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Effect of a mobile app chatbot and an interactive small-group webinar on COVID-19 vaccine intention and confidence in Japan: a randomised controlled trial

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ABSTRACT

Introduction We investigated the effect of social media-based interventions on COVID-19 vaccine intention (VI) and confidence in Japan.

Methods We conducted a three-arm randomised controlled trial between 5 November 2021 and 9 January 2022 during a low incidence (<1000/day) of COVID-19 in Japan in the midst of the second and the third waves. Japanese citizens aged ≥20 who had not received any COVID-19 vaccine and did not intend to be vaccinated were randomly assigned to one of the following three groups: (1) a control group, (2) a group using a mobile app chatbot providing information on COVID-19 vaccines and (3) a group using interactive webinars with health professionals. VI and predefined Vaccine Confidence Index (VCI) measuring confidence in the importance, safety and effectiveness were compared before and after the interventions under intention-to-treat principle. Logistic regression models were used to investigate the effect of each intervention on postintervention VI and changes of VCI compared with control.

Results Among 386 participants in each group, 359 (93.0%), 231 (59.8%) and 207 (53.6%) completed the postsurvey for the control, chatbot and webinar groups, respectively. The average duration between the intervention and the postsurvey was 32 days in chatbot group and 27 days in webinar group. VI increased from 0% to 18.5% (95% CI 14.5%, 22.5%) in control group, 15.4% (95% CI 10.8%, 20.1%) in chatbot group and 19.7% (95% CI 14.5%, 24.9%) in webinar group without significant difference (OR for improvement=0.8 (95% CI 0.5, 1.3), p=0.33 between chatbot and control, OR=1.1 (95% CI 0.7, 1.6), p=0.73 between webinar and control). VCI change tended to be larger in chatbot group compared with control group without significant difference (3.3% vs −2.5% in importance, OR for improvement=1.3 (95% CI 0.9, 2.0), p=0.18; 2.5% vs 1.9% in safety, OR=1.1 (95% CI 0.7, 1.9), p=0.62; −2.4% vs −7.6% in effectiveness, OR=1.4 (95% CI 0.9, 2.1), p=0.09). Improvement in VCI was larger in webinar group compared with control group for importance (7.8% vs −2.5%, OR=1.8 (95% CI 1.2, 2.8), p<0.01), effectiveness (6.4% vs −7.6%, OR=2.2 (95% CI 1.4, 3.4), p<0.01) and safety (6.0% vs 1.9%, OR=1.6 (95% CI 1.0, 2.6), p=0.08).

Conclusion This study demonstrated that neither the chatbot nor the webinar changed VI importantly compared with control. Interactive webinars could be an effective tool to change vaccine confidence. Further study is needed to identify risk factors associated with decreased vaccine confidence and investigate what intervention can increase VI and vaccine confidence for COVID-19 vaccines.

Trial registration number UMIN000045747.

INTRODUCTION

Regulatory approval of COVID-19 vaccines in Japan lagged behind other countries.[1] Starting in February 2021, COVID-19 vaccines were initially administered to only healthcare workers[1]; then to older adults, those with chronic disease and those working for nursing facilities (around April 2021); and, finally, to the general population. Although the COVID-19 vaccine coverage of the primary two-dose series gradually increased to ~80% in 2022, vaccine uptake was lower in Japan than it was in other high-income countries at the beginning of the vaccine rollout in 2021.[2] For instance, the coverage rate in Japan was 49% as of early August 2021, while other G7 countries, such as Canada, the UK, France and Italy, all achieved over 65% coverage rate at that time.[2]

While the delay of regulatory approval and logistical issues influenced slow rollout, it was also rooted in public vaccine hesitancy.[3] A previous study revealed that Japan was one of the least vaccine-confident countries in

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Japan is one of the least vaccine-confident countries in the world and has a long history of public uncertainties about vaccines in general.
⇒ Social media-based interventions have been implemented to increase vaccine uptake; however, there have been conflicting data available on whether social media-based interventions can increase vaccine intention and confidence.
⇒ There is a paucity of studies investigating the effect of a mobile app chatbot and interactive webinars on COVID-19 vaccine intention and confidence in Japan.

WHAT THIS STUDY ADDS

⇒ This randomised controlled trial did not find sufficient evidence that the chatbot or the webinars changed COVID-19 vaccine intention among those with high vaccine hesitancy and low acceptance in Japan in 2021 compared with control.
⇒ COVID-19 vaccine confidence for importance, safety and effectiveness increased with the webinar intervention compared with control.
⇒ Vaccine confidence in importance and effectiveness of COVID-19 vaccines decreased in the control group over time.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Interactive small-scale webinars featuring live Q&A with medical professionals may serve as an efficacious method for addressing public concerns about COVID-19 vaccines and enhancing vaccine confidence.
⇒ In light of the worsening vaccine confidence among unvaccinated individuals without any mitigation, local governments and public health organisations may necessitate conducting regular, interactive, small-group webinars, particularly in regions with low vaccine uptake or high vaccine hesitancy.
⇒ Further research is needed to investigate the strategies for recruiting and retaining participation of individuals with vaccine hesitancy in randomised controlled trials and to assess the effects of social media-based interventions on increasing vaccine intention and the vaccine confidence for COVID-19 vaccines.

the world, even before the COVID-19 pandemic.[4] Japan has a long history of public uncertainties about vaccines, such as the human papillomavirus vaccine, which led to a severe drop in coverage, from over 70% to less than 1% after the rise of public anxiety and the government's suspension of proactive recommendation of the vaccine due to public pressure about suspected vaccine adverse events.[5] A survey conducted in 15 countries in January 2021 found that intention to be vaccinated against COVID-19 was lower in Japan than in other countries: 36% of surveyed Japanese adults strongly or somewhat disagreed with being vaccinated against COVID-19.[6 7] As success of vaccine rollout ultimately depends on the public's willingness to be vaccinated,[8] increasing vaccine intention (VI) and vaccine confidence among those who are unwilling or hesitant to be vaccinated was a critical priority in 2021 to improve vaccine uptake in Japan.

During the COVID-19 pandemic, too much information and rumours, both accurate and false, have spread widely and rapidly through online platforms.[9] This 'infodemic' confused people and created uncertainty about trust in the COVID-19 vaccine. A past nationwide survey in Japan demonstrated that many study participants wanted to obtain more information on COVID-19 vaccines to make a decision about being vaccinated, including information about the compatibilities between the vaccine and their personal health conditions, the effectiveness of vaccines and medical doctors' recommendations.[7] To provide the non-health expert public with scientific evidence-based information on COVID-19 vaccines in a user-friendly manner, it is important to explore the best platform(s) to optimise public understanding of COVID-19 vaccine information and ultimately improve their VI and confidence.

Past studies indicated the potential of online interventions to increase VI and uptake by providing accurate information on vaccines and disease and by increasing public perception of vaccine benefits. For example, a randomised controlled study in 2017 demonstrated that mothers presented with accurate vaccine information on social media during their pregnancy were more likely to vaccinate their infants on time.[10] A recent cross-sectional study showed that small-group Zoom webinars helped address misconceptions surrounding COVID-19 vaccines and was associated with increased willingness to be vaccinated among 91 Asian immigrants in Canada and the USA.[11] Virtual webinars were also reported to be effective in reducing vaccine hesitancy at black church congregations.[12] On the other hand, another study suggested that social media use itself may not be directly associated with people's willingness to receive a COVID-19 vaccination.[13] There have been conflicting data available about whether and how online or virtual webinars can be used to address COVID-19 vaccine hesitancy. Furthermore, we previously published a cross-sectional study investigating the association between COVID-19 VI and the use of a chatbot in a popular messenger app in Japan.[14] Though this study indicated the potential usefulness of a social media-based chatbot to reduce vaccine hesitancy, this study was subject to multiple limitations in terms of the study design since the study was cross-sectional only among chatbot users without a comparison group. Therefore, it had both internal (eg, recall bias, interview bias) and external validity issues, and the association between chatbot use and VI could not be clearly evaluated.

To address this knowledge gap, we investigated whether social media-based interventions could increase COVID-19 VI and vaccine confidence among those with vaccine hesitancy. We used two different online interventions, a social media-based chatbot and webinars, and examined which of these were more effective at increasing COVID-19 VI and vaccine confidence. By conducting two online interventions, we examined how different online tools can be used depending on people's demands and available resources.

METHODS

Study design and setting

We conducted a three-arm randomised controlled trial to investigate the impact of a mobile app chatbot and an online interactive seminar (webinar) on COVID-19 VI and vaccine confidence among those (1) unvaccinated and unwilling or hesitant to be vaccinated; and (2) aged 20 or older in Japan from 5 November 2021 until 9 January 2022. We assessed COVID-19 VI and vaccine confidence by performing preintervention and postintervention cross-sectional surveys.

During the study period, three COVID-19 vaccines were publicly available: BNT162b2, mRNA-1273 and ChAdOx1-S/nCoV-19. The costs of vaccines were covered in full by public funds for all Japanese nationals and all eligible foreign residents. The government has strongly recommended that all people get vaccinated given the global evidence shows that the benefits of vaccination are greater than the risk of adverse event. Thanks to the government's recommendations, about 80% of Japanese people had received at least one dose of a COVID-19 vaccine when this study was conducted.[15] Third dose of COVID-19 vaccines was only available to limited healthcare workers during the present study. No new vaccines became available and no new policy was implemented during the study period of 2.5 months. The period when the postsurvey was conducted (between late December 2021 and early January 2022) covered the two key phases that influenced public perceptions on vaccines: (1) when the daily reported COVID-19 cases were relatively low with less than 1000 cases per day; and (2) when the Omicron variant emerged.

Study participants

Study participants were recruited from the panel of a Japanese internet research service company (NTTCom Online Marketing Solutions), which had approximately 120 million registered individuals as of October 2021. First, the screening survey was sent to 700 000 randomly selected persons in the panel on 20 October 2021 with the following five questions: (1) 'How old are you?'; (2) 'Have you received a COVID-19 vaccine?'; (3) 'Do you intend to be vaccinated?' (with answer options of 'Yes', 'Not sure but toward Yes', 'Not sure but toward No' and 'No'); (4) 'Do you have LINE (one of the most popular messenger apps in Japan) installed on your mobile phone? If not, are you willing to download LINE to participate in this study?'; and (5) 'Are you capable of using Zoom for webinars?' Eligibility criteria included: (1) age 20 or older; (2) had never received a COVID-19 vaccine; (3) those who selected an answer other than 'Yes' to question 3; (4) willing to use LINE; and (5) willing to use Zoom. Monetary incentives were given as follows: 1000 yen (~US$8) for those who completed the presurvey and postsurvey in the control group, 1500 yen for those who used the chatbot at least once and completed the presurvey and postsurvey and 3000 yen for those who attended at least one of 14 webinars for at least 15 min and completed presurveys and postsurveys.

Preintervention survey

Eligible persons were invited to participate in the presurvey by email on 5 November 2021. Questionnaires were placed in a secure section of a website, and persons who consented electronically received the link to the questionnaires. The presurvey ended on 10 November 2021 (a total of 5 days). The presurvey had a total of 30 questions (online supplemental text S2), including survey items used in similar studies,[16] as well as our own questions. The survey also asked for age, sex, geographic location, educational attainment, employment status, work in a healthcare setting, annual household income, presence of chronic diseases identified as risk factors for severe COVID-19 by the Japanese government,[17] history of influenza vaccine in the previous season, history of COVID-19 infection, history of any side effect from any previous vaccination and COVID-19 VI for their children, if any. Geographic locations were combined using the following categories: Hokkaido, Tohoku, Kanto (eg, Tokyo), Chubu, Kansai (eg, Osaka), Kinki, Chugoku, Shikoku, Kyushu regions and outside of Japan.[18] In addition, questions were asked about personal experience with social media involving COVID-19 vaccine information. These questions included which social network the participants use most to obtain COVID-19 vaccine information, which social media they trust most and how long they use social media per day, among others.

Intervention with LINE chatbot (chatbot group)

Persons who answered the presurvey between 5 and 10 November 2021 were randomly assigned to one of the following three groups: (1) no exposure to the LINE chatbot nor webinar (control group); (2) the mobile app chatbot users (chatbot group); and (3) online interactive seminar users (webinar group). Randomisation into three groups was conducted between 11 and 14 November 2021 by biostatisticians (EHYL and JW). Instructions for each intervention were sent on 15 November 2021 to all three groups. The chatbot was accessible on 15 November and webinars started on 16 November 2021.

LINE is a free messenger app available on electronic devices, such as smartphones, tablets and personal computers. LINE users can exchange texts, images, video and audio. LINE is the most popular messenger app in Japan: about 86 million people in Japan (roughly two-thirds of the population) use this messenger app.[19] We created a chatbot in LINE to answer COVID-19 vaccine frequently asked questions (FAQs) via text messages (online supplemental figure S1).[14] This chatbot has approximately 200 sets of questions and answers. Our chatbot works as follows: (1) users tap to select the item that they want to ask from a menu of options; the menu options are well organised with clearly labelled sections, such *as 'How do COVID-19 vaccines work?', 'What are the possible side effects of the vaccine?'* and *'What is the eligibility for vaccination?'*; (2) the chatbot automatically lists more specific questions relevant to the item that users choose in step 1; (3) users further choose a specific question that

they want to ask from the list; and (4) the chatbot automatically provides detailed information and answers to a chosen question. Users can also search questions via free text keywords and the chatbot shows potential questions that include the entered keywords. With these phased steps, users can access information that they seek very quickly without consuming a vast amount of time to find specific information from internet search engines.

The first email was sent on 15 November 2021 to study participants assigned to the chatbot group to explain how to use the chatbot and to provide them with a link through which they can access the chatbot; they also received a link to a 5 min YouTube video (https://youtu.be/nJBTHaXapQ8). One reminder was sent to participants who did not access the chatbot on 24 November 2021. The participants could access the chatbot until the end of the study period. In addition, we tracked who downloaded the chatbot and how frequently each FAQ was accessed in the chatbot during the study period to determine which participants were included for final analysis.

Intervention with interactive webinars

We conducted a total of 14 webinars via Zoom between 16 November and 7 December 2021. Each seminar was held on Tuesdays and Fridays at 10:00 and 20:00 hours to allow study participants to choose suitable dates and times. We asked participants in the webinar group to attend at least one webinar for 30 min. They were allowed to participate in more than one webinar if they preferred. They were required to choose their preferred date and time for the webinar and to register in advance through a temporary website with links to the 14 different webinar sessions. Each webinar was limited to a maximum of 40 participants to allow greater interactivity between health experts and participants. Reminder emails were sent to registrants 24 hours and 1 hour before each webinar using an automated reminder system in Zoom. We sent an email to the webinar group participants (n=386) a total of four times (initial instruction email and three reminders) to encourage them to register for at least one of the 14 seminars. Each webinar included a brief lecture about the COVID-19 vaccine (10 min) presented by physicians using PowerPoint slides, followed by Q&A sessions (additional 20–50 min). We tracked who registered and participated in each webinar. Those who stayed on a webinar less than 15 min (of 30 min) were not considered to have attended the webinar and were not included in the final analysis (n=1). The lecture included the history of vaccines, the necessity and the efficacy of the COVID-19 vaccine and the possible risks of short-term and long-term adverse events with the COVID-19 vaccine. Participants were encouraged to ask questions throughout a webinar through the Zoom Q&A chat feature, and questions from participants were collected before and during the webinar. Attendees could submit questions anonymously if they chose. Three of seven Japanese physicians (TK, YY, HT, KH, YN, KT, HM and KI) were required to attend each webinar as presenters, and the webinars were conducted in the Japanese language only. Each webinar included three physicians, one moderator and one office administrator, and all questions submitted on registrations through Zoom and during webinars were answered by physicians during the webinars.

Postintervention survey

We created three different postsurveys specific to each of the assigned groups. All three groups were asked about their history of COVID-19 vaccination since the presurvey, and their current VI and vaccine confidence for safety, importance and effectiveness. The postsurvey was sent to the chatbot and webinar groups (online supplemental text S3) between 22 December 2021 and 9 January 2022.

Sample size calculation

A previous study in France investigating the impact of an interactive web tool on patients with COVID-19 vaccine hesitancy showed that 8% of 1200 patients accepted COVID-19 vaccination after their intervention.[20] We assumed that the estimated proportion of VI in the intervention group after intervention would be 10% and that the proportion of VI in the control group would remain zero. For achieving an 80% power at 5% level of significance with equal allocation, a dropout rate of 40% and a superiority margin of 5%, the calculated sample size for each arm was 371 participants.

Outcome data and statistical analysis

The primary analysis was based on the intention-to-treat (ITT) principle. Participant characteristics were summarised using frequencies and percentages. For two-group comparisons, the χ^2 test or Fisher's exact test was used for categorical variables and the Mann-Whitney U test was used for continuous variables. For three-group comparisons, the χ^2 test was used for categorical variables.

Primary outcomes were VI and vaccine confidence. VI was measured by the proportion of those who had received a COVID-19 vaccine since the presurvey, and those who had not but who answered 'Yes, definitely' in the postsurvey to the question 'Do you intend to be vaccinated against COVID-19?'. Vaccine confidence was quantified using the Vaccine Confidence Index (VCI).[21] A previous study demonstrated that, among a multiplicity of factors influencing vaccine decisions, key drivers of public confidence in vaccines were identified as trust in the importance, safety and effectiveness of vaccines, along with compatibility of vaccination with religious beliefs.[21] A vaccine confidence survey tool was developed in 2015 and has been used in multiple different types of vaccine studies.[22] The VCI includes four vaccine confidence statements: 'Overall I think vaccines are important'; 'Overall I think vaccines are safe'; 'Overall I think vaccines are effective'; and 'Vaccines are compatible with my religious beliefs'. We decided not to use the statement about religious beliefs in our study because this statement does not fit well with Japanese customs since more than 80% of people in Japan have no religion.[23] We

present for each intervention group the proportions of participants having improvement in vaccine confidence, defined by those who responded 'do not know', 'tend to disagree' and 'strongly disagree' before intervention and responded 'strongly agree' or 'tend to agree'.

Differences in the proportion (postintervention compared with preintervention) of VI and VCI across arms were compared by fitting a logistic regression model on the postintervention VI (participants who responded 'Yes, definitely') and the postintervention VCI (participants who responded 'strongly agree' or 'tend to agree' to these specific questions on vaccine confidence). The baseline VI, VCI and intervention group were used as predictor. Missing outcomes were imputed using multivariate imputation by chained equations with 50 imputations, based on baseline characteristics including demographics, health conditions, vaccine confidence and intervention group assignment. We obtained the final estimates by pooling the estimates from 50 imputed data sets using Rubin's rules. We used R V.4.0.4 (R Development Core Team, Vienna) for statistical analysis. A p value of 0.05 was considered statistically significant.

Patient and public involvement

Patients were not involved in designing the study, determining the research questions, deciding the outcomes measured, recruiting participants or conducting the study. The burden of the intervention was not assessed; however, study participants' feedback about the chatbot and the webinars was obtained in the postsurvey. All relevant data will be shared on our website (https://corowakun-supporters.studio.site/#news). Patient advisors were not involved with this study.

RESULTS

A total of 99965 persons responded to the screening questions between 5 November and 10 November 2021. Of these, 15398 (15.4%) had not received a vaccine yet, of which 13314 (86.5%) did not intend to be vaccinated. Among 13314 eligible persons, 1158 agreed to participate in the study, completed the presurvey and were randomly assigned to one of the three different groups: control group (n=386), chatbot group (n=386) and webinar group (n=386) (figure 1). In the control group, 359/386 (93.0%) answered the postsurvey. In the chatbot group, 237/386 (61.4%) accessed the chatbot at least once, of which 231 (97.5%) answered the postsurvey. In the webinar group, 215/386 (55.7%) attended a webinar at least once, of which 207 (96.3%) answered the postsurvey. The average duration between the intervention and the postsurvey was 32 days in chatbot group and 27 days in webinar group. All 1158 participants were included for the final analysis under ITT principle. Baseline characteristics and demographics of participants were balanced across the three groups for most variables (table 1 for selected variables and online supplemental table S1 for all variables).

VI and VCI

VI was 0% for all three groups at the baseline according to inclusion and exclusion criteria. Among the control group, VI increased to 18.5% (95% CI 14.5%, 22.5%) (table 2). Vaccine confidence decreased by 2.5% (95% CI −4.3%, 9.4%) for importance of vaccines and by 7.6% (95% CI 0.7%, 14.4%) for effectiveness naturally without any intervention, while it increased by 1.9% (95% CI −2.4%, 6.2%) for safety.

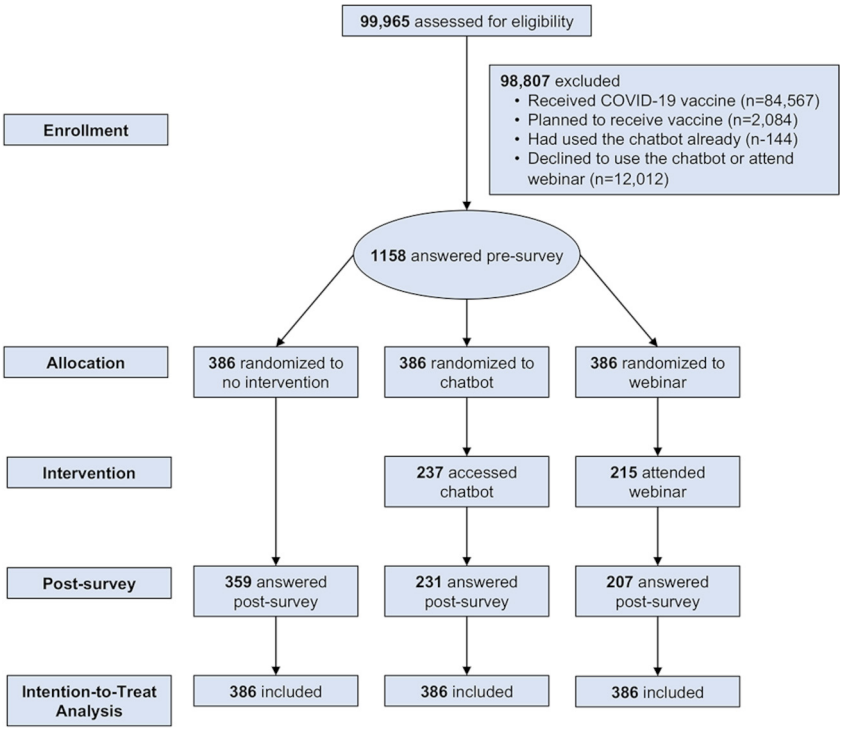

Figure 1 Study enrolment and participation.

Table 1 Baseline participant characteristics and perceptions of COVID-19 vaccines by intervention groups

All participants n=1158	Group 1 (control) n=386	Group 2 (chatbot) n=386	Group 3 (webinar) n=386
Characteristics			
Age (years), mean	44.7	45.8	46.2
Gender (%), male	53.1	54.9	55.7
Education (%)			
High school or less	28.5	26.7	32.9
Professional or vocational qualification	20.5	22.3	16.3
Bachelor's degree or above	51.0	51.0	50.8
Employment (%)			
Full time	56.2	52.6	53.1
Part-time	16.3	16.3	19.7
Unemployed	15.8	18.4	16.8
Retired	2.3	3.6	3.1
Students	0.8	1.0	0.5
Others	8.5	8.0	6.7
Healthcare worker (%)	4.7	3.1	3.1
Marital status (%)			
Married	54.1	47.2	48.7
Never married	39.6	40.7	39.4
Divorced	6.0	11.4	10.4
Widowed	0.3	0.5	1.6
Others	0.0	0.3	0.0
Income (%)			
<JPY200 million	31.6	37.6	36.5
JPY200–399 million	29.0	26.4	25.6
JPY400–599 million	21.8	19.7	23.3
JPY600–799 million	8.5	6.2	8.8
≥JPY800 million	9.1	10.1	5.7
Underlying health conditions (%)	5.4	3.6	4.7
Usually received influenza vaccine (%)	17.4	11.7	17.1
Diagnosed with COVID-19 (%)	2.6	2.3	1.3
Ever experienced a side effect or allergy after any vaccination (%)			
Yes	9.1	7.8	10.1
No	86.0	85.2	82.6
Unsure	4.9	7.0	7.3
Perception of COVID-19 vaccine			
Do you want to receive a COVID-19 vaccine in the future? (%)			
Yes, definitely (screened out)	0	0	0
Unsure, but leaning towards yes	21.8	18.9	20.7
Unsure, but leaning towards no	34.2	33.9	34.7
No, definitely not	44.0	47.2	44.6
COVID-19 vaccines are important (%)			
Strongly agree	7.3	6.0	6.7
Tend to agree	29.8	27.7	29.0

Continued

Table 1 Continued

All participants n=1158	Group 1 (control) n=386	Group 2 (chatbot) n=386	Group 3 (webinar) n=386
Do not know	31.3	36.0	32.6
Tend to disagree	15.0	16.4	16.3
Strongly disagree	16.6	14.2	15.3
COVID-19 vaccines are safe (%)			
Strongly agree	0.5	1.6	0.8
Tend to agree	8.5	8.5	9.3
Do not know	38.3	38.9	37.3
Tend to disagree	25.9	28.0	28.5
Strongly disagree	26.7	23.1	24.1
COVID-19 vaccines are effective (%)			
Strongly agree	3.9	4.7	3.9
Tend to agree	36.5	36.5	35.5
Do not know	33.7	34.5	32.1
Tend to disagree	10.6	12.2	16.3
Strongly disagree	15.3	12.2	12.2

JPY, Japanese yen.

In the chatbot group, VI increased to 15.4% (95% CI 10.8%, 20.1%). Vaccine confidence increased by 3.3% (95% CI −4.0%, 10.7%) for importance and 2.5% (95% CI −2.3%, 7.4%) for safety, and it decreased by 2.4% (95% CI −5.2%, 9.9%) for effectiveness. There was no statistically significant difference in VI in the postsurvey between the chatbot and control groups (15.4% in the chatbot group and 18.5% in the control group, OR of improvement=0.8 (95% CI 0.5, 1.3), p=0.330, table 2). Vaccine confidence tended to be higher in the chatbot compared with the control group but there was no significant difference in importance (3.3% vs −2.5%, OR of =1.3 (95% CI 0.9, 2.0), p=0.177), safety (2.5% vs 1.9%, OR=1.1 (95% CI 0.7, 1.9), p=0.622) or effectiveness (−2.4% vs −7.6%, OR=1.4 (95% CI 0.9, 2.1), p=0.093).

In the webinar group, VI increased to 19.7% (95% CI 14.5%, 24.9%). Vaccine confidence increased by 7.8% (95% CI 0.3%, 15.4%) for importance, 6.0% (95% CI 0.6%, 11.4%) for safety and 6.4% (95% CI −1.4%, 14.3%) for effectiveness. VI in the postsurvey was similar between the control group and webinar group (19.7% in the webinar group and 18.5% in the control group, OR=1.1

Table 2 Vaccine intention and confidence after interventions under an intention-to-treat analysis

All participants (n=1158)	Group 1 (control) n=386 % (95% CI)	Group 2 (chatbot) n=386 % (95% CI)	Group 3 (webinar) n=386 % (95% CI)	Group 2 versus group 1		Group 3 versus group 1	
				OR (95% CI)	P value*	OR (95% CI)	P value*
Willing to be vaccinated†	18.5 (14.5, 22.5)	15.4 (10.8, 20.1)	19.7 (14.5, 24.9)	0.8 (0.5, 1.3)	0.330	1.1 (0.7, 1.6)	0.730
Change in vaccine confidence‡							
COVID-19 vaccines are important.	−2.5 (−9.4, 4.3)	3.3 (−4.0, 10.7)	7.8 (0.3, 15.4)	1.3 (0.9, 2.0)	0.177	1.8 (1.2, 2.8)	0.004
COVID-19 vaccines are safe.	1.9 (−2.4, 6.2)	2.5 (−2.3, 7.4)	6.0 (0.6, 11.4)	1.1 (0.7, 1.9)	0.622	1.6 (1.0, 2.6)	0.077
COVID-19 vaccines are effective.	−7.6 (−14.4, −0.7)	−2.4 (−9.9, 5.2)	6.4 (−1.4, 14.3)	1.4 (0.9, 2.1)	0.093	2.2 (1.4, 3.4)	<0.001

Missing outcomes were imputed using multiple imputation method.
*Assessed by logistic regression models (full results in online supplemental table S2).
†Including those who have received a COVID-19 vaccine or have not received a COVID-19 vaccine but are willing.
‡Difference in % (postintervention vs preintervention) of those who responded 'strongly agree' or 'tend to agree'. (Other responses were 'do not know', 'tend to disagree' and 'strongly disagree'.)

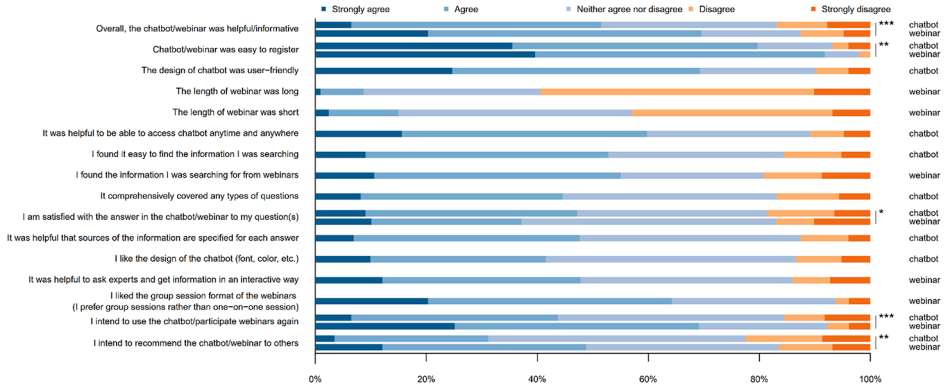

Figure 2 Feedback on chatbot and webinar interventions. Statistically significant differences indicated by *p<0.05, **p<0.01 and ***p<0.001, respectively.

(95% CI 0.7, 1.6), p=0.730, table 2). Vaccine confidence for importance and effectiveness significantly increased in the webinar group compared with the control group (7.8% vs −2.5%, OR=1.8 (95% CI 1.2, 2.8), p=0.004 and 6.4% vs −7.6%, OR=2.2 (95% CI 1.4, 3.4), p<0.001). Vaccine confidence for safety increased in the webinar group; however, the difference was not statistically significant (6.0% vs 1.9%, OR=1.6 (95% CI 1.0, 2.6), p=0.077). The full logistic model results were shown in online supplemental table S2.

Feedback for the chatbot and the webinar

Figure 2 presents feedback obtained from the postsurvey for the chatbot and webinar groups. Overall, a favourable response was more frequently seen in the webinar group compared with the chatbot group for most questions. The proportion of those who strongly agreed that the intervention was informative was 6.5% in the chatbot group and 20.3% in the webinar group (p<0.001). The proportion of those who strongly agreed that they intend to recommend the intervention to others was 3.5% in the chatbot group and 12.1% in the webinar group (p=0.001). The proportion of those who strongly agreed to use the intervention again was 6.5% in the chatbot group and 25.1% in the webinar group (p<0.001).

Comparison within the chatbot group

The association between the number of chatbot accesses and VI and VCI is summarised in online supplemental table S3. The median number of chatbot accesses was 15 in those willing to be vaccinated in the postsurvey compared with 9 in those who remained vaccine hesitant (p<0.001). The number of chatbot accesses was not associated with vaccine confidence.

Comparison within the webinar group

The association between webinar attendance and VI and VCI within the webinar group is summarised in online supplemental table S4. The duration of webinar attendance in minutes was not associated with either VI or VCI. The number of attended webinar sessions was not associated with either VI or vaccine confidence.

DISCUSSION

We did not find sufficient evidence that the chatbot or the webinar changed COVID-19 VI among those with vaccine hesitancy in Japan in 2021 compared with control. However, vaccine confidence for importance, safety and effectiveness increased with the webinar intervention compared with control. A small-group interactive webinar might be an effective tool for changing vaccine hesitancy. However, given there was no increase in VI despite improved confidence in importance and effectiveness, confidence index alone might not correlate well with COVID-19 VI in Japan. Further research is needed to investigate how to recruit and retain those with vaccine hesitancy in randomised controlled trials and whether social media-based interventions can increase VI and VCI for COVID-19 vaccines.

In this study, 15%–20% of participants with vaccine hesitancy, in either the control or intervention group, changed their minds and were accepting of the COVID-19 vaccine by the end of the study period. Social norms and awareness of COVID-19 vaccine status of persons close to those with vaccine hesitancy are important factors in Japan,[24 25] and the already high vaccine uptake at the beginning of the study period (at ~80%) might have helped change vaccine hesitancy over time regardless of whether VCI decreased or increased. Additionally, according to a global systematic review on the determinants of vaccine hesitancy, perceived vaccine safety was one of the most frequently cited factors in past studies.[26] Previous nationwide surveys in Japan also suggested that concerns about side effects and the safety of COVID-19 vaccines could be influential reasons for vaccine unwillingness or hesitancy.[7 27] Therefore, we speculate one potential reason why VI did not significantly increase with the webinar intervention despite the increase in vaccine confidence might be due to the lack of significant change in confidence for safety compared with control.

We calculated the proportion of those willing to be vaccinated after intervention, stratified by groups with and without improvement in the three dimensions of vaccine confidence and intervention arms (online supplemental table S5) to see the association between

VI and vaccine confidence after interventions. However, we observed different patterns of VI across three arms, which indicates that interventions may have modified the relationship between VI and confidence. The Working Group on Vaccine Hesitancy established by the Strategic Advisory Group of Experts of WHO indicated that vaccine hesitancy is the behaviour that reflects a constellation of factors that may influence the vaccination decision-making.[28] This group highlighted 3Cs including complacency, convenience and confidence as a model of vaccine hesitancy. The fact that our intervention might have affected the factors above differently and we only focused on confidence factor in the postsurvey may explain why we observed a different pattern in the association between COVID-19 VI and confidence across three arms. We need to explore how different social media-based interventions change various factors (ie, 3Cs) that affect VI, so we can understand the most appropriate intervention for each factor.

Our previous cross-sectional study indicated that a free chatbot had the possibility to decrease vaccine hesitancy[14]; however, this randomised controlled trial demonstrated that the chatbot did not change VI nor vaccine confidence. We hypothesise that the chatbot might have been more effective early in the pandemic when accurate, specific and sought-after information was not readily and widely available to the public. This may be because vaccine hesitancy is due to lack of scientific information and is about underlying emotions behind vaccine decision-making.[29] Changing people's perceptions of vaccines requires more interaction between the public and the medical community to understand the emotions involved in vaccine hesitancy and confidence.[30]

Thus, the webinar offered a platform where a health expert addressed an individual's vaccine concerns and negative emotions by talking with them directly. In fact, our interactive webinar significantly increased vaccine confidence for importance and effectiveness. Feedback from participants showed a significantly favourable response in the webinar group compared with the chatbot group. Live questions asked by webinar participants covered topics like the safety of COVID-19 vaccines, vaccine effectiveness of the three available vaccines, the influence of new variants and common myths, among others. Nevertheless, there have been conflicting data available on whether educational interventions reduce vaccine hesitancy.[31–33] Our study limited the number of participants in webinars to 40, and questions were asked anonymously. Providing a small, interactive and possibly anonymous webinar where individuals can discuss their concerns directly with professionals might be an effective strategy for increasing vaccine confidence, which could in turn decrease vaccine hesitancy.

Confidence in the importance and effectiveness of COVID-19 vaccines decreased in the control group over time. This means that those who remain vaccine hesitant may be even more hesitant about COVID-19 vaccines than before. The period when the postsurvey was conducted covered two key phases that possibly influenced the participants' perceptions on vaccines. During the first phase, the daily reported COVID-19 cases in Japan were relatively low, which might have affected 'importance' in vaccine confidence. The second phase was the emergence of the Omicron variant in other countries despite available vaccines, which might have affected 'effectiveness' in vaccine confidence. Also, the fact that individuals, including those who are vaccinated, are still at risk for COVID-19 infection even in the third year of the pandemic might have caused tiredness, frustration and anxiety, possibly contributing to this worsening VCI in the control group.

This study has several limitations. First, since the study was conducted entirely online, actual vaccine uptake after the intervention could not be investigated. Second, we could not evaluate the effect of in-person seminars. Although some people prefer online seminars with anonymous participation—especially in Japanese culture contexts—in-person seminars may have more potential, including more direct, open and honest communication than occurs online. In addition, in-person seminars can provide COVID-19 vaccines on-site immediately following the seminars for those who become agreeable. Third, even with a monetary incentive, the participation rate was not as high as we expected. To reduce attrition bias, we used multivariate imputation to predict outcome variables of non-respondents. The ITT and per-protocol analyses gave broadly similar outcomes (table 2 and online supplemental table S6), and all numbers were within the 95% CIs indicating statistically insignificant differences. Additionally, we compared the participants' characteristic between those who completed assigned interventions and those who did not (online supplemental table S7). However, we could not identify a clear difference between the two groups. Fourth, though our study confirmed that an interactive webinar might have a role in increasing vaccine confidence, our research cannot determine the most effective method to recruit those who have not received and do not intend to receive a COVID-19 vaccine in a real-world setting without any incentive. Fifth, those who did not have internet access were unable to participate in our study. Given that digital technologies are now considered a new determinant of health, we need to discuss the best way to recruit those with vaccine hesitancy who do not have internet access.[34] Sixth, racial differences were not evaluated because all participants were Japanese. Seventh, this study used three professionals, one moderator and one administrative person for each webinar, and scheduling webinars with medical professionals and administrative persons on a regular basis might not be feasible without providing incentives to presenters, likely requiring support from local communities or external funding.

In conclusion, neither the chatbot nor the webinar improved VI among those with vaccine unwillingness and hesitancy in Japan in 2021 compared with control. Small interactive webinars that include live Q&A sessions with

medical experts have the potential to effectively address public concerns regarding COVID-19 vaccines and to improve vaccine confidence. Future research needs to focus on the relationship between vaccine confidence and COVID-19 VI in Japan. Given the worsening vaccine confidence among those unvaccinated without intervention, local government and public health agencies may need to organise regular, small interactive webinars, especially in areas with low vaccine uptake or high vaccine hesitancy. More prospective studies are needed to evaluate the effect of on-site interactive seminars with the capability of administering vaccines during or after the seminar to those who change their COVID-19 VI.

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Patient consent for publication Obtained.

Ethics approval This study involves human participants and was approved by the Institutional Review Board at Kanto Central Hospital, Tokyo, Japan. Participants gave informed consent to participate in the study before taking part. This study was registered with UMIN Clinical Trials Registry (UMIN000045747) (online supplemental text S1). All participants signed an electronic consent form.

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