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Does online communication mitigate the association between a decrease in face-to-face communication and laughter during the COVID-19 pandemic? A cross-sectional study from JACSIS study

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ABSTRACT

Laughter has a protective effect on human health. The spread of coronavirus disease 2019 (COVID-19) has changed opportunities for face-to-face communication and might decrease opportunities for laughter. This cross-sectional study aimed to investigate whether the decrease in face-to-face communication during the COVID-19 pandemic is associated with a decrease in laughter. Additionally, we investigated whether an increase in online communication mitigates this association. Data from the "Japan COVID-19 and Society Internet Survey (JACSIS)," conducted between August and September 2020, were used. Participants aged 15–79 years were included in this study. The outcome was a decrease in laughter before the onset of the COVID-19 pandemic. The explanatory variables were decreased face-to-face communication with friends and increased online communication (text message, telephone, and video contact). Causal mediation analysis was used to calculate prevalence ratios (PRs) and 95 % confidence intervals (CIs) of the controlled direct effects of increased online communication. Furthermore, the proportions eliminated (PEs) by an increase in online communication were calculated. Among the 25,482 participants, 40.4 % had decreased face-to-face communication and 21.4 % had a decreased frequency of laughter. After adjusting for confounders, a decrease in face-to-face communication was significantly associated with a decrease in laughter (PR = 1.62, 95 %CI = 1.55–1.70). PEs for decrease in laughter were 27.2 % (95 %CI = –2.0 to 56.4) for text-based communication, 36.1 % (95 %CI = 12.3–59.8) for telephone-based communication, and 28.6 % (95 %CI = 0.6–56.6) for video-based communication. Although a decrease in face-to-face communication was associated with a decrease in laughter during the COVID-19 pandemic, online communication, particularly telephone-based communication, mitigated this association.

1. Introduction

Laughter in daily life has been reported to have a protective effect on several health outcomes, such as mental health, cognitive decline, cardiovascular diseases, onset of disabilities, and all-cause mortality (Hayashi et al., 2016; Ko and Youn, 2011; Sakurada et al., 2020; Tamada et al., 2021). Laughter is more likely to occur when sharing time with others, such as friends and family, than when alone (Devereux and Ginsburg, 2010). Laughing with others, especially through face-to-face communication, positively affects general health by buffering psychological stress (Tamada et al., 2022; Hayashi et al., 2016).

The coronavirus disease 2019 (COVID-19) pandemic may have changed face-to-face communication. In the early stages of the COVID-19 pandemic, the governments of many countries imposed lockdowns

Abbreviations: PR, Prevalence ratio; TE, Total effect; CDE, Controlled direct effect; PE, Proportion eliminated.

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and promoted staying at home, working at home, and closing schools to minimize COVID-19 infection (Flaxman et al., 2020; Ren, 2020; Onyeaka et al., 2021). The first case of COVID-19 in Japan was confirmed on January 15, 2020, and on April 7, 2020, the Japanese government proclaimed a state of emergency, which was later extended to all prefectures (ended on May 25, 2020) (Watanabe and Yabu, 2021; Okubo et al., 2021). Although there was no legally binding force, people had limited face-to-face communication, and many avoided face-to-face communication even after the state of emergency was lifted (Watanabe and Yabu, 2021). These dramatic changes in face-to-face communication due to COVID-19 could have resulted in reduced laughter.

In contrast, the COVID-19 pandemic has increased the use of online communication (Nguyen et al., 2020). Text messages, phone calls, and video contact were alternatives to face-to-face communication during the COVID-19 pandemic. Previous studies have suggested that people who used the internet or communicated online had better mental and physical health (Juvonen et al., 2021; Katayama et al., 2022; Nakagomi et al., 2022b, 2022a; Wu et al., 2021). Other studies have emphasized the importance of using instant messages to communicate with family members during the COVID-19 pandemic (Gong et al., 2022; Gong et al., 2021). In contrast, other studies have suggested an inverse association between online communication and happiness (Newson et al., 2021). These studies have mentioned that one possible reason for this negative association is the difficulty in understanding facial expressions and listening to voices in online communication (Newson et al., 2021).

To date, whether the decrease in face-to-face communication due to COVID-19 has decreased laughter in the broader population has not been studied. In addition, it is unclear whether online communication has replaced face-to-face communication during the COVID-19 pandemic. Therefore, we investigated the following two hypotheses:

(1) The decrease in face-to-face communication due to the COVID-19 pandemic is associated with a decrease in laughter frequency.
(2) The increase in online communication mitigated the association between the decrease in face-to-face communication and laughter frequency during the COVID-19 pandemic.

2. Methods

2.1. Study population, study design, data sources

This cross-sectional study was conducted using the Japan "COVID-19 and Society" Internet Survey (JACSIS) study. JACSIS is a large-scale, self-reported web survey conducted between August and September 2020 using Rakuten Insight, with nearly 2.2 million quantified panelists in 2019 (Rakuten Insight Inc., Tokyo, Japan; https://member.insight.rakuten.co.jp/). Using simple random sampling, questionnaires were distributed to 224,389 panelists from all over Japan (47 prefectures) who were registered with Rakuten Insight, considering sex, age, and prefectures. Of whom, 28,000 participants aged 15–79 years were included in this study. We excluded 2,518 participants with invalid responses; the total number of participants were 25,482. Details of the survey have been described elsewhere (Murayama et al., 2021; Okubo et al., 2021; Arakawa et al., 2023). The outcome variables, explanatory variables, mediators, and covariates were assessed using a self-reported questionnaire. There were no missing values because all the questions had to be answered.

2.2. Outcome variable

We used a decrease in the frequency of laughter compared with before the COVID-19 pandemic as the outcome variable. Since the first confirmed case of pneumonia associated with COVID-19 in Japan was in January 2020, we asked the participants, "How have your opportunities to laugh out loud changed in the last month (July to August 2020; during the COVID-19 pandemic) compared with before the COVID-19 pandemic (January 2020)?", with participants answering in one of three ways (increase, no change, or decrease). We dichotomized these answers as either "Yes (decrease)" or "No (not decrease)," with "no change" and "increase" being considered as "No.".

2.3. Explanatory variable

We used the decrease in the frequency of face-to-face communication with friends compared with before the COVID-19 pandemic as an explanatory variable. We asked the participants, "How often did you meet your friends/acquaintances face-to-face before the COVID-19 pandemic (before January 2020) and in the last month (July to August 2020; during the COVID-19 pandemic), respectively?" Participants answered using the choices provided (seldom, once a month, 2–3 times per month, once a week, 2–3 times per week, 4–5 times per week, and almost every day). We then categorized the frequency of face-to-face communication as "decrease," "no change," or "increase" depending on whether the frequency of face-to-face communication with friends was compared with before the COVID-19 pandemic. For multivariate analysis, we dichotomized this variable as "decrease" or "not decrease.".

2.4. Mediators

We used three variables related to online communication with friends as mediators: an increase in text-based contact (e.g., mail, chat, and chat via an application), an increase in telephone-based contact (phone calls, cellphone calls, smartphone calls, and calls via an application), and an increase in video-based contact. Each participant was asked three questions: "How often did you contact your friends by email or text message/voice call/video call?" before the COVID-19 pandemic (before January 2020) and during the COVID-19 pandemic (July to August 2020). The answers provided were as follows: seldom, once a month, 2–3 times per month, once a week, 2–3 times per week, 4–5 times per week, and almost every day. The detailed questionnaires are provided in Supplementary Description 1. We dichotomized the frequency of online communication as "increase" or "not increase" depending on whether the frequency of online communication contact with friends had increased compared with before the COVID-19 pandemic.

2.5. Covariates

The covariates included the following variables based on previous studies: sex (men or women), age (15–19, 20–29, 30–39, 40–49, 50–59, 60–69, and 70–79 years), educational attainment (junior high school/high school, vocational/technical college/junior college, university/graduate school, other), household equivalent income (low, low-middle, middle, high, no response), occupational status (employer, independent, full-time employment, part-time employment, others, unemployed), comorbidities (yes, no), and living arrangements (with others, alone) (Arakawa et al., 2023; Nagai et al., 2021; Newson et al., 2021). In Japan, it takes nine years to graduate from junior high school, 12 years from high school, 14–15 years from vocational/junior college, 16 years from university, and $>$ 16 years from postgraduate studies. The equivalent household income was calculated by dividing household income by the square root of the number of households. We used this continuous variable partitioned into quartiles (Japanese million yen: 0.00–247.49, 247.49–350.00, 350.00–491.94, $\geq$ 491.94). For comorbidities, the presence of hypertension, diabetes mellitus, asthma, chronic obstructive pulmonary disease (COPD), cardiovascular disease, cerebrovascular disease, cancer, chronic pain, depression, and other psychiatric disorders were considered.

2.6. Statistical analysis

First, the descriptive characteristics of the sample, divided by the decrease in laughter, were calculated. Subsequently, the sample included in the analysis were compared with the national census data (Statistics Bureau et al., 2021). A Poisson regression model was used to calculate the prevalence ratios (PRs). Standard errors and bias-corrected 95 % confidence intervals (CIs) for a decrease in laughter compared with before the COVID-19 pandemic were estimated at 2,000 bootstrap samples. Model 1 was adjusted for sex and age. For Model 2, educational status, equivalent household income, occupational status, comorbidities, and living arrangements were added to Model 1. For the explanatory variables and covariates, we checked for collinearity and confirmed no higher multicollinearity among the variables.

A causal mediation analysis was conducted to calculate the total effect (TE), controlled direct effect (CDE), and proportion eliminated (PE) to evaluate the protective effect of the increase in the three types of online communication on the decrease in laughter (Kusama et al., 2021; Vanderweele, 2013). CDE (m) captured the effect of exposure on the outcome if the mediator was set at level "m". The CDE (m = 1) (an increase in online communication) was calculated, which could be interpreted as a situation in which all participants had increased online communications. The PEs (m = 1) are used for policy measures and indicates the amount of the effect of the exposure on the outcome that could be eliminated by intervening at level "m" (Vanderweele, 2013). The PEs (m = 1) were calculated using the following formula: PE (m = 1) = ([PR^{TE} – $PR^{CDE\ (m\ =\ 1)}$]/ [PR^{TE} – 1]. Stata command "*paramed*" was used for causal mediation analysis (Vanderweele, 2013). The mediators, the three types of online communication, were used as binary variables of "increase/not increase.".

Two sensitivity analyses were conducted to examine the robustness of the results. First, a sex-stratified analysis was conducted. Second, the participants were stratified according to whether they were younger (15–59 years) or older (60–79 years).

Stata 17.0 MP (Stata Corporation LP, Windows version) was used for all the analyses. The significance level was set at 0.05, and the STROBE guidelines for reporting were followed.

Ethical approval

This study was conducted in accordance with the Declaration of Helsinki. The JACSIS study conducted in 2020 followed procedures approved by the Ethics Committee on Research on Human Subjects at the Research Ethics Committee of the Osaka International Cancer Institute (No. 20084–2). All participants provided informed consent at registration of Rakuten Insight which conducted the survey. Before responding to the online questionnaire, all participants were asked to provide informed consent and were given the option to opt out at any time. Regarding consent from those aged < 20 years, Rakuten Insight notes that if they register as respondents with the company, they must have a guardian or other legal representative read through the monitor terms, conditions, and privacy policy and obtain their consent before registering.

Table 1
Descriptive characteristics of the study sample who participated JACSIS study conducted in Japan, August 2020-September 2020 (n = 25,482).

		Total		The decrease in laughter compared with before the COVID-19 pandemic			
				No		Yes	
		n	% (col)	n	% (row)	n	% (row)
Changes in face-to-face communication	No changes	13,198	51.8	11,037	83.6	2,161	16.4
	Increase	1,979	7.8	1,560	78.8	419	21.2
	Decrease	10,305	40.4	7,365	71.5	2,940	28.5
Sex	Men	12,673	49.7	10,286	81.2	2,387	18.8
	Women	12,809	50.3	9,676	75.5	3,133	24.5
Age	15–19	1,214	4.8	885	72.9	329	27.1
	20–29	3,211	12.6	2,373	73.9	838	26.1
	30–39	3,767	14.8	2,992	79.4	775	20.6
	40–49	4,894	19.2	3,921	80.1	973	19.9
	50–59	4,256	16.7	3,338	78.4	918	21.6
	60–69	4,243	16.7	3,339	78.7	904	21.3
	70–79	3,897	15.3	3,114	79.9	783	20.1
Educational status	Junior high school and high school	7,611	29.9	6,165	81.0	1,446	19.0
	Vocational/technical college/junior college	5,637	22.1	4,393	77.9	1,244	22.1
	University and graduate school	12,172	47.8	9,359	76.9	2,813	23.1
	The other	62	0.2	45	72.6	17	27.4
Income	Low	5,339	21.0	4,157	77.9	1,182	22.1
	Low-middle	5,052	19.8	3,992	79.0	1,060	21.0
	Middle-high	4,993	19.6	3,882	77.7	1,111	22.3
	High	4,824	18.9	3,692	76.5	1,132	23.5
	No response	5,274	20.7	4,239	80.4	1,035	19.6
Occupational status	Employer	847	3.3	659	77.8	188	22.2
	Independent	1,645	6.5	1,348	81.9	297	18.1
	Full-time employment	8,666	34.0	6,802	78.5	1,864	21.5
	Non full-time employment	4,296	16.9	3,391	78.9	905	21.1
	The other	7,013	27.5	5,340	76.1	1,673	23.9
	Unemployed	3,015	11.8	2,422	80.3	593	19.7
Comorbidities	No	16,813	66.0	13,345	79.4	3,468	20.6
	Yes	8,669	34.0	6,617	76.3	2,052	23.7
Living status	With others	20,485	80.4	16,324	79.7	4,161	20.3
	Alone	4,997	19.6	3,638	72.8	1,359	27.2
Increase in text-based communication	No	22,957	90.1	18,055	78.6	4,902	21.4
	Yes	2,525	9.9	1,907	75.5	618	24.5
Increase in telephone-based communication	No	22,235	87.3	17,596	79.1	4,639	20.9
	Yes	3,247	12.7	2,366	72.9	881	27.1
Increase in video-based communication	No	23,128	90.8	18,353	79.4	4,775	20.6
	Yes	2,354	9.2	1,609	68.4	745	31.6
	Total	25,482	100.0	19,962	78.3	5,520	21.7

3. Results

Table 1 presents the descriptive characteristics of the study participants. The total sample comprised 25,482 participants (men: 49.7 %). The mean age was 48.8 years (SD = 17.3). Of the participants, 40.4 % had a decreased frequency of face-to-face communication, and 21.7 % of the participants had a decreased frequency of laughter compared to before the COVID-19 pandemic. In addition, text messages, voice calls, and video calls increased contact for 9.9 %, 12.7 %, and 9.2 % of participants, respectively. Women, younger participants, and those with higher educational status, higher income, comorbidities, or those living alone were more likely to experience a decrease in laughter. The demographic characteristics (sex, age, and living status) of the study participants were similar to those of the 2020 national census data (Statistics Bureau et al., 2021; Supplementary Table 1).

Table 2 shows the results of the Poisson regression model. After adjusting for confounders, a decrease in face-to-face communication was significantly associated with a decrease in the frequency of laughter during the COVID-19 pandemic (PR = 1.62, 95 % CI = 1.55–1.70).

Table 3 presents the results of the causal mediation analysis, showing the TE and CDE of a decrease in face-to-face communication with a decrease in laughter when the mediator (m) was fixed at m = 1 (an increase in online communication). The CDE (m = 1) for a decrease in laughter was smaller than the TE for the three types of online communication. The PEs for a decrease in laughter were statistically significant for telephone-based communication (PE = 36.1 %; 95 % CI = 12.3–59.8) and video-based communication (PE = 28.6 %; 95 % CI = 0.6–56.6) but not for text-based communication (PE = 27.2 %; 95 % CI = –2.0 to 56.4). The PE of the increase in telephone-based communication was the highest among the three types of communication.

Sensitivity analyses showed a tendency similar to that observed in the primary analysis. However, there were variations among the target populations. First, in the sex-stratified analysis (Supplementary Tables 2 and 3), the PE of the increase in telephone-based communication was statistically significant at 53.9 % in men. In contrast, the PE of the increase in any communication did not show a statistical significance among women. When stratified by age (Supplementary Tables4 and 5), the PE of the increase in telephone-based communication was statistically significant at 48.5 % in older adults. Among the younger population, the PE of the increase in any communication did not show statistical significance, and the estimates were not higher than those in older adults.

4. Discussion

A decrease in face-to-face communication has been associated with a decrease in opportunities for laughter during the COVID-19 pandemic. In addition, increased telephone-based and video-based communication mitigated this association. In particular, increased telephone-based communication potentially lowered the risk of decreased laughter by 36.1 % owing to a decrease in face-to-face communication.

These results are consistent with those of a previous study, which showed that social activities are associated with higher frequencies of laughter (Nagai et al., 2021). We found that a decrease in face-to-face communication was associated with a decrease in laughter during the COVID-19 pandemic. Additionally, our results, which showed the protective effect of online communication on the association between a decrease in face-to-face communication and laughter, are supported by the findings of previous studies (Juvonen et al., 2021; Kumar and Epley, 2021; Liu et al., 2019; Sahi et al., 2021). A study conducted after the spread of COVID-19 suggested that having a greater number of virtual interaction partners was associated with maintaining better mental health (Sahi et al., 2021). Other studies have suggested that connecting with friends via online communication would have a protective role against loneliness, anxiety, and depressive symptoms when satisfied with communication (Juvonen et al., 2021).

The following are possible mechanisms for the association between a decrease in face-to-face communication and laughter. After the confirmation of COVID-19 and declaration of a state of emergency in Japan (Okubo et al., 2021), person-to-person contact was restricted, which may have reduced laughter due to face-to-face communication with others. Previous studies have shown that people tend to laugh more

Table 2
Association between a decrease in face-to-face interaction and laughter compared to before the COVID-19 pandemic among the study sample who participated JACSIS study conducted in Japan, August 2020-September 2020 (n = 25,482).

		Model 1		Model 2	
		PR	95 %CI	PR	95 %CI
Decrease in face-to-face communication (Ref: No)	Yes	**1.65**	**(1.58–1.73)**	**1.62**	**(1.55–1.70)**
Sex (Ref: Men)	Women	**1.24**	**(1.18–1.30)**	**1.32**	**(1.25–1.39)**
Age (Ref: 15–19)	20–29	0.97	(0.87–1.08)	**0.89**	**(0.79–0.99)**
	30–39	**0.77**	**(0.69–0.86)**	**0.74**	**(0.65–0.83)**
	40–49	**0.75**	**(0.67–0.84)**	**0.72**	**(0.64–0.81)**
	50–59	**0.80**	**(0.72–0.89)**	**0.76**	**(0.68–0.86)**
	60–69	**0.78**	**(0.70–0.87)**	**0.73**	**(0.65–0.82)**
	70–75	**0.73**	**(0.65–0.81)**	**0.67**	**(0.60–0.76)**
Educational status (Ref: Junior high school and high school)	Vocational/technical college/junior college			**1.11**	**(1.03–1.18)**
	University and graduate school			**1.20**	**(1.13–1.28)**
	The other			1.44	(0.93–2.21)
Income (Ref: Low)	Low-middle			0.96	(0.89–1.04)
	Middle-high			0.99	(0.92–1.07)
	High			1.03	(0.96–1.11)
	No response			**0.88**	**(0.82–0.95)**
Occupational status (Ref: Employer)	Independent			**0.82**	**(0.70–0.97)**
	Full-time employment			0.93	(0.82–1.07)
	Part-time employment			0.89	(0.77–1.02)
	The other			0.97	(0.84–1.11)
	Unemployed			0.92	(0.79–1.06)
Comorbidities (Ref: No)	Yes			**1.26**	**(1.20–1.33)**
Living arrangements (With others)	Alone			**1.31**	**(1.24–1.39)**
Constant		**0.19**	**(0.17–0.21)**	**0.17**	**(0.14–0.20)**

Model 1: Adjusted for sex and age.
Model 2: Model 1 + Educational status, income, occupational status, comorbidities, and living arrangements added.
Abbreviation: PR; Prevalence Ratio, CI; Confidence Interval
Note: Bold values indicate P < 0.05

Table 3
Mediating effect of an increase in online communications on the association between a decrease in face-to-face communication and laughter by causal mediation analysis among the study sample who participated JACSIS study conducted in Japan, August 2020-September 2020 (n = 25,482).

		Model 1				Model 2			
		PR	95 % CIs	PE (%)	95 % CIs	PR	95 % CIs	PE (%)	95 % CIs
Increase in text-based communication	TE	**1.65**	**(1.58–1.73)**	24.2	(-5.0–53.4)	**1.62**	**(1.55–1.70)**	27.2	(-2.0–56.4)
	CDE	**1.49**	**(1.32–1.72)**			**1.45**	**(1.27–1.67)**		
Increase in telephone-based communication	TE	**1.65**	**(1.58–1.73)**	**35.1**	**(11.9–58.4)**	**1.63**	**(1.55–1.70)**	**36.1**	**(12.3–59.8)**
	CDE	**1.42**	**(1.27–1.60)**			**1.40**	**(1.26–1.58)**		
Increase in video-based communication	TE	**1.65**	**(1.58–1.73)**	**29.5**	**(2.8–56.2)**	**1.62**	**(1.55–1.70)**	**28.6**	**(0.6–56.6)**
	CDE	**1.46**	**(1.29–1.65)**			**1.45**	**(1.28–1.64)**		

Model 1: Adjusted for sex and age.
Model 2: Model 1 + Educational status, income, occupational status, comorbidities, and living arrangements added.
Abbreviations: PR: Prevalence ratio, CI: Confidence Intervals, TE: Total Effect, CDE: Controlled direct effect, PE: Proportion Eliminated
Note: Bold values indicate $P < 0.05$

when talking with friends than when watching TV or reading books alone (Tamada et al., 2022; Yamamoto et al., 2022). Furthermore, mental health and laughter are highly correlated, and studies have indicated many cases of mental health deterioration following the COVID-19 pandemic (Santomauro et al., 2021). Therefore, the present finding that a decrease in face-to-face communication due to COVID-19 is associated with a decrease in laughter is reasonable.

Plausible reasons for the largest preventive effect of telephone-based communication and the second-largest preventive effect of video-based communication among all online communications are as follows. First, by comparing text messages, telephone contact was more likely to lead to laughter through direct conversation. Although text-based communication utilizes symbols such as “emojis” and “character stickers” in messaging applications to convey emotions (Liu et al., 2019; Wang, 2016), a previous study has mentioned a negative aspect of text-based communication, such as a lack of cues to express emotions (Newson et al., 2021). In a previous Cochrane review, video-based communication was described as seemingly important for maintaining social bonds and working positively by seeing each other’s eyes and faces (Noone et al., 2020). In addition, video-based communication allows for both synchronous and multimodal communication (Dennis et al., 2008; Juvonen et al., 2021). Therefore, in our study, video-based communication led to laughter through facial expressions, rather than text-based communication.

Sensitivity analysis revealed variations in the results in terms of age and sex. In the analysis divided by age, only the PE of telephone-based communication showed statistical significance among older adults aged $\geq$ 60 years, but any online communication did not show statistical significance among the younger population. Previous studies have shown that older adults tend to experience barriers to initiating new modes of communication (Nakagomi et al., 2022b). In Japan, the proportion of smartphone users has increased by 60.9 % (in 2017) (Ministry of Internal Affairs and Communications, 2018). In the younger population, the usage rate is approximately 90 %. However, the usage rate among older adults remains low (44.6 %). Therefore, telephone-based communication is an effective communication tool for older adults. Regarding why any communication did not appear to be effective among the younger population, future studies should investigate pathways other than online communication. In the sex-stratified analysis, PE for telephone communication was statistically significant in men. However, the PEs associated with the increase in online communication modes were not statistically significant among women. Effective interventions that consider these slight differences may be needed to minimize the decrease in laughter associated with a decrease in face-to-face communication, as these results indicate that communication varies according to sex. Further studies are required to explore these possible mechanisms.

This study highlighted the importance of increasing online communication as a public health implication. When face-to-face communication is not possible, for example, if there is a COVID-19 outbreak in a nursing home, online communication, particularly telephone- and video-based communication, is highly encouraged to counteract the decrease in laughter. Laughter has been suggested to be effective for positive health outcomes via stress-buffering effects and other factors (Hayashi et al., 2016; Ko and Youn, 2011; Sakurada et al., 2020; Tamada et al., 2021, 2022). Thus, during the post-COVID-19 pandemic and outbreaks of other infectious diseases, an increase in online communication would be an important factor in achieving healthy longevity.

This study had some limitations. First, causality cannot be mentioned, as this study had a cross-sectional design. Future longitudinal studies are required to explore more detailed mechanisms. Second, we did not collect information before the COVID-19 pandemic. We used the variables “decrease in laughter compared with before the COVID-19 pandemic” and “increase in the three types of communication compared with before the COVID-19 pandemic.” However, the JACSIS study was conducted after the COVID-19 pandemic; therefore, recall bias may have persisted. Third, we used dichotomized variables for exposure, mediators, and outcomes owing to the restrictions of the statistical analysis. This may have caused over- or underestimation of the results. Fourth, because this study relied on a web survey, the sample may have been overrepresented among those with high internet literacy (Andrade, 2020). This may have led to a selection bias; however, we confirmed that this population was not unbalanced compared with the national census data. Fifth, our study used variables assessed using a self-reported questionnaire. The questions used in this study are specific to COVID-19; therefore, their validity was not fully examined. Laughter is a complex social and emotional behavior that includes both physiological and psychological aspects, and its measurement is challenging. Additionally, this subjective measurement is difficult to examine for internal validity, as there are no objective measurements to investigate the frequency of laughter in daily life. Objective assessments using portable sensors to detect laughter expressions and voices have been developed (Cosentino et al., 2016). Future studies should use objective measurements in addition to self-reported assessments. However, the fact that the study was based on a large-scale web survey conducted among residents of 47 prefectures in Japan is a strength that helps ensure high generalizability.

5. Conclusions

A decrease in face-to-face communication has been associated with a decrease in laughter frequency during the COVID-19 pandemic. In addition, an increase in online communication, particularly telephone-based communication, plays a protective role in mitigating this association. Online communication is expected to become an alternative to face-to-face communication during the COVID-19 pandemic or during outbreaks of other infectious diseases.

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Data availability JACSIS data is available on request by contacting the data management office (https://jacsis-study.jp/howtouse/).

CRediT authorship contribution statement

Sakura Kiuchi: Conceptualization, Methodology, Writing – original draft. **Kenji Takeuchi:** Conceptualization, Methodology, Supervision, Writing – review & editing. **Taro Kusama:** Methodology, Writing – review & editing. **Upul Cooray:** Methodology, Writing – review & editing. **Yudai Tamada:** Methodology, Writing – review & editing. **Ken Osaka:** Supervision. **Takahiro Tabuchi:** Data curation, Project administration.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2023.102432.

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