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Association between internet use and annual health checkups among older Japanese adults: propensity score-matched analysis, Japan gerontological evaluation study cross-sectional study 2016

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Abstract

Background The integration of the Internet into daily life has potential implications for public health, especially in promoting preventive healthcare measures like annual health checkups. This study explores the association between Internet use and the likelihood of participating in these checkups among older Japanese citizens.

Methods Participants aged 65 and older were randomly selected from 37 municipalities in Japan, ensuring they required no long-term care. Out of 24,313 responses to a postal questionnaire, 11,495 participants were deemed eligible for analysis, achieving a valid participation rate of 70.1%. We applied propensity score matching to balance Internet users and non-users, resulting in 6,504 matched cases. Poisson regression analysis was then used to adjust for demographic, socioeconomic, and behavioral variables that could act as potential confounders.

Results Our findings show that 55.1% of participants used the Internet several times a month, and among these, 63.5% had attended an annual health checkup in the preceding year. After adjusting for potential confounders, Internet users were found to be 9% more likely to participate in annual health checkups compared to non-users (95% Confidence Interval: 1.02–1.15).

Conclusions This study concludes that there is a positive association between Internet use and participation in annual health checkups among older individuals in Japan. The results suggest that Internet use may serve as a tool to promote preventive healthcare practices in older populations. However, the study underscores the need for further investigation to understand the underlying mechanisms of this association and to establish a causal relationship.

Keywords Internet, Annual health checkup, Gerontology

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Background

Since the enactment of the IT Basic Law in Japan in 2000, the government has been working on digitalization through various national strategies, such as the e-Japan Strategy. Significant progress has been made in developing optical fibers and other broadband services. According to the Ministry of Internal Affairs and Communications [1], the overall Internet usage rate in 2020 was 83.4%; nevertheless, there was a generational gap in the use of information and communication devices. Notably, a low usage rate (approximately 50%) [2] among older adults over 70 has been reported.

Even so, among older adults who are reluctant to use digital devices [3], previous studies have shown that Internet use is associated with positive health-related outcomes, such as well-being and activities of daily living [4–6]. Other studies indicate that Internet users have better life satisfaction, well-being [4], and less social isolation [7]. Moreover, as a promoting factor for physically active aging, preventing depression, decreasing life stress, and improving quality of life, Internet use can facilitate daily life in basic activities such as shopping and management [3]. Those results may indicate that the Internet will further improve public health and can aid in promoting health and well-being.

The Japanese government has taken the initiative to conduct a wide range of annual health checkups and cancer screenings based on the Health Care Law for the Elderly, enacted in 1982. The primary purpose of annual health checkups is to detect people aged 40–74 years with a high risk for malignant neoplasms, ischemic heart diseases, and other non-communicable diseases. They encourage the detection of diseases earlier and provide necessary health guidance, treatment, and rehabilitation to maintain and improve quality of life. The annual health checkup included physical examination, height and weight measurements, blood pressure, urinalysis, and blood tests. Many municipalities simultaneously offer cancer screening for stomach, lung, prostate, uterine, and breast cancer at low costs. Therefore, encouraging participation in annual health checkups for the target population is one of the most significant tasks of municipal offices in Japan.

Although the annual health checkup rate among the general Japanese population is relatively high (overall 73.3%) [8], the imbalance in participation rate between areas or age groups is a challenge for improving public health in Japan. For example, in 2019, the rate of persons aged 65 and over participating in annual health checkups in Tokyo was as high as 73.8%, while in the Kansai region, the rate was around 50% [8]. Therefore, studies have been conducted from various perspectives to increase the participation rate. Some studies have investigated the factors that promote participation in annual health checkups or cancer screening. For example, high educational background [9–11], the availability of medical institutions in the neighborhood, the convenience of the venue [11], being active in social networks, and having social support [10, 11] affect participation positively. In addition, socioeconomic factors such as high educational attainment, house ownership, and low equivalent household expenditure [11] or individuals' positive health beliefs are known promoting factors [12]. Although prior studies have consistently demonstrated a correlation between Internet use and health screenings [13], to our knowledge, no previous studies have investigated the association between Internet usage and participation in annual health checkups after propensity score matching for Internet use, especially among older adults. Previous studies have not fully adjusted confounding by indication; non-Internet users with older ages have social characteristics that differ from Internet users.

This study aimed to clarify the relationship between Internet use in older adults and participation in annual health checkups using a large-scale, population-based cohort study called the Japan Gerontological Evaluation Study (JAGES; https://www.jages.net/ [14].

Methods

Study participants and data collection

The study participants were obtained from cross-sectional data of the JAGES conducted in 2016. The JAGES is research [5, 14] that aims to create a scientific basis for preventive policies for healthy aging. This large-scale, population-based, collaborative study of voluntarily participating municipalities started in 1999 [5, 14]. The 2016 JAGES survey is a self-report questionnaire posted to community-dwelling older adults aged 65 and older and certified seniors without long-term care needs. The study participants were sampled from 39 municipalities in 18 prefectures out of the 47 total prefectures in Japan from 3 October 2016 to 5 December 2016, including an additional data collection in January 2017 [5, 6, 14–16]. Study participants were selected by random sampling from the municipal long-term care insurance subscriber list. In some municipalities, an all-inclusive survey was conducted (total target population: 279,661). Internet-related questionnaires were mailed to approximately one-nineth of total target population ($N=34,566$). Of which, 24,260 responded to the survey with a response rate of 70.2%. The study area is available on the JAGES website.

After excluding all participants with missing data for Internet use, annual health checkups, and other covariates, 11,495 (5,883 men and 5,612 women) were eligible for the analysis. (Data selection process is shown in Fig. 1.)

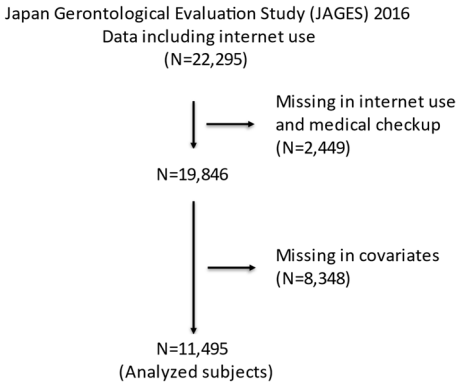

Fig. 1 Participants selection process

Dependent variable

The questionnaire about participation in the annual health checkup was "Have you ever had a checkup at a health center, your workplace, a medical institution, or another place?". The category was separated into two groups; "I had one within a year," "I had one sometime between 1 and 4 years ago", "I had one more than 4 years ago", and "I have never had one." We categorized "I had one within a year" as "Yes" and others as "No."

Independent variable

Internet use was evaluated using a subjective questionnaire: "Have you used the Internet or e-mail in the past year? If yes, please indicate how often." The responses were categorized into four groups. No, Yes (less than a few times a month), Yes (two to three times a week), Yes (almost every day). We categorized "No" as not using the Internet and the other three answers from "less than a few times a month" to "almost every day" as "Yes."

Covariates

Based on literature and theoretical considerations [3, 6], we selected several sociodemographic and health-related covariates for the propensity score calculation, including age, gender, education level, and household income [3, 6]. These factors are associated with reduced Internet accessibility among older adults. Additionally, we included employment status (never employed, retired, currently employed), marital status (married, single, or others), and living arrangements (living alone), as these variables can influence internet usage and health behaviors. The individual's Activities of Daily Living status was considered, as decreased functional capacity can impact Internet access [3]. Furthermore, we accounted for geographic location by considering population density differences between urban and rural areas, which affect broadband connectivity [6]. This comprehensive selection of covariates ensures effective control of potential confounding factors, providing a more accurate assessment of the relationship between Internet use and participation in annual health checkups.

Age, sex, income tertile, years of education, employment, and city size were included as confounding factors. Age was categorized into five groups at five-year intervals: 65–69, 70–74, 75–79, 80–84, and older. As for income tertile, we first calculated annual equivalized income by using household income and the number of residents and categorized it into tertiles: JPY 1.25 million per year and below as "Low"; 1.25–3.06 million per year as "Middle"; and 3.62 million per year and higher as "High." Educational history was assessed as years of schooling (0–9, 10–12, or ≥ 13 years), and employment was defined as the longest job by asking, 'What was the job that you did for most of your working life?' Responses were categorized into five groups: professional, managerial/clerical, sales/manual, other, and unemployed. The city size was defined by the population density of the inhabitable land area and categorized into three groups: the municipality with 1,500 residents /1 km^2 or more as "Urban," 1,000–1,499 as "Sub-urban," and less than 1,000 as "Rural." [1] [6].

Marital status was categorized as married, widowed, divorced, unmarried, or other. The number of acquaintances seen within a month was examined by the question "how often you meet with family or friends in a month" and categorized into 0 times, 1–2 times/month, 3–5 times /month, 6–9 times /month and 10 ≤ times/month.

Lifestyle factors included smoking status (current smoker, ex-smoker, or non-smoker), alcohol intake (current drinker/ex-drinker or non-drinker), time spent walking per day (< 30 min or ≥ 30 min) [16], meat/fish intake per day, and fruit/vegetable intake per day. Whether each participant had a past medical history was also considered. Past medical history was defined as the presence of one or more of the following diseases: hypertension, cardiovascular disease, cerebrovascular disease, hyperlipidemia, diabetes mellitus, cancer, gastrointestinal disease, liver disease, respiratory disease, osteoporosis, joint disease, psychiatric disease, vision disorder, hearing disorder, elimination disorder, and sleep disorder. The 15-item short form of the Geriatric Depression Scale (GDS) (Japanese version) was used to assess depressive symptoms (no depression (0–4), moderate depression (5–9), and depression (10 +) [17–19].

Statistical analysis

We used Student's t-test and chi-squared test for continuous and categorical data to compare baseline characteristics between Internet users and non-users.

Multicollinearity was not observed in the selected covariates.

We established multivariate models to estimate the association between internet use and participation in annual health checkups, adjusting for all potential confounders identical to the ones used in propensity score matching analysis. The model was adjusted for age, sex, marital status, social networks, health behaviors, medical history, and depressive symptoms. Additionally, we calculated the propensity score for each individual to minimize the possibility that Internet users and non-users were demographically and socioeconomically different. To calculate the propensity scores, we included the 16 potential confounding factors in Table 1 in a standard logistic regression model (C-statistic = 0.80). We used one-to-one calliper (0.01) matching with no replacement to match the treatment and control groups (i.e., Internet users vs. non-users) using the Stata command "psmatch2." The standardized difference was 0.005 below 0.1 for all variables. We calculated the prevalence ratios (PRs) and 95% confidence intervals (CIs) using Poisson regression with propensity score matching to examine the association between Internet usage and participation in annual health checkups. We used prevalence ratios from Poisson regression because they provide a more interpretable measure of relative risk in cross-sectional studies, especially when the outcome is common. This approach avoids the potential overestimation of risk associated with odds ratios. The analysis used Stata SE version 15.0 (Stata Corp, College Station, TX, USA).

Results

A total of 11,495 participants (5,883 men (51.2%) and 5,612 women (48.8%)) were included in the analysis (Fig. 1). Of these participants, 6,338 (55.5%) were Internet users. In addition, 7,303 (63.5%) patients participated in annual health checkups within a year. Among Internet users, 68.5% participated in annual health checkups, whereas 57.4% did not ($p < 0.001$). Concerning the potential covariates between Internet users and non-users, our study participants showed significantly different characteristics, except for sex (Table 1). After propensity score matching, 3,252 cases for each arm were matched. No significant differences were found in the characteristics between users and non-users. 65.5% of Internet users participated in annual health checkups within a year, while 60.3% of non-Internet users participated in annual health checkups within a year (Table 1).

Table 2 shows the prevalence ratio (PR) for participation in annual health checkups before and after propensity score matching and adjustment for possible confounding factors. Before matching, the PR for the involvement in annual health checkups among Internet users in the crude model was 1.19 (95% CI: 1.14–1.25), and after the additional adjustment for socio-demographic factors in the multivariate model, the PR decreased to 1.08 (95% CI: 1.03–1.14) (Table 2) but remained significant. The PR of Internet users after propensity score matching was 1.09 (95% CI: 1.02–1.15) compared to non-users (Table 2). Moreover, we performed a sensitivity analysis, and the results are presented in APPENDIX 2 and 3. The crude percentage of the four categories is shown in APPENDIX 1.

Discussion

This study examined the association between Internet use and participation in annual health checkups among older Japanese adults using cross-sectional data with propensity score matching. The main findings are as follows: Internet users were more likely to participate in annual health checkups than non-Internet users, and a higher participation rate in annual health checkups was observed even after propensity score matching. This is the first study to examine the association between Internet use and annual health checkup visits using propensity score matching.

Previous research has consistently recorded a positive association between Internet use and health screenings [13]. Our study, using propensity score matching, showed the same direct relationship. The potential mechanism may be that the Internet is the primary information source for modern people, providing daily news and health information for older people [2, 20, 21]. For example, previous studies have shown that Internet use is associated with cancer screening, such as receiving a prostate exam, colorectal cancer screening, and mammography [22, 23]. It would be possible to anticipate that one's Internet motive would be to seek preventative health practices [22], including consistent participation in annual health checkups. In addition, Internet users are more likely to see information about their health and the schedule of annual health checkups through the Internet.

In this study, the positive correlation between Internet use and annual health checkups remained in our multivariate model after adjusting for social networks. Previous studies have shown that those with broad social networks could be one of the motivations to participate in annual health checkups [10, 24]. Moreover, it is known that groups that utilize the Internet to find a lot of health information are exposed to much other information, not only health information [21]. It can also be assumed that people with solid social networks and interactions with others are happier [24, 25] than those without networks and interactions. Also, in the present cross-sectional analysis, we could not exclude the possible mechanism; Internet use expanded the network and thus promoted

Table 1 Characteristics of participants of the standard and after propensity score matching

Internet use		Crude			After PSM		
		Number of people (%)			Number of people (%)		
		Yes	No		Yes	No	
		(*N* = 6,338)	(*N* = 5,157)	p-value[a]	(*N* = 3,252)	(*N* = 3,252)	*p*-value[a]
Received a medical checkup within a recent year	Yes	4342 (68.5%)	2961 (57.4%)	< 0.001	2129 (65.5%)	1962 (60.3%)	< 0.001
	No	1996 (31.5%)	2196 (42.6%)		1123 (34.5%)	1290 (39.7%)	
Age, years (IQR in PSM model)	65–59	2915 (46.0%)	1165 (22.6%)	< 0.001	1025 (31.5%)	1038 (31.9%)	0.77
	70–74	1923 (30.3%)	1367 (26.5%)		1012 (31.1%)	1024 (31.5%)	
	75–79	1011 (16.0%)	1323 (25.7%)		780 (24.0%)	746 (22.9%)	
	80–84	395 (6.2%)	829 (16.1%)		335 (10.3%)	353 (10.9%)	
	85-	94 (1.5%)	473 (9.2%)		100 (3.1%)	91 (2.8%)	
Sex	Male	3298 (52.0%)	2585 (50.1%)	0.042	1630 (50.1%)	1688 (51.9%)	0.15
	Female	3040 (48.0%)	2572 (49.9%)		1622 (49.9%)	1564 (48.1%)	
Income quartile[b]	Poor	1571 (24.8%)	2243 (43.5%)	< 0.001	1179 (36.3%)	1145 (35.2%)	0.42
	Moderate	2191 (34.6%)	1548 (30.0%)		1109 (34.1%)	1095 (33.7%)	
	Rich	2576 (40.6%)	1366 (26.5%)		964 (29.6%)	1012 (31.1%)	
Years of education	Other	18 (0.3%)	23 (0.4%)	< 0.001	14 (0.4%)	15 (0.5%)	0.57
	-9yrs	883 (13.9%)	2073 (40.2%)		810 (24.9%)	820 (25.2%)	
	10-12yrs	2920 (46.1%)	2154 (41.8%)		1673 (51.4%)	1621 (49.8%)	
	13-yrs	2517 (39.7%)	907 (17.6%)		755 (23.2%)	796 (24.5%)	
Employment	Professional	1451 (22.9%)	826 (16.0%)	< 0.001	623 (19.2%)	635 (19.5%)	0.94
	Manager/Clerical	2409 (38.0%)	1068 (20.7%)		858 (26.4%)	880 (27.1%)	
	Manual/Service	1853 (29.2%)	2317 (44.9%)		1330 (40.9%)	1305 (40.1%)	
	Other	374 (5.9%)	532 (10.3%)		264 (8.1%)	255 (7.8%)	
	Unemployed	251 (4.0%)	414 (8.0%)		177 (5.4%)	177 (5.4%)	
Marital status	Married	5152 (81.3%)	3696 (71.7%)	< 0.001	2480 (76.3%)	2501 (76.9%)	0.94
	Widowed	792 (12.5%)	1044 (20.2%)		529 (16.3%)	512 (15.7%)	
	Separated/Unmarried	383 (6.0%)	381 (7.4%)		232 (7.1%)	228 (7.0%)	
	Others	11 (0.2%)	36 (0.7%)		11 (0.3%)	11 (0.3%)	
Self-rated health	Exellent	1098 (17.3%)	582 (11.3%)	< 0.001	423 (13.0%)	437 (13.4%)	0.84
	Good	4606 (72.7%)	3637 (70.5%)		2390 (73.5%)	2377 (73.1%)	
	Fair	556 (8.8%)	784 (15.2%)		371 (11.4%)	378 (11.6%)	
	Poor	78 (1.2%)	154 (3.0%)		68 (2.1%)	60 (1.8%)	
City size[c]	Urban	4576 (72.2%)	3095 (60.0%)	< 0.001	2103 (64.7%)	2151 (66.1%)	0.46
	Sub-urban	828 (13.1%)	856 (16.6%)		510 (15.7%)	489 (15.0%)	
	Rural	934 (14.7%)	1206 (23.4%)		639 (19.6%)	612 (18.8%)	
The number of acquaintances seen within a month	0/month	397 (6.3%)	645 (12.5%)	< 0.001	290 (8.9%)	298 (9.2%)	1.00
	1–2/month	911 (14.4%)	1128 (21.9%)		597 (18.4%)	595 (18.3%)	
	3–5/month	1454 (22.9%)	1345 (26.1%)		846 (26.0%)	851 (26.2%)	
	6–9/month	918 (14.5%)	628 (12.2%)		438 (13.5%)	436 (13.4%)	
	10 ≤ /month	2658 (41.9%)	1411 (27.4%)		1081 (33.2%)	1072 (33.0%)	
Alcohol consumption	Drinker	2895 (45.7%)	1804 (35.0%)	< 0.001	1252 (38.5%)	1264 (38.9%)	0.73
	Ex-drinker	598 (9.4%)	631 (12.2%)		364 (11.2%)	380 (11.7%)	
	None	2845 (44.9%)	2722 (52.8%)		1636 (50.3%)	1608 (49.4%)	
Smoking consumption	Smoker	684 (10.8%)	639 (12.4%)	< 0.001	394 (12.1%)	412 (12.7%)	0.63
	Ex-smoker	2105 (33.2%)	1538 (29.8%)		998 (30.7%)	1016 (31.2%)	
	None	3549 (56.0%)	2980 (57.8%)		1860 (57.2%)	1824 (56.1%)	
Walking time, min/day	< 30	1395 (22.0%)	1537 (29.8%)	< 0.001	829 (25.5%)	826 (25.4%)	0.93
	30 ≤	4943 (78.0%)	3620 (70.2%)		2423 (74.5%)	2426 (74.6%)	

Table 1 (continued)

Internet use		Crude			After PSM		
		Number of people (%)			Number of people (%)		
		Yes	No		Yes	No	
		(*N* = 6,338)	(*N* = 5,157)	p-value[a]	(*N* = 3,252)	(*N* = 3,252)	*p*-value[a]
Meat/fish intake, servings/day	1 ≤ /day	3558 (56.1%)	2399 (46.5%)	< 0.001	1606 (49.4%)	1630 (50.1%)	0.55
	< 1/day	2780 (43.9%)	2758 (53.5%)		1646 (50.6%)	1622 (49.9%)	
Fruit/vegetable intake, servings/day	1 ≤ /day	5298 (83.6%)	3980 (77.2%)	< 0.001	2581 (79.4%)	2605 (80.1%)	0.46
	< 1/day	1040 (16.4%)	1177 (22.8%)		671 (20.6%)	647 (19.9%)	
Past medical history	No	1338 (21.1%)	886 (17.2%)	< 0.001	598 (18.4%)	609 (18.7%)	0.80
	Yes	4827 (76.2%)	4131 (80.1%)		2570 (79.0%)	2552 (78.5%)	
	Missing	173 (2.7%)	140 (2.7%)		84 (2.6%)	91 (2.8%)	
GDS15[d]	0–4	5322 (84.0%)	3717 (72.1%)	< 0.001	2545 (78.3%)	2557 (78.6%)	0.78
	5–9	814 (12.8%)	1081 (21.0%)		544 (16.7%)	544 (16.7%)	
	10–15	202 (3.2%)	359 (7.0%)		163 (5.0%)	151 (4.6%)	

[a] Chi-squared test for whether receiving medical checkup within a year or not

[b] Income tertiles: JPY 1.25 million per year and below as "Low"; 1.25–3.06 million per year as "Middle"; and 3.62 million per year and higher as "High"

[c] Population density (number of people/km^2)

[d] Geriatric depression scale

participation in annual health checkups. The possible underlying effect could explain why the positive association remained even after adjusting for social networks.

Adjusting for health behaviors, such as smoking, drinking alcohol, and eating vegetables/fruits, did not change the positive correlation. Numerous previous studies have revealed that health behaviors throughout one's life affect the tendency to participate in annual health checkups [26–28]. Hiramatsu et al. [28] found that those with low activity capacity and poor subjective health and GDS had lower participation rates in annual health checkups than those with such capacity. In addition, although some studies showed that socioeconomic status is inversely related to the tendency to participate in annual health checkups, Ashida et al. [28] showed that future plan or enjoyment could also positively influence the tendency to participate in annual health checkups even among low socioeconomic status groups and older populations. Interestingly, as mentioned above, older adults using the Internet may help improve their life satisfaction and well-being [4–6, 29]. This aspect of the population of Internet users may indicate that Internet use is not only explained by health behaviors.

Surprisingly, adjustment for medical history or depression did not change the results. In recent years, the relationship between depression and participation in annual health checkups is quite evident: depressed individuals are less likely to participate in annual health checkups [28, 30], while those with a past medical history, not necessarily mental diseases, are more likely to participate in annual health checkup [29]. Therefore, we adjusted for depressive tendencies and medical history as confounding factors. However, even after adjustment, the association remained that non-Internet users were more likely to have difficulty participating in annual health checkups than Internet users. The reasons for not using the Internet are assumed not only because of age or past medical history, including mental health [28–30], but also because they may not be good at asking others for help; that is, social relationships may be more fragile among non-Internet users than among users. Considering that Internet users have a lower risk of having depression [5], a higher subjective sense of health [5, 6], more extraordinary ability in activities of daily living [5], and better social relationships [4, 15], non-Internet users are a proxy population for those who cannot utilize health-related systems such as annual health checkups [27, 28]. Regardless of depression or the existence of past medical history, non-Internet users may be associated with not participating in annual health checkups.

This study had some limitations. One is its cross-sectional nature. Due to the cross-sectional method, reverse causation could be possible; participation in annual health checkups promotes Internet use. Second, since our data were not from all prefectures of Japan, it could be challenging to generalize the results. However, the study population was randomly sampled from 39 municipalities from north to south, including urban, suburban, and rural areas in Japan. Thus, the results can somehow depict the reality of older Japanese adults. In addition, a

Table 2 Prevalence ratios (95% confidence intervals) for participation in annual health checkups before and after propensity score matching

Characteristics		Crude Model (*N* = 11,495)	Multivariate Model (*N* = 11,495)	PSM[a] (*N* = 6,504)
Internet use (ref: Non-Internet user)	Internet user	1.19 (1.14–1.25)	1.08 (1.03–1.14)	1.09 (1.02 – 1.15)
Income tertile[b] (ref: rich)	Poor	—	0.93 (0.88–1.00)	—
	Moderate	—	0.96 (0.91–1.02)	—
Years of education (ref: 13yrs-)	≤ 9 yrs	—	1.01 (0.94–1.09)	—
	10–12 yrs	—	1.01 (0.95–1.07)	—
	Others	—	1.17 (0.81–1.68)	—
Employment (ref: Professional)	Manager/Clerical	—	1.02 (0.96–1.10)	—
	Manual/Service	—	1.01 (0.94–1.08)	—
	Other	—	1.01 (0.91–1.12)	—
	Unemployed	—	0.99 (0.88–1.11)	—
Marital status (ref: Married)	Widowed	—	1.08 (1.01–1.16)	—
	Separated/Unmarried	—	0.98 (0.89–1.08)	—
	Others	—	0.67 (0.42–1.08)	—
Self-rated health (ref: Excellent)	Good	—	0.92 (0.87–0.99)	—
	Fair	—	0.85 (0.77–0.94)	—
	Poor	—	0.76 (0.62–0.94)	—
City size[c] (ref: Urban)	Sub-urban	—	1.03 (0.96–1.10)	—
	Rural	—	1.06 (1.00–1.13)	—
The number of acquaintances seen within a month (ref: 0/month)	1–2/month	—	1.02 (0.92–1.13)	—
	3–5/month	—	1.10 (1.00–1.22)	—
	6–9/month	—	1.16 (1.04–1.29)	—
	≥ 10/month	—	1.18 (1.06–1.29)	—
Alcohol consumption (ref: Drinker)	Ex-drinker	—	0.90 (0.83–0.99)	—
	None	—	0.99 (0.93–1.05)	—
Walking time, min/day (ref: < 30)	≥ 30	—	1.07 (1.01–1.13)	—
Meat/fish intake, servings/day (ref: ≥ 1/day)	< 1/day	—	0.96 (0.91–1.01)	—
Fruit/vegetable intake, servings/day (ref: 1 = < /day)	< 1/day	—	0.89 (0.83–0.95)	—
Past medical history (ref: No)	Yes	—	1.20 (1.12–1.27)	—
	Missing	—	1.08 (0.93–1.26)	—
GDS15[d] (ref: 0–4)	5–9	—	0.95 (0.89–1.01)	—
	10–15	—	0.83 (0.72–0.94)	—

[a] PSM, propensity score matching

[b] Income tertiles: JPY 1.25 million per year and below as "Low"; 1.25–3.06 million per year as "Middle"; and 3.62 million per year and higher as "High"

[c] Population density (number of people/km^2)

[d] Geriatric depression scale

selection bias should be mentioned. In 2016, for those aged 20 years and older, 67.3% had participated in annual health checkups [8]. In this study, 61% of the participants underwent annual health checkups. The reason for this difference may be that more than 90% of the study population had a family doctor who routinely checked their health by taking blood samples, and many of them did not bother to participate in annual health checkups organized by their municipalities. Since the present study population has a group with more than 90% of the population having a family doctor, it is possible that our population could recognize their health status without annual health checkups. Likewise, unmeasured confounding factors could affect the results. For example, we recognize that regional differences in healthcare access, socioeconomic factors, and cultural attitudes toward health

checkups could influence these results. Therefore, while our findings provide valuable insights, they should be interpreted cautiously and not be assumed to apply universally across Japan's older population. However, the relatively large sample size and propensity-matched analysis could be considered a study's strength. As a result, we suggest that Internet usage can be one factor that promotes participation in annual health checkups.

Conclusions

We found a positive relationship between Internet use and participation in annual health checkups among older Japanese adults. Encouraging Internet accessibility among older adults may promote participation in annual health checkups. Future longitudinal and interventional studies should clarify whether promoting Internet use will create a positive attitude towards participation in annual health checkups and improve health behaviors.

Abbreviations

CI	Confidence Interval
GDS	Geriatric Depression Scale
IT	Information Technology
JAGES	Japan Gerontological Evaluation Study
PR	Prevalence Ratio

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

Yuya Ando: Conceptualization, Methodology, Formal analysis, Writing – original draft. Yuiko Nagamine: Conceptualization, Methodology, Formal analysis, Writing – original draft, funding acquisition. Atsushi Nakagomi: Methodology, Writing – review & editing. Chie Koga: Writing – review & editing. Naoki Kondo: Writing – review & editing. Kazushige Ide: Writing – review & editing. Katsunori Kondo: Investigation, Resources, Writing – review & editing, Funding acquisition. Takeo Fujiwara: Methodology, Writing – review & editing.

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Availability of data and materials

The data underlying this study are from the JAGES and contain sensitive information. The data for research purposes are available upon request. Requests for the data can be made to dataadmin.ml@jages.net.

Declarations

Ethics approval and consent to participate

The JAGES protocol was approved by the Ethics and Conflict of Interest Committee of the National Center for Geriatrics and Gerontology in Japan (approval number: 992) and the Ethics Review Committee of the Graduate School of Medicine, Chiba University (approval number: 2493). Written informed consent was assumed with the voluntary return of the questionnaire. The ethics committees approved the use of assumed consent upon return of the questionnaire. All methods were performed in accordance with the relevant guidelines and regulations.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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