



HOKKAIDO UNIVERSITY

Title	Traditional and social media usage associated with COVID-19 vaccine uptake in Sapporo, Japan
Author(s)	Sunohara, Satoshi; Asakura, Toshiaki R.; Kimura, Takashi et al.
Citation	Asia-pacific journal of public health https://doi.org/10.1177/10105395241240952
Issue Date	2024-03-30
Doc URL	https://hdl.handle.net/2115/93094
Rights	Sunohara S, Asakura TR, Kimura T, Saijo M, Tamakoshi A. Traditional and Social Media Usage Associated With COVID-19 Vaccine Uptake in Sapporo, Japan. Asia Pacific Journal of Public Health. 2024;36(4):358-365. Copyright © 2024 by Asia-Pacific Academic Consortium for Public Health. DOI: 10.1177/10105395241240952.
Type	journal article
File Information	manuscript_fin.pdf



Traditional and social media usage associated with COVID-19 vaccine uptake in Sapporo, Japan

Satoshi Sunohara^{1,2}, Toshiaki R. Asakura, MD^{2,3}, Takashi Kimura, PhD^{2*}, Masayuki Saijo, MD, PhD⁴, Akiko Tamakoshi, MD, PhD²

¹ School of Medicine, Hokkaido University, Kita 15, Nishi 7, Kita-ku, Sapporo, Hokkaido, 060-8638, Japan

² Department of Public Health, Faculty of Medicine, Hokkaido University, Kita 15, Nishi 7, Kita-ku, Sapporo, Hokkaido, 060-8638, Japan

³ Faculty of Infectious and Tropical Diseases, London School of Hygiene & Tropical Medicine, London, WC1E 7HT, United Kingdom

⁴ Public Health Office, Health and Welfare Bureau, Sapporo Municipal Government, Odori 19, Chuo-ku, Sapporo, Hokkaido, 060-0042, Japan

* Corresponding author

E-mail: kimura@med.hokudai.ac.jp

Contact number: +81-(0)-11-706-5068

Fax: +81-(0)-11-706-7805

Abstract

This study aimed to determine the relationship between specific information source usage and uptake of the coronavirus disease 2019 (COVID-19) vaccine. We analysed 3348 participants aged 20-65 years who were not diagnosed with COVID-19 in the case-control study in Sapporo, Japan. The most prevalent information source on COVID-19 was television (TV) (87.8%), followed by online news sites (74.3%), newspapers (38.7%), websites of public institutions (30.9%), and families (29.7%). Multivariate logistic regression showed the adjusted odds ratios of incompleteness of second vaccinations for users of TV and newspaper to gather COVID-19 information were 0.31 (95% confidence interval, 0.21–0.44) and 0.32 (0.20–0.50), respectively, while those for users of books, commercial video sites, Facebook, and “personal blog or bulletin board system” were 3.34 (1.58–7.06), 2.22 (1.44–3.43), 2.36 (1.24–4.48), and 4.81 (2.72–8.48), respectively. Social media use among older or male participants was associated with lower vaccine uptake.

Keywords: COVID-19, information source, Japan, social media, vaccine hesitancy

39 **What We Already Know**

- 40 • Vaccine hesitancy, defined as a delay in the acceptance or refusal of vaccines despite
41 the availability of vaccination services, hinders high vaccination coverage in high-
42 income countries.
- 43 • Social media platforms such as Facebook or Twitter can disperse misinformation and
44 anxiety, which influence the general population's attitudes toward the uptake of the
45 coronavirus disease 2019 (COVID-19) vaccines.
- 46 • Inconsistent findings from previous studies on the usage of traditional or social media
47 platforms are due to differences in the type of information sought and usage of specific
48 information sources.

49 **What This Article Adds**

- 50 • Television (TV) and online news sites were prevalent sources of information on
51 COVID-19, and users of TV and newspapers were more likely to be vaccinated.
- 52 • Those who obtained information from social media, especially older or male
53 participants, were less likely to receive vaccinations.
- 54 • Females who sought information through the websites of universities or academic
55 institutions had a lower vaccine uptake than those who did not.

Introduction

Coronavirus disease 2019 (COVID-19) vaccines play a significant role in reducing the morbidity and mortality of patients with COVID-19 and responding properly to the large-scale COVID-19 pandemic. Numerous studies have proven the effectiveness of COVID-19 vaccines.¹ However, even in developed countries where vaccines are sufficiently secure, some populations choose not to be vaccinated. Vaccine hesitancy is the major factor hindering vaccination and is defined as “a delay in acceptance or refusal of vaccines despite the availability of vaccination services” by the Strategic Advisory Group of Experts on Immunization.² Several factors are associated with vaccine hesitancy: socioeconomic status (such as low income or low educational attainment) and lack of trust in vaccines, healthcare workers, or the government.³⁻⁵ With regard to COVID-19, some people are concerned about the safety, adverse reactions, and efficacy of vaccines against variants of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) because the development of and research on vaccines has progressed rapidly. Additionally, misinformation, fake news, and conspiracy theories about COVID-19 have spread enormously worldwide and confused the general population.^{6,7} Disseminating this information has fuelled anxiety, mistrust, and anti-vaccination campaigns,⁸ leading to COVID-19 vaccine hesitancy.⁹

Recently developed social media platforms can disperse misinformation and threaten public health by increasing vaccine hesitancy. However, the relationship between media platforms and vaccine hesitancy is not consistent or conclusive. One study found a

negative association between influenza vaccination and the use of social media, such as Twitter and Facebook, but also showed that participants who sought health information on social media were more likely to get vaccinated.¹⁰ Several COVID-19 studies reported that the use of social media was associated with vaccine hesitancy.^{11,12} In contrast, older Portuguese adults who viewed social media as a reliable information source had greater vaccine acceptance.¹³ Other studies did not indicate an association between social media use and vaccine acceptance.^{11,14} These inconsistent findings come from the different measurements of trust, frequency, and information-seeking behaviour for each platform.^{10,11,15} In contrast, users of traditional platforms such as television (TV) and newspapers were positively associated with higher vaccine uptake.^{12,14}

In Japan, COVID-19 vaccine allocation was initiated on 17 February 2021. Among the entire population, 80.4% had received a second dose of the vaccine, and 39.6% had received the omicron-targeting booster vaccine by 19 January 2023.¹⁶ Further vaccine delivery is required to slow the spread of SARS-CoV-2 and to prevent severe outcomes in at-risk populations.

For future planning of vaccination promotion campaigns, it is important to analyse how and where people obtain COVID-19-related information and then assess the effect of information-gathering methods, such as social media usage, on COVID-19 vaccine acceptance or hesitancy among the general population. In this study, we analysed the relationship between social media usage for gathering COVID-19-related information and the completion of two COVID-19 vaccinations among the population of Sapporo.

Methods

Study design and participants

We conducted a case-control study to assess the long-term health impact of SARS-CoV-2 infection. We recruited patients with laboratory-confirmed COVID-19, and controls aged 20–64 years, from Sapporo, Japan.¹⁷ The controls were Sapporo residents who had not been diagnosed with COVID-19 as of 1 February 2022. The age and sex distributions of the control group were matched with those of the general population of Sapporo. We mailed the study documents describing the purposes and protocols to the selected candidates. Participants who consented were asked to access and answer the questionnaires online. We sent documents on 21 February 2022 and 3 March 2022 and opened the server on 21 February 2022, which was planned to be operational until 31 March 2022. In the present study, we included only a control group for the analysis and excluded patients with laboratory-confirmed COVID-19 to avoid bias in the vaccine-related behavioural changes stimulated by COVID-19 infection. Therefore, for our analysis purpose, the participant selection methodology adheres to a cross-sectional study design. In the questionnaire, participants reported their history of COVID-19 infection, and those who experienced COVID-19 were excluded from the analyses. Although our original cut-off was 64, we used self-reported answers for age and included 58 controls aged 65 years.

Ethics approval

This study was approved by the Ethical Review Board for Life Science and Medical Research, Hokkaido University Hospital (protocol code 021-0190). We ensured that no individuals who received this document by mail were known to be COVID-19 cases by others. No reward was given to the participants who answered the questionnaire.

Assessment of COVID-19 vaccination status

Participants were divided into two groups according to the date of the survey response: those who completed two COVID-19 vaccinations (vaccine-completed group) and those who did not (incomplete group). The coverage for the completion of the two COVID-19 vaccinations reached a plateau at the time of the survey (Supplementary Figure S1), which reduced the bias from participants with delayed vaccination. This enabled us to evaluate the factors affecting vaccine uptake. Third and subsequent vaccinations were not considered in our study because the vaccination progress after the third vaccination was insufficient during the survey response period in Japan. Vaccination status was determined based on data from 26 September 2022 from the Vaccination Record System (VRS), a nationwide system for recording COVID-19 vaccination status. We obtained the VRS data from the Public Health Office, City of Sapporo. In addition, we compared this record with the answers to the questionnaire asking about vaccination status, “Have you received novel coronavirus vaccines?” We excluded participants whose VRS data were inconsistent with the self-reported vaccination status, and those who lacked second vaccination status but had

third and later vaccination records on the VRS, possibly because of translocation from other cities to Sapporo or not reporting the second one.

Exposures related to the COVID-19 vaccination

In the questionnaire, participants were asked, “How do you obtain information about the novel coronavirus infection?” The participants answered the question by selecting multiple answers from “None”, “TV”, “Radio”, “LINE”, “Twitter”, “Facebook”, “Instagram”, “Online news site”, “Commercial video site”, “Personal blog or bulletin board system (BBS)”, “Newspaper”, “Magazine”, “Book”, “Family”, “Friend or acquaintance”, “Medical institution”, “Website of public institutions”, and “Website of universities or academic institutions”.

In our analysis, we categorised information sources into three types: traditional media, social media, and other. Traditional media are sources of information that are widely broadcasted to the public without the Internet. The traditional media category included "TV", "Radio", "Newspaper", "Magazine", and "Book". Social media are defined as information sources established through Internet-based services where users communicate interactively using their content on the Internet. The social media category included "LINE", "Twitter", "Facebook", "Instagram", "Commercial video site", and "Personal blog or BBS". Information sources belonging to neither traditional nor social media were categorised as others. For consistency, we excluded answers that selected both "None" and any other information sources.

We also included confounding factors in the association between information sources and COVID-19 vaccine uptake. We included age (25–34, 35–49, or 50–65 years), sex (male or female), body mass index calculated from height and weight (“<25”, “≥25, <30” or “≥30” kg/m²), high-risk underlying medical conditions (none or exist), educational background (“senior high school and below”, “vocational school, junior college and higher professional school (HPS)”, or “university and above”), working place (“health care”, “nursing care and public welfare”, “catering”, or “others”), working position (“company executive”, “self-employed/family business”, “regular employee”, “non-regular employee”, “student/homemaker”, or “unemployed”), annual household income (“<2 million yen”, “≥2 million yen, <6 million yen”, “≥6 million yen, <10 million yen”, “≥10 million yen” or “refusal to answer or unknown”), and the number of cohabitant families (0, 1, 2, 3, or ≥4). The data on these variables were collected using a questionnaire. Because of the non-applicability to analysis, participants who chose some answers were excluded from the analysis (sex or educational background as “Other”). Additionally, participants who reported an implausible number of cohabiting families (10 or more) were excluded. High-risk underlying medical conditions were assigned as “Exist” if participants had any medical history of “malignant tumour”, “myocardial infarction”, “angina pectoris”, “heart failure”, “atrial fibrillation”, “myocarditis”, “hypertension”, “diabetes”, “chronic obstructive pulmonary disease”, “chronic bronchitis”, “bronchial asthma”, “chronic renal failure”, “hepatitis or cirrhosis”, “collagen disease”, “immune deficiency syndrome”, “human immunodeficiency virus infection or acquired immunodeficiency syndrome” or “sleep

apnoea”. The selection of these diseases was based on the vaccine priority group classification developed by the Ministry of Health, Labour and Welfare, Japan.¹⁸

Statistical methods

We performed logistic regression analysis with the incomplete vaccination group as the response variable and each source of information as the explanatory variable, adjusting for confounding factors. Univariate and multivariate analyses were performed to estimate crude and adjusted odds ratios (ORs). We did not mutually adjust for information sources during the multivariate analyses, because the use of information sources was highly correlated. For statistical analyses and visualisations, we used Python 3.9.7 and the following packages: Statsmodels 0.13.2, Pandas 1.4.1, NumPy 1.21.5, Matplotlib 3.5.1, and MyForestPlot 0.2.3.

Results

We mailed documents to 21434 possible controls and collected 3708 answers by 31 March 2022. After excluding 360 participants who met the exclusion criteria, 3348 controls were included in the analysis (Supplementary Figure S2). Regarding participant demographics, 20.3% (678/3348), 37.9% (1268/3348), and 41.9% (1402/3348) were aged 20–34, 35–49, and 50–65, respectively. Female participants accounted for 56.5% (1893/3348) (Table 1). From publicly available data,¹⁹ among the 20–64-year-old population in Sapporo, as of 1 January 2022, the proportions of those aged 20–34, 35–49,

and 50–64 years were 27.3%, 37.0%, and 35.7%, respectively. The proportion of female patients was 51.9%. Thus, the proportions of older and female population was higher in this survey than those in the Sapporo population.

“INSERT TABLE 1 HERE”

Regarding vaccination status, 94.9% (3177/3348) of the participants completed the second vaccination. The second vaccination coverage plateaued by March 2022, when we conducted the survey (Supplementary Figure S1). Regarding the proportion of COVID-19-related information sources, the top five categories were TV (87.8% [2938/3348]), online news sites (74.3% [2487/3348]), newspapers (38.7% [1297/3348]), websites of public institutions (30.9% [1036/3348]), and families (29.7% [995/3348]). The number and percentage of each information source stratified by age and sex are presented in Supplementary Table S1.

The second vaccination coverage and the mean age of users for each information source were visualised using a bubble chart (Figure 1). The mean age was approximately 50 years for users who relied on newspapers, radio, magazines, and books as their information source, whereas it was less than 40 years for those who used Twitter, Instagram, or none. Vaccination coverage among newspaper users was the highest and was particularly low among users of a personal blog or BBS, or those who relied on nothing.

“INSERT FIGURE 1 HERE”

We observed both adjusted ORs and confidence intervals (CIs) below one among TV or newspaper users compared with those among non-users of TV or newspapers, while

we observed both adjusted ORs and CIs above one among those who used books, commercial video sites, Facebook, or “personal blog or BBS” (Figure 2).

“INSERT FIGURE 2 HERE”

The ORs for the age and sex subgroups are illustrated in a forest plot (Supplementary Figure S3) and are summarised in Supplementary Tables S2 and S3. In the age-stratified analysis, participants aged 50–65 years had higher ORs of incompleteness of the second vaccination than those aged 20–34 or 35–49 years for Twitter, Instagram, Facebook, websites of public institutions, and websites of universities or academic institutions. Male participants had higher ORs than female participants for Twitter, LINE, Instagram, Facebook, websites of public institutions, and none, whereas male participants had lower ORs than female participants for websites of universities or academic institutions.

If the participants used a higher number of traditional media platforms, we observed lower ORs for incomplete secondary vaccinations. Conversely, as the number of social media platforms increased, we observed higher ORs for incomplete secondary vaccinations (Supplementary Table S4).

Discussion

The most prevalent sources of COVID-19-related information among the participants were TV (87.8%) and online news sites (74.3%), and we observed a high percentage regardless of age or sex (Supplementary Table S1). The third highest percentage

of participants obtained COVID-19-related information from newspapers (38.7%). However, participants 20–34 years of age were unlikely to use newspapers (15.3%) and mainly collected information from Twitter (42.5%). Those collecting COVID-19-related information from TV or newspapers were more likely to receive vaccination than those who did not, whereas social media users were unlikely to receive vaccination compared to non-users of each social media platform, including commercial video sites (i.e. YouTube), Instagram, Facebook, and “a personal blog or BBS”. The use of more traditional media platforms was associated with vaccination, whereas the use of more social media platforms was associated with lower vaccine uptake.

Among traditional media platforms, TV and newspaper users had a greater tendency to be vaccinated, even after age and sex stratification. This result is consistent with those of previous studies showing an association between traditional media use and high vaccine acceptance.^{12,14} Traditional media are generally linked to the government and universities, and provide high-quality information that attains the trust of listeners. Therefore, TV and newspapers still play a major role in providing trusted information and promoting vaccination, even for the younger generations.

Previous studies before the COVID-19 pandemic found that Twitter content had a higher proportion of information supportive of immunisation or substantiated information compared to that of other social media platforms.^{20,21} Several months after the emergence of COVID-19, Twitter companies began to raise alarm labels for COVID-19 information, and this kind of fact-checking label was effective in promoting vaccine uptake.²² Because

of these positive factors and the ease of posting text messages, Twitter users communicated effectively with others compared to users of other social media platforms. Another explanation for the lower ORs of incomplete second vaccination compared to other platforms is that the differences in usage intent or trust level on Twitter influence behaviour.^{10,13} LINE is the most prevalent personal communication tool in Japan. People do not pay careful attention to news in their LINE feed, which leads ORs towards the null.

Those using commercial video sites, Instagram, Facebook, or “a personal blog or BBS” were unlikely to be vaccinated and using more social media platforms was associated with lower vaccine uptake. Our results are consistent with studies reporting a negative relationship between vaccine uptake and social media usage.^{10,23} Fake news is known to spread more rapidly than facts, specifically on Facebook.²⁴ Therefore, some interventions such as health literacy campaigns are recommended to reduce vaccine hesitancy by increasing individuals’ ability to detect misinformation.²⁵

Participants 50–65 years of age or men who used social media were less likely to be vaccinated than those in other groups. In contrast, a study targeting Portuguese adults aged 65 years or older found that those who regarded social media information as reliable had more intentions to be vaccinated.¹³ Country or regional differences in the characteristics of older social media users could result in estimates opposite to ours.

Female participants seeking information from universities or academic institutions had a higher odds ratio for incompleteness of the second vaccination. This result is intriguing because many academic studies have demonstrated the effectiveness of the vaccine,^{1,26–28}

which should promote vaccination. However, the reason behind this could be the higher risk of having adverse events among females than among males.²⁹ The concern about harmful outcomes after being vaccinated was a major factor for vaccination hesitancy.³⁰ While mass media sources like TV only provide general descriptions, academic studies provide detailed information about the risks of adverse events. Therefore, academic studies may have unintentionally contributed to vaccine hesitancy among females, resulting in lower vaccination rates.

Our analyses used the actual vaccination statuses registered in the VRS and did not rely on self-reports. The present study randomly selected participants from all Sapporo citizens who had not been confirmed to have COVID-19. This method improves the accuracy and reliability of our datasets. We believe that our results can be generalised to other Japanese cities.

The present study had several limitations. First, the response rate was approximately 17%, which may have biased the profile of the respondents. The proportion of respondents in our study who received a second vaccination was 94.9%, which was quite high compared to the overall 20–64-year-old population in Sapporo (second vaccination coverage rate as of 10 February 2023:83.3%). Those who were willing to participate in the present study might have had a higher awareness of their health than the general population. There is the selection bias in that these people are more likely to receive the COVID-19 vaccine. Second, we did not investigate the reasons for non-vaccination. The main reasons for not receiving a vaccine could be hesitancy or emotional concerns; however, health conditions

cannot be denied as contributing factors. Third, our study asked participants about their information sources using simple multiple-choice questions. Therefore, we could not determine the primary information source influencing decisions regarding vaccine uptake.²³ Fourth, we could not determine the causality between information sources and vaccine uptake from this cross-sectional study. The information provided through these media platforms may have influenced users' vaccination behaviours. However, the causality can be reversed. For example, people who are more sceptical about public policy and strongly opposed to vaccines may be willing to use one of these media sources. Nevertheless, in the future, public health authorities need to understand the characteristics of the users of each medium to tailor their messages to the target population.

Conclusion

We clarified the prevalence of media platform usage for COVID-19-related information and the relationship between media platform use and vaccine uptake. The use of TV and newspapers was associated with higher vaccine uptake, even among the younger generation, whereas the use of social media was related to lower vaccine uptake.

Acknowledgements

We thank Hiroyasu Iso, the Institute for Global Health Policy Research, the Bureau of International Cooperation, the National Centre for Global Health and Medicine; Hidehiro Ozawa and Masami Iwama, the Public Health Office, the Health and Welfare Bureau, and

319 the Sapporo Municipal Government, Sapporo, Hokkaido, Japan, for their cooperation in
320 launching this study.

321 **Declaration of Conflicting Interests**

322 The Author(s) declare(s) that there is no conflict of interest.

323 **Funding**

324 The author(s) disclosed receipt of the following financial support for the research,
325 authorship, and/or publication of this article: This work was supported by the Japan Agency
326 for Medical Research and Development (AMED) (Grant Number JP 20fk0108471) and the
327 Ministry of Health, Labour and Welfare (MHLW) Special Research Program (Grant
328 Number JPMH20CA2046).

329

References

1. Zheng C, Shao W, Chen X, Zhang B, Wang G, Zhang W. Real-world effectiveness of COVID-19 vaccines: a literature review and meta-analysis. *Int J Infect Dis.* 2022;114:252-260. doi:10.1016/j.ijid.2021.11.009
2. World Health Organization. Report of the SAGE Working Group on Vaccine Hesitancy. Accessed February 13, 2023. https://www.asset-scienceinsociety.eu/sites/default/files/sage_working_group_revised_report_vaccine_hesitancy.pdf
3. Leigh JP, Moss SJ, White TM, et al. Factors affecting COVID-19 vaccine hesitancy among healthcare providers in 23 countries. *Vaccine.* 2022;40(31):4081-4089. doi:10.1016/j.vaccine.2022.04.097
4. Machida M, Nakamura I, Kojima T, et al. Acceptance of a COVID-19 vaccine in Japan during the COVID-19 pandemic. *Vaccines.* 2021;9(3):210. doi:10.3390/vaccines9030210
5. Malik AA, McFadden SM, Elharake J, Omer SB. Determinants of COVID-19 vaccine acceptance in the US. *EClinicalMedicine.* 2020;26:100495. doi:10.1016/j.eclinm.2020.100495
6. Wilson SL, Wiysonge C. Social media and vaccine hesitancy. *BMJ Glob Health.* 2020;5(10):e004206. doi:10.1136/bmjgh-2020-004206
7. Pertwee E, Simas C, Larson HJ. An epidemic of uncertainty: rumors, conspiracy theories and vaccine hesitancy. *Nat Med.* 2022;28(3):456-459. doi:10.1038/s41591-022-01728-z
8. Rotolo B, Dubé E, Vivion M, MacDonald SE, Meyer SB. Hesitancy towards COVID-19 vaccines on social media in Canada. *Vaccine.* 2022;40(19):2790-2796. doi:10.1016/j.vaccine.2022.03.024
9. Loomba S, de Figueiredo A, Piatek SJ, de Graaf K, Larson HJ. Author Correction: Measuring the impact of COVID-19 vaccine misinformation on vaccination intent in the UK and USA. *Nat Hum Behav.* 2021;5(7):960-960. doi:10.1038/s41562-021-01172-y
10. Ahmed N, Quinn SC, Hancock GR, Freimuth VS, Jamison A. Social media use and influenza vaccine uptake among White and African American adults. *Vaccine.* 2018;36(49):7556-7561. doi:10.1016/j.vaccine.2018.10.049

- 362 11. Mascherini M, Nivakoski S. Social media use and vaccine hesitancy in the European
363 Union. *Vaccine*. 2022;40(14):2215-2225. doi:10.1016/j.vaccine.2022.02.059
- 364 12. Murphy J, Vallières F, Bentall RP, et al. Psychological characteristics associated with
365 COVID-19 vaccine hesitancy and resistance in Ireland and the United Kingdom. *Nat*
366 *Commun*. 2021;12(1):29. doi:10.1038/s41467-020-20226-9
- 367 13. Silva TM, Estrela M, Roque V, et al. Perceptions, knowledge and attitudes about
368 COVID-19 vaccine hesitancy in older Portuguese adults. *Age Ageing*.
369 2022;51(3):afac013. doi:10.1093/ageing/afac013
- 370 14. Piltch-Loeb R, Savoia E, Goldberg B, et al. Examining the effect of information
371 channel on COVID-19 vaccine acceptance. Gesser-Edelsburg A, ed. *PLoS ONE*.
372 2021;16(5):e0251095. doi:10.1371/journal.pone.0251095
- 373 15. Cascini F, Pantovic A, Al-Ajlouni YA, et al. Social media and attitudes towards a
374 COVID-19 vaccination: A systematic review of the literature. *eClinicalMedicine*.
375 2022;48:101454. doi:10.1016/j.eclinm.2022.101454
- 376 16. Prime Minister of Japan and His Cabinet. COVID-19 Vaccines. Accessed January 21,
377 2023. <https://japan.kantei.go.jp/ongoingtopics/vaccine.html>
- 378 17. Asakura T, Kimura T, Kurotori I, et al. Case–Control Study of Long COVID, Sapporo,
379 Japan. *Emerg Infect Dis*. 2023;29(5). doi:10.3201/eid2905.221349
- 380 18. Ministry of Health, Labour and Welfare, Japan. Novel corona vaccine Q&A. Accessed
381 January 21, 2023. <https://www.cov19-vaccine.mhlw.go.jp/qa/0130.html>
- 382 19. City of Sapporo. Population in basic resident register. Accessed February 11, 2023.
383 <https://www.city.sapporo.jp/toukei/jinko/juuki/juuki.html>
- 384 20. Love B, Himelboim I, Holton A, Stewart K. Twitter as a source of vaccination
385 information: Content drivers and what they are saying. *Am J Infect Control*.
386 2013;41(6):568-570. doi:10.1016/j.ajic.2012.10.016
- 387 21. McNeill A, Harris PR, Briggs P. Twitter influence on UK vaccination and antiviral
388 uptake during the 2009 H1N1 pandemic. *Front Public Health*. 2016;4.
389 doi:10.3389/fpubh.2016.00026
- 390 22. Zhang J, Featherstone JD, Calabrese C, Wojcieszak M. Effects of fact-checking social
391 media vaccine misinformation on attitudes toward vaccines. *Prev Med*.
392 2021;145:106408. doi:10.1016/j.ypmed.2020.106408

23. Horiuchi S, Sakamoto H, Abe SK, et al. Factors of parental COVID-19 vaccine hesitancy: A cross sectional study in Japan. *PLOS ONE*. 2021;16(12):e0261121. doi:10.1371/journal.pone.0261121
24. Guess AM, Nyhan B, Reifler J. Exposure to untrustworthy websites in the 2016 US election. *Nat Hum Behav*. 2020;4(5):472-480. doi:10.1038/s41562-020-0833-x
25. Montagni I, Ouazzani-Touhami K, Mebarki A, et al. Acceptance of a Covid-19 vaccine is associated with ability to detect fake news and health literacy. *J Public Health (Oxf)*. 2021;43(4):695-702. doi:10.1093/pubmed/fdab028
26. Wang K, Wang L, Li M, et al. Real-word effectiveness of global COVID-19 vaccines against SARS-CoV-2 variants: A systematic review and meta-analysis. *Front Med*. 2022;9:820544. doi:10.3389/fmed.2022.820544
27. Pratama NR, Wafa IA, Budi DS, et al. Effectiveness of COVID-19 vaccines against SARS-CoV-2 Omicron variant (B.1.1.529): A systematic review with meta-analysis and meta-regression. *Vaccines*. 2022;10(12):2180. doi:10.3390/vaccines10122180
28. Chalkias S, Harper C, Vrbicky K, et al. A bivalent Omicron-containing booster vaccine against Covid-19. *N Engl J Med*. 2022;387(14):1279-1291. doi:10.1056/NEJMoa2208343
29. Green MS, Peer V, Magid A, Hagani N, Anis E, Nitzan D. Gender Differences in Adverse Events Following the Pfizer-BioNTech COVID-19 Vaccine. *Vaccines (Basel)*. 2022;10(2):233. doi:10.3390/vaccines10020233
30. Okubo R, Yoshioka T, Ohfuji S, Matsuo T, Tabuchi T. COVID-19 vaccine hesitancy and its associated factors in Japan. *Vaccines*. 2021;9(6):662. doi:10.3390/vaccines9060662

Figure Legends

Figure 1. A bubble chart visualising second vaccination coverage and the mean age of participants who used each information source. The circle size is proportional to the size of each information source user. TV represents television. BBS represents the Bulletin Board System.

Figure 2. Crude and multivariate odds ratios of incomplete second vaccination for participants with access to each information source. The multivariate model was adjusted for age, sex, body mass index, high-risk underlying medical conditions, educational background, working place, working position, household income, and the number of cohabitant families. OR and CI represent the odds ratio and confidence interval, respectively. TV represents television. BBS represents the Bulletin Board System.

431 **Table 1.** Baseline characteristics of the study participants and those stratified by second
432 vaccination status.

Categories		Numbers (%)		
		Total 3348	2 nd vaccination status	
			Complete	Incomplete
			3177	171
Age	20–34	678 (20.3%)	638 (20.1%)	40 (23.4%)
	35–49	1268 (37.9%)	1184 (37.3%)	84 (49.1%)
	50–65	1402 (41.9%)	1355 (42.7%)	47 (27.5%)
Sex	Male	1455 (43.5%)	1384 (43.6%)	71 (41.5%)
	Female	1893 (56.5%)	1793 (56.4%)	100 (58.5%)
Body mass index (kg/m²)	<25	2465 (73.6%)	2342 (73.7%)	123 (71.9%)
	≥25, <30	683 (20.4%)	649 (20.4%)	34 (19.9%)
	≥30	200 (6.0%)	186 (5.9%)	14 (8.2%)
High-risk underlying medical conditions	Non-exist	2379 (71.1%)	2244 (70.6%)	135 (78.9%)
	Exist	969 (28.9%)	933 (29.4%)	36 (21.1%)
Educational background	Senior high school and below	943 (28.2%)	887 (27.9%)	56 (32.7%)
	Vocational school, junior college and HPS ^a	1115 (33.3%)	1051 (33.1%)	64 (37.4%)
	University and above	1290 (38.5%)	1239 (39.0%)	51 (29.8%)
Working place	Health care	366 (10.9%)	357 (11.2%)	9 (5.3%)
	Nursing care and public welfare	146 (4.4%)	141 (4.4%)	5 (2.9%)
	Catering	80 (2.4%)	73 (2.3%)	7 (4.1%)
	Others	2756 (82.3%)	2606 (82.0%)	150 (87.7%)
Working position	Company executive	147 (4.4%)	142 (4.5%)	5 (2.9%)
	Self-employed/family business	164 (4.9%)	151 (4.8%)	13 (7.6%)
	Regular employee	1640 (49.0%)	1569 (49.4%)	71 (41.5%)
	Non-regular employee	848 (25.3%)	803 (25.3%)	45 (26.3%)
	Student/homemaker	391 (11.7%)	366 (11.5%)	25 (14.6%)
	Unemployed	158 (4.7%)	146 (4.6%)	12 (7.0%)

Household income	<2 million yen	405 (12.1%)	370 (11.6%)	35 (20.5%)
	≥2 million yen, <6 million yen	1321 (39.5%)	1253 (39.4%)	68 (39.8%)
	≥6 million yen, <10 million yen	903 (27.0%)	856 (26.9%)	47 (27.5%)
	≥10 million yen	339 (10.1%)	333 (10.5%)	6 (3.5%)
	Refusal to answer or unknown	380 (11.4%)	365 (11.5%)	15 (8.8%)
Number of cohabitant families	0	627 (18.7%)	592 (18.6%)	35 (20.5%)
	1	983 (29.4%)	927 (29.2%)	56 (32.7%)
	2	833 (24.9%)	802 (25.2%)	31 (18.1%)
	3	652 (19.5%)	619 (19.5%)	33 (19.3%)
	≥4	253 (7.6%)	237 (7.5%)	16 (9.4%)
Information source (traditional media)	TV ^b	2938 (87.8%)	2817 (88.7%)	121 (70.8%)
	Newspaper	1297 (38.7%)	1271 (40.0%)	26 (15.2%)
	Radio	424 (12.7%)	407 (12.8%)	17 (9.9%)
	Magazine	149 (4.5%)	140 (4.4%)	9 (5.3%)
	Book	76 (2.3%)	67 (2.1%)	9 (5.3%)
Information source (social media)	Twitter	636 (19.0%)	593 (18.7%)	43 (25.1%)
	LINE	624 (18.6%)	597 (18.8%)	27 (15.8%)
	Commercial video site	286 (8.5%)	256 (8.1%)	30 (17.5%)
	Instagram	169 (5.0%)	153 (4.8%)	16 (9.4%)
	Facebook	114 (3.4%)	102 (3.2%)	12 (7.0%)
Information source (others)	Personal blog or BBS ^c	89 (2.7%)	71 (2.2%)	18 (10.5%)
	Online news site	2487 (74.3%)	2363 (74.4%)	124 (72.5%)
	Website of public institutions	1036 (30.9%)	998 (31.4%)	38 (22.2%)
	Family	995 (29.7%)	954 (30.0%)	41 (24.0%)
	Friend or acquaintance	964 (28.8%)	916 (28.8%)	48 (28.1%)
Information source (others)	Medical institution	401 (12.0%)	386 (12.1%)	15 (8.8%)
	Website of universities or academic institutions	176 (5.3%)	164 (5.2%)	12 (7.0%)
	None	43 (1.3%)	37 (1.2%)	6 (3.5%)

433 ^a HPS represents Higher Professional School.

434 ^bTV represents television.

435 ^cBBS represents the Bulletin Board System.

436

437

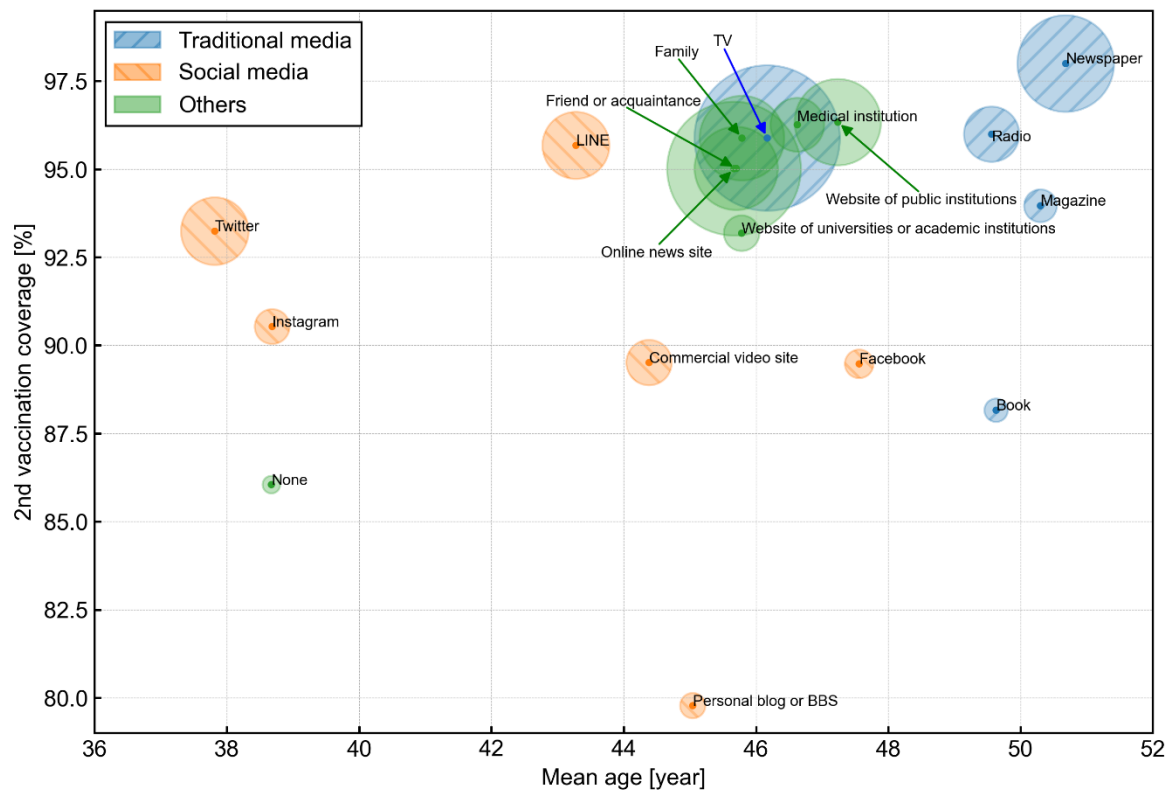


Figure 1.

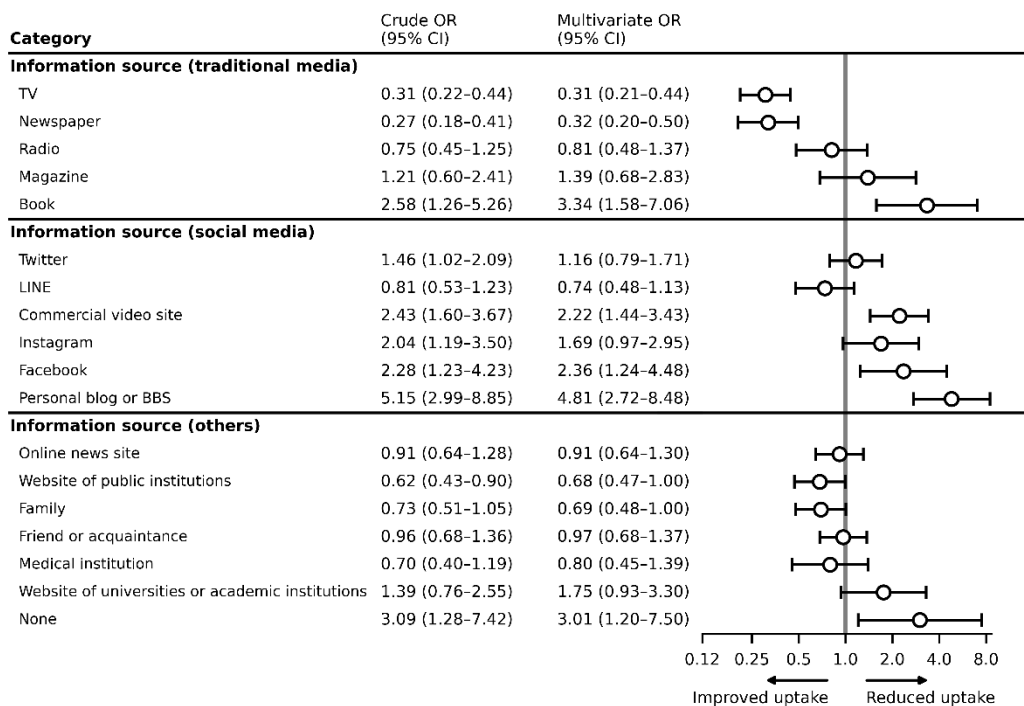


Figure 2.