penalties.³² Although attention should be paid to regional transmission and policy differences, we emphasize the potential moderating effects of non-face-to-face social interactions on the mental health of older adults living alone.

This study is meaningful because it provides evidence on measures used to mitigate mental health decline in older adults living alone during the pandemic. However, there were several limitations. First,

the surveys were conducted relatively early in the COVID-19 pandemic, corresponding with the first and second waves of the pandemic in Japan. Because it is unclear whether this study's results are generalizable to the later period of the pandemic, further follow-up is required. Second, because the baseline survey coincided with the beginning of the COVID-19 pandemic in Japan,²⁷ the psychological effects may have already begun to occur. However, the baseline survey was conducted before the emergency declaration state for the first wave. Therefore, this effect may be small. Third, the self-reported assessment in this study may lead to measurement errors. Particularly, misclassification due to low specificity on the scale for assessing depressive symptoms may cause bias in the results. Fourth, non-face-to-face social interactions were assessed by recall in the follow-up survey, which may cause information bias. Fifth, because only non-face-to-face social interactions by phone or email were evaluated, the influence of interactions through other means, such as video chat or social networking services, is unknown. Finally, this study's methods were derived in a non-western culture, Japan, and the recruitment was conducted in 1 municipality in Japan. The generalizability of the results is limited.

Despite the limitations, these findings imply the importance for medical providers and other health care workers to assess individuals' social resources, including non-face-to-face social connections. Understanding older people's social resources, particularly for those living alone, is necessary for the practice of social prescribing,³³ which also may be useful for identifying high-risk individuals, especially in an unstable social situation such as a pandemic. Furthermore, it is suggested that fostering social resources, including non-face-to-face

Table 3
Association Between Living Arrangement and Changes in Depressive Symptom Status, Based on Multinomial Logistic Regression With Multiple Imputation Approach

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|-------------------|-------------------|-------------------|--------------------|
| | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| Onset (ref: non-case) | | | | |
| Living alone (ref: living together) | 2.01* (1.16–3.50) | 1.89* (1.02–3.49) | 1.92* (1.03–3.56) | 4.32† (1.71–10.90) |
| Weekly non-face-to-face social interactions during the pandemic (ref: less than weekly) | | | 0.84 (0.52–1.36) | 1.04 (0.62–1.76) |
| Living alone × weekly non-face-to-face social interactions during the pandemic | | | | 0.23* (0.06–0.84) |
| Remission (ref: non-case) | | | | |
| Living alone (ref: living together) | 1.10 (0.57–2.13) | 1.01 (0.49–2.06) | 0.96 (0.47–1.99) | 2.31 (0.76–6.98) |
| Weekly non-face-to-face social interactions during the pandemic (ref: less than weekly) | | | 1.44 (0.88–2.36) | 1.68 (1.00–2.83) |
| Living alone × weekly non-face-to-face social interactions during the pandemic | | | | 0.24 (0.06–1.06) |
| Persistence (ref: non-case) | | | | |
| Living alone (ref: living together) | 1.55 (0.99–2.44) | 1.43 (0.84–2.44) | 1.39 (0.81–2.37) | 2.34 (0.93–5.88) |
| Weekly non-face-to-face social interactions during the pandemic (ref: less than weekly) | | | 1.39 (0.94–2.08) | 1.51 (0.99–2.31) |
| Living alone × weekly non-face-to-face social interactions during the pandemic | | | | 0.46 (0.15–1.44) |

Model 1: Crude model; Model 2: added age, gender, educational attainment, subjective economic status, comorbidities, basic activities of daily living performance, instrumental activities of daily living performance, subjective health status, subjective memory complaints, motor function, frequency of going out, and frequency of meeting with friends to Model 1; Model 3: added non-face-to-face social interactions during the pandemic to Model 2; Model 4: added the product term of living arrangement (code: living together = 0, living alone = 1) and non-face-to-face social interactions during the pandemic (code: less than weekly = 0, weekly = 1) to Model 3.

* $P < .05$.

† $P < .01$.

social connections, is meaningful for supporting community-dwelling older adults living alone.

Conclusions and Implications

This study found a high risk of depressive symptom onset among older adults living alone during the COVID-19 pandemic. Further, it showed that non-face-to-face social interactions during the pandemic may have reduced the risk for older adults living alone. Our findings suggest the importance of maintaining social connectedness for the mental health of older adults living alone, even when social behavior is restricted. To support community-dwelling older adults, evaluating and fostering their social resources may contribute to their mental health resilience during the pandemic.

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Supplementary Table 1

The Covariates Used in This Study and Their Definitions

| Variables | Definition |
|-----------------------------------|---|
| Age, y | Continuous quantity |
| Gender | Male or female |
| Educational attainment, y | Educational attainment was dichotomized as “low” (<10 y) and “high” (≥10). |
| Subjective economic status | Subjective economic status was dichotomized from 5 possible responses as “severe” (“very severe” or “slightly severe”) and “normal or rich” (“normal,” “slightly rich,” or “very rich”). |
| Comorbidities | Participants selected those illnesses for which they received treatment from a list of 16 illnesses. The number of selected illnesses was then summed, and participants were classified as having “none,” “1,” and “2 or more.” |
| BADL performance | BADL performance was assessed using the question, “Do you need someone’s care or assistance in your daily life?” and dichotomized as “not difficulty” (“no need for care or assistance”) and “difficulty” (“need some care or assistance but do not currently receive any” or “currently receive some care”). |
| IADL performance | IADL performance was assessed using a 5-item subscale based on a previous study* and categorized participants who had difficulty with at least 1 item as “difficulty” and the others as “not difficulty.” |
| Subjective health status | Subjective health status was assessed by the question, “How is your current health status,” and dichotomized as “poor” and “good.” |
| Subjective memory complaints | Subjective memory complaints were assessed by the following question, “Do you feel you are forgetful?” and participants were classified according to their responses of “yes” and “no.” |
| Motor function | Motor function was assessed using a 5-point subscale based on a previous study [†] and classified as “not impaired” (<3 points) and “impaired” (≥3). |
| Frequency of going out | The frequency of going out was categorized as “≥5 d/wk,” “2 to 4 d/wk,” and “≤1 d/wk.” |
| Frequency of meeting with friends | The frequency of meeting with friends was categorized as “≥ once/wk,” “once/mo to once/wk,” and “< once/mo.” |

BADL, basic activities of daily living; IADL, instrumental activities of daily living.

*Koyano W, Shibata H, Nakazato K, et al. Measurement of competence: Reliability and validity of the TMIG index of competence. *Arch Gerontol Geriatr.* 1991; 13(2):103–116.

[†]Satake S, Kinoshita K, Matsui Y, Arai H. Physical domain of the Kihon Checklist: a possible surrogate for physical function tests. *Geriatr Gerontol Int.* 2020; 20(6):644–646.

Supplementary Table 2

Association Between Living Arrangement and Changes in Depressive Symptoms, Based on Multinomial Logistic Regression With Multiple Imputation Approach (Full Results Shown)

| | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
|--|------------------|---------|------------------|---------|------------------|---------|-------------------|---------|
| | OR (95% CI) | P Value | OR (95% CI) | P Value | OR (95% CI) | P Value | OR (95% CI) | P Value |
| Onset (ref: non-case) | | | | | | | | |
| Living arrangement (ref: living together) | | | | | | | | |
| Living alone | 2.01 (1.16–3.50) | .013 | 1.89 (1.02–3.49) | .044 | 1.92 (1.03–3.56) | .039 | 4.32 (1.71–10.90) | .002 |
| Non–face-to-face social interactions during the pandemic (ref: less than weekly) | | | | | | | | |
| Weekly | | | | | 0.84 (0.52–1.36) | 0.474 | 1.04 (0.62–1.76) | .878 |
| Age, y | | | 0.99 (0.95–1.04) | .762 | 0.99 (0.95–1.04) | .766 | 1.00 (0.95–1.05) | .858 |
| Gender (ref: male) | | | | | | | | |
| Female | | | 1.13 (0.70–1.81) | .619 | 1.16 (0.72–1.87) | .550 | 1.15 (0.71–1.86) | .574 |
| Educational attainment, y (ref: high) | | | | | | | | |
| Low | | | 1.13 (0.71–1.82) | .603 | 1.12 (0.70–1.80) | .630 | 1.11 (0.69–1.79) | .663 |
| Subjective economic status (ref: normal or rich) | | | | | | | | |
| Severe | | | 1.56 (0.92–2.64) | .100 | 1.56 (0.92–2.64) | .101 | 1.55 (0.91–2.63) | .106 |
| Comorbidities (ref: none) | | | | | | | | |
| 1 | | | 0.56 (0.26–1.25) | .158 | 0.56 (0.25–1.23) | .148 | 0.53 (0.24–1.18) | .119 |
| ≥2 | | | 0.58 (0.25–1.31) | .188 | 0.57 (0.25–1.29) | .174 | 0.55 (0.24–1.26) | .160 |
| BADL performance (ref: not difficulty) | | | | | | | | |
| Difficulty | | | 1.87 (0.77–4.57) | .168 | 1.87 (0.77–4.56) | .170 | 1.88 (0.77–4.61) | .166 |
| IADL performance (ref: not difficulty) | | | | | | | | |
| Difficulty | | | 1.56 (0.72–3.39) | .262 | 1.55 (0.71–3.37) | .270 | 1.54 (0.71–3.37) | .277 |
| Subjective health status (ref: good) | | | | | | | | |
| Poor | | | 3.58 (1.83–6.98) | < .001 | 3.53 (1.80–6.89) | < .001 | 3.55 (1.81–6.95) | < .001 |
| Subjective memory complaints (ref: no) | | | | | | | | |
| Yes | | | 1.68 (1.06–2.68) | .028 | 1.67 (1.05–2.65) | .032 | 1.66 (1.04–2.64) | .034 |
| Motor function (ref: not impaired) | | | | | | | | |
| Impaired | | | 0.56 (0.23–1.38) | .208 | 0.56 (0.23–1.39) | .212 | 0.56 (0.23–1.38) | .209 |
| Frequency of going out (ref: ≥5 d/wk) | | | | | | | | |
| 2 to 4 d/wk | | | 0.83 (0.49–1.41) | .498 | 0.83 (0.49–1.41) | .497 | 0.85 (0.50–1.44) | .536 |
| ≤1 d/wk | | | 1.05 (0.60–1.84) | .862 | 1.02 (0.58–1.80) | .945 | 1.01 (0.57–1.80) | .960 |
| Frequency of meeting with friends (ref: ≥ once/wk) | | | | | | | | |
| Once/mo to once /wk | | | 0.77 (0.47–1.27) | .302 | 0.76 (0.46–1.25) | .279 | 0.75 (0.46–1.25) | .271 |
| < once/mo | | | 1.45 (0.76–2.78) | .257 | 1.44 (0.75–2.75) | .271 | 1.48 (0.77–2.84) | .239 |
| Living arrangement × non–face-to-face social interactions during the pandemic | | | | | | | 0.23 (0.06–0.84) | .026 |
| Remission (ref: non-case) | | | | | | | | |
| Living arrangement (ref: living together) | | | | | | | | |
| Living alone | 1.10 (0.57–2.13) | .771 | 1.01 (0.49–2.06) | .988 | 0.96 (0.47–1.99) | .919 | 2.31 (0.76–6.98) | .140 |
| Non–face-to-face social interactions during the pandemic (ref: less than weekly) | | | | | | | | |
| Weekly | | | | | 1.44 (0.88–2.36) | .144 | 1.68 (1.00–2.83) | .052 |
| Age, y | | | 1.02 (0.97–1.07) | .481 | 1.02 (0.97–1.07) | .446 | 1.02 (0.97–1.07) | .399 |
| Gender (ref: male) | | | | | | | | |
| Female | | | 1.31 (0.80–2.13) | .280 | 1.24 (0.76–2.02) | .399 | 1.23 (0.75–2.02) | .403 |
| Educational attainment, y (ref: high) | | | | | | | | |
| Low | | | 1.02 (0.63–1.66) | .938 | 1.04 (0.64–1.69) | .882 | 1.03 (0.63–1.68) | .916 |
| Subjective economic status (ref: normal or rich) | | | | | | | | |
| Severe | | | 1.07 (0.59–1.91) | .828 | 1.09 (0.61–1.95) | .778 | 1.08 (0.60–1.94) | .798 |
| Comorbidities (ref: none) | | | | | | | | |
| 1 | | | 1.14 (0.40–3.21) | .805 | 1.16 (0.41–3.26) | .784 | 1.12 (0.39–3.16) | .837 |
| ≥2 | | | 1.48 (0.52–4.20) | .466 | 1.50 (0.52–4.27) | .452 | 1.46 (0.51–4.19) | .477 |
| BADL performance (ref: not difficulty) | | | | | | | | |
| Difficulty | | | 1.32 (0.53–3.30) | .548 | 1.33 (0.53–3.33) | .537 | 1.35 (0.54–3.38) | .519 |
| IADL performance (ref: not difficulty) | | | | | | | | |
| Difficulty | | | 1.20 (0.53–2.75) | .658 | 1.20 (0.53–2.74) | .663 | 1.20 (0.52–2.75) | .672 |
| Subjective health status (ref: good) | | | | | | | | |
| Poor | | | 3.88 (2.01–7.48) | < .001 | 4.12 (2.12–8.00) | < .001 | 4.16 (2.14–8.10) | < .001 |
| Subjective memory complaints (ref: no) | | | | | | | | |
| Yes | | | 2.76 (1.72–4.44) | < .001 | 2.81 (1.75–4.52) | < .001 | 2.80 (1.74–4.51) | < .001 |
| Motor function (ref: not impaired) | | | | | | | | |
| Impaired | | | 1.10 (0.49–2.47) | .823 | 1.10 (0.49–2.48) | .822 | 1.08 (0.48–2.44) | .848 |
| Frequency of going out (ref: ≥5 d/wk) | | | | | | | | |
| 2 to 4 d/wk | | | 1.08 (0.63–1.85) | .789 | 1.10 (0.64–1.90) | .724 | 1.12 (0.65–1.93) | .689 |
| ≤1 d/wk | | | 1.18 (0.65–2.12) | .584 | 1.26 (0.70–2.30) | .442 | 1.27 (0.70–2.30) | .440 |
| Frequency of meeting with friends (ref: ≥ once/wk) | | | | | | | | |
| Once/mo to once /wk | | | 0.68 (0.41–1.14) | .148 | 0.68 (0.41–1.14) | .145 | 0.68 (0.40–1.13) | .137 |
| < once/mo | | | 1.07 (0.55–2.11) | .836 | 1.07 (0.54–2.10) | .852 | 1.09 (0.55–2.14) | .811 |

(continued on next page)

Supplementary Table 2 (continued)

| | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
|---|------------------|---------|------------------|---------|------------------|---------|------------------|---------|
| | OR (95% CI) | P Value | OR (95% CI) | P Value | OR (95% CI) | P Value | OR (95% CI) | P Value |
| Living arrangement × non–face-to-face social interactions during the pandemic Persistence (ref: non-case) | | | | | | | 0.24 (0.06–1.06) | .059 |
| Living arrangement (ref: living together) | | | | | | | | |
| Living alone | 1.55 (0.99–2.44) | .057 | 1.43 (0.84–2.44) | .187 | 1.39 (0.81–2.37) | .229 | 2.34 (0.93–5.88) | .072 |
| Non–face-to-face social interactions during the pandemic (ref: less than weekly) | | | | | | | | |
| Weekly | | | | | 1.39 (0.94–2.08) | .102 | 1.51 (0.99–2.31) | .057 |
| Age, y | | | 0.96 (0.92–1.00) | .034 | 0.96 (0.92–1.00) | .036 | 0.96 (0.92–1.00) | .041 |
| Gender (ref: male) | | | | | | | | |
| Female | | | 2.13 (1.43–3.15) | < .001 | 2.02 (1.35–3.01) | < .001 | 2.01 (1.35–3.01) | .001 |
| Educational attainment, y (ref: high) | | | | | | | | |
| Low | | | 0.84 (0.56–1.24) | .377 | 0.85 (0.57–1.26) | .424 | 0.84 (0.57–1.26) | .405 |
| Subjective economic status (ref: normal or rich) | | | | | | | | |
| Severe | | | 2.15 (1.40–3.28) | < .001 | 2.18 (1.43–3.35) | .000 | 2.17 (1.41–3.33) | < .001 |
| Comorbidities (ref: none) | | | | | | | | |
| 1 | | | 0.69 (0.33–1.42) | .310 | 0.69 (0.34–1.44) | .328 | 0.68 (0.33–1.41) | .296 |
| ≥2 | | | 1.05 (0.51–2.19) | .889 | 1.06 (0.51–2.22) | .872 | 1.05 (0.50–2.19) | .896 |
| BADL performance (ref: not difficulty) | | | | | | | | |
| Difficulty | | | 1.93 (0.93–4.00) | .077 | 1.94 (0.93–4.02) | .076 | 1.95 (0.94–4.05) | .073 |
| IADL performance (ref: not difficulty) | | | | | | | | |
| Difficulty | | | 1.91 (1.01–3.61) | .048 | 1.92 (1.01–3.64) | .045 | 1.94 (1.02–3.68) | .044 |
| Subjective health status (ref: good) | | | | | | | | |
| Poor | | | 4.66 (2.71–8.02) | < .001 | 4.91 (2.84–8.49) | < .001 | 4.94 (2.86–8.56) | < .001 |
| Subjective memory complaints (ref: no) | | | | | | | | |
| Yes | | | 2.98 (2.05–4.35) | < .001 | 3.03 (2.08–4.43) | < .001 | 3.02 (2.07–4.41) | < .001 |
| Motor function (ref: not impaired) | | | | | | | | |
| Impaired | | | 1.42 (0.74–2.72) | .288 | 1.42 (0.74–2.73) | .289 | 1.40 (0.73–2.69) | .308 |
| Frequency of going out (ref: ≥5 d/wk) | | | | | | | | |
| 2 to 4 d/wk | | | 0.95 (0.62–1.45) | .795 | 0.95 (0.62–1.46) | .831 | 0.96 (0.62–1.47) | .837 |
| ≤1 d/wk | | | 1.09 (0.68–1.74) | .724 | 1.15 (0.72–1.85) | .561 | 1.15 (0.71–1.84) | .575 |
| Frequency of meeting with friends (ref: ≥ once/wk) | | | | | | | | |
| Once/mo to once /wk | | | 1.06 (0.70–1.60) | .779 | 1.07 (0.71–1.62) | .732 | 1.07 (0.71–1.62) | .738 |
| < once/mo | | | 1.62 (0.94–2.81) | .085 | 1.64 (0.94–2.84) | .080 | 1.66 (0.96–2.89) | .071 |
| Living arrangement × non–face-to-face social interactions during the pandemic | | | | | | | 0.46 (0.15–1.44) | .181 |

BADL, basic activities of daily living; IADL, instrumental activities of daily living.

Model 1: crude model; Model 2: added age, gender, educational attainment, subjective economic status, comorbidities, basic activities of daily living performance, instrumental activities of daily living performance, subjective health status, subjective memory complaints, motor function, frequency of going out, and frequency of meeting with friends to Model 1; Model 3: added non–face-to-face social interactions during the pandemic to Model 2; Model 4: added the product term of living arrangement (code: living together = 0, living alone = 1) and non–face-to-face social interactions during the pandemic (code: less than weekly = 0, weekly = 1) to Model 3.

Supplementary Table 3

Stratified Analysis by Non-Face-to-Face Social Interactions During the COVID-19 Pandemic, Association Between Living Arrangement and Changes in Depressive Symptoms, Based on Multinomial Logistic Regression With Multiple Imputation Approach

| | Non-face-to-face social interactions during the COVID-19 pandemic | |
|--|---|-------------------------------------|
| | Less than weekly | Weekly |
| | Living alone (ref: living together) | Living alone (ref: living together) |
| | OR (95% CI) | OR (95% CI) |
| Changes in depressive symptom status (ref: non-case) | | |
| Onset | 4.70* (1.82–12.14) | 1.00 (0.38–2.66) |
| Remission | 2.36 (0.77–7.25) | 0.56 (0.20–1.53) |
| Persistence | 2.55 (1.00–6.47) | 0.92 (0.45–1.88) |

Adjusted by age, gender, educational attainment, subjective economic status, comorbidities, basic activities of daily living performance, instrumental activities of daily living performance, subjective health status, subjective memory complaints, motor function, frequency of going out, and frequency of meeting with friends.

* $P < .01$.