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Association of COVID-19 information media, providers, and content with vaccine uptake among Tokyo residents

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ABSTRACT

To elucidate appropriate ways to induce behavior that prevents the spread of infection, we examined the association between COVID-19 vaccination and COVID-19-related information after more than 85% of the population had been vaccinated. Nonprobability quota sampling was used to recruit 2000 Tokyo residents as participants. The association between previous vaccine uptake and how much people thought they were affected by each of nine media, seven providers, and four content types of information was assessed using an online survey form. Subjective influence was assessed, and order logistic regression analyses were performed. We further calculated standardized partial regression coefficients for the independent variables. The results showed that while people did not think they were strongly affected by any COVID-19 information, significant positive associations between 9 of 20 variables, and significant negative associations between 7 of 20 variables were observed with vaccine uptake. The regression analysis involving the interaction terms between independent variables and sex showed a significant association between vaccine uptake and only daily conversation. Simple slope analysis showed a stronger positive association for females than for males. Regression analysis with interaction terms between each independent variable and age showed a significant association between vaccine uptake and print newspapers, social networking services, prefectural governors, family/relatives, accessibility, side effects, and supply visibility. Simple slope analysis also showed that the positive association between the subjective influence of newspapers and vaccine uptake was observed only for older people (≥69 years), and that of prefectural governors was more significant for older than younger people (≤32 years). In contrast, the trustworthy information provided by family/relatives was positively associated with vaccine uptake only for younger people. These results suggest that careful consideration must be given to the differences in age and sex to provide appropriate information that motivates Tokyo residents to receive vaccination during COVID-19 pandemic.

Introduction

After Coronavirus disease 2019 (COVID-19) had spread rapidly across the world by March 2020, the World Health Organization (WHO) declared a global pandemic that would lead to serious impacts on human health and society. In May 2023, the WHO declared the end of the COVID-19 pandemic. Over the past 3 years, about 800 million people worldwide were infected with COVID-19 and about 7 million people died. In Japan, about 34 million people were infected and about 75 thousand died. Without effective medicines or treatment, the government and the prefectural governor asked people to comply with preventive behaviors such as "wearing a mask" and "avoiding closed spaces, crowded places, and close-contact settings" [1–3]. Cross-sectional studies conducted in America, Asia, and Europe have shown the associations between multiple information sources and preventive behaviors for COVID-19 [4–9]. A longitudinal study on information usage and

Abbreviations: β, standardized partial regression coefficient; CI, confidence interval; OR, odds ratio; SD, standard deviation; SNS, social networking services; VIF, variance inflation factor.

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compliance with preventive behaviors showed that various information sources such as medical workers, professionals, the government, Twitter, news websites, and TV news were associated with a higher probability of compliance with multiple preventive behaviors for COVID-19 [10].

By the end of 2020, rapidly developed COVID-19 vaccines, such as the BNT162b2 (Pfizer-BioNTech) vaccine, mRNA-1273 (Moderna) vaccine, and Ad26.COV2.S (Johnson & Johnson-Janssen) vaccine, received an Emergency Use Authorization from the US Food and Drug Administration [11,12]. The Pfizer–BioNTech vaccine first received emergency approval in Japan in February 2021. Although vaccines are believed to be a cornerstone against the spread of infection, for many people, the anxiety created by COVID-19 vaccines that had been developed in less than 1 year was greater than their anticipation or relief [13]. Several studies reported that people's trust in their government was associated with the acceptance of vaccinations against influenza A(H1N1) (i.e., swine flu) [14], influenza vaccination [15], and COVID-19 vaccination [16–18]. During the COVID-19 pandemic, people were exposed to a large amount of information from different sources [19]. Just prior to the beginning of vaccination in February 2021, an Internet survey was completed among people over 20 years old living in Japan [20]. The authors found that providing public health messages that were tailored to the sociodemographic and psychological characteristics of people who were unsure or unwilling in their intention to be vaccinated against COVID-19, may have helped to increase the vaccine uptake in that population. Another cross-sectional survey was conducted in August 2021, 5 months after the start of COVID-19 vaccination for the general public under emergency approval [8]. About 800 participants living in one of seven prefectures in which a state of emergency had been declared were recruited. Trust in public health experts and primary care physicians showed significant positive associations with COVID-19 vaccination behavior while trust in the government showed little association. In December 2021, Yoda et al. conducted an online cross-sectional study with a sample of about 800 participants in Japan [9]. They set vaccine willingness/hesitancy and refusal as dependent variables in a logistic regression analysis, with sources of vaccine information and other sociodemographic variables as independent variables. They found that whereas the vaccine willingness/already vaccinated group was more likely than the other groups to use TV and newspapers as sources of information, those who refused or hesitated to be vaccinated were more likely to use social networking services (SNS), Internet video sites, and doctors' personal websites as sources of COVID-19 vaccine information. Most previous studies in Japan recruited participants from several prefectures [8] or across the country [9]. However, given that prefectural governors have unique characteristics (e.g., regarding their policies, authority, and frequency of media appearances), it is important to survey residents in each prefecture. We thus focused on residents in Tokyo, both because it is the capital city and because its governor makes frequent TV appearances.

In March 2023, we conducted a cross-sectional survey of 18–89-year-old Tokyo residents to explore the association between vaccination behavior and information about COVID-19, categorized as information media (tools), information providers (sources), and information content. At the time of the survey, most people had already been vaccinated, or had chosen not to, and were able to look back calmly at what had affected their vaccination decision. The results of the present study may provide insights into the most effective way to motivate people to comply with preventive behavior in the event of another pandemic.

Materials and methods

To conduct the study, we employed the Internet research panel data from QiQUMO, which is operated by Cross Marketing Inc., Tokyo, Japan. More than 2 million people were registered in this research panel in Japan. Inappropriate participants were eliminated in accordance with the stipulations of Cross Marketing Inc. We allowed a larger margin to account for incomplete responses and collected 2000 participants, who ranged in age from 18 to 89 years old. The numbers of each of 10 s to 80 s were collected according to the age distribution of Tokyo residents. The online survey was conducted from 14 to 19 March 2023 until the required number of responders in each age group was reached.

The participants reported their sex, age, number of vaccinations, and subjective knowledge about viruses and immunization. Regarding the number of vaccinations, they selected one of three options: 2 or more times, once, and no vaccinations. They then evaluated the effects of information media (i.e., tools), information providers (i.e., sources), and information content on their vaccination. The information media for COVID-19 vaccines were as follows: (a) television (TV) broadcast by Japan Broadcasting Corporation (NHK), (b) TV commercials, (c) newspapers, (d) books and magazines, (e) radio, (f) Internet news (e.g., Line news, Yahoo, Google), (g) SNS (e.g., Line, Twitter, Instagram), (h) daily conversation, and (i) individual feelings and principles. The information providers for COVID-19 vaccines were as follows: (a) government (e.g., prime minister, ministers), (b) prefectural governors (e.g., Tokyo governor), (c) first expert group (e.g., medical doctors, president of medical association), (d) second expert group (Novel Coronavirus Expert Committee, Advisory Board), (e) talents who are TV personalities and influencers, (f) family and relatives, and (g) trustable persons. The information content for COVID-19 vaccine were as follows: (a) vaccine efficacy, (b) vaccine accessibility (c) side effects, and (d) supply visibility. According to the method reported by Nakayachi et al. [21], participants were asked how much they thought they were affected by COVID-19 vaccine information on each of the above items, using a single question (e.g., "Do you think you were affected by government as an information provider for your COVID-19 vaccination behavior?"). Each item was assessed on a 5-point Likert scale (1 = was not affected at all, 2 = was barely affected, 3 = was affected a little, 4 = was affected, and 5 = was affected very much).

We analyzed the characteristics of the relationship between the number of participants taking the vaccine and the information media, information providers, and information content by using subjective influence and ordered logistic regression analyses, where the number of taking the vaccine was set as the dependent variable, with media, providers, and content of COVID-19 vaccine information, sex, and age group set as the independent variables. We calculated the standardized partial regression coefficient (β), odds ratio (OR), and confidence interval (CI). After regression analysis with the interaction term of either sex or age, simple slope analysis was performed. Sex was male or female, according to participant response. As the participant age mean and standard deviation (SD) was 50.62 ± 18.01, we coded those ≤ 32 (mean $-$ 1 SD) years as younger and those ≥ 69 (mean + 1 SD) years as older. The significance level was set at $p < 0.05$ or $p < 0.001$.

The study was approved by the Ethical Committee of Doshisha University (approval number: 22075). Implied consent rather than formal written consent was sought to ensure the anonymity of the participants, who clicked the "I agree" button before commencing the Internet survey to indicate their consent.

Results

Table 1 presents the participants' characteristics and vaccination status. As stated in the Materials and methods section, the sex and age distribution of the participants was matched with the general population of Tokyo residents. More than 85% of the Tokyo residents had received twice or more vaccinations by the end of March 2023.

Fig. 1 shows the subjective influence scores for nine information media items (Fig. 1A), seven information provider items (Fig. 1B), and four information content items (Fig. 1C), which were calculated for each group: that is, the nonvaccinated and vaccinated (i.e., twice or more) groups. All the scores in the vaccinated group were higher than those in the nonvaccinated group, except for anxiety about side effects. Considering the information media and providers variables, only the feelings/

Table 1
The characteristics of participants and vaccination status.

	Total (n = 2000)		number of times of vaccination					
			0		1		≥2	
Variables	n	%	n	%	n	%	n	%
Sex								
Male	**985**	**49.3**	**118**	**12.0**	**6**	**0.6**	**861**	**87.4**
Female	**1015**	**50.8**	**129**	**12.7**	**10**	**1.0**	**876**	**86.3**
Age								
18–19	**39**	**2.0**	**7**	**17.9**	**1**	**2.6**	**31**	**79.5**
20–29	**281**	**14.1**	**46**	**16.4**	**2**	**0.7**	**233**	**82.9**
30–39	**316**	**15.8**	**56**	**17.7**	**5**	**1.6**	**255**	**80.7**
40–49	**373**	**18.7**	**53**	**14.2**	**3**	**0.8**	**317**	**85.0**
50–59	**349**	**17.5**	**42**	**12.0**	**1**	**0.3**	**306**	**87.7**
60–69	**240**	**12.0**	**23**	**9.6**	**1**	**0.4**	**216**	**90.0**
70–79	**251**	**12.6**	**11**	**4.4**	**1**	**0.4**	**239**	**95.2**
80–89	**151**	**7.6**	**9**	**6.0**	**2**	**1.3**	**140**	**92.7**

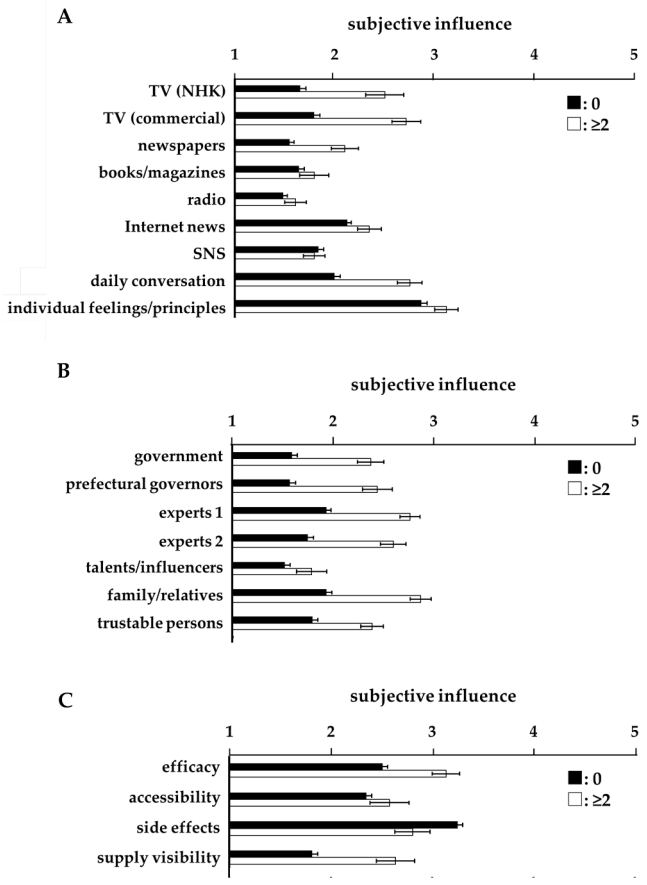

Fig. 1. Subjective influence scores of information media, providers, and content for non-vaccinated and vaccinated (two or more). **A**, Subjective influence scores of information media; **B**, subjective influence scores of information providers; **C**, subjective influence scores of information content.

principles score exceeded 3 points (Fig. 1A, 1B). The scores for NHK TV, TV commercials, newspapers, and daily conversation were higher in the vaccinated group than in the nonvaccinated group (Fig. 1A). In addition, the scores in the vaccinated group were higher for all information providers (Fig. 1B). Furthermore, the 95% CI of these scores did not overlap between the two groups.

Tables 2-4 show the results of the ordered logistic regression analyses. The OR in the ordered logistic regression analysis was interpreted as follows; for a one-unit change in the explanatory variable, the odds in a group that was greater than a level of the dependent variable were proportionately larger than the odds in a group that was less than or equal to the level. For example, for a one-unit increase in the subjective influence of NHK, the odds for the vaccinated group were around 1.57 times greater than for the unvaccinated group, when other variables were held constant in the model.

Table 2
Association between information sources and COVID-19 vaccine uptake among Tokyo residents.

Variables	β	OR	p-value	VIF
sex	−0.026 [−0.111–0.058]	0.876 [0.573–1.341]	0.543	1.052
age	0.173 [0.081–0.265]	1.024 [1.011–1.038]	< 0.001	1.334
TV (NHK)	0.222 [0.112–0.331]	1.569 [1.255–1.960]	< 0.001	2.884
TV (commercial)	0.222 [0.124–0.321]	1.575 [1.288–1.927]	< 0.001	2.580
newspapers	0.116 [0.006–0.225]	1.286 [1.014–1.632]	0.038	2.718
books and magazines	−0.219 [−0.322–−0.116]	0.558 [0.424–0.733]	< 0.001	2.298
radio	−0.024 [−0.100–0.052]	0.935 [0.756–1.157]	0.536	1.789
Internet news	−0.090 [−0.177–−0.004]	0.814 [0.669–0.991]	0.040	1.883
SNS	−0.130 [−0.212–−0.048]	0.717 [0.582–0.885]	0.002	1.756
daily conversation	0.309 [0.218–0.400]	1.934 [1.593–2.349]	< 0.001	1.855
individual feelings and principles	−0.091 [−0.151–−0.031]	0.837 [0.743–0.942]	0.003	1.384
TV (NHK) × sex	−0.048 [−0.157–0.062]	0.823 [0.528–1.284]	0.391	2.817
TV (commercial) × sex	0.061 [−0.036–0.157]	1.281 [0.863–1.901]	0.218	2.557
newspapers × sex	−0.006 [−0.112–0.099]	0.972 [0.614–1.539]	0.905	2.179
books and magazines × sex	−0.061 [−0.153–0.031]	0.723 [0.444–1.179]	0.194	2.031
radio × sex	0.004 [−0.071–0.079]	1.022 [0.671–1.557]	0.918	1.488
Internet news × sex	−0.039 [−0.117–0.040]	0.838 [0.585–1.199]	0.334	1.829
SNS × sex	0.043 [−0.032–0.118]	1.248 [0.849–1.834]	0.260	1.588
daily conversation × sex	0.094 [0.009–0.179]	1.498 [1.038–2.163]	0.031	1.800
individual feelings and principles × sex	−0.051 [−0.108–0.006]	0.819 [0.654–1.026]	0.082	1.364
TV (NHK) × age	0.057 [−0.047–0.162]	1.006 [0.995–1.018]	0.282	3.181
TV (commercial) × age	0.013 [−0.089–0.115]	1.001 [0.990–1.013]	0.805	2.906
newspapers × age	0.122 [0.000–0.244]	1.014 [1.000–1.029]	0.049	2.572
books and magazines × age	−0.063 [−0.173–0.047]	0.991 [0.975–1.007]	0.262	2.068
radio × age	−0.002 [−0.083–0.079]	1.000 [0.988–1.012]	0.961	1.696
Internet news × age	0.057 [−0.038–0.153]	1.007 [0.995–1.019]	0.241	1.990
SNS × age	−0.099 [−0.187–−0.012]	0.986 [0.975–0.998]	0.025	1.784
daily conversation × age	0.026 [−0.066–0.118]	1.003 [0.992–1.014]	0.582	1.801
individual feelings and principles × age	−0.049 [−0.112–0.014]	0.995 [0.988–1.002]	0.127	1.455
McFadden' R^2 = 0.157				

Values in brackets indicate 95% confidence intervals. β, standardized partial regression coefficient; OR, odds ratio; VIF, variance inflation factor.

Table 2 shows the results of the analysis with each information source as an independent variable. On the one hand, NHK TV, TV commercials, daily conversation, and newspapers showed significant

Table 3
Association between information sources and COVID-19 vaccine uptake among Tokyo residents.

Variables	β	OR	p-value	VIF
sex	−0.053 [−0.139–0.033]	0.777 [0.515–1.172]	0.230	1.026
age	0.170 [0.085–0.255]	1.023 [1.011–1.034]	< 0.001	1.101
government	0.088 [−0.038–0.214]	1.209 [0.921–1.587]	0.171	2.768
prefectural governors	0.295 [0.178–0.413]	1.867 [1.457–2.394]	< 0.001	2.705
experts 1	0.078 [−0.034–0.190]	1.166 [0.936–1.453]	0.171	2.902
experts 2	0.123 [0.007–0.238]	1.283 [1.015–1.622]	0.037	3.325
talents and influencers	−0.229 [−0.342–−0.116]	0.545 [0.404–0.735]	< 0.001	1.598
family and relatives	0.218 [0.129–0.306]	1.524 [1.284–1.809]	< 0.001	1.631
trustable persons	−0.064 [−0.171–0.044]	0.873 [0.694–1.097]	0.244	1.872
government × sex	−0.071 [−0.191–0.048]	0.735 [0.439–1.231]	0.242	2.791
prefectural governors × sex	0.050 [−0.060–0.161]	1.237 [0.776–1.972]	0.372	2.655
experts 1 × sex	0.046 [−0.054–0.146]	1.197 [0.807–1.776]	0.371	2.883
experts 2 × sex	0.029 [−0.082–0.141]	1.127 [0.716–1.774]	0.606	3.281
talents and influencers × sex	0.019 [−0.083–0.121]	1.103 [0.643–1.894]	0.721	1.590
family and relatives × sex	−0.082 [−0.172–0.008]	0.727 [0.513–1.030]	0.073	1.591
trustable persons × sex	0.004 [−0.098–0.106]	1.016 [0.656–1.572]	0.945	1.852
government × age	0.015 [−0.103–0.134]	1.002 [0.988–1.016]	0.804	2.856
prefectural governors × age	0.144 [0.028–0.260]	1.016 [1.003–1.030]	0.015	2.817
experts 1 × age	0.074 [−0.043–0.191]	1.008 [0.995–1.021]	0.215	2.696
experts 2 × age	0.061 [−0.058–0.180]	1.007 [0.993–1.020]	0.317	3.078
talents and influencers × age	−0.054 [−0.163–0.056]	0.993 [0.977–1.008]	0.337	1.662
family and relatives × age	−0.105 [−0.191–−0.018]	0.989 [0.980–0.998]	0.017	1.590
trustable persons × age	−0.106 [−0.215–0.002]	0.988 [0.975–1.000]	0.054	1.832
Mc Fadden' R^2 = 0.161				

Values in brackets indicate 95% confidence intervals. β, standardized partial regression coefficient; OR, odds ratio; VIF, variance inflation factor; experts 1 (medical doctors, president of medical association); experts 2 (Novel Coronavirus Expert Committee, Advisory Board).

positive associations with vaccine uptake. On the other hand, books/magazines, SNS, individual feelings/principles, and Internet news showed significant negative associations with vaccine uptake. The regression analysis with sex (male or female) as the interaction term showed a significant association of vaccine uptake with only the subjective influence of daily conversation. Simple slope analysis showed that the positive association between the subjective influence of daily conversation and vaccine uptake was stronger for females ($\beta = 0.404$, $p < 0.001$) than for males ($\beta = 0.214$, $p = 0.001$). The regression analysis with age (≤32 years or ≥ 69 years) as the interaction term showed a significant association between the subjective influence of newspapers and vaccine uptake. Simple slope analysis also showed that the significant positive association between the subjective influence of newspapers and vaccine uptake was observed for older people ($\beta = 0.233$, $p = 0.008$) but not for younger people ($\beta = -0.001$, $p = 0.988$). A significant interaction term between the subjective influence of SNS and age was also observed ($p = 0.025$). In addition, simple slope analysis showed that the negative association between SNS and vaccine uptake was observed for older people ($\beta = -0.227$, $p = 0.001$) but not for younger people ($\beta = -0.033$, $p = 0.479$).

Table 4
Association between information content and COVID-19 vaccine uptake among Tokyo residents.

Variables	β	OR	p-value	VIF
sex	0.026 [−0.049–0.100]	1.131 [0.789–1.622]	0.502	1.033
age	0.195 [0.118–0.271]	1.026 [1.016–1.037]	< 0.001	1.081
efficacy of vaccines	0.197 [0.107–0.288]	1.494 [1.244–1.795]	< 0.001	1.760
accessibility for vaccination	−0.151 [−0.244–−0.058]	0.715 [0.581–0.880]	0.002	2.003
side effects	−0.335 [−0.411–−0.260]	0.499 [0.427–0.583]	< 0.001	1.492
supply visibility	0.508 [0.397–0.619]	3.035 [2.382–3.868]	< 0.001	2.134
efficacy of vaccines × sex	0.033 [−0.050–0.116]	1.142 [0.816–1.599]	0.438	1.709
accessibility for vaccination × sex	0.067 [−0.015–0.150]	1.349 [0.935–1.946]	0.109	1.983
side effects × sex	0.000 [−0.067–0.067]	1.000 [0.755–1.324]	0.998	1.445
supply visibility × sex	−0.021 [−0.118–0.076]	0.914 [0.598–1.396]	0.677	2.094
efficacy of vaccines × age	0.057 [−0.027–0.142]	1.006 [0.997–1.016]	0.182	1.853
accessibility for vaccination × age	−0.127 [−0.217–−0.036]	0.985 [0.974–0.996]	0.006	2.084
side effects × age	−0.124 [−0.202–−0.047]	0.986 [0.977–0.995]	0.002	1.506
supply visibility × age	0.207 [0.100–0.314]	1.025 [1.012–1.038]	< 0.001	2.304
Mc Fadden' R^2 = 0.180				

Values in brackets indicate 95% confidence intervals. β, standardized partial regression coefficient; OR, odds ratio; VIF, variance inflation factor.

Table 3 shows the results of the analyses with each information source as an independent variable. Significant positive associations were observed between vaccine uptake and the subjective influence of prefectural governor, family/relatives, and the second expert group (i.e., Novel Coronavirus Expert Committee, advisory board). However, no significant association was found between vaccine uptake and the subjective influence of government (prime minister/ministers) and the first expert group (i.e., medical doctors/president of medical association). A significant negative association between vaccine uptake and the subjective influence of talents/influencers was observed. The regression analysis with sex as the interaction term was not statistically significant. The regression analysis with age as the interaction term showed a significant association between vaccine uptake and the subjective influence of prefectural governor and family/relatives. Simple slope analysis showed a stronger positive association between vaccine uptake and the subjective influence of prefectural governor for older people ($\beta = 0.435$, $p < 0.001$) than for younger people ($\beta = 0.156$, $p = 0.022$). In contrast, the significant positive association between family/relatives and vaccine uptake was observed for younger people ($\beta = 0.322$, $p < 0.001$) but not for older people ($\beta = 0.114$, $p = 0.076$).

Table 4 shows the results of the analyses with each information source as the independent variable. Significant positive associations between vaccine uptake and the subjective influence of vaccine efficacy and supply visibility for all participants were found. Significant negative associations with concerns about side effects and vaccine accessibility were observed for all participants. The regression analysis with sex as

the interaction term was not statistically significant. The regression analysis with age as the interaction term showed significant associations with the subjective influence of supply visibility, side effects, and accessibility. Simple slope analysis showed a stronger positive association between vaccine uptake and the subjective influence of supply visibility for older people ($\beta = 0.712, p < 0.001$) than for younger people ($\beta = 0.304$, $p < 0.001$). In addition, simple slope analysis showed that the negative association between vaccine uptake and the subjective influence of accessibility was observed for older people ($\beta = -0.276, p = 0.001$) but not for younger people ($\beta = -0.026, p = 0.598$), and that a stronger negative association between vaccine uptake and the subjective influence of side effects was observed for older people ($\beta = -0.461, p < 0.001$) than for younger people ($\beta = -0.210, p < 0.001$).

Discussion

Many studies examining the association between COVID-19 information and vaccination behavior were performed between February and December 2021, the first year of vaccination in Japan, when people were under a great deal of uncertainty and anxiety. In the beginning, older people were given the vaccination early since they had a higher risk of severe disease than younger people [22]. The studies conducted in February focused on people's cognition, including vaccine acceptance and behavioral intentions [10,14–18]. Many participants requested more information about the compatibility of the vaccine with their personal health conditions, and expected physicians, TV, newspapers, and the government to provide reliable information [20,23]. As sources of information about COVID-19, the Internet news, YouTube, family members, and scientists were associated with higher odds of being unsure or unwilling to be vaccinated. Herein, simple slope analysis revealed a significant positive association between family/relatives and vaccine uptake for younger people but not for older people. The difference in the effects of vaccine information from family may be due to the various times that the surveys were administered (February 2021 vs March 2023), or the participants (30,000 residents in Japan vs 2000 residents in Tokyo), among other possibilities. Nevertheless, the reason that association between vaccine uptake and family/relatives was not observed for older people must be examined.

Several studies have reported that people's trust in traditional media sources such as TV and newspapers was greater than their trust in nontraditional sources, including Internet news and websites [9,20,24]. Similar results were obtained in the present study, with a significant positive association of vaccine uptake with TV and newspaper, but a significant negative association with Internet news and SNS (Table 2). A significant positive association with newspapers and a significant negative association with SNS were only observed for older people. Given that young Japanese do not typically read newspapers [25], they no longer represent an information source and consequently do not affect the vaccine uptake decision. Older people seem to be less familiar with SNS information rather than younger people. Age-specific approaches should be considered to promote vaccination behavior [26]. The negative association of books/magazines was also shown in the present study. Weekly magazines in Japan tended to inflame anxiety. A more precise study should be conducted by asking about books and magazines separately. It is noteworthy to consider other tools, since a study of 4000 university students reported the usefulness of educational videos about COVID-19 vaccines [27]. To understand the significant effects of individual differences, other demographic factors such as education level, employment status, and income should be considered [28,9]. The subjective influence of daily conversation was significantly and positively associated with vaccine uptake, and was more significant among females than among males (Table 2). It would be interesting to compare these results with those from other countries to explore whether Japanese men generally engage less in daily conversation.

Considering information providers, in contrast to previous studies [18,29–39], Okada et al. reported that government trust was not associated with vaccination behavior [8]. Tanaka et al. also pointed out that the trust of people on the government in Japan was lower compared with that in other countries [40]. The same results were observed in the present study, regardless of sex and age (Table 3). Early in the COVID-19 pandemic, Japanese people changed their precautionary behavior in accordance with the government's request for cooperation (e.g., social-distancing measures) [41]. The main purpose of this goverment's request was to prevent not only their own infection but also that of others by taking a social distancing. This call may have aroused the prosocial behavior of the Japanese, which may have contributed to the low infection rate in the early stages of Covid-19. It would be interesting to investigate the relationship between prosocial tendency and infection prevention in different countries. But the July 2021 decision by the government to allow the Tokyo Olympics to open may be one reason for the reduction in government trust [8]. The first expert group did not show any association either. As Okada et al. mentioned, medical doctors may not have been able to make definitive recommendations via the media regarding COVID-19 vaccines, while primary physicians developed a trusting relationship with people. In the present study, we did not ask about primary physicians as information providers; however, about 20 participants gave primary physicians high scores in the free-description question. A significant positive association with the second expert group was observed, but the statistical significance disappeared in the analyses when adding either sex or age as the interaction term, indicating that the association between experts and vaccine uptake was weak. Furthermore, it may be worth analyzing these survey data using a scale of source credibility or goodwill, as reported by McCroskey and Teven [42]. Although the association with Tokyo prefectural governor looked strongly significant, the significance was only shown for older people. The characteristics of prefectural governors vary from prefecture to prefecture. The behavior patterns also vary in different prefectures [43]. Our study should also be conducted among residents in other prefectures to explore the most effective ways to present information to motivate people's preventive behavior. The finding that family/relatives did not represent functional information sources for vaccine uptake among older people living in Tokyo may indicate a serious issue that warrants examination in other large cities where more than 2 million people live such as Yokohama and Osaka.

Considering information content, consistent with previous studies, the present study showed that vaccine efficacy was positively associated with vaccination behavior while vaccine side effects were negatively associated (Table 4). Before vaccination started in Japan in 2021, men showed less hesitancy toward being vaccinated [44–46]. Two years later, after 86.5% of Tokyo residents had completed two or more vaccinations, a significant difference between male and female about the association of vaccine uptake with information contents studied in the present study was not observed. The negative associations between accessibility and vaccine uptake shown for older people indicate that reservation systems that are easy for older people to use and places where elderly people can go for to be vaccinated should be developed in preparation for the next pandemic. We must interpret the significant positive associations between supply visibility and vaccine uptake with caution because visibility has both advantages and disadvantages. In 2021, there were not enough vaccines for all people in Japan. People became aware of this insufficient supply via information media. Ironically, people's impatience for the vaccine shortage might exceed their anxiety about being vaccinated. Further investigation is needed to explore this point.

The results of this study should be carefully interpreted to consider their limitations as described previously [8]. Because our present study was also a cross-sectional study, we cannot draw any conclusions about causality. To explore the cause and effect relationship regarding COVID-19 information and vaccine uptake, Dai et al. conducted two sequential randomized controlled trials by designing the first and the second reminders to participants [47]. They found designs that included behavioral nudges that increased COVID-19 vaccinations in the United States.

We should conduct similar randomized controlled trials to test the effect of behavioral interventions on vaccine uptake in our country. Another limitation is that the data in the present study are subjective rather than objective. More precise studies should be conducted in the future to obtain objective data with appropriate question items. As indicated by the low VIF values, each question item is independent of the others. In the present study, we did not examine the effect of a combination of media and provider (e.g., the prefectural governor sends a message on TV).

However, the present study explored the efficacy of the characteristics of information media, providers, and content about the COVID-19 vaccine in promoting people's vaccination behavior, even when they did not think they were strongly affected by information regarding their decision in March 2023 when the survey was conducted. These findings have important implications for developing strategies to motivate people to comply with preventive behavior during a pandemic.

Conclusions

Tokyo residents refer to TV- and newspaper-based information more than to nontraditional media such as Internet news and SNS, for promoting vaccine uptake. Older people are especially more likely to trust newspapers than SNS. Daily conversation was a positively influential medium regarding vaccine uptake, and more so among females than males. Tokyo governors must consider strategies to reach all residents because their previous attempts promoted vaccine uptake more effectively among older people than younger people. In contrast, family/relatives were positively influential sources of information for vaccine uptake only among younger people. Even with a search limited to Tokyo residents, the efficacy of information varied by sex and age, which implies the importance of providing information tailored to the demands of all people.

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CRediT authorship contribution statement

Noriko Noguchi: Conceptualization, Funding acquisition, Investigation, Writing – original draft, Writing – review & editing. **Ryosuke Yokoi:** Data curation, Formal analysis. **Taichi Masu:** Conceptualization, Methodology, Investigation. **Masataka Watanabe:** Conceptualization. **Sayoko Itoh:** Data curation, Visualization. **Sayumi Yumoto:** Data curation, Visualization.

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

The data that has been used is confidential.

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