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Vaccine hesitancy and COVID-19 risk behaviors associated with social media use in Japan

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Abstract

We examined the associations between use of different types of media and COVID-19 vaccine hesitancy, as well as risk behaviors for contracting COVID-19 in Japan in late 2021. A series of cross-sectional surveys were conducted using rapid online surveys of residents in Iwate Prefecture from February 5 to 7, 2021, and again from October 1 to 3, 2021. Each individual's risk of acquiring SARS-CoV-2 infection was calculated using a quantitative assessment tool (the microCOVID). Intention to get vaccinated for COVID-19 was assessed by self-report. Usage of five types of media for obtaining COVID-related information was assessed: (1) newspapers, (2) television or radio, (3) internet or news apps, (4) social network services (SNS) (excluding LINE, a popular messaging app), and (5) other.

While reliance on SNS did not show significant associations with intentions to get vaccinated or engaging in risky behavior for acquiring COVID-19, users of the internet or news apps were more likely to be vaccine-hesitant but also less likely to engage in high-risk behaviors for infection (odds ratios [with 95% confidence intervals] for vaccine hesitancy: 1.58 [1.19 - 2.10] and high-risk behavior: 0.71 [0.49 - 1.02]). The differential associations between different types of media use and COVID-19 prevention behaviors may assist in preparing for future pandemic outbreaks. Policymakers should disseminate accurate information, taking into consideration differences in demographic subgroups' use of different types of media.

Keywords: COVID-19; microCOVID; behavioral risk; vaccine hesitancy; Japan; social media; internet; digitalization

Introduction

The state of pandemic preparedness in Japan was revealed to be lacking during COVID-19, especially in terms of the use of digital technology for contact tracing and risk communication. During the early phase of the pandemic, a significant burden was placed on health care workers who conducted contact tracing (via telephone) without the support of digital tools.[1] By contrast, some countries, including South Korea and China, implemented sophisticated strategies for quarantine using digital tools, such as tracing patients with geographical information services.[2]

Japan also made insufficient use of digital media in risk communication as a risk management tool. Understanding how people consume different media is a first step in developing an effective risk communication strategy. For example, the spread of COVID-related misinformation via social media (e.g., Twitter and Facebook) has been noted previously.

The tools people use to obtain information had been diversifying before the pandemic. During the period of lockdowns and mobility restrictions, many people relied on social media to interact with others and to share up-to-date information about the pandemic. However, while traditional media are bound by editorial fact-checking and curation of content, social media often present the personal opinions of users, and erroneous (and sometimes deliberately misleading) views can spread unchecked.[3]

Earlier studies have shown the influence of media usage on COVID-19 vaccine hesitancy[4-8] as well as people's readiness to engage in preventive behaviors.[9-18] However, the impact of social media use on adoption of preventive behaviors may depend on the cultural context.[15] Previous studies indicated that different effects might be mainly related to the study areas; i.e., the people who gained information from social media or one specific program on TV tended to be vaccine hesitant or engaging in high-risk behaviors in Western countries[4,5,7,11,18] while the people getting information by media (including social media) or the internet had increased preventive behaviors in Asian countries, especially in Japan.[12-17] Moreover, people's behaviors may change with the passage of time. While several studies were conducted in Japan in 2020, only one study was conducted in late 2021.[6] Furthermore, no studies have examined the association between different types of media usage and vaccine intention or preventive behaviors. The aim of this study was to determine whether in Japan in late 2021 there were associations between either the utilization of media for COVID-19-related information and people's behavioral risks for contracting COVID-19, or COVID-19 vaccine hesitancy.

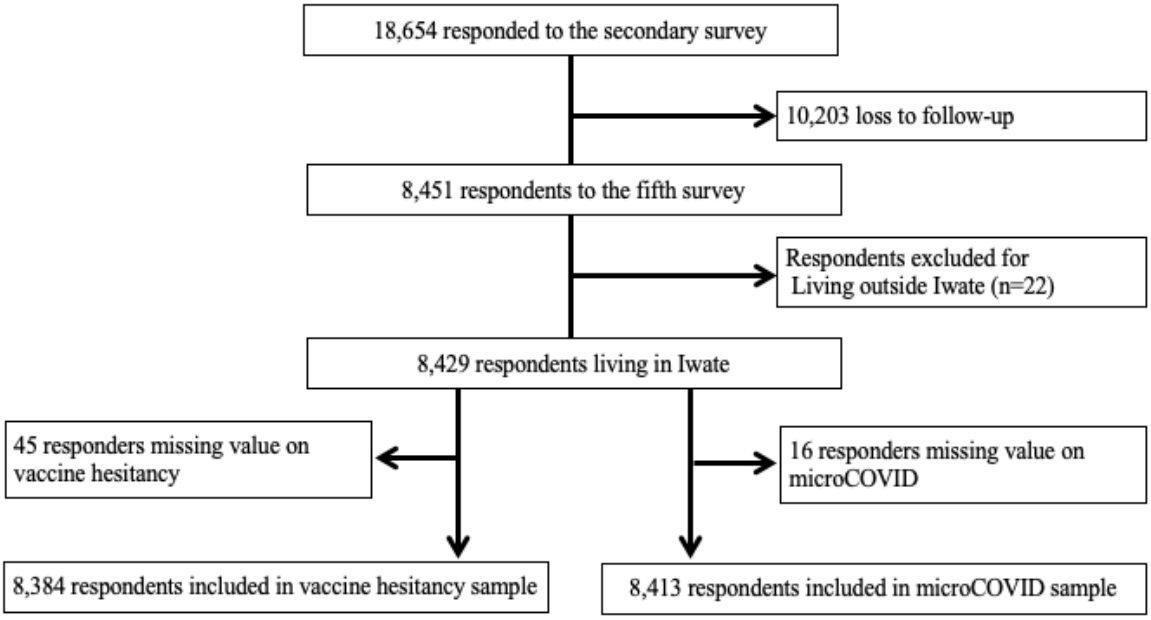
Materials and Methods

Study area and data collection

The Iwate Prefecture, which is located in the northern part of Japan 500 km from Tokyo, has a population of approximately 1.2 million. The total number of COVID-19 cases as of May 7, 2023, was 237,996, including 625 cases of COVID-19-related deaths.[19] Since the beginning of the pandemic, the Iwate Prefectural Government has conducted a series of online surveys of residents in Iwate Prefecture using a social network platform called LINE (LINE Corporation, Tokyo, Japan). The official data from LINE Corporation shows that the number of LINE users in Japan is about 89 million (70% of the total population). A series of cross-sectional surveys were started in December 2020 when the number of confirmed cases started to rise in Iwate. Surveys were then conducted every two months to determine people's behavioral risks during the COVID-19 pandemic.

The online questionnaires were sent to approximately 170,000 people who were registered at the time of the baseline survey. We used the data collected in the second survey of registered people (from February 5 to 7, 2021) and the fifth survey (from October 1 to 3, 2021), which represent periods when COVID-19 vaccines were recommended and available to all citizens in Japan. The number of valid responses for analysis was 8,451, after excluding 10,203 participants due loss to follow-up between the second and fifth survey. After excluding subjects who moved away from Iwate or did not report on the outcomes of interest, the final analytic sample was 8,384 respondents in the vaccine hesitancy arm and 8,413 in the behavioral risks arm, respectively (**Figure 1**).

Figure 1



Ethical considerations

The surveys were conducted in accordance with applicable Japanese law and Iwate Prefectural Government policy. As this research was a secondary analysis using anonymized public data from Iwate Prefecture, further ethics review was not required.

Outcomes

We examined two outcomes. First, intention to get vaccinated for COVID-19 was assessed with a single question: "Do you want to receive the COVID-19 vaccine?" The seven possible answers were: "I have already received the vaccine," "I want to receive the vaccine, but I cannot (e.g. for health reasons)," "I want to receive the vaccine," "I possibly want to receive the vaccine," "I am neither willing nor hesitant to receive the vaccine," "I somewhat do not want to receive the vaccine," and "I do not want to receive the vaccine." We grouped respondents into two categories: vaccine-hesitant individuals (people who answered the latter three options), and vaccine acceptors (the first four categories).

To assess behavioral risks for acquiring COVID-19, we applied a weighting system called microCOVID, which is a calculator to numerically quantify the risk of getting COVID-19 from daily activities. MicroCOVID values are computed using three major factors: activity risk, personal risk, and the number of people with whom an individual interacts. For example, activity risk was calculated by considering the duration of interactions, mask-wearing, indoor/outdoor environment, distance from each other, the volume of conversation, and frequency (times a week). We obtained a microCOVID score for each person by multiplying activity risk, number of people and personal risk. Further details of the microCOVID risk calculator have been published previously.[20] A score of "1.0 microCOVID" is equivalent to a one-in-a-million chance of getting COVID. We classified each individual respondent's risk level into either "low risk" (low-risk group, ≤20 microCOVIDs) or "high risk" of infection (high-risk group, >20 microCOVIDs).

Covariates

The second survey wave included items about different types of media use to obtain COVID-19 information. Respondents were asked: "Please select the media (other than LINE, a popular messaging app in Japan) that you use to obtain information related to COVID-19." Possible responses included: (1) newspapers, (2) television or radio, (3) internet or news apps, (4) social network services (SNS) excluding LINE, and (5) other.

The fifth survey questionnaire included questions about the subject's age, sex, occupation, municipality of residence, perceived vulnerability to getting COVID, and perceived severity of disease if they caught COVID-19. The participants were grouped into three age categories: young (people under 40 years of age), middle age (people aged 40 to 59 years) and elderly (people aged 60 years or older). Residential areas were dichotomized into inland or coastal/mountainous, based on the geography of Iwate. Occupation was divided

into five groups: health care workers, workers in service industries (transportation, customer-facing occupations in the retail/hospitality sector, or office workers), education sector (teachers or students), government workers, and all others (workers in manufacturing, farmers/agricultural workers, workers in other jobs, or unemployed). Perceived vulnerability was assessed by the question, "How likely do you think you are to contract COVID-19?" Individuals chose one of five responses (very likely, likely, moderate, unlikely, and very unlikely) and the answers were classified into two groups: likely (very likely and likely) or unlikely (moderate, unlikely, and very unlikely). Perceived severity was assessed by the question, "How serious an illness do you think you will get if you were infected by SARS-CoV-2?" Individuals chose one of five responses (much less serious, less serious, moderate, serious, and more serious) and the answers were divided into two groups: less to moderate serious (much less serious, less serious, moderate) or highly serious (serious, and more serious).

Statistical analyses

Baseline characteristics, including age group, sex, occupation, residential area, perceived vulnerability, perceived severity, and types of media use (newspapers, television or radio, internet or news apps, SNS, and other), were compared among participants according to their level of vaccine hesitancy and behavioral risks for acquiring COVID-19 by using the chi-squared test. We built two models for logistic regression analyses: model 1, which adjusted for age group, sex, and five types of media use; and, model 2, which added residential area, occupation, perceived vulnerability, and perceived severity.

Missing covariate data from the fifth survey was imputed by multiple imputation using the Markov Chain Monte Carlo method, creating five imputed datasets. For sensitivity analyses, we re-ran all analyses stratified by age group. The Statistical Package for Social Sciences (SPSS) software program version 25.0 (IBM, Chicago, IL, USA) was used for all analyses. All statistical tests were two-sided, and analysis items with P-values <0.05 were considered statistically significant.

Results

The baseline characteristics of the participants according to vaccination intention and behavioral risks are summarized in **Table 1**. People in both the vaccine-hesitant and high-risk behavior groups were more likely to be younger and to be SNS users. Workers in the service industry were over-represented in the vaccine hesitancy group, while health care workers were more likely to be in the high-risk behavior group. People who obtained information about COVID from newspapers and television or radio were significantly less likely to be vaccine hesitant compared to non-users of these media. Users of internet sites or news apps groups were significantly more likely to be vaccine hesitant compared to users of other types of media.

In logistic regression Model 1, adjusted for age group, sex, and media use, the ORs of vaccine hesitancy were significantly elevated in the users of internet or news apps, while the ORs were significantly lower in those who relied on newspapers and television or radio (**Table 2**). In the model adjusting for remaining variables (Model 2), the associations between vaccine hesitancy and internet or news apps, newspapers, and television or radio remained significant (OR [95% confidence interval (CI)]: newspapers readers, 0.63 [0.50 - 0.79]; television or radio users; 0.75 [0.57 - 0.99]; internet or news apps, 1.58 [1.19 - 2.10]). SNS use did not have a significant association with vaccine hesitancy in either model.

Young and middle-aged people had significantly high ORs for behavioral risks in Model 1, but these associations disappeared in Model 2. Although users of internet or news apps were marginally significantly more likely to engage in high-risk behavior (OR [95% confidence interval (CI): 0.71 [0.49 – 1.02]; P = 0.065]), SNS users did not show a significant association with behavioral risks even after an adjustment for related factors.

We also re-ran the analyses stratified by age group (**Supplementary Table 1**). In the analyses of vaccine hesitancy, although a significant association between vaccine hesitancy and the usage of internet or news apps were not found in the young group, those associations remained significant in the middle age and elderly groups. SNS users had significantly high ORs in elderly, but not in young or middle age groups. In the analyses of behavioral risks, the results were similar to the unstratified analyses by age groups.

Discussion

In contrast to previous studies reported in the western context, SNS users in this Japanese sample were neither more likely to be vaccine hesitant nor more likely to engage in risk behaviors for acquiring COVID-19. Users of the internet or news apps were more likely to be vaccine hesitant, but at the same time they were less likely to engage in high-risk behaviors. These results were consistent with other studies reported in Asian countries; for example, Chua showed use of online news channels (such as online news websites/applications and social media) as sources of information about COVID-19 was associated with high-compliance behavior against COVID-19.[17]

In addition, we found differences between SNS users and internet or news apps users in vaccine hesitancy and the COVID-19 prevention behaviors. To the best of our knowledge, this is the first study to identify differential associations between specific types of media usage for COVID-19 information and COVID prevention behaviors.

Previous studies

While the usage of social media increased the risks of both vaccine hesitancy and high-risk behaviors in studies reported in Western countries, the usage of social media did not show the same association in Japan. Ahmed et al. reported that social media usage in the United States was linked to consumption of news content that increased users' skepticism regarding the efficacy of vaccines.[5] Bridgman et al. found that social media exposure was more likely to lead to decreased social distancing compliance in a Canadian sample.[11] Reno et al. showed that social media directly or indirectly increased vaccine hesitancy towards COVID-19 vaccination in Italy.[7] By contrast, in Japan in 2022, Sakamoto et al. showed that concern about the COVID-19 vaccine was inversely associated with information obtained from Twitter, while Uchibori et al. identified negative correlations between internet or social media as sources of information about COVID-19 and lack of adoption of preventive behaviors.

The timing of the various studies in the literature might be a factor in the conflicting results. Cato et al. reported that daily LINE users and daily web aggregator users had significantly high ORs of reducing the frequency of dining out, per people's social distancing behaviors in studies conducted in April and September, 2020. By contrast, Suzuki et al. showed that in 2020, SNS browsing had a positive effect on preventing going out that was not observed in 2021.[15] The timing and the results on SNS usage in Suzuki's 2021 survey were both similar to our results. We speculate that individual SNS users might have been significantly influenced by social media at the beginning of the pandemic, but its influence might have waned with the passage of time due to people's recognizing of misinformation in social media.

With regard to vaccine hesitancy, several cross-sectional studies have been conducted but no study conducted a longitudinal study on the association between media usage and vaccine hesitancy. In some cross-sectional studies, the associations have not been consistent, with results indicating positive associations shown in some studies conducted as of early 2021[4,5,7] and negative associations in a study in late 2021.[6] However, the subjects in the studies conducted as of early 2021 were located in Western countries, while the participants in Sakamoto's study in late 2021 were university students in Japan; thus the differences in results might reflect the heterogeneity of the study's subjects.

Differences by type of media

In the present study's multivariate analyses, we did not show significant associations between social media usage and the two outcomes. The Government of Japan reported that while broadcast media had high levels of use and trust, news apps and websites had high levels of use but not as high levels of trust.[21] Previous studies have reported inconsistent findings: while six Western studies and one Asian study showed social media usage increased vaccine hesitancy and high-risk behaviors[4,5,7,10,11,18], eight Asian studies found that social media usage was associated with decreased high-risk behaviors[9,12-17],

and one study[6] showed that social media usage reduced vaccine hesitancy. In an analysis of over 137 million tweets in the United States, Muric et al. found that accounts engaged in anti-vaccination narratives tended to be from the right-wing of the political spectrum and that vaccine hesitancy is fueled by misinformation originating from websites with already questionable credibility.[4] A survey conducted by the Japanese Ministry of Internal Affairs and Communications reported that Twitter had the highest percentage (57.0%) of respondents who had seen false or misleading information about COVID-19.[21]

The contrasting directions of the associations between internet and news apps users and vaccine hesitancy (positive) vs. high-risk behaviors (negative) suggests a more complex relationship between media usage and attitudes in Japan compared to the West. In the United States, vaccine hesitancy (or outright refusal) was prominent among Republican voters, and the same group also expressed skepticism about adopting protective behaviors, such as wearing face coverings.[22,23] That is, the groups expressing vaccine hesitancy and unwillingness to adopt protective behaviors overlap, for reasons such as political affiliation and objections against restrictions on individual freedom. By contrast, Japanese society is less politically polarized compared to countries such as the United States, and citizens may express more nuanced views about preventive behaviors. For example, individuals might adopt preventive behavior measures (such as social distancing) but decide not to take the vaccine based on perceived risks, such as side effects and safety concerns.[24]

Pandemic risk communication in Japan

The Government of Japan disseminated information through some media as a risk communication measure. One successful example of risk communication in Japan is the campaign through all forms of media on the "three C's" (closed spaces, crowded spaces, and close-contact settings). Since that message is simple and easy to remember, people adopted them for preventive behaviors.

However, the Government of Japan did not fully consider how residents consume information from different sources throughout the pandemic. In the present study, middle-aged and older people were more likely to be vaccine hesitant when they relied on the internet and news apps, but the same association was not found among young people (**Supplementary Table 2**). Previously we found that young women were more hesitant about receiving vaccines.[24] The Government's survey reported that, when people received incorrect information, young people were more likely to share or spread incorrect information, but they were also more likely to take steps to verify the accuracy/ authenticity of information sources, compared to other age groups, when they suspected the information source.[21] This difference in media literacy among age groups suggests that policy makers should implement appropriate measures to adjust for demographic variation in digital media literacy.

Limitations

There are some limitations to the study. First, our surveys did not gather other background information, such as socioeconomic status, educational attainment, or household income. Second, the possibility of selection bias should be considered for the interpretation of the results, since respondents had to register to participate in the online health surveys. The relatively high level of digital media literacy this required might overestimate the vaccine hesitancy and high-risk behaviors for contracting COVID-19 in our study group. We do show, however, that the characteristics of our sample resemble the characteristics of the whole population in Iwate in 2021 (**Supplementary Table 2**).

Conclusions

In this Japanese sample, people who obtained information about COVID-19 through social media were not more likely to be vaccine hesitant. Users of the internet or news apps were more hesitant toward vaccination, but were also more likely to adopt preventive behaviors against COVID-19. A detailed understanding of the differential associations between different types of media use and COVID-19 prevention behaviors may assist in preparing for future pandemic outbreaks. Policymakers should disseminate accurate information, while taking into consideration differences in use of different types of media by demographic subgroups.

Declarations

Ethics committee approval

The surveys were conducted in accordance with applicable Japanese law and Iwate Prefectural Government policy. Since this study was a secondary analysis using anonymized data from Iwate Prefecture, ethics review was not required.

Data availability statement for Basic Data Sharing Policy

The data that support the findings of this study are available from the corresponding author (Dr. Shuko Takahashi) and the Division of the Health and National Health Insurance in the Department of Health and Welfare, Iwate Prefecture Governmental. Restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of Division of the National Health Insurance in the Department of Health and Welfare, Iwate Prefecture Government.

Competing interests

All authors have no conflicts of interest to disclose.

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Authors' contributors

S Takahashi: funding acquisition, conceptualization, formal analysis and writing – original draft. N Takahashi: investigation and writing – review & editing. M Nohara: project administration, resources, supervision and writing – review & editing. I Kawachi: methodology, supervision, validation and writing – review & editing.

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Tables

Table 1. Baseline characteristics of participants in the survey

		Vaccine hesitancy (n=8,384)			High-risk behavior (n=8,413)		
		Missing	Hesitancy (n=386)	*P* value	Missing	High risk (n=169)	*P* value
		n (%)	n (%)				
Age group	Young	0 (0.0)	134 (7.3)	<0.001	0 (0.0)	59 (3.2)	<0.001
	Middle age		233 (4.6)			94 (1.9)	
	Elderly		19 (1.3)			16 (1.1)	
Sex	Men	38 (0.5)	87 (3.5)	0.002	38 (0.5)	43 (1.7)	0.209
	Women		294 (5.0)			126 (2.1)	
Occupation	Health care workers	0 (0.0)	27 (1.7)	<0.001	39 (0.5)	71 (4.3)	<0.001
	Service industries		158 (6.6)			40 (1.7)	
	Education sector		22 (3.3)			26 (3.8)	
	All other		150 (5.4)			19 (0.7)	
	Government workers		29 (3.2)			13 (1.4)	
Residential area	Inland areas	0 (0.0)	323 (4.8)	0.118	0 (0.0)	137 (2.0)	0.881
	Coastal & mountainous areas		63 (3.9)			32 (2.0)	
Perceived vulnerability	Unlikely	52 (0.6)	318 (4.7)	0.113	52 (0.6)	92 (1.4)	<0.001
	Likely		62 (3.8)			76 (4.7)	
Perceived severity	Less to moderate serious	0 (0.0)	75 (11.7)	<0.001	0 (0.0)	16 (2.5)	0.385
	Highly serious		311 (4.0)			153 (2.0)	
Newspapers	Newspapers readers	43 (0.5)	141 (3.0)	<0.001	43 (0.5)	83 (1.8)	0.333
	Newspapers non-readers		244 (6.6)			77 (2.1)	
Television or radio	Television or radio users	43 (0.5)	309 (4.2)	<0.001	43 (0.5)	134 (1.8)	0.161
	Television or radio non-users		76 (7.3)			26 (2.5)	
Internet or news apps	Internet or news apps users	43 (0.5)	323 (5.1)	<0.001	43 (0.5)	113 (1.8)	0.157
	Internet or news apps non-users		62 (3.0)			47 (2.3)	
SNS	SNS users	43 (0.5)	121 (6.4)	<0.001	43 (0.5)	47 (2.5)	0.044
	SNS non-users		264 (4.1)			113 (1.7)	
Other	Other users	43 (0.5)	7 (6.9)	0.277	43 (0.5)	5 (4.9)	0.026
	Other non-users		378 (4.6)			155 (1.9)	

Categorical variables are presented as number of cases (%).

P-values were calculated using the chi-squared test.

Abbreviation: SNS=social networking services

Table 2. Results of analysis using models for risks of vaccine hesitancy (n=8,384), and high risks of behavior (n=8,413).

		Vaccine hesitancy				High-risk behavior			
		Model 1		Model 2		Model 1		Model 2	
		OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value
Age groups	Young (ref: elderly)	3.86 (2.33 - 6.39)	<0.001	5.05 (3.02 - 8.44)	<0.001	3.05 (1.68 - 5.54)	<0.001	1.76 (0.95 - 3.26)	0.073
	Middle age	2.91 (1.81 - 4.69)	<0.001	3.52 (2.17 - 5.71)	<0.001	1.80 (1.05 - 3.11)	0.034	1.16 (0.66 - 2.04)	0.599
Sex	Women (ref: men)	1.26 (0.98 - 1.61)	0.068	1.42 (1.10 - 1.83)	0.007	1.16 (0.81 - 1.65)	0.41	1.07 (0.74 - 1.55)	0.709
Occupation	Health care workers (ref: government workers)			0.46 (0.27 - 0.79)	0.005			2.85 (1.55 - 5.27)	0.001
	Service industries			1.85 (1.23 - 2.80)	0.003			1.15 (0.60 - 2.18)	0.676
	Education sector			0.85 (0.48 - 1.50)	0.565			2.49 (1.26 - 4.93)	0.009
	All other			1.86 (1.22 - 2.81)	0.004			0.56 (0.27 - 1.16)	0.121
Residential areas	Inland areas (ref: coastal and mountainous areas)			1.22 (0.92 - 1.62)	0.167			1.02 (0.68 - 1.51)	0.939
Perceived vulnerability	Unlikely (ref: likely)			1.09 (0.81 - 1.45)	0.578			0.35 (0.26 - 0.49)	<0.001
Perceived severity	Less to moderate serious (ref: highly serious)			2.53 (1.91 - 3.34)	<0.001			1.93 (1.11 - 3.34)	0.019
Newspapers	Newspapers readers (ref: Newspapers non-readers)	0.58 (0.46 - 0.72)	<0.001	0.63 (0.50 - 0.79)	<0.001	1.09 (0.77 - 1.53)	0.631	1.06 (0.75 - 1.50)	0.752
Television or radio	Television or radio users (ref: Television or radio non-users)	0.73 (0.56 - 0.96)	0.024	0.75 (0.57 - 0.99)	0.041	0.86 (0.55 - 1.33)	0.486	0.84 (0.54 - 1.31)	0.431
Internet or news apps	Internet or news apps (ref: Internet or news apps non-users)	1.59 (1.20 - 2.10)	0.001	1.58 (1.19 - 2.10)	0.002	0.73 (0.51 - 1.04)	0.081	0.71 (0.49 - 1.02)	0.065
SNS	SNS users (ref: SNS non-nonusers)	1.23 (0.98 - 1.55)	0.081	1.13 (0.89 - 1.43)	0.311	1.19 (0.83 - 1.70)	0.34	1.20 (0.83 - 1.72)	0.337
Other	Other users (ref: Other non-users)	1.86 (0.86 - 4.02)	0.115	2.16 (0.98 - 4.75)	0.055	3.40 (1.18 - 9.78)	0.025	2.40 (0.85 - 6.79)	0.095

Abbreviations: SNS=social networking services; OR=Odds ratio; CI=confidence interval

Appendix

Supplementary Table 1. Results of analysis using models for risks of vaccine hesitancy (n=8,384) and high risks of behavior (n=8,413) stratified age groups.

		Young							
		Vaccine hesitancy (n=1843)				High-risk behavior (n=1850)			
		Model 1		Model 2		Model 1		Model 2	
		OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value
Sex	Women (ref: men)	1.60 (0.99 - 2.57)	0.056	1.71 (1.05 - 2.78)	0.031	1.35 (0.70 - 2.60)	0.37	1.29 (0.66 - 2.53)	0.461
Occupation	Health care workers (ref: government workers)			0.88 (0.36 - 2.15)	0.786			3.02 (1.10 - 8.25)	0.032
	Service industries			2.44 (1.12 - 5.32)	0.024			1.34 (0.46 - 3.86)	0.59
	Education sector			1.09 (0.43 - 2.76)	0.851			1.79 (0.59 - 5.45)	0.309
	All other			2.65 (1.21 - 5.78)	0.015			0.47 (0.12 - 1.81)	0.271
Residential areas	Inland areas (ref: coastal and mountainous areas)			1.15 (0.71 - 1.88)	0.564			1.01 (0.51 - 1.98)	0.979
Perceived vulnerability	Unlikely (ref: likely)			0.77 (0.49 - 1.19)	0.236			0.43 (0.25 - 0.77)	0.004
Perceived severity	Less to moderate serious (ref: highly serious)			2.37 (1.48 - 3.79)	<0.001			1.62 (0.65 - 4.03)	0.299
Newspapers	Newspapers readers (ref: Newspapers non-readers)	0.59 (0.38 - 0.91)	0.016	0.62 (0.40 - 0.96)	0.032	1.68 (0.94 - 2.97)	0.078	1.62 (0.90 - 2.91)	0.105
Television or radio	Television or radio users (ref: Television or radio non-users)	0.64 (0.42 - 0.98)	0.039	0.68 (0.44 - 1.04)	0.077	0.75 (0.38 - 1.50)	0.416	0.67 (0.33 - 1.37)	0.273
Internet or news apps	Internet or news apps (ref: Internet or news apps non-users)	1.29 (0.81 - 2.04)	0.28	1.30 (0.81 - 2.07)	0.276	0.78 (0.41 - 1.48)	0.44	0.77 (0.40 - 1.47)	0.423
SNS	SNS users (ref: SNS non-nonusers)	1.11 (0.78 - 1.59)	0.563	1.08 (0.75 - 1.56)	0.68	1.46 (0.85 - 2.50)	0.174	1.45 (0.84 - 2.51)	0.186
Other	Other users (ref: Other non-users)	1.27 (0.22 - 7.15)	0.789	1.38 (0.24 - 8.17)	0.718	6.88 (1.52 - 31.03)	0.013	5.26 (1.13 - 24.52)	0.035

Abbreviations: SNS, social networking services; OR, Odds ratio; CI, confidence interval

		Middle age							
		Vaccine hesitancy (n=5048)				High-risk behavior (n=5065)			
		Model 1		Model 2		Model 1		Model 2	
		OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value
Sex	**Women (ref: men)**	1.02 (0.76 - 1.37)	0.9	1.18 (0.87 - 1.60)	0.298	1.11 (0.69 - 1.77)	0.668	0.98 (0.60 - 1.60)	0.923
Occupation	**Health care workers (ref: government workers)**			0.29 (0.14 - 0.62)	0.001			3.04 (1.32 - 7.00)	0.009
	Service industries			1.67 (1.01 - 2.75)	0.045			1.14 (0.48 - 2.71)	0.767
	Education sector			0.82 (0.38 - 1.77)	0.608			3.47 (1.37 - 8.80)	0.009
	All other			1.67 (1.01 - 2.77)	0.047			0.57 (0.21 - 1.56)	0.275
Residential areas	**Inland areas (ref: coastal and mountainous areas)**			1.23 (0.86 - 1.76)	0.253			1.12 (0.65 - 1.94)	0.686
Perceived vulnerability	**Unlikely (ref: likely)**			1.42 (0.94 - 2.13)	0.093			0.31 (0.20 - 0.47)	<0.001
Perceived severity	**Less to moderate serious (ref: highly serious)**			2.33 (1.61 - 3.38)	<0.001			2.44 (1.17 - 5.11)	0.018
Newspapers	**Newspapers readers (ref: Newspapers non-readers)**	0.55 (0.42 - 0.73)	<0.001	0.61 (0.46 - 0.80)	<0.001	0.81 (0.52 - 1.26)	0.34	0.74 (0.47 - 1.16)	0.192
Television or radio	**Television or radio users (ref: Television or radio non-users)**	0.78 (0.55 - 1.12)	0.18	0.77 (0.54 - 1.11)	0.163	0.81 (0.45 - 1.45)	0.479	0.85 (0.47 - 1.54)	0.6
Internet or news apps	**Internet or news apps (ref: Internet or news apps non-users)**	1.56 (1.09 - 2.24)	0.016	1.55 (1.07 - 2.23)	0.02	0.70 (0.44 - 1.11)	0.131	0.70 (0.44 - 1.12)	0.135
SNS	**SNS users (ref: SNS non-nonusers)**	1.23 (0.90 - 1.68)	0.194	1.10 (0.80 - 1.52)	0.542	1.05 (0.62 - 1.78)	0.848	1.06 (0.62 - 1.80)	0.844
Other	**Other users (ref: Other non-users)**	2.41 (1.02 - 5.73)	0.046	3.01 (1.24 - 7.31)	0.015	0.87 (0.12 - 6.53)	0.889	0.48 (0.06 - 3.89)	0.491

Abbreviations: SNS, social networking services; OR, Odds ratio; CI, confidence interval

		Elderly							
		Vaccine hesitancy (n=1493)				High-risk behavior (n=1498)			
		Model 1		Model 2		Model 1		Model 2	
		OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value
Sex	**Women (ref: men)**	4.05 (1.18 - 13.94)	0.028	4.72 (2.47 - 9.02)	0.016	1.04 (0.53 - 2.04)	0.956	1.10 (0.56 - 2.18)	0.887
Occupation	**Health care workers (ref: government workers)**								
	Service industries								
	Education sector								
	All other								
Residential areas	**Inland areas (ref: coastal and mountainous areas)**			1.37 (0.64 - 2.94)	0.68			0.46 (0.24 - 0.90)	0.247
Perceived vulnerability	**Unlikely (ref: likely)**			0.89 (0.19 - 4.10)	0.878			0.31 (0.09 - 1.13)	0.08
Perceived severity	**Less to moderate serious (ref: highly serious)**			6.98 (2.44 - 19.94)	<0.001			1.85 (0.70 - 4.90)	0.521
Newspapers	**Newspapers readers (ref: Newspapers non-readers)**	0.79 (0.27 - 2.33)	0.667	0.97 (0.32 - 2.99)	0.959	4.88 (1.37 - 17.42)	0.213	5.61 (1.57 - 20.14)	0.177
Television or radio	**Television or radio users (ref: Television or radio non-users)**	1.34 (0.16 - 11.20)	0.788	1.37 (0.16 - 11.63)	0.781				
Internet or news apps	**Internet or news apps (ref: Internet or news apps non-users)**	9.84 (3.51 - 27.62)	0.027	9.24 (3.28 - 26.02)	0.032	0.54 (0.17 - 1.65)	0.288	0.50 (0.16 - 1.60)	0.243
SNS	**SNS users (ref: SNS non-nonusers)**	3.25 (1.14 - 9.30)	0.028	3.09 (1.04 - 9.15)	0.042	1.22 (0.47 - 3.15)	0.833	1.32 (0.51 - 3.44)	0.787
Other	**Other users (ref: Other non-users)**								

Abbreviations: SNS, social networking services; OR, Odds ratio; CI, confidence interval

Supplementary Table 2. Comparison of characteristics of the analytic sample at the survey and the whole population in the 2021 local census in Iwate.

		2021 local census	All analytic sample in the survey	
			Vaccine hesitancy	Behavioral risks
		n (%)	n (%)	
Sex	**Men**	567225 (48.0)	2493 (29.9)	2497 (29.8)
	Women	614140 (52.0)	5853 (70.1)	5877 (70.2)
Age classes	**Young**	382476 (32.4)	1830 (21.9)	1837 (21.9)
	Middle age	309772 (26.2)	5025 (60.2)	5041 (60.2)
	Elderly	489117 (41.4)	1491 (17.9)	1496 (17.9)
	Unknown	906777 (76.8)	6726 (80.6)	6749 (80.6)
Area	**Inland areas**	274588 (23.2)	1620 (19.4)	1625 (19.4)
	Coastal and mountainous areas	567225 (48.0)	2493 (29.9)	2497 (29.8)