

The purpose of internet use and face-to-face communication with friends and acquaintances among older adults: A JAGES longitudinal study

(高齢者におけるインターネット利用目的と友人知人との対面交流：JAGES 縦断研究)

千葉大学大学院薬学府先進予防医学共同専攻

(主任：櫻井健一教授)

千嶋 巖

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Abstract

Internet use influences social interactions in society. However, there is no consensus on whether and what kind of Internet use increases face-to-face communication (FFC). This study investigated the mode of Internet use that increases FFC among older adults after three years. Participants were 8734 adults aged 65 or older who responded to the Japan Gerontological Evaluation Study (JAGES) surveys in 2016 and 2019. The exposures were the purposes of Internet use in 2016. The outcome was the frequency of FFC with friends or acquaintances in 2019. The confounders included 13 demographic, socioeconomic, and psychological variables. I performed modified Poisson regression analyses and found that Internet use for communication in 2016 increased FFC in 2019, especially for low-frequency FFC in 2016. Internet-based non-FFC may help promote FFC and prevent social isolation among older adults who are less likely to interact with others.

What this paper adds

- Internet use for communication is associated with an increase in face-to-face communication (FFC) among those who interact infrequently.
- Internet use for communication is not associated with an increase in FFC among those who interact frequently.
- Internet use other than for other purposes is not associated with an increase in FFC.

Applications of study findings

- Promote FFC among socially isolated older adults by encouraging Internet-based communication.

- Accumulate research on the types and content of Internet use for communication that can promote FFC and prevent social isolation.

Abstract

Internet use influences social interactions in society. However, there is no consensus on whether and what kind of Internet use increases face-to-face communication (FFC). This study investigated the mode of Internet use that increases FFC among older adults after three years. Participants were 8734 adults aged 65 or older who responded to the Japan Gerontological Evaluation Study (JAGES) surveys in 2016 and 2019. The exposures were the purposes of Internet use in 2016. The outcome was the frequency of FFC with friends or acquaintances in 2019. The confounders included 13 demographic, socioeconomic, and psychological variables. I performed modified Poisson regression analyses and found that Internet use for communication in 2016 increased FFC in 2019, especially for low-frequency FFC in 2016. Internet-based non-FFC may help promote FFC and prevent social isolation among older adults who are less likely to interact with others.

Social isolation, the objective state of having few social relationships or infrequent social contact with others, has become a serious public health issue. The prevalence of social isolation is high worldwide, with an incidence of 24% in the USA (Cudjoe et al., 2018) and 10%–43% in North America (Nicholson, 2012). In Japan, the prevalence of social isolation increased from 21% before the 2019 SARS-CoV-2 pandemic to 28% after the pandemic (Murayama et al., 2021).

As older adults age and have less time left in their lives, they become more selective, limiting social interactions, and investing more resources in emotionally meaningful goals and activities (Carstensen, 1992). Life transitions and events in old age (e.g., retirement; loss of spouse, partner, or friends; migration to or from children; and disability or loss of mobility) are likely to affect older adults and are important risk factors for social isolation (National Academies of Sciences & Medicine, 2020). Older adults' social relationships shrink due to the following: intra-individual problems (e.g., lack of social skills and confidence); inter-individual problems (e.g., illness, bereavement, and migration); and community problems (e.g., reduced social ties, changes in place of

residence). The solution is to rebuild social relationships (e.g., participation in residents' associations or volunteer groups); however, failure to do so leads to a vicious circle in which relationships shrink further (Fokkema & Knipscheer, 2007). With increasing longevity and aging of populations worldwide, social isolation among older adults is expected to increase further (National Academies of Sciences & Medicine, 2020; World Health Organization, 2021).

Among the components of social isolation, social interaction with friends or acquaintances is an important component (Cornwell & Waite, 2009). Poor social interaction with friends or acquaintances was strongly associated with a wide range of health and well-being outcomes (Saito et al., 2015). Less frequent social interaction with friends or acquaintances was associated with higher mortality, a need for long-term care, and the development of dementia (Nakagomi et al., 2023). Given the negative impact of social isolation on health and well-being, several countries, including the United Kingdom and Japan, have implemented policies for prevention and action against isolation and loneliness and appointed a Minister for Loneliness. Tackling social isolation and loneliness is considered a primary strategy to promote health and well-being globally.

Social interactions can be divided into face-to-face communication (FFC) and non-FFC, such as letters, phone calls, emails, video conferencing, and social networking services (Noguchi et al., 2021). Internet use for communication can provide the same communicative effect as FFC interaction (Mirzaei & Kashian, 2020) and may alleviate physical or psychological problems (Fujiwara et al., 2022; Katayama et al., 2022; Noguchi et al., 2021).

Although technological advances over the past 10–15 years have led to a growing interest in Internet-based interventions in social interaction (Ibarra et al., 2020; Thangavel et al., 2022), the relationship between Internet use and FFC is inconclusive in some areas. First, although the definition of social contact includes FFC and non-FFC, the two are not clearly distinguished (Zhang et al., 2020). Second, there is little information on the relationship between details of Internet use and FFC. Although social, informational, and instrumental uses are all positively associated with social participation, such as volunteering and church attendance (Choi & DiNitto, 2013; Ihm & Hsieh,

2015; Szabo et al., 2019), to the best of my knowledge, there is no literature showing an association with FFC.

Whether and what kind of Internet use increases FFC among older adults is unclear. Therefore, I conducted a longitudinal study of the association between the purposes of Internet use in 2016 and the frequency of FFC among older adults aged 65 years and over in 2019. I hypothesized that Internet use for communication in 2016 would increase the frequency of FFC in 2019.

Methods

Study Population

I used data from the 2016 and 2019 waves of the Japan Gerontological Evaluation Study (JAGES). JAGES is a repeated nationwide population-based gerontological cohort study in Japan that focuses on social determinants of health and functional disability. JAGES is a self-administered questionnaire survey of adults aged 65 or older who are independent in both physical and cognitive functions and who are not certified to be eligible for the benefits of the long-term care insurance system (Kondo et al., 2018). A census was conducted for all residents in municipalities with fewer than 5000 eligible residents, while random sampling was used for large municipalities with 5000 or more eligible residents. The 2016 survey consisted of a common set of questions and eight modules, and participants were randomly assigned to one of those eight modules. A section on the purpose of Internet use was included in one of the eight modules. Of the 22,295 participants from 34 municipalities (response rate 70.2%) who responded to the module that asked about their Internet use, 12,656 participants could not be traced for one of the following reasons: they became eligible for long-term care insurance, died, did not respond, or did not consent to the 2019 survey. Among the 9600 participants who responded to the 2019 survey, 866 were excluded because of gender discrepancies, age discrepancies, reduced activities of daily living, and missing values of activities of

daily living. Finally, 8734 participants (47.6% male, mean age 73.1 years) were included in the study. (Figure 1).

Figure 1. Flow chart of the participants and Inclusion/exclusion Criteria

Frequency of FFC with Friends or Acquaintances

In response to the question "How often do you meet with your friends or acquaintances?" participants selected one of the following: "almost every day," "twice or thrice a week," "once a week," "once or twice a month," "several times a year," and "not at all." I created a binary variable with two attributes, "more than once a week" and "less than once a week" based on a previous study (Nakagomi et al., 2023).

Frequency and Purpose of Internet Use

First, I asked participants how often they had used the Internet in the past year. Participants selected one of the following: "almost every day," "two or three times a week," "several times a month or less," and "not at all." The respondents who selected "almost every day," "two or three times a week," and "several times a month or less" were further asked about the purpose of their Internet use: "communicating with friends and family," "LINE (messaging application widely used in Japan, Taiwan, Thailand, and Indonesia), Facebook and Twitter," "searching for information other than health or medical care," "searching for information on health and medical care," "searching for maps and traffic information," "purchasing products and services," and "bank transactions, stock and securities trading." Participants could select more than one purpose when they engaged in them. Each category was analyzed as a binary variable: "yes" or "no." Participants who answered "no" included both those who had never used the Internet and those who used the Internet but not for the relevant purposes.

Control Variables

In 2016, I adjusted for a series of demographic factors, including physical health, psychological health, and social factors. I included age and gender as demographic factors (Freedman & Nicolle, 2020). There is a gender gap in Internet use (Parent, 2023). The frequency of Internet use decreases with age (Kondo et al., 2021). I analyzed age as a continuous variable and gender as a binary variable: male and female.

Both decreased physical function and comorbidity are risk factors for decreased social interaction (Freedman & Nicolle, 2020). Older adults with limited activity and comorbidity due to physical problems may have barriers to accessing the Internet (Czaja, 2017). I adopted a 5-item self-report measure of instrumental activities of daily living as an indicator of instrumental activities of daily living (score range: 0–5) (Koyano, 1987). I created a binary variable of no decline (5 points) and decline (0–4 points) (Tanimoto et al., 2012). The comorbidity question consisted of 17 diseases relating to atherosclerotic diseases, which comprise major medical diseases including cancer, dementia, musculoskeletal diseases, and sensory system diseases. Participants were considered to have comorbidity if they suffered from any of them. I created a binary variable about the absence or presence of comorbidity.

Depression has been associated with decreased social interaction (Santini et al., 2020) and decreased Internet use (Kondo et al., 2021). I assessed depressive symptoms using the Geriatric Depression Scale, which consists of 15 questions, with higher scores indicating more depressive symptoms. Participants with a geriatric depression scale score of five or higher were considered to indicate depression (Nyunt et al., 2009). Self-rated health is a subjective measure of health status. Self-rated health was associated with increased social interaction (Mukerjee, 2013) and Internet use (Kouvonen et al., 2021). I created a binary variable for self-rated health. Participants responded to the question, “How are your current health stats?” (1) “Excellent” or (2) “Good” was considered good, while (3) “Fair” or (4) “Poor” was considered poor.

Socioeconomic status, marital status, and living arrangement are factors that contribute to social interaction (Freedman & Nicolle, 2020; Keefe. et al., 2006) and are also associated with poor access to the Internet (Kondo et al., 2021). To assess household income, I used “equivalized household income,” which is income divided by the square of the number of persons in the household (Dalstra et al., 2006). This takes into account the fact that different household sizes and compositions require different levels of income to achieve a given standard of living (Whiteford, 1997). I defined three categories: less than 2 million, 2–4 million, and more than 4 million. I also defined education (≤ 9 , 9–12, and ≥ 13 years), occupation (not employed, retired, and never employed), marital status (never married, married, and widowed), and living arrangement (living alone, living with no spouse, and living with a spouse).

Social interaction at baseline was also related to social interaction at follow-up. The frequency of meeting friends or acquaintances in 2016 may be related to the frequency of interaction in 2019.

Social interaction is associated with Internet use (Lelkes, 2013). I created the binary variables “more than once a week” and “less than once a week.” Low social support was associated with high social isolation (Keefe. et al., 2006). Receiving emotional support was expected to promote Internet use among older adults (Kondo et al., 2021). Internet use may not only promote emotional support but also help maintain and strengthen existing relationships with geographically distant friends or acquaintances (Quan-Haase et al., 2017). I asked participants, “Do you have someone who listens to your problems and frustrations?” I created a binary variable of “yes” and “no.”

Statistical Analysis

I used modified Poisson regression models to calculate the cumulative incidence ratios (CIRs) and 95% confidence intervals (CIs) of meeting friends or acquaintances more than once a week. Purposes of Internet use were included simultaneously in the modified Poisson regression model.

As the frequency of face-to-face interactions may vary with the purpose of Internet use (Kondo et al., 2021), I considered it necessary to examine whether the association between the purpose of Internet

use in 2016 and the frequency of FFC in 2019 varied according to the frequency of FFC in 2016. I created the product terms for FFC frequency in 2016 and the purpose of Internet use in 2016, and performed a Poisson regression analysis to calculate the CIR and 95% CI. The purposes of Internet use were simultaneously included in the modified Poisson regression model.

I performed two sensitivity analyses. First, I assumed that some older adults meet only a few friends or acquaintances frequently because, as older adults age, they become more aware of making the most of their existing relationships rather than expanding their relationships (Carstensen, 1992). I replaced the outcome with the binary variable of the number of friends or acquaintances the respondent met in a month. I asked, "How many friends or acquaintances have you met in the past month? Count the number of times you met the same person as one." The number of friends or acquaintances the respondent met in a month in 2019 was categorized as "one or more," "three or more," "six or more," or "ten or more" as a binary variable of "yes" or "no." I conducted the analysis in two ways. In one, I tested the probability of increasing the number of friends or acquaintances the respondent met in a month from zero to one or more, from two or less to three or more, from five or less to six or more, and from nine or less to ten or more between 2016 and 2019, respectively. In the other, I tested the probability that the number of friends or acquaintances the respondent met in a month in 2016 would not decrease in 2019; I created binary variables for more than one, more than three, more than six, and more than nine people, respectively. I conducted a modified Poisson regression analysis and calculated the CIR, 95% CI, and *p*-value.

Second, the statistical analysis method was modified to test robustness. Ordinal logistic regression analysis was performed using the frequency of seeing friends or acquaintances as continuous values. "Never," "a few times a year," "once or twice a month," "once a week," "several times a week," and "almost every day" were assigned in this order from 1 to 6 (Nakagomi et al., 2023). Coefficients, 95% CIs, and *p*-values were calculated.

I conducted multiple imputations using the multivariate normal method, assuming that all data were missing at random. Data were missing in 1.8% of the variables for the purpose of Internet use in

2016, 16.8% for income in 2016, 14.3% for the geriatric depression scale score in 2016, and 14.1% for employment status in 2016, respectively. The missing data for other variables was less than 10%. I created 20 imputed data sets and combined the effect estimates using Rubin's rule (Rubin, 1996). I analyzed all data using STATA 17.0 software (STATA Corp. LLC, College Station, TX, USA). Continuous variables were expressed as a mean (standard deviation [SD]), and categorical variables were reported as percentages.

The JAGES was approved by the Ethics Committee at the National Center for Geriatrics and Gerontology (1274-2), Chiba University Faculty of Medicine (3442), and the Japan Agency for the Gerontological Evaluation Study (2019-01).

Results

Compared to Internet non-users, older adults who used the Internet tended to be young, female, without comorbidities, had fewer instrumental activities of daily living decline, higher equivalized household incomes, higher educational attainment, better self-rated health, and a better geriatric depression scale score, were married, and lived with someone. The most common purpose of Internet use was to communicate with friends and family (71.0%), whereas only 13.8% of Internet users used social networking services (Table 1).

Table 1. Characteristics of internet Nonusers and Users in Japan in 2016.

Both Internet use for communication and social networking services were more common among females or those who had a higher frequency of meeting friends or acquaintances in 2016. Internet use for communication was more common than for other purposes among those who had a low income or lived alone. The use of the Internet for social networking services was more common than for other purposes among those who were single, currently employed, or received emotional support. For those who did not have comorbidities, the use of the Internet was more common for the

collection of health information than for other purposes. The use of the internet for banking, stocks, and securities trading was more common than for other purposes among males, those who had a lower frequency of meeting friends or acquaintances in 2016, had higher incomes, had higher education levels, and lived with someone (Table 2).

Table 2. Characteristics of Older Adults Using internet for Each Purpose in Japan in 2016.

The modified Poisson regression models showed that Internet use for communication with friends or acquaintances in 2016 was associated with an increased probability of meeting friends or acquaintances more than once a week in 2019 (CIR: 1.08; 95% CI = [1.00, 1.16], $p = .027$, reference: Internet non-users or older adults who did not use the Internet for the relevant purposes), whereas Internet use for any other purposes, including for social networking services in 2016, was not associated with an increased probability of meeting friends or acquaintances more than once a week in 2019 (Table 3).

Table 3. Associations Between Purposes of internet Use in 2016 and Frequency of Meeting Friends or Acquaintances in 2019 (Modified Poisson Regression Model).

I created interaction terms because the frequency of meeting friends or acquaintances in 2016 may have an interaction with the purposes of Internet use in 2016. A statistically significant association was found only in the product terms of Internet use for communication and frequency of interaction with friends or acquaintances in 2016 (Supplemental Table 1).

Table 4 shows the associations between purposes of Internet use and the frequency of meeting friends or acquaintances in 2019, stratified by the frequency of meeting friends or acquaintances in 2016 (modified Poisson regression model). Among those who met friends or acquaintances less than

once a week in 2016, Internet use for communication was associated with a statistically significant increase in meeting friends or acquaintances more than once a week in 2019 (CIR: 1.20, 95% CI [1.04,1.39], $p = .014$, reference: older adults who did not use the Internet for communication).

Among those who met friends or acquaintances more than once a week in 2016, Internet use for communication was not associated with a statistically significant increase in meeting friends or acquaintances more than once a week in 2019 (CIR: 1.05, 95% CI [0.97,1.13], $p = .215$).

Table 4. Associations Between the Purposes of internet Use in 2016 and Frequency of Meeting Friends or Acquaintances in 2019, Stratified by Frequency of Interaction with Friends and Acquaintances at Baseline (Modified Poisson Regression Model).

I performed analyses among those who reported an increase in the number of friends and acquaintances they met in a month from 2016 to 2019. I found no association between Internet use for communication in 2016 and an increase in the number of friends or acquaintances the respondents met in a month from 0 to more than 1 in 2019 (CIR: 1.17, 95% CI [0.87, 1.57], $p = .302$, reference: older adults who did not use the Internet for communication). However, an association was found between Internet use for communication in 2016 and an increase in the number of friends or acquaintances the respondents met in a month in 2019 from less than 2 to more than 3 (CIR: 1.23, 95% CI [1.03, 1.46], $p = .022$), from less than 5 to more than 6 (CIR: 1.32, 95% CI [1.14, 1.53], $p = <.001$), and from less than 9 to more than 10 (CIR: 1.40, 95% CI [1.21,1.64], $p = <.001$), respectively. Furthermore, I performed analyses among those who did not report a decrease in the number of friends and acquaintances they met in a month from 2016 to 2019. I found no association between Internet use for communication in 2016 and not decreasing the number of friends and acquaintances respondents met in a month in 2019 less than 1 (CIR: 1.03, 95% CI [0.98, 1.08], $p = .335$). I found an association between internet use for communication in 2016 and not decreasing the number of friends and acquaintances respondents met in a month in 2019 less than 3 (CIR: 1.06, 95% CI [1.00, 1.13], $p = .037$), less than 6 (CIR: 1.11, 95% CI [1.03, 1.21], $p = .008$) and

less than 10 (CIR: 1.11, 95% CI [1.00, 1.23], $p = .042$), respectively (Supplemental Table 2).

Another sensitivity analysis of the ordinal logistic regression model showed a positive association between Internet use for communication in 2016 and the frequency of FFC with friends or acquaintances in 2019 (Coefficient: 0.21; 95% CI = [0.12, 0.30], $p = <.001$) (Supplemental Table 3).

Discussion

I found that Internet use for communication with friends or family in 2016 increased the FFC with friends or acquaintances in 2019, especially among those who had a low frequency of FFC with friends or acquaintances prior to 2016. The results were consistent with previous studies showing that Internet use for communication was associated with improved social relationships (Cotten et al., 2013; Ibarra et al., 2020; Szabo et al., 2019). My study is valuable because I have demonstrated the potential of Internet use for communication to increase FFC in Asia.

I considered two mechanisms by which Internet use for communication increases FFC among older adults. The first is the effect of Internet use for communication. Online chat room discussions reduce the psychosocial burden of FFC and facilitate communication (Ho & McLeod, 2008). The use of social media platforms, such as those for video calling and email, is associated with increased social contact, including FFC and non-FFC (Zhang et al., 2020). The second is Internet literacy among older adults (Ministry of Internal Affairs and Communications, 2022). Older adults make active attempts to use simple and accessible communication technologies (Ibarra et al., 2020). Older adults are willing to make an effort to learn and use the Internet if they recognize its usefulness in achieving their life goals (Joshi et al., 2020). The more participants used the Internet for communication, the greater the benefits would be.

Internet use for communication may be effective, especially among those who have a low frequency of FFC. Internet use for communication can alleviate intra-individual problems as it reduces social isolation among older adults by connecting them to the outside world, providing social support, helping them engage in activities of interest, and increasing their confidence (Chen & Schulz, 2016).

It also alleviates inter-individual problems as individuals overcome social and spatial barriers (Winstead et al., 2013). Moreover, it alleviates community problems as individuals deepen existing relationships (Cornejo et al., 2013). Overall, Internet use for communication can break the vicious circle of declining social relationships (Fokkema & Knipscheer, 2007).

My study showed that using social networking services was not associated with increased FFC with friends or acquaintances. The following could be some possible reasons. First, only 13.8% of Internet users in my study used social networking services, which may have resulted in insufficient statistical power. Second, Internet use for communication and social networking services overlaps and cannot be completely separated. Third, existing social networking service applications (e.g., Facebook, Twitter) mainly target the younger generation and do not take into account the needs of older adults (Thangavel et al., 2022). Fourth, the impact of social networking services on FFC is controversial: in an observational study, problematic social networking service use was associated with increased perceptions of social isolation among older adults (Meshi et al., 2020). Social networking service usage for more than 1 hour per day is associated with reduced health among older adults (Habibi et al., 2021).

My study has several limitations. First, selection bias could not be completely ruled out. Participants were expected to be relatively healthy compared to non-participants of the same age. In addition, non-respondents were expected to have declining physical and mental function and to include socially isolated older adults (Colsher & Wallace, 1989). Second, I could not fully determine the causality of the associations. Although I controlled for reverse causality by stratifying the frequency of FFC at baseline and adjusting for several potential confounders, there may still be unmeasured confounders. Third, the type of online communication was not identified. Some may talk online, whereas others may send emails or messages or use the chat function on social networking services. It remains unclear whether there are specific types of online communication that can increase the frequency of FFC. Fourth, questions about social networking services were related to the application name and not to the content of the service. Furthermore, it is important to examine usage rates and

the content of social networking service applications in each country. The most commonly used social networking service application in Japan is LINE (Ministry of Internal Affairs and Communications, 2022), which is mainly used for chatting and telephone/video calls. A cross-sectional survey performed in Japan in 2016 (Ministry of Internal Affairs and Communications, 2016) showed that the usage rate of LINE among older adults aged 60–69 years was only 23.8%. As the survey population in this study was over 65 years of age and the usage rate could be even lower, the effect on the usage rate of the participants in my study is expected to be small.

Conclusion

I used longitudinal data from many municipalities across Japan in 2016 and 2019 to investigate the relationships between the purpose of Internet use and the frequency of FFC with friends or acquaintances more than once a week. The results showed that Internet use for communication with family and friends increased FFC with friends or acquaintances, especially among those whose frequency of FFC with friends or acquaintances was lower in 2016. Similar findings were not observed when the Internet was used for other purposes, including social networking services. The results suggest that Internet use for communication other than social networking services may be a useful tool to promote FFC and prevent social isolation in older adults who are less likely to interact with others.

Figure 1. Flow Chart of Participants and Inclusion/Exclusion Criteria.

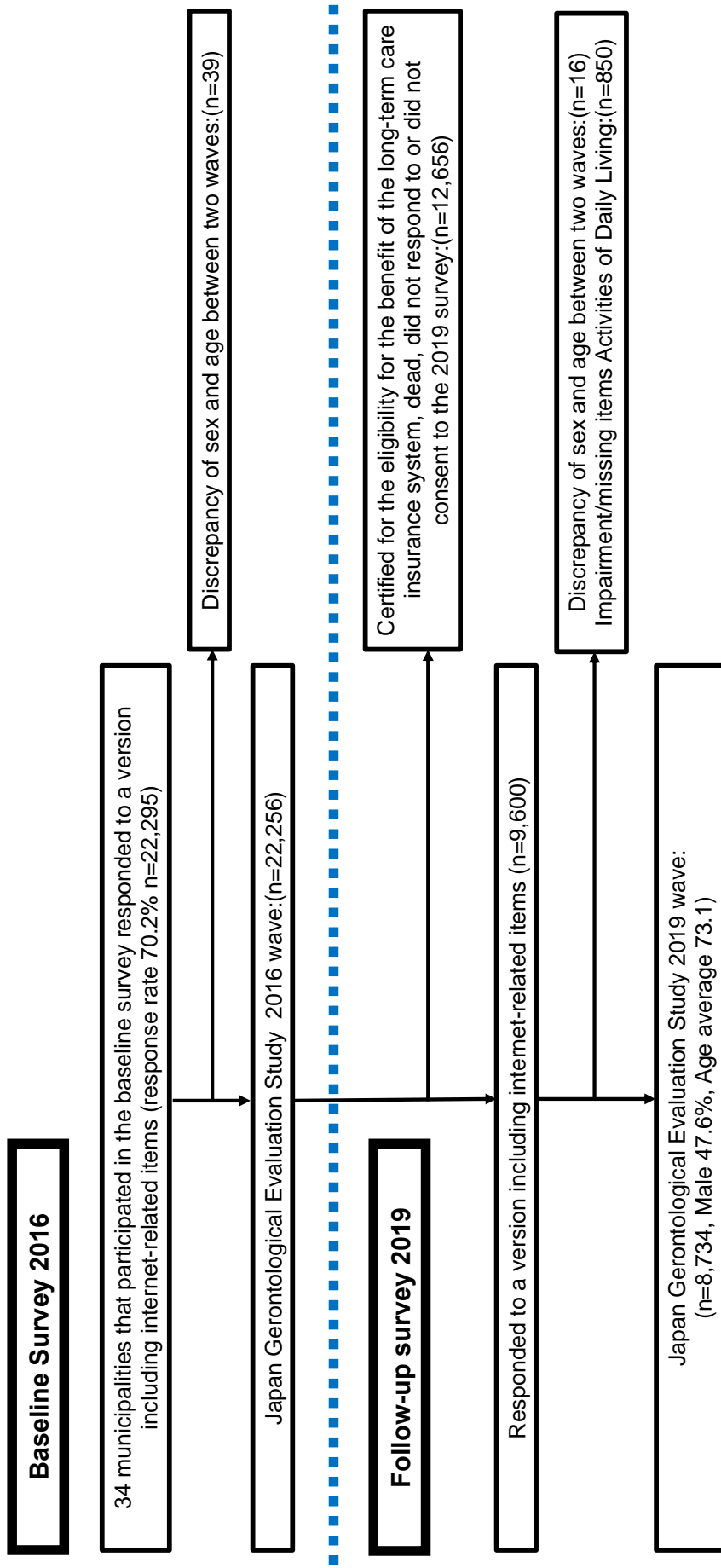


Table 1. Characteristics of Internet Nonusers and Users in Japan in 2016.

Variable	Internet non-users (n=3,414)		Internet users (n=4,777)	
	N	%	N	%
Meeting friends or acquaintances	1,738	52.0	2,172	46.0
Gender	1,833	53.7	2,437	51.0
Age	74.8	5.7	71.7	4.9
Instrumental activities of daily living	3,015	90.7	4,488	95.6
Equivalized household income	310	9.3	209	4.4
	223	8.3	626	14.9
	977	36.3	2,031	48.4
Educational attainment	1,488	55.4	1,537	6.6
	603	17.9	1,888	39.8
	1,428	42.3	2,173	45.8
	1,344	39.8	684	14.4
Occupational status	756	26.9	1,417	33.0
	1,835	65.2	2,682	62.4
	222	7.9	196	4.6
Subjective health	2,959	87.3	4,403	92.7
	431	12.7	345	7.3
Marital status	2,405	71.8	3,791	80.0
	821	24.5	822	17.3
	124	3.7	126	2.7
Living arrangement	1,041	32.3	1,226	26.6
	1,639	50.8	2,785	60.3
	547	17.0	604	13.1
Geriatric Depression Scale	2,232	77.4	3,597	86.0
	650	22.6	584	14.0
Comorbidity	2,677	80.9	3,591	77.7
Received emotional support	175	5.2	186	3.9
Purpose of internet usage			3,327	71.0
			646	13.8
			1,089	23.2
			1,870	39.9
			1,942	41.5
			1,034	22.1
			600	12.8

Note. Data were missing in 543 people for the variable internet use among participants at baseline (n = 8,734).

Table 2. Characteristics of Older Adults Using Internet for Each Purpose in Japan in 2016.

Variable	People using the Internet for						
	Communication with friends or family	LINE, Facebook, Twitter	Information collection about health	Information collection other than health	Mapping and traffic information	Purchasing goods and services	Banking, Stocks, Securities Trading
meeting friends or acquaintances	n=3,327	n=646	n=1,089	n=1,870	n=1,942	n=1,034	n=600
Gender	1,391 (42.3%)	396 (62.0%)	4,418 (51.5%)	944 (51.1%)	992 (51.5%)	538 (52.4%)	299 (50.4%)
Age	1,981 (59.5%)	354 (54.8%)	459 (42.1%)	669 (35.8%)	685 (35.3%)	342 (33.1%)	124 (20.7%)
Instrumental activities of daily living	71.7 (4.9)	70.2 (4.4)	71.1 (4.9)	71.2 (4.8)	71.3 (4.8)	71.0 (4.7)	71.6 (5.0)
	3,161 (96.6%)	623 (97.8%)	1,021 (95.2%)	1,758 (95.0%)	1,828 (95.2%)	978 (95.5%)	561 (94.8%)
equivalized household income	110 (3.4%)	14 (2.2%)	51 (4.8%)	92 (5.0%)	93 (4.8%)	46 (4.5%)	31 (5.2%)
	419 (14.3%)	112 (19.6%)	164 (16.7%)	311 (18.1%)	309 (17.4%)	161 (17.0%)	139 (24.8%)
Educational attainment	1,413 (48.3%)	278 (48.6%)	526 (53.5%)	919 (53.6%)	953 (53.6%)	500 (52.7%)	285 (50.9%)
	1,091 (37.3%)	182 (31.8%)	294 (29.9%)	486 (28.3%)	515 (29.0%)	288 (30.3%)	136 (24.3%)
	1,294 (39.1%)	304 (47.3%)	562 (52.1%)	986 (53.1%)	974 (50.4%)	551 (53.5%)	361 (60.4%)
	1,523 (46.0%)	282 (43.9%)	432 (40.0%)	751 (40.4%)	794 (41.1%)	395 (38.4%)	203 (33.9%)
Occupational status	491 (14.8%)	57 (8.9%)	85 (7.9%)	121 (6.5%)	166 (8.6%)	83 (8.1%)	34 (5.7%)
	924 (30.9%)	231 (39.3%)	298 (29.8%)	528 (30.7%)	602 (33.5%)	328 (34.1%)	183 (32.7%)
	1,902 (63.5%)	334 (56.8%)	670 (66.9%)	1,143 (66.5%)	1,139 (63.5%)	609 (63.2%)	362 (64.6%)
Subjective health	167 (5.6%)	23 (3.9%)	33 (3.3%)	49 (2.8%)	54 (3.0%)	26 (2.7%)	15 (2.7%)
Marital status	218 (6.6%)	32 (5.0%)	83 (7.6%)	132 (7.1%)	120 (6.2%)	61 (5.9%)	41 (6.9%)
	2,561 (77.7%)	512 (80.1%)	905 (83.4%)	1,588 (85.3%)	1,638 (84.7%)	878 (85.1%)	514 (86.2%)
	660 (20.0%)	111 (17.4%)	145 (13.4%)	223 (12.0%)	239 (12.4%)	117 (11.3%)	66 (11.1%)
	76 (2.3%)	16 (2.5%)	35 (3.2%)	51 (2.7%)	56 (2.9%)	37 (3.6%)	16 (2.7%)
Living arrangement	859 (26.7%)	141 (22.7%)	274 (25.7%)	451 (24.7%)	492 (26.1%)	268 (26.6%)	148 (25.3%)
	1,896 (59.0%)	385 (62.0%)	661 (62.1%)	1,187 (65.0%)	1,197 (63.6%)	634 (63.0%)	386 (66.0%)
Geriatric Depression Scale	460 (14.3%)	95 (15.3%)	130 (12.2%)	189 (10.3%)	193 (10.3%)	105 (10.4%)	51 (8.7%)
	2,541 (87.3%)	520 (88.3%)	860 (87.6%)	1,497 (88.8%)	1,565 (89.1%)	829 (88.4%)	488 (89.2%)
	369 (12.7%)	69 (11.7%)	122 (12.4%)	188 (11.2)	192 (10.9%)	109 (10.6%)	59 (10.8%)
Comorbidity	2,492 (77.4%)	467 (74.8%)	863 (81.5%)	1,398 (77.0%)	1,435 (76.1%)	763 (76.1%)	455 (77.9%)
received emotional support	115 (3.5%)	21 (3.3%)	38 (3.5%)	68 (3.7%)	63 (3.3%)	34 (3.3%)	14 (2.3%)

Note. Data were missing in 635 people for the variable internet use purposes among participants at baseline (n = 8,734).

Table 3. Associations Between Purposes of Internet Use in 2016 and Frequency of Meeting Friends or Acquaintances in 2019 (modified Poisson regression model).

	CIR	95%CI	P-Value
Communication with friends/family	1.08	1.00-1.16	0.027
LINE, Facebook, Twitter	1.05	0.94-1.18	0.369
Information collection about health	0.97	0.87-1.08	0.526
Information collection other than health	1.01	0.92-1.12	0.761
Mapping and traffic information	1.03	0.94-1.14	0.506
Purchasing goods and services	1.01	0.90-1.12	0.927
Banking/Stocks/Securities Trading	1.01	0.89-1.15	0.865

Note. Controlled for the frequency of meeting friends, age, gender, instrumental activities of daily living, marital status, living arrangement, equivalized income, educational attainment, current working, self-rated health, depression, and emotional social support. CIR = cumulative incidence ratio; CI = confidence intervals.

Table 4. Associations Between the Purposes of Internet Use in 2016 and Frequency of Meeting Friends or Acquaintances in 2019, Stratified by Frequency of Interaction with Friends and Acquaintances at Baseline (modified Poisson regression model).

	(1)				(2)				
	CIR	95%CI	P-Value	CIR	95%CI	P-Value	CIR	95%CI	P-Value
Communication with friends/family	1.20	1.04-1.39	0.014	1.05	0.97-1.13	0.215			
LINE, Facebook, Twitter	1.09	0.83-1.43	0.542	1.04	0.92-1.18	0.511			
Information collection about health	0.91	0.72-1.17	0.470	0.98	0.87-1.10	0.722			
Information collection other than health	0.93	0.76-1.14	0.476	1.04	0.94-1.16	0.436			
Mapping and traffic information	1.02	0.83-1.25	0.882	1.04	0.93-1.15	0.527			
Purchasing goods and services	1.00	0.79-1.26	0.974	1.01	0.89-1.14	0.909			
Banking/Stocks/Securities Trading	1.03	0.78-1.35	0.842	1.00	0.87-1.16	0.948			

Note. Controlled for the frequency of meeting friends, age, gender, instrumental activities of daily living, marital status, living arrangement, equivalized income, educational attainment, current working, self-rated health, depression, and emotional social support. CIR = cumulative incidence ratio; CI = confidence intervals. (1)=meeting friends or acquaintances less than once a week at baseline. (2)=meeting friends or acquaintances more than once a week at baseline.

Supplementary Table 1. Associations Between The interaction of Frequency of Meeting Friends or Acquaintances at Baseline × Purposes of Internet Use on Frequency of Meeting Friends or Acquaintances at three-year follow-up survey (modified Poisson regression model).

	CIR	95%CI	P-Value
Frequency of Meeting Friends or Acquaintances at Baseline × Communication with friends/family	0.85	0.73-1.00	0.045
Frequency of Meeting Friends or Acquaintances at Baseline × LINE, Facebook, Twitter	0.93	0.70-1.23	0.609
Frequency of Meeting Friends or Acquaintances at Baseline × Information collection about health	1.10	0.88-1.38	0.402
Frequency of Meeting Friends or Acquaintances at Baseline × Information collection other than health	1.11	0.93-1.33	0.235
Frequency of Meeting Friends or Acquaintances at Baseline × Mapping and traffic information	1.05	0.88-1.25	0.613
Frequency of Meeting Friends or Acquaintances at Baseline × Purchasing goods and services	1.05	0.84-1.32	0.667
Frequency of Meeting Friends or Acquaintances at Baseline × Banking/Stocks/Securities Trading	1.03	0.77-1.37	0.844

Note. Controlled for the frequency of meeting friends, age, gender, instrumental activities of daily living, marital status, living arrangement, equivalized income, educational attainment, current working, self-rated health, depression, and emotional social support. CIR = cumulative incidence ratio; CI = confidence intervals.

Supplementary Table 2. Associations Between Internet Usage for Communication in 2016 and number of friends or acquaintances in 2019 (modified Poisson regression model).

	(1)				(2)			
	CIR	95% CI	p-value	CIR	95% CI	p-value	p-value	
meeting more than 1 friends or acquaintances per month	1.17	0.87-1.57	0.302	1.03	0.98-1.08	0.335		
meeting more than 3 friends or acquaintances per month	1.23	1.03-1.46	0.022	1.06	1.00-1.13	0.037		
meeting more than 6 friends or acquaintances per month	1.32	1.14-1.53	<0.001	1.11	1.03-1.21	0.008		
meeting more than 10 friends or acquaintances per month	1.40	1.21-1.64	<0.001	1.11	1.00-1.23	0.042		

Note. Controlled for the frequency of meeting friends, age, gender, instrumental activities of daily living, marital status, living arrangement, equivalized income, educational attainment, current working, self-rated health, depression, and emotional social support. CIR = cumulative incidence ratio; CI = confidence intervals. (1)=with a decrease in the number of friends and acquaintances they meet in a month in 2016. (2)=without a decrease in the number of friends and acquaintances they meet in a month in 2016.

Supplementary Table 3. Associations Between Internet Usage Purposes in 2016 and frequency of meeting friends or acquaintances in 2019 (multiple linear regression model).

	β	95%CI	P-Value
Communication with friends/family	0.14	0.07~0.20	<0.001
LINE, Facebook, Twitter	0.08	-0.03~0.19	0.136
Information collection about health	-0.05	-0.15~0.04	0.265
Information collection other than health	0.00	-0.08~0.08	0.966
Mapping and traffic information	0.02	-0.07~0.10	0.694
Purchasing goods and services	0.06	-0.04~0.15	0.244
Banking/Stocks/Securities Trading	0.03	-0.08~0.14	0.628

Note. Controlled for the frequency of meeting friends, age, gender, instrumental activities of daily living, marital status, living arrangement, equivalized income, educational attainment, current working, self-rated health, depression, and emotional social support. CIR = cumulative incidence ratio; CI = confidence intervals.

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