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Are non-face-to-face interactions an effective strategy for maintaining mental and physical health?

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ABSTRACT

Background: The coronavirus disease 2019 (COVID-19) pandemic has led to social isolation measures, forcing many people to stay indoors, stop daily outdoor activities, and limit face-to-face social interactions with friends, colleagues, and family. This study aimed to identify if non-face-to-face interaction affects depressive symptoms and frailty in older adults.

Methods: We included 3834 older adults (age: 71.1 ± 6.9 [mean ± standard deviation] years; range: 60–96 years; 2153 women) from the National Center for Geriatrics and Gerontology–Study of Geriatric Syndromes. Interaction status was assessed using a self-reported questionnaire. Participants were categorized into: "both interactions" (both face-to-face and non-face-to-face interactions), "face-to-face only" (only face-to-face interactions), "non-face-to-face only" (only non-face-to-face interactions), "no interactions" (neither face-to-face nor non-face-to-face interactions) groups. Depressive symptoms and frailty were measured using the 15-item Geriatric Depression Scale and Kihon Checklist, respectively.

Results: Potential confounding factors-adjusted odds ratios for both, face-to-face only and non-face-to-face only groups for developing depressive symptoms were 0.39 (95%CI, 0.26–0.57; p<0.001), 0.56 (95%CI, 0.38–0.84; p=0.004), and 0.51 (95%CI, 0.27–0.96; p=0.038), respectively, and those for development of frailty were 0.44 (95%CI, 0.30–0.65; p<0.001), 0.59 (95%CI, 0.39–0.87; p=0.008), and 0.63 (95%CI, 0.34–1.15; p=0.128), respectively.

Conclusions: Our findings indicate that non-face-to-face interactions are also important in preventing the deterioration of mental health, which is a concern during the COVID-19 pandemic. However, non-face-to-face interactions alone may not be sufficient to maintain physical health, and it is important to maintain opportunities for face-to-face interaction among older adults, particularly during the COVID-19 pandemic.

COVID-19, the coronavirus disease 2019; LTCI, long-term care insurance; NCGG–SGS, National Center for Geriatrics and Gerontology–Study of Geriatric Syndromes; SD, standard deviation; ADLs, activities of daily living; BMI, body mass index, ORs, hazard ratios; CIs, confidence intervals

1. Introduction

The coronavirus disease 2019 (COVID-19) pandemic has had a major impact on all aspects of society, including mental and physical health (Holmes et al., 2020). Indeed, the COVID-19 pandemic has led to social isolation measures, forcing many people to stay indoors, stopping daily outdoor activities, and limiting social interactions with friends, colleagues, and family (Ceolin et al., 2021). Notably, a study of the general population in China within two weeks of a COVID-19 outbreak showed that individuals were indoors for 20–24 hours per day due to lifestyle changes (Wang et al., 2020). A recent study of older adults found that increased social isolation was predictive of more severe depression and anxiety symptoms (Santini et al., 2020). Additionally, recent reports suggest the COVID-19 pandemic may be causing many older adults to be less physically active (Jakobsson et al., 2020; Jimenez-Pavon et al., 2020). Therefore, there is an urgent need to investigate mental and

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physical health during the COVID-19 pandemic. Surveys of the general population revealed that there are widespread concerns regarding the effect of social isolation and distancing on wellbeing and the practical implications of the pandemic, including financial difficulties. Additionally, that there is an increase in anxiety, depression, stress, and other negative feelings (Bedard-Thomas and Christian, 2020; MORI, 2020; National Academies of Sciences and Medicine, 2020). Another study found that driving, which also serves as a means of social interaction among the older adults, is significantly associated with well-being, loneliness, and internet use (Mohaqeqi Kamal et al., 2021). Identifying coping strategies and preventive interventions that support vulnerable groups, such as older adults, in the context of the COVID-19 pandemic is needed to help us respond to future waves of infectious diseases and pandemics (Holmes et al., 2020).

Depression is a significant psychiatric illness affecting more than 264 million people around the world. A longitudinal study of older adults showed that social disconnection could be a risk factor for depression (Santini et al., 2020). Indeed, since the COVID-19 pandemic, studies conducted in various countries have strongly indicated a dramatic increase in the prevalence of depressive psychopathology and suicidal tendencies, resulting in a mental health crisis (Ceolin et al., 2021). A systematic review of mental illness during the COVID-19 pandemic showed that the prevalence of depressive symptoms ranged from 14.6 to 48.3% in all populations; however, in each study, the incidence of depressive symptoms varied due to different methods of investigation and diagnosis (Xiong et al., 2020). It is important to note that presence of depressive symptoms does not imply a clinical diagnosis of depression. In the United States, the prevalence of depression-related symptoms increased more than threefold during the COVID-19 pandemic compared to that in the pre-outbreak (Ettman et al., 2020). In London, after lockdown, the prevalence of depression was 12.8% among those aged ≥50 years (Robb et al., 2020). The prevalence of depressive symptoms among community-dwelling older adults, according to a study that examined depressive symptoms among older Japanese adults, before and during the COVID-19 pandemic, was 25.8% and 32.3, respectively (Aihara and Kiyoshi, 2021).

A study conducted before and during the first wave of COVID-19 outbreaks in Japan (January to April 2020) showed that the duration of physical activity in older adults decreased by approximately 30% after the first wave (Yamada et al., 2020a). Similarly, the number of steps taken by older Japanese adults decreased by up to 30% after the initial spread of COVID-19 (Tison et al., 2020). Physical inactivity and sedentary behavior are of great concern because they are risk factors (Warburton and Bredin, 2017) for cardiovascular disease, obesity, cancer, diabetes, hypertension, bone and joint diseases, depression, and premature death (Wedig et al., 2021). Interestingly, a study found that although the daily physical activity time was more difficult to recover when living alone and being socially inactive, it recovered after the spread of COVID-19 (in June 2020) up to pre-pandemic levels (in January 2020) (Yamada et al., 2020b). Furthermore, it has been suggested that older adults who live alone and are not socially active are more likely to experience incidental frailty/disability due to decreased physical activity during the COVID-19 pandemic. A study, which examined whether the number of older Japanese adults with frailty increased during the COVID-19 pandemic, found that the prevalence of frailty was 7.9% at baseline and 11.8% at follow-up, suggesting an increase in frailty (Shinohara et al., 2021). These previous studies suggest that reduced social interaction because of fewer opportunities to go out due to the spread of COVID-19 may increase the number of older adults with frailty. While it is not completely understood, health-related declines associated with social isolation and loneliness may be a consequence of dysregulated health behaviors such as social connectedness and physical activity (Courtin and Knapp, 2017; Shankar et al., 2011).

Accumulating studies have shown that participation in social activities is associated with a reduced risk of developing disability, dementia, and depression in the future, thereby maintaining the health of older adults (Fratiglioni et al., 2004; Hikichi et al., 2015; Makizako et al., 2015; Merema, 2014). The COVID-19 crisis has exacerbated these challenges by increasing social isolation and loneliness among older adults who live alone or do not participate in social activities because of their physical frailty. The pandemic has also caused a decline in the well-being of older adults who used to have active and healthy social lives (Cudjoe and Kotwal, 2020). Therefore, the importance of non-face-to-face interactions, such as communication by phone or video call, have been emphasized when face-to-face interaction is no longer possible (Cudjoe and Kotwal, 2020), particularly during the spread of COVID-19, and non-face-to-face interaction with friends and acquaintances may prevent depressive symptoms and frailty in older adults. However, no evidence has indicated whether non-face-to-face interaction affects depressive symptoms and frailty. Therefore, this study aimed to clarify whether non-face-to-face interaction is associated with depressive symptoms and frailty. We hypothesized that older adults who engage in impersonal interactions would have a lower risk of the development of depressive symptoms and frailty than those who engage in neither face-to-face nor non-face-to-face interactions.

2. Methods

2.1. Study design

This thirty-month prospective cohort study recruited adults who were enrolled in a population-based cohort study in Japan—the National Center for Geriatrics and Gerontology–Study of Geriatric Syndromes (NCGG–SGS). The NCGG–SGS' primary goal is to establish a screening system for geriatric syndromes and validate evidence-based interventions to prevent them (Shimada et al., 2016).

2.2. Participants

The original plan of our study was to target the Japanese older population, aged ≥65 years. Takahama City, a residential suburb in Nagoya, Japan, provided full cooperation for this study but requested us to include people aged ≥60 years; therefore, this study included participants who resided in Takahama City and were aged ≥60 years at the time of the study (September 2015 to February 2017). Takahama City provided us with the address information of residents aged ≥60 years. We sent invitation letters to 9716 participants who were aged 60 years or older, lived in Takahama City, were not hospitalized, were not in residential care, were not certified by the long-term care insurance (LTCI) system as having functional disability, or were not participating in another study. All participants provided written informed consent at the study site before participating in the study. The study protocol was approved by the Ethics Committee of the National Center for Geriatrics and Gerontology (No. 1440–3). A total of 4167 community-dwelling older adults participated in the baseline survey, which included face-to-face interviews and physical and cognitive function evaluations. We excluded the following participants from the statistical analysis: (1) those with health problems (dementia, Parkinson's disease, and stroke) (n=263) based on information obtained by a qualified nurse who interviewed the participants face-to-face, (2) those who needed support or care—as certified by the Japanese public LTCI system—due to disability (n=58), and (3) those with disabilities affecting basic activities of daily living (n=6); in addition, responses with missing variables of (4) exclusion criteria (n=2) or (5) interaction status (n=4) were also excluded. Of the initial 4167 participants, 333 were excluded based on the criteria mentioned above. A follow-up mail survey of the remaining 3834 participants who completed the baseline survey was conducted for an average of 30 months after the baseline survey to assess depressive symptoms and frailty (July 2018 through September 2018). Of those, 1320 did not return a completed questionnaire, and the analysis was performed based on the data provided by the remaining 2514 respondents (65.6% follow-up response rate) (mean age: 70.9 ± 6.6 years;

55.0% females).

2.3. Measurements of face-to-face and non-face-to-face interactions

Interaction status was assessed using a self-reported questionnaire consisting of 2 sections (face-to-face and non-face-to-face) and 4 items. Questionnaire items were adapted from the NCGG–SGS (Bae et al., 2020; Katayama et al., 2021). The face-to-face interaction items included (1) “Do you go eating out or tea party with friends” and (2) “Do you go shopping with friends.” Interaction frequency was assessed by participants as never, once a month or less, several times a month, 1–2 times per week, 3–6 times per week, and every day. In this study, individuals who answered “never” to both questions were classified as having no face-to-face interaction, while those who answered other than "never" to either question were classified as having face-to-face interaction. The non-face-to-face interaction items included (3) “How many days in a week do you call or email your friends” and (4) “How many days in a week do you call or email acquaintances (including neighbors and business associates)” irrespective of the application they used, because only a few older adults used applications such as Skype, FaceTime, and WhatsApp. Interaction frequency was assessed by participants as 0–1 day, 2–3 days, 4–5 days, and 6–7 days. Individuals who answered “0–1 day” to both questions were classified as having no non-face-to-face interaction, while those who answered other than “0–1 day” to either question were classified as having non-face-to-face interaction. Then, based on the responses for face-to-face and non-face-to-face interactions, we categorized participants into the following four groups: “both interactions” (both face-to-face and non-face-to-face interactions), “face-to-face only” (only face-to-face interactions), “non-face-to-face only” (only non-face-to-face interactions), and “no interactions” (neither face-to-face nor non-face-to-face interactions).

2.4. Measurement of depressive symptoms and frailty

Depressive symptoms were measured using the 15-item Geriatric Depression Scale (GDS) (Yesavage, 1988). The GDS focuses on functional and mood symptoms of depression rather than on potentially misleading somatic features, and therefore, contains fewer somatic items. The 15-item GDS is the shortened, less time-consuming version of the 30-item GDS which was specifically designed to screen for depression in the older adults. Participants were required to respond with “yes” or “no” to each question on the questionnaire. Those who scored $\geq$6 on the GDS were defined as having depressive symptoms (Tsutsumimoto et al., 2016; Yesavage, 1988).

Frailty was measured using the Kihon Checklist (KCL) (Arai and Satake, 2015; Sewo Sampaio et al., 2014). The KCL is a simple yes/no questionnaire that assesses multiple aspects of function in daily living, such as instrumental activities of daily living (ADL), social ADL, physical activities and falls, nutrition state, oral functions, outdoor activities, cognitive function, and depressive mood (Sewo Sampaio et al., 2016). In the KCL, difficulty with any of the questions is counted as one point, and a higher score in each area of the checklist indicates a higher risk of needing help and care in that area. A cutoff point of 5/6 for the subtotal score of 20 items, excluding depressive mood from the KCL components, has been demonstrated to be effective in identifying frailty, as defined by the cardiovascular health study criteria (Ogawa et al., 2011). Since the purpose of this study was to use the KCL as an indicator of physical health, a subtotal score of 0-5 on the KCL excluding mood was defined as "robust" and a score of 6 or more as "frailty" (Kera et al., 2017; Tsubota-Utsugi et al., 2018).

2.5. Potential confounding factors

Potential confounders of depressive symptoms and frailty include demographic variables, chronic diseases, and lifestyle factors associated with depressive symptoms and frailty in older adults (Antiporta et al., 2021; Hoogendijk et al., 2019; Makizako et al., 2015; Shimada et al., 2015; Tsutsumimoto et al., 2018; Tsutsumimoto et al., 2016). Our model included the following covariates: age at enrollment, sex, years of education, presence of chronic diseases, number of medication use, body mass index (BMI), walking speed, history of alcohol, history of smoking, Mini-Mental State Examination (MMSE) score (Folstein et al., 1975), frequency of going out, living alone, and paid work. The presence of the following self-reported chronic diseases was also included among the covariates: heart disease, hypertension, and diabetes. Frequency of going out was assessed by a response of "yes" to the question "Go out at least once a week?" (Arai and Satake, 2015). Walking speed was measured in seconds with a stopwatch. Participants walked on a flat and straight surface at a comfortable speed, and markers were used to indicate both the start and end of a 2.4 m walking path. A 2 m section was marked at the start and end of the path. Participants traversed this section before passing the start marker so that they were walking at a comfortable pace when they reached the timed path. To ensure a consistent walking pace on the timed path, participants were asked to continue walking for an additional 2 m past the end of the timed path.

2.6. Statistical analysis

Participants were classified as having or having no depressive symptoms or frailty according to their baseline status. Student t-test and Pearson’s chi-square tests were used to compare baseline characteristics among groups based on baseline depressive symptoms or frailty. Adjusted standardized residuals $>$1.96 indicate $p<0.05$. Development of depressive symptoms or frailty was evaluated for each group at the thirty-month follow-up survey. The associations between baseline interaction status (both interactions, face-to-face only, non-face-to-face only, and no interaction) and the development of depressive symptoms or frailty at the thirty months follow-up survey were examined using crude and adjusted binomial logistic regression analyses, and odds ratios (ORs) with 95% confidence intervals (CIs) for depressive symptoms or frailty were calculated. The adjusted models were adjusted for covariates known to be associated with depressive symptoms or frailty in previous studies (Hoogendijk et al., 2019; Makizako et al., 2015; Shimada et al., 2015; Tsutsumimoto et al., 2018; Tsutsumimoto et al., 2016). Model 1 was a crude model, and Model 2 was adjusted for age at enrollment, sex, years of education, presence of chronic diseases, number of medication use, BMI, walking speed, history of alcohol, history of smoking, MMSE score, frequency of going out, living alone, and paid work. Depressive symptoms were added to model 2 for frailty. The significance level was set at $p<0.05$. All analyses were performed using IBM SPSS (version 25.0; IBM Japan, Tokyo).

3. Results

The baseline analysis included data from 3834 older adults (age: 71.1 $\pm$ 6.9 [mean $\pm$ standard deviation] years; range: 60–96 years; 2153 women). There were 1905 participants with both face-to-face and non-face-to-face interactions, 1200 with only face-to-face interactions, 219 with only non-face-to-face interactions, and 510 with neither face-to-face nor non-face-to-face interactions. Among the 3834 participants, 578 (15.1%) participants had depressive symptoms at baseline. Five participants were excluded because they had missing values in the GDS score. In addition, 880 (23.0%) participants had frailty at baseline. Table 1 shows baseline characteristics of the study participants with or without depressive symptoms or frailty. Participants who developed depressive symptoms (n=272, 14.3%) were older and had shorter education years, diabetes, more medications, slower walking speed, lower MMSE score, and fewer interactions than those who remained depressive symptoms-free during the follow-up ($P<0.05$); participants who developed frailty (n=380, 22.2%) were older and had shorter education years, no diabetes, more medications, slower walking speed, lower MMSE score, work, and fewer interactions than those who remained

Table 1
Comparisons of potential confounders and interaction status between the participants with and without depressive symptoms/frailty at baseline and follow-up.

	Baseline						Follow-up					
	Depressive symptoms			Frailty			Depressive symptoms			Frailty		
	No n = 3251	Yes n = 578	*p*-Value	No n = 2954	Yes n = 880	*p*-Value	No n = 1632	Yes n = 272	*p*-Value	No n = 1329	Yes n = 380	*p*-Value
Age, y	70.9±6.8	72.4±7.6	<.001*	70.4±6.6	73.3±7.4	<.001*	70.0±6.2	71.0±6.8	0.020*	69.5±5.9	71.3±6.8	<.001*
Sex, female	1850 (56.9)‡	299 (51.7)§	0.021†	1628 (55.1)§	525 (59.7)‡	0.017†	884(54.2)	143(52.6)	0.626	696(52.4)	200(52.6)	0.928
Education, y	11.4±2.4	10.7±2.4	<.001*	11.5±2.4	10.5±2.3	<.001*	11.8±2.4	11.3±2.4	0.001*	11.9±2.4	11.1±2.5	<.001*
Heart disease, no	2786 (85.7)	491(84.9)	0.637	2545 (86.2)	736(83.6)	0.062	1396 (85.5)	228(83.8)	0.459	1144 (86.1)	323(85.0)	0.594
Hypertension, no	1757 (54.0)	304(52.7)	0.546	1622 (54.9)‡	443 (50.4)§	0.019†	921(56.4)	138(50.7)	0.080	753(56.7)	201(52.9)	0.193
Diabetes, no	2825 (86.9)	485(83.9)	0.053	2597 (87.9)‡	718 (81.6)§	<.001†	1447 (88.7)‡	221 (81.3)§	0.001†	1187 (89.3)‡	321 (84.5)§	0.010†
Medication, number	2.6±2.5	3.3±3.0	<.001*	2.5±2.4	3.4±2.9	<.001*	2.4±2.3	3.0±2.8	<.001*	2.2±2.1	3.0±2.7	<.001*
BMI	23.6±3.3	23.3±3.6	0.152	23.4±3.1	23.8±3.9	0.022*	23.5±3.1	23.5±3.4	0.856	23.4±2.9	23.6±3.3	0.481
Walking speed, m/sec.	1.1±0.2	1.0±0.2	<.001*	1.1±0.2	1.0±0.2	<.001*	1.1±0.2	1.1±0.2	<.001*	1.2±0.2	1.1±0.2	<.001*
Current drinker, no	2100 (64.9)	387(67.0)	0.345	1874 (63.4)§	627 (71.3)‡	<.001†	1013 (62.1)	179(65.8)	0.238	799(60.1)	237(62.4)	0.429
Smoking status			<.001†			0.041†			0.855			0.959
Non-smoker	2026 (62.4)‡	309 (53.6)§	-	1799 (61.0)	541(61.6)	-	1007 (61.9)	167(61.4)	-	789(59.5)	223(58.7)	-
Past Smoker	907(27.9)	180(31.2)	-	859(29.1)	228(26.0)	-	482(29.6)	79(29.0)	-	420(31.7)	123(32.4)	-
Current Smoker	314(9.7)§	88(15.3)‡	-	293(9.9)§	109 (12.4)‡	-	139(8.5)	26(9.6)	-	117(8.8)	34(8.9)	-
MMSE score	27.4±2.5	26.5±3.1	<.001*	27.5±2.4	26.3±3	<.001*	27.8±2.2	27.5±2.4	0.036*	27.9±2.1	27.6±2.3	0.028*
Go out at least once a week, yes	3158 (97.1)‡	533 (92.2)§	<.001†	2896 (98.0)‡	800 (90.9)§	<.001†	1593 (97.6)	261(96.0)	0.114	1303 (98.0)	369(97.1)	0.268
Living alone, no	2925 (90.0)‡	479 (82.9)§	<.001†	2645 (89.5)‡	764 (86.8)§	0.024†	1481 (90.7)	240(88.2)	0.193	1200 (90.3)	336(88.4)	0.286
Work, yes	1358 (41.8)‡	173 (29.9)§	<.001†	1244 (42.1)‡	291 (33.1)§	<.001†	904(55.4)	167(61.4)	0.066	735 (55.3)‡	236 (62.1)§	0.019†
Interaction status			<.001†			<.001†			<.001†			<.001†
Both interactions, n (%)	1709 (52.6)‡	192 (33.2)§	-	1571 (53.2)‡	334 (38.0)§	-	903 (55.3)‡	113 (41.5)§	-	745 (56.1)‡	171 (45.0)§	-
Face-to-face only, n (%)	988 (30.4)§	212 (36.7)‡	-	911(30.8)	289(32.8)	-	487(29.8)	88(32.4)	-	410(30.9)	125(32.9)	-
Non-face-to-face only, n(%)	179(5.5)	39(6.7)	-	155(5.2)§	64(7.3)‡	-	84(5.1)	15(5.5)	-	63(4.7)	23(6.1)	-
No interactions, n (%)	375 (11.5)§	135 (23.4)‡	-	317 (10.7)§	193 (21.9)‡	-	158(9.7)§	56(20.6)‡	-	111(8.4)§	61(16.1)‡	-

* p-values reported from Student t-test.
† p-values obtained by Pearson's chi-square test.
‡ Statistically significant association was determined by adjusted standardized residual >1.96 ($p < 0.05$).
§ Statistically significant association was determined by adjusted standardized residual < −1.96 ($p < 0.05$). BMI, body mass index; MMSE, Mini-Mental State Examination; n, number; y, years.

frailty-free during the follow-up (P<0.05) (Table 1).

Table 2 shows ORs and 95% CIs estimated by both crude and adjusted binomial logistic regression analyses with presence of depressive symptoms at follow-up as a dependent variable. After adjusting for potential confounding factors (i.e., demographic variables and chronic disease), both interactions (crude model: OR=0.35, 95% CI=0.25–0.51; adjusted model: OR=0.39, 95% CI=0.26–0.57), face-to-face interactions only (crude model: OR=0.51, 95% CI=0.35–0.75; adjusted model: OR=0.56, 95% CI=0.38–0.84), and non-face-to-face interactions only (crude model: OR=0.50, 95% CI=0.27–0.94; adjusted model: OR=0.51, 95% CI=0.27–0.96) were independently associated with depressive symptoms at follow-up. Table 3 shows ORs and 95% CIs estimated by both crude and adjusted binomial logistic regression analyses with presence of frailty at follow-up as a dependent variable. After adjusting for potential confounding factors, both interactions (crude model: OR=0.42, 95% CI=0.29–0.60 and adjusted model: OR=0.44, 95% CI=0.30–0.65) and face-to-face interactions only (crude model: OR=0.56, 95% CI=0.38–0.80 and adjusted model: OR=0.59, 95% CI=0.39–0.87) were independently associated with frailty at follow-up, but non-face-to-face interactions only (crude model: OR=0.66, 95% CI=0.38–1.18 and adjusted model: OR=0.63, 95% CI=0.34–1.15) were not.

4. Discussion

In this observational 30-month prospective cohort study of adults, we found 1905 participants with both face-to-face and non-face-to-face interactions, 1200 with only face-to-face interactions, 219 with only non-face-to-face interactions, and 510 with neither face-to-face nor non-face-to-face interactions at baseline survey. The prevalence of depressive symptoms and frailty at the baseline survey was 15.1% and 23.0%, respectively, and at the 30-month follow-up survey, 14.3% and 22.2% of participants had newly developed depressive symptoms and frailty, respectively. The prevalence in this study is generally similar to that of previous studies (Kera et al., 2017; Tsubota-Utsugi et al., 2018; Xiong et al., 2020).

Table 2
Binomial logistic regression analysis, presence of depressive symptoms at follow-up as dependent variable.

	Crude model			Adjusted model		
	OR	95% CI	*p*-Value	OR	95% CI	*p*-Value
No interactions	1.00			1.00		
Both interactions	0.35	0.25–0.51	<.001	0.39	0.26–0.57	<.001
Face-to-face only	0.51	0.35–0.75	0.001	0.56	0.38–0.84	0.004
Non-face-to-face only	0.50	0.27–0.94	0.032	0.51	0.27–0.96	0.038
Age, y				1.00	0.97–1.02	0.935
Sex, female				0.88	0.59–1.32	0.547
Education, y				0.94	0.89–1.00	0.052
Heart disease, no				1.09	0.74–1.61	0.674
Hypertension, no				0.92	0.68–1.24	0.585
Diabetes, no				0.63	0.43–0.93	0.020
Medication, number				1.05	0.99–1.12	0.108
BMI				0.98	0.94–1.03	0.449
Walking speed, m/sec.				0.40	0.20–0.79	0.008
Current drinker, no				1.17	0.86–1.60	0.324
Current Smoker				1.00		
Non-smoker				0.95	0.55–1.65	0.861
Past Smoker				0.87	0.52–1.44	0.586
MMSE score				0.98	0.93–1.04	0.575
Go out at least once a week, yes				0.63	0.31–1.27	0.194
Living alone, no				0.84	0.55–1.30	0.438
Work, yes				0.97	0.72–1.30	0.835

BMI, body mass index; MMSE, Mini-Mental State Examination; n, number; y, years.

Table 3
Binomial logistic regression analysis, presence of frailty at follow-up as dependent variable.

	Crude model			Adjusted model		
	OR	95% CI	*p*-Value	OR	95% CI	*p*-Value
No interactions	1.00			1.00		
Both interactions	0.42	0.29–0.60	<.001	0.44	0.30–0.65	<.001
Face-to-face only	0.56	0.38–0.80	0.002	0.59	0.39–0.87	0.008
Non-face-to-face only	0.66	0.38–1.18	0.160	0.63	0.34–1.15	0.128
Age, y				1.01	0.99–1.04	0.311
Sex, female				1.08	0.74–1.59	0.682
Education, y				0.90	0.85–0.96	<.001
Heart disease, no				1.24	0.87–1.79	0.240
Hypertension, no				1.23	0.94–1.60	0.131
Diabetes, no				0.92	0.64–1.33	0.651
Medication, number				1.15	1.08–1.22	<.001
BMI				1.01	0.96–1.05	0.823
Walking speed, m/sec.				0.16	0.08–0.29	<.001
Current drinker, no				0.93	0.71–1.22	0.612
Current Smoker				1.00		
Non-smoker				0.91	0.55–1.50	0.702
Past Smoker				0.89	0.56–1.40	0.604
MMSE score				1.01	0.95–1.07	0.762
Go out at least once a week, yes				0.76	0.36–1.63	0.480
Living alone, no				0.97	0.66–1.42	0.859
Work, yes				1.01	0.77–1.31	0.969

BMI, body mass index; MMSE, Mini-Mental State Examination; n, number; y, years.

The potential confounding factors-adjusted ORs for the development of depressive symptoms in the “both interactions,” “face-to-face-only,” and “non-face-to-face only” groups were 0.39, 0.56, and 0.51, respectively, which correspond to 61%, 34%, and 53% decreases in the association with depressive symptoms for participants with both interactions, face-to-face only interactions, and non-face-to-face only interactions, respectively. The potential confounding factors-adjusted ORs for development of frailty in the “both interactions” and “face-to-face-only” groups were 0.44 and 0.59, respectively, which correspond to 56% and 41% decreases in the association with frailty for participants with both interactions and face-to-face only interactions, respectively. Studies have shown a positive relationship between participation in social activities and mental health. For example, older adults who were embedded in social networks had fewer depressive symptoms (Oxman et al., 1992; Russell and Cutrona, 1991), and participation in social gatherings with friends and neighbors was associated with fewer depressive symptoms (Min et al., 2016). Indeed, maintaining good mental health in old age is important for physical health (Han et al., 2021; Moussavi et al., 2007) and well-being (Noël et al., 2004), and social activities can promote psychological well-being by fostering a sense of purpose and belonging and providing supportive relationships that alleviate psychological distress (Berkman et al., 2000; Kawachi and Berkman, 2001). Considering that participation in social activities may be an important predictor of mental health in older adults, it is not surprising that face-to-face interaction was associated with decreased depressive symptoms in this study. Regarding non-face-to-face interactions, the most frequently used social networking services in older adults is LINE (a popular message application in Japan). A previous study found that frequent usage of LINE (both posting and checking) among older adults was independently associated with better well--being.(Sakurai et al., 2021) We also found that high activity on Facebook Messenger might have a positive impact on depressed mood

(Frison and Eggermont, 2016). The novelty of this study is that we evaluated face-to-face interaction and non-face-to-face interaction independently, and even non-face-to-face interaction alone might prevent the development of depressive symptoms. Our findings suggest that maintaining non-face-to-face interaction and avoiding social isolation may be important to prevent mental health deterioration, which is a concern with the spread of COVID-19.

Frailty in older adults, often defined as a physiological decline in later life (Clegg et al., 2013; Fried et al., 2001), is gaining international attention as population aging increases globally (Hoogendijk et al., 2019). Frailty could lead to several adverse health outcomes (Hoogendijk et al., 2019). Physical frailty and social participation have been reported to be associated with reduced frequency of social participation (Hand and Howrey, 2019) and engagement in activities with others (Duppen et al., 2019; Katayama et al., 2020). Lifestyle factors related to the onset or progression of physical frailty include physical inactivity, and social factors include living alone and loneliness (Dent et al., 2019). In this study, face-to-face interaction was associated with the reduced development of frailty, however, only non-face-to-face interaction was not associated with it. This result indicates that non-face-to-face interaction alone may not be sufficient to maintain physical health and suggests the importance of maintaining opportunities for face-to-face interaction among older adults. Notably, since the COVID-19 pandemic has continued, various methods for non-face-to-face interactions have been devised, such as using live video streaming to promote physical activity. Further studies are necessary to examine the relationship between various types of non-face-to-face interactions and frailty.

This study has some limitations. First, the participants in our study were only older adults who had access to health checkups from their homes, implying that the sample excluded people with various other conditions. Second, 1322 participants were lost in the follow-up, which might have led to an underestimation of the development of depressive symptoms and frailty due to a survival effect. Notably, the prevalence in this study was generally similar to that of previous studies. Therefore, the effects of the sampling bias and survival effects were minimal in this study. Third, we were unable to assess in detail the types of applications used for non-face-to-face interactions, such as Skype, FaceTime, and WhatsApp, or the content, such as whether it was an audio or video call. These points are currently under consideration in another longitudinal study. Fourth, since we excluded participants with poor health conditions in this study, we cannot apply the present results to these older adults. Despite these limitations, the notable strengths of the study are the large cohort size recruited from a single community, the independent assessment of face-to-face and non-face-to-face interactions, and the adjustment of various confounding factors.

5. Conclusions

Our findings indicate that non-face-to-face interactions are also important in preventing the deterioration of mental health, which is a concern with the spread of COVID-19. However, non-face-to-face interaction alone may not be sufficient to maintain physical health, and it is important to maintain opportunities for face-to-face interaction among older adults, particularly during the COVID-19 pandemic.

CRediT authorship contribution statement

Osamu Katayama: Conceptualization, Methodology, Formal analysis, Writing – original draft, Visualization, Funding acquisition. **Sangyoon Lee:** Methodology, Formal analysis, Investigation, Writing – review & editing, Supervision, Project administration. **Seongryu Bae:** Investigation, Writing – review & editing. **Keitaro Makino:** Investigation, Writing – review & editing. **Ippei Chiba:** Investigation, Writing – review & editing. **Kenji Harada:** Investigation, Writing – review & editing. **Masanori Morikawa:** Investigation, Writing – review & editing. **Kouki Tomida:** Investigation, Writing – review & editing. **Hiroyuki Shimada:** Investigation, Writing – review & editing, Supervision, Project administration, Funding acquisition.

Declaration of Competing Interest

The authors declare no conflict of interest.

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