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How did internet information influence COVID-19 vaccination? The cyclical influence of the internet information, beliefs, attitudes, and intentions toward vaccines from a three-wave longitudinal study

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A B S T R A C T

This study examined the psychological processes leading to the formation of COVID-19 vaccination in Japan, a country with strong vaccine hesitancy, using integrative health behavior theory. We conducted a three-wave longitudinal study of 990 Japanese adults to investigate what information on the internet cyclically influences vaccination attitudes and intentions. The results showed that the psychological process that leads to the acceptance of the COVID-19 vaccine can be explained by applying integrative health behavior theory. However, while susceptibility to and fear of infection significantly influenced vaccination intention at the beginning of the pandemic, only the severity of the disease was significant at Time 3, indicating that the factors that promote vaccination intention can change over time. Nevertheless, subjective norms and self-efficacy were consistently associated with COVID-19 vaccination intentions and beliefs throughout the entire period. Furthermore, although information obtained from the internet influences vaccination intention, this influence varies depending on the content. In particular, information on the availability of vaccines increases vaccination intentions, and vaccination intentions facilitate the viewing of information in the next wave, indicating that information gathering on the internet and vaccine attitudes have a cyclical influence. Although expert information reduced self-efficacy and community benefits in the first wave, this effect decreased over time. The findings provide practical insight into how to increase vaccination intentions in the context of information confusion before and after vaccination programs are launched.

1. Introduction

In December 2019, coronavirus disease 2019 (COVID-19) had spread worldwide, and the World Health Organization (WHO) declared it a pandemic in March 2020. With the rapid spread of the disease and the lack of development and dissemination of therapeutic agents, vaccination was one of the most cost-effective ways to prevent the disease [1]. Thus, COVID-19 vaccines were developed and approved at an unprecedented speed. Consequently, the world's first two-dose COVID-19 vaccination program began in the United Kingdom in December 2020, and vaccine coverage subsequently expanded to other countries around the world.

However, even before the COVID-19 outbreak, Japan was rated a country with a very high level of "vaccine hesitancy" [2]. Vaccine hesitancy refers to a delay in accepting or refusing vaccines despite the availability and quality of vaccine services [3]. Therefore, vaccine hesitancy is one of the world's greatest health threats [4]. Japan is considered to have a low level of vaccine confidence, according to a survey conducted in 149 countries between 2015 and 2019 [2] on vaccination intentions for existing vaccines prior to the COVID-19 vaccine. In Japan, repeated reports of adverse effects from the human papillomavirus (HPV) vaccine have led to vaccine avoidance, with HPV vaccination rates dropping to less than 1 % [5]. Although the development of vaccines began immediately after the start of the COVID-19 pandemic, research on the acceptance of new vaccines progressed until these vaccines were implemented [6–9]. Notably, another survey conducted in February 2021, just before COVID-19 vaccination began in Japan, showed that 32.9 % and 11.0 % of respondents answered "not sure" or "no", respectively, regarding their intention to be vaccinated against COVID-19 [10].

In Japan, the government's call for social distancing, which was in place since the onset of the COVID-19 pandemic, restricted outdoor activities and large group events [11]. In particular, the declaration of a state of emergency and the implementation of priority measures to prevent the spread of disease, which were issued intermittently from March 2020 to September 2021, required individuals to restrict various movements, including going outside. In this situation, the primary sources of information for the Japanese population shifted to the internet and social media [12]. The role of social media as a primary source of information has become increasingly prominent, superseding

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its previous status as a secondary medium [13]. However, it has also been suggested that with the increased use of the internet during the pandemic, highly uncertain information became more widespread [14]. Side effects and safety concerns were among the main reasons for refusing vaccination [15], but misinformation was also actively searched for and disseminated through social media [16]. In Japan, the number of online posts pertaining to vaccines increased on a daily basis, and the dissemination of misinformation was confirmed [17]. It has been suggested that exposure to a variety of sources of vaccine information, including social media, may reinforce vaccine hesitancy and influence intentions [18]. However, the impact of the content of specific internet information on COVID-19 vaccine hesitancy has not yet been examined. Therefore, the purpose of this study is to clarify how information on the internet influenced vaccination intentions in Japan, where the nationwide level of vaccine hesitancy is very high.

1.1. Vaccine hesitancy and models that explain vaccination intention

Historically, the rejection of vaccines has been observed in a variety of countries. This behavior was observed as far back as 1840 in the United Kingdom [19]. Acceptance of or hesitancy toward vaccines results from a complex decision-making process that involves various factors [3,20]. For instance, influenza is one of the most widespread infectious diseases that threatens children, adults, and older adults. A systematic review of factors related to seasonal and pandemic influenza vaccination was conducted on 470 articles published between 2005 and 2016 to examine factors such as psychological processes [21]. Based on the theory of planned behavior (TPB; Ajzen [22]), Schmid et al. [21] showed that a lack of confidence, inconvenience, calculation, and complacency are barriers to influenza vaccine uptake in at-risk groups. Attempts to construct a model of the psychological process preceding vaccination have been conducted since the emergence of the TPB. Examples include the health belief model (HBM [23]), in which perceived susceptibility and severity, fear, perceived benefits or barriers, and self-efficacy explain behaviors and behavioral intentions. The extended parallel process model (EPPM [24]) proposes that self-efficacy as well as perceived threat (severity and sensitivity) motivate behavior. These theories of health behavior have been used to explain people's health behaviors [25]. Some studies have applied these theories to influenza and HPV vaccination, but the elements that constitute the model overlap [26]. Therefore, an approach that integrates multiple models may provide a solution to this problem.

To consolidate previous discussions and apply them to COVID-19 vaccination, Chu and Liu [27] investigated the psychological process that influences vaccination intentions among Americans. Before the widespread use of the COVID-19 vaccine, three models, the HBM, TPB, and EPPM, were used to provide a comprehensive view of the psychological factors and processes that influence vaccination intentions. The integrative health behavior theory model is outlined below (Fig. 1). Vaccination intention is defined based on COVID-19 risk perception, fear, self-efficacy, and vaccination attitude. Furthermore, attitudes toward COVID-19 vaccination are influenced by perceived benefits and barriers. Specifically, psychological and social aspects, such as subjective norms, attitudes toward conventional vaccines, influenza vaccination history, and cues to action, can influence these perceptions.

Based on integrative health behavior theory, Chu and Liu [27] found that these factors determine COVID-19 vaccination intentions, and research on COVID-19 vaccination intentions has been conducted in various countries using this theory. For example, predictors that significantly affect COVID-19 vaccine hesitancy in Malaysia include susceptibility, attitude, and subjective norms [28].

The present study applied this framework to examine the psychological processes that lead to vaccination in Japan. Previous evidence has suggested that the factors included in the HBM can effectively explain COVID-19 vaccination among Japanese people. Machida et al. [29] indicated that the psychological factors that may lead to Japanese people's decision to vaccinate against COVID-19 are "susceptibility," (i.e., feeling that they are likely to be infected with COVID-19), "severity," (i.e., believing that COVID-19 is a serious disease), "effectiveness," and "community benefit," (i.e., protecting the health of others by vaccinating themselves). Some studies have reported that "barriers," such as side effects and safety concerns, were cited by more than half of Japanese respondents as reasons for COVID-19 vaccine hesitancy [15]. Therefore, it is useful to apply the HBM framework to predict vaccination intention or hesitancy among Japanese people. However, no attempt has been made to integrate multiple health models to explain vaccination intention. Therefore, this study used Chu and Liu's integrated model to explain the factors that influence vaccination. The present study tested the following hypothesis.

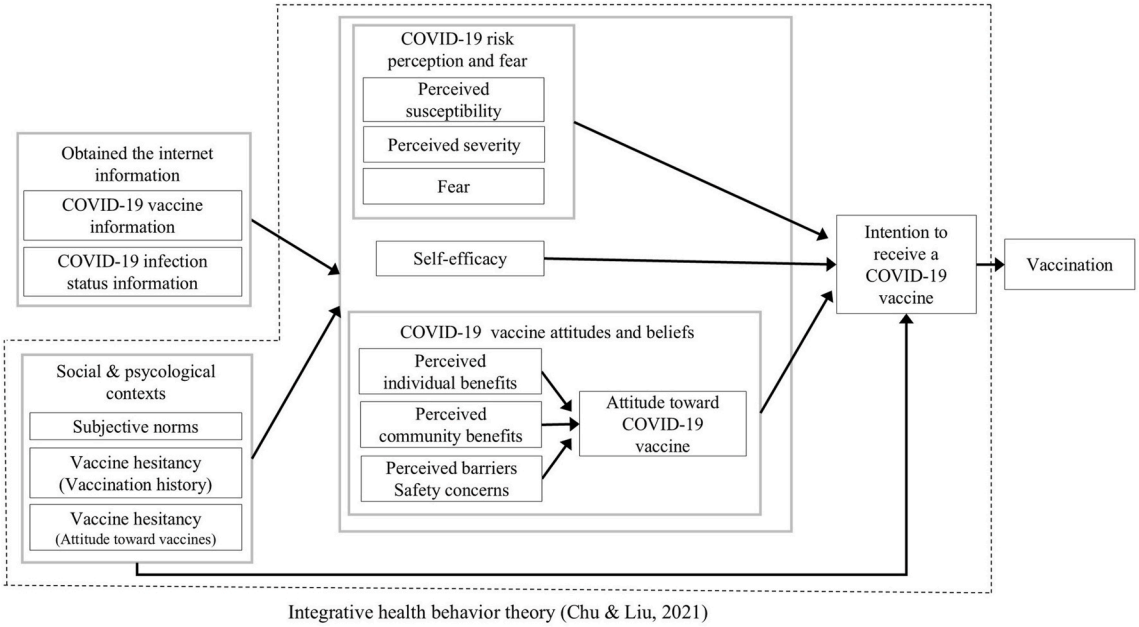

Fig. 1. Integrative health behavior theory [27] and influence of internet information.

H1. Integrative health behavior theory can explain the psychological processes that lead to vaccination intention among the Japanese people with regard to the COVID-19 vaccine. Attitudes toward the COVID-19 vaccine are influenced by individual and community benefits and safety concerns, and constitute vaccination intentions, along with severity, susceptibility, fear, and self-efficacy for vaccination.

1.2. Previous studies on internet information and vaccination intentions

This study adopted integrative health behavior theory to investigate Japanese people's level of contact with vaccine information on the internet and whether this contact influences their vaccination intentions.

As mentioned above, these health behavior theories have been used in many studies to explain COVID-19 vaccination intention. However, it has been suggested that while these theories apply to existing vaccines, they may not be directly applicable to COVID-19 vaccination [30]. Therefore, attention should be given to the factors that characterize the recent COVID-19 epidemic.

One of these factors is the internet. Since the onset of the COVID-19 pandemic, information about COVID-19 vaccines has spread via the internet [18]. The internet can help people gather vaccination information [31]. However, this does not necessarily include only science-based information; it may also include fake news stories and conspiracy theories, which are particularly prominent on social media [18] and spread faster than the truth [32]. In experimental studies, misinformation about COVID-19 vaccines has been shown to decrease vaccination intentions [33].

Thus, the influence of media information on the intention to receive COVID-19 vaccines has attracted attention, and previous empirical studies have shown that information gathered on the internet influences people's vaccination intentions. Pires [34] conducted a systematic review and showed that online information provided by experts improves vaccine hesitancy. Roozenbeek et al. [35] found that susceptibility to misinformation negatively affects people's willingness to be vaccinated. Some findings from Japan indicate that internet contact resulting in information about the COVID-19 vaccine influences people's vaccination intentions [36].

Based on the above discussion, it can be assumed that exposure to information found on the internet can influence people's vaccination intentions and the underlying psychological factors related to these intentions (i.e., various factors included in integrative health behavior theory). Therefore, it is necessary to apply current extensions of the HBM and to update the model in relation to the recent situation by considering trends found on the internet. The importance of this focus is also supported by the fact that in recent years, the use of internet media has become widespread. Furthermore, it has been shown that time spent using the internet on weekdays exceeds time spent watching TV for all ages in Japan [37]. In the early stages of the pandemic in Japan, both scientifically confirmed and unconfirmed information was disseminated through social media [12] Previous studies that have examined the impact of internet information have suggested that the content of the information also has a considerable effect. Betsch et al. [38] explained that 5–10 min of exposure to a website that is critical of vaccination increases the level of vaccine risk perception. Nan and Madden [39] showed that while exposure to positive blogs has little effect on attitudes toward vaccines, exposure to negative information on blogs makes people more negative toward vaccines. Similar findings have been reported for COVID-19 vaccines. Goel and Nelson [40] investigated the relationship between internet search content and COVID-19 vaccination rates. The authors found that vaccination rates increased as information on the availability of COVID-19 vaccines became more readily available [40].

It is important to consider information content when examining the social consequences of information exposure during the spread of the COVID-19 epidemic. However, there is little knowledge of the kind of internet information available to Japanese people with regard to vaccines. In this study, we explore how this information is categorized through exploratory factor analysis and by considering a wide range of questions about the content of the information that Japanese people are exposed to on the internet. We include the factors in Chu and Liu's [27] integrative health behavior theory to examine their influence on vaccination intentions. We present the following hypothesis.

H2. Information obtained on the internet influences COVID-19 vaccination intention and other factors via integrative health behavior theory. The direction of influence also depends on the content of the information obtained via the internet. Specifically, positive information about vaccines positively influences vaccination intentions, whereas negative information has a negative influence on these intentions.

Previous studies have suggested that the effects of internet-based information on vaccination intentions are not limited to short-term periods. It has been noted that people do not treat different sources of information equally; rather, they tend to selectively connect with only those sources that are favorable to them and consistent with their own beliefs. The resulting closed internet space creates "echo chambers" [41–43] that lead to group polarization, where people exchange opinions with others who share similar ideas and further strengthen their own beliefs over time. It has long been noted that users of internet media, especially social media users, tend to aggregate in communities of interest, which fosters reinforcement and confirmation bias [44]. It has also been argued that this mechanism applies to decision-making about vaccination. For example, people who use social media to follow health-related organizations that promote vaccination are more positive about vaccination [45]. Furthermore, some findings have indicated that people who oppose vaccination are likely to use the internet more frequently to view similar opinions. These individuals are likely to agree only with their allies and are not interested in listening their opponents' opinions [46].

In line with the prediction made in H2, gathering information via the internet not only influences individuals' intention to receive a COVID-19 vaccine but also determines the information content to which they are subsequently exposed depending on their attitude toward vaccination. The long-term cyclical process by which individuals' attitudes are reinforced via exposure to information has been theoretically validated [47]. Therefore, this study also focused on the possibility of cyclical reinforcement and influence of information obtained through internet media and vaccination intention as well as the psychological factors behind this intention in relation to integrative health behavior theory. To examine this long-term effect, we conducted a longitudinal study. Our third hypothesis is as follows.

H3. : *Encountering information about the COVID-19 vaccine via the internet affects beliefs, attitudes, and vaccination intentions toward the vaccine, and vaccination intentions determine individuals' subsequent level of contact with information on the internet. Thus, information contact and vaccination intentions are cyclically influential. In other words, information does not unilaterally affect attitudes and intentions; rather, after attitudes and intentions have been formed, they impact people's level of contact with information gathering.*

2. Materials and methods

2.1. Participants

The respondents were informed in advance that participation was voluntary and that all responses collected would be anonymous and confidential. The participants were not compelled to respond to the survey and were guaranteed the right to withdraw from the study at any time. Three waves of web-based longitudinal surveys were conducted approximately every two months on June 30, 2021 (T1), August 30, 2021 (T2), and November 2, 2021 (T3). The number of fully vaccinated

persons (excluding healthcare professionals) on the start date of this study (T1) was 13,470,603, accounting for approximately 10.7 % of the Japanese population. The number of fully vaccinated persons at the end of the study (T3) was 88,652,268, accounting for approximately 70.4 % of the Japanese population [48].

When determining the sample and its size, we considered the following factors: (a) participants should be from different ages, sexes and provinces, and should have different levels of COVID-19 vaccine intention, (b) data collection should be completed within a week due to changes in the day-to-day vaccination situation in Japan, and (c) to use measurement items from prior studies [27], the sample size had to be the same as that of Chu and Liu [27].

The Tokyo-based internet research service company Asmarq Co., Ltd. randomly selected potential respondents (n = 933,000) from among its registrants. We recruited people aged 25–64 years who resided in Japan. In a screening survey, we excluded healthcare workers, people over 65 years of age and those with underlying diseases who were given priority COVID-19 vaccinations. Furthermore, since vaccination operations differ by prefecture, our panel was structured to provide a distribution similar to the Japanese population with regard to key demographic and geographic variables.

We obtained 1000 responses, with 861 respondents participating through the third wave. Three participants provided almost no answers, 4 participants provided inconsistent answers, and 106 participants tested positive for the COVID-19 polymerase chain reaction (PCR) test and/or COVID-19 antibodies. These respondents were removed in accordance with previous studies [27]. This resulted in a final sample of 748 participants who responded from T1 through T3 to test H1. A flowchart of the subjects in each analysis period is shown in Fig. 2.

The average age of the participants was 46.61 years old (SD = 9.95, 375 male and 373 female). The overall demographic characteristics of our sample are presented in Table 1.

Table 1
The demographic characteristics of all the participants.

Variable		n (N = 748)	Proportion (%)
Gender	Female	373	49.87
	Male	375	50.13
Marital status	Married	411	54.95
	Other	337	45.05
Age group (years)	25–34	120	16.04
	35–44	193	25.80
	45–54	235	31.42
	55–64	200	26.74
Place of residence	Tokyo metropolitan area	255	34.09
	Others	493	65.91
Occupation	Office worker	435	58.16
	Public employee	33	4.41
	Freelance	34	4.55
	Full-time homemaker	81	10.83
	Part timer	110	14.71
	Unemployed	49	6.55
	Other	6	0.80
Living with persons	at age <12	95	12.7
	at age ≥65	185	24.7
	taking medication	168	22.5
	Healthcare worker or Caregiver or Service	99	13.2
	None	152	20.3

2.2. Materials and methods

At the beginning of the study, approval was obtained from the ethics committee at the second author's institution. Informed consent was provided online depending on the initial means of recruitment. After the participants read and agreed to informed consent, they were asked to complete the web survey. All questions were presented in random order for each participant. After the participants completed all demographic questions, including age, gender, marital status, and place of residence, they answered questions about their intention to receive the COVID-19 vaccine and vaccination situations. Each participant received a monetary reward upon completion of the online survey.

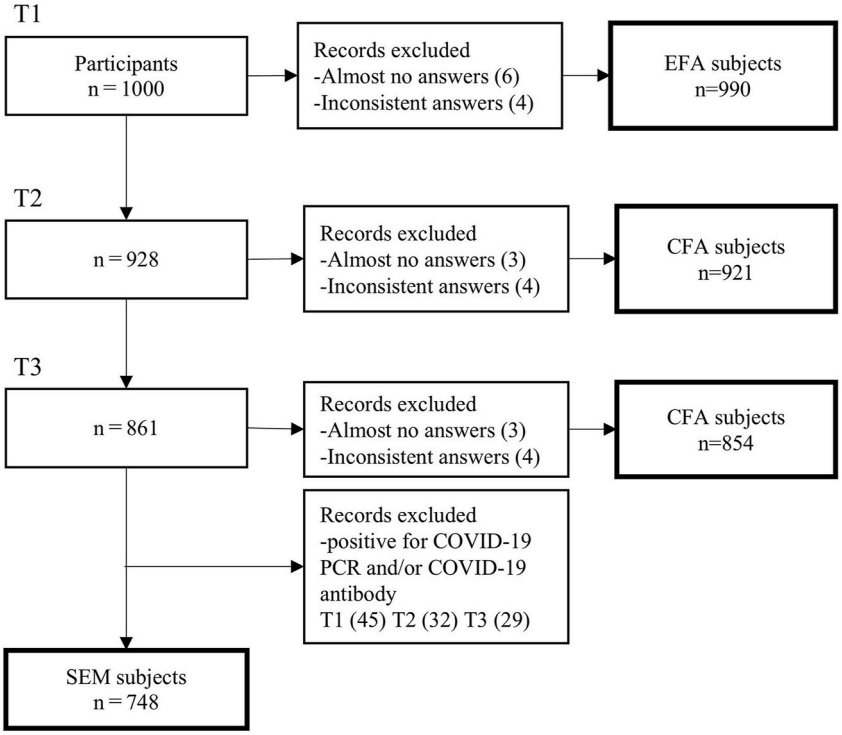

Fig. 2. Flowchart of the subjects in each analysis.

2.3. Measurement

2.3.1. Integrative health behavior theory

This study adapted previously validated measurement items from prior studies [27]. First, measurement items were translated from English into Japanese based on the Professional Society for Health Economics and Outcomes Research (ISPOR) guidelines [49]. Responses were obtained using the scale of Chu and Liu [27], which was developed to examine COVID-19 vaccination intention based on the health behavior theories of the HBM, TPB and TPPM. The survey measured fear of COVID-19, perceived severity of and susceptibility to COVID-19, perceived individual benefits of COVID-19, community benefits of COVID-19, perceived barriers to receiving the COVID-19 vaccine including safety concerns, subjective norms, baseline vaccine hesitancy, including attitudes toward vaccines in general and recent vaccination history, cues to actions, and demographics. Attitudes toward vaccines were captured by using the semantic deferential (SD) method, and other items were rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Although cost concerns were obtained by Chu and Liu [27], these concerns were excluded from the current analysis because vaccination is publicly funded in Japan, and all Japanese people can receive the COVID-19 vaccination for free. In addition, the responses "Family or close friend passed away due to COVID-19″ and "Someone you knew passed away due to COVID-19″ were included in the cues to action (COVID-19 exposure) but were excluded from the questionnaire with the permission of the original author due to their psychological invasiveness.

2.3.2. Obtaining information about COVID-19 vaccination on the internet

Items on information about COVID-19 vaccination on the internet were developed through the following steps in a preliminary survey. First, an online survey was conducted with 71 working adults (32 male and 39 female) who ranged in age from 22 to 67 years [M = 39.8 years, SD = 11.36] with a focus on COVID-19 information they had viewed on the internet in the previous two months. Second, based on the categorization process, 30 categories were created by the first author, who was a pharmacist and graduate student in psychology and a researcher in social psychology. Each item was rated on a five-point Likert scale ranging from 1 (not viewed) to 5 (very well viewed).

Furthermore, we created our own items to obtain information available on the internet on the status of COVID-19 infection. Information about COVID-19 infection status was predicted to influence variables such as COVID-19 risk perception and fear in integrative health behavior theory. We focused on news items related to the number of cases in all of Japan, other regions and abroad and news about celebrities who had been infected. As with the vaccine items, the questions were rated on a 5-point Likert scale. To confirm the internal consistency of the four items of information about COVID-19 infection status on the internet, we calculated the Cronbach's alpha coefficients, which were all above the acceptable level: T1 = 0.90 (n = 990) T2 = 89 (n = 921), and T3 = 0.91 (n = 854).

2.3.3. Demographic variables

Demographic variables included sex, age and employment. In addition, we asked the respondents about living with individuals older than 65 years or younger than 12 years and whether they lived with a person who took medication. Previous studies in Japan have shown that COVID-19 vaccine refusal and hesitancy are stronger in people who live alone [50]. Scholars have also observed the influence of living with a person who is at risk of serious illness.

2.4. Common method bias

To avoid problems of common method bias (CMB), this study followed the recommendations of previous literature by implementing preventive and postdetection procedures. These procedures helped us hide construct names, randomize the order of items, and ensure the anonymity of the respondents.

In addition, we conducted Harman's single-factor test with exploratory factor analysis (EFA) to assess CMB. The results showed that the first factor explained 35.50 % of the variance in T1, 37.15 % in T2 and 36.79 % in T3, which did not exceed the recommended threshold of 50 % [51]. Based on this result, we assumed that CMB was not present in this study.

2.5. Statistical analyses

We used SPSS ver. 27 software (IBM Corp., Armonk, NY, United States) to conduct descriptive statistics and exploratory factor analysis (EFA). In addition, confirmatory factor analysis was performed using SPSS Amos version 27.0 (IBM Corp., Armonk, NY, United States). To assess the hypothetical structural model, we conducted a covariance structure analysis using the full information maximum likelihood method with R version 4.1.1 (http://cran.r-project.org/). A path model based on the theoretical framework illustrated in Fig. 3 was then estimated. Exogenous variables in the model were allowed to covary considering conceptual covariances.

Latent integrative health behavior theory constructs without specified directional effects were allowed to covary to account for common method and conceptual covariances. To account for nonnormality, all measurement and path models were analyzed with maximum likelihood estimation with robust standard errors.

We used the robust comparative fit index (R-CFI) and the robust root mean square error of approximation (R-RMSEA) to assess the structural model fit. CFI values $\geq$ 0.90 and RMSEA values in the range of 0.05–0.08 were considered to indicate an acceptable fit [52].

3. Results

Based on the 990 responses that excluded respondents who provided almost no answers or inconsistent answers obtained from T1, exploratory factor analysis (EFA) was conducted on information obtained from the internet. We conducted confirmatory factor analysis (CFA) to test the validity of the results using data from the samples collected at each time point, excluding inconsistent and dishonest respondents, for the T2 sample (n = 921) and the T3 sample (n = 854).

Next, based on the 748 responses that excluded subjects with positive PCR results for COVID-19 obtained from T1 to T3, structural equation modeling (SEM) was conducted on the effect of internet information on the psychological variables of integrative health behavior theory.

Table 2 shows the descriptive statistics for all study variables.

3.1. Exploratory factor analysis (EFA)

We conducted exploratory factor analysis for information about COVID-19 vaccination available on the internet. First, the mean and SD in T1 (N = 990) were calculated for each of the 30 items related to information about COVID-19 vaccination available on the internet to check for nonnormality. There were no items that should be excluded. Second, as criteria for determining the number of factors, we also calculated and compared the AIC (1 factor: 1270.51, 2 factor: 602.08, 3 factor: 244.63, 4 factor: 72.18), BIC (1 factor: −713.06, 2 factor: −1239.46, 3 factor: −1459.77, 4factor: - 1499.98), and CAIC (1 factor: −308.06, 2 factor: −863.46, 3 factor: −1111.77, 4 factor: −1178.98). Since the AIC tends to select a model with a larger number of factors when the sample size is large, we focused on the selection by BIC and CAIC, which take the sample size into account. However, when a 4-factor solution based on BIC and CAIC was attempted, only two items showed sufficient factor loadings (.529 and .474) on the fourth factor, making factor interpretation quite difficult. Given these results as well as interpretability, we concluded that it was appropriate to set the number of factors to 3. The results of EFA (maximum likelihood estimation and

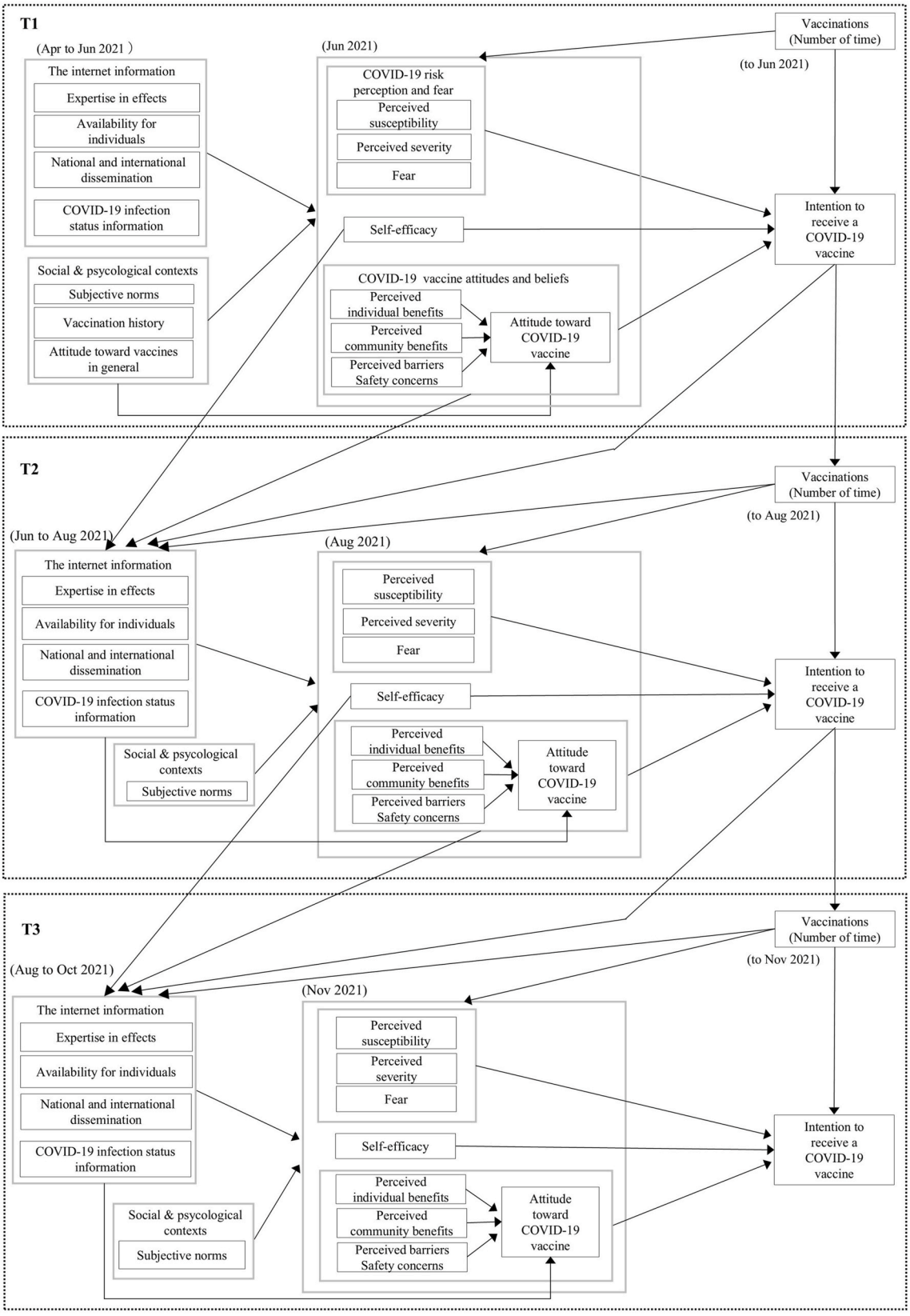

Fig. 3. Hypothetical diagram of the longitudinal influence of information about COVID-19 vaccination available on the internet on variables.

Table 2
Descriptive statistics and reliability coefficient of the survey (Scale: Min 1 to Max 5).

	T1			T2			T3		
	M	*SD*	*α*	*M*	*SD*	*α*	*M*	*SD*	*α*
COVID-19 risk perception and fear									
Perceived susceptibility to COVID-19	3.48	0.74	0.83	3.63	0.71	0.82	3.45	0.73	0.83
Perceived severity to COVID-19	3.79	0.83	0.87	3.96	0.77	0.87	3.75	0.80	0.87
Fear	3.81	0.97	0.95	3.99	0.92	0.94	3.71	1.00	0.96
COVID-19 vaccines attitudes and beliefs									
Attitude toward COVID-19 vaccines	3.67	0.95	0.97	3.80	0.96	0.98	3.85	0.96	0.98
Perceived individual benefits of COVID-19	3.70	0.80	0.94	3.67	0.82	0.93	3.77	0.82	0.93
Perceived community benefits of COVID-19	3.79	0.79	0.94	3.84	0.79	0.93	3.85	0.81	0.93
Perceived barriers of getting COVID-19 vaccines (safety concern)	3.73	0.94	0.91	3.78	0.97	0.90	3.57	0.96	0.88
Self-efficacy	3.70	0.80	0.89	3.79	0.85	0.89	3.87	0.85	0.91
Social and psychological contexts									
Subjective norm	3.70	0.75	0.86	3.80	0.74	0.84	3.83	0.71	0.84
Attitude toward vaccines in general	3.70	0.86	0.97	3.76	0.90	0.98	3.83	0.87	0.98
Intention to receive a COVID-19 vaccine	3.86	0.87	0.90	4.07	0.91	0.92	3.95	0.96	0.93
Internet information of COVID-19 vaccines									
Information on expertise in effects	2.32	0.97	0.97	2.51	0.99	0.96	2.60	1.06	0.97
Information on availability for individuals	2.51	1.05	0.94	2.79	1.08	0.95	2.86	1.10	0.95
Information on national and international dissemination	2.57	1.01	0.96	2.78	1.02	0.96	2.79	1.06	0.96
Internet information of COVID-19 infection status	2.70	1.03	0.90	2.90	1.04	0.90	2.94	1.08	0.92

promax rotation) of the T1 data are shown in Table 3. To measure the adequacy of the sample, the Kaiser–Meyer–Olkin (KMO) test was calculated at 0.99, which is greater than the suggested threshold of 0.60 [53]. Based on the results of the EFA, items with factor loadings below 0.40 and items that showed high factor loadings on more than one factor (all above 0.40) were removed. Through these procedures, 6 items were removed, and 24 items remained. This final solution with three factors spanning 24 items explained 77.0 % of the total variance.

The clustering of the items suggested that the first factor contained items that indicated information on expertise in effects (e.g., information indicating that the vaccine is not effective and problems in the domestic vaccine development process) (α = .97). The second factor referred to information on availability for individuals (e.g., vaccination timing and scheduling and a time when they might be able to receive the vaccination) (α = .94). The last factor involved information on national and international dissemination and included eight items, such as the "rapid spread of vaccines overseas" and "vaccination trends overseas" (α = .96).

To confirm validation, we conducted confirmatory factor analysis using the maximum likelihood method for information about COVID-19 vaccination available on the internet with all data obtained at each period of T2 (n = 921) and T3 (n = 854). The χ^2 and CFI both suggested a good fit of the model [T2; χ^2 (249) = 1370.64 ($p < .001$), CFI = 0.954, RMSEA = 0.070 [90 % CI:0.066-0.074)] [T3; χ^2 (249) = 1435.344 ($p < .001$), CFI = 0.954, RMSEA = 0.075 [90 % CI:0.071-0.079)]. Furthermore, in both T2 and T3, acceptable values were shown for AVE (in T2 data, F1: 0.69, F2: 0.77, F3: 0.74; in T3 data, F1: 0.75, F2: 0.78, F3: 0.77) and CR (in T2 data, F1: 0.95, F2: 0.92, F3: 0.94; in T3 data, F1: 0.96, F2: 0.92, F3: 0.95) [55]. Based on these results, we analyzed the addition of these 24 items to the hypothetical model.

3.2. Structural equation modeling (SEM)

The result of the covariance structure analysis based on hypothetical model (Fig. 1) suggested an acceptable fit: χ^2 (845) = 3257.33 ($p < .001$), R-CFI = 0.920, and R-RMSEA = 0.066 [90 % CI:0.064-0.069]. The CFI measures signified good fit indices. Additionally, the RMSEA measures suggested an acceptable fit index. Thus, the psychological processes leading to vaccination intention and its formation among Japanese people for the COVID-19 vaccine were explained by integrative health behavior theory (**H1**). The results are shown in Appendix.

The results indicated that the three factors related to vaccine information that was available on the internet influenced each psychological variable at T1. F1 had a negative influence on self-efficacy and perceived benefits, F3 had an influence on individual benefits and safety concerns, and F2 had a positive influence on self-efficacy and perceived community benefits and a negative influence on safety concerns. At T2, the influence of each factor was weakened, and at T3, only the influence of F2 remained. Furthermore, F2 had a direct positive effect on attitude at all time points, i.e., T1 to T3. In other words, information obtained via the internet had different effects on vaccination intentions depending on the content (**H2**).

In particular, F2, exposure to internet information, influenced psychological variables from time T1, leading to vaccination intention. Intention at T1 also influenced F2 exposure at T2. The results for T3 were similar. Thus, with regard to internet information, information about the availability of vaccination (F2) was found to have a cyclically positive effect on vaccination intention (**H3**). Fig. 4 shows only the variables related to internet information.

4. Discussion

We examined how information about the COVID-19 vaccine that is available on the internet affects vaccination intention and behavior based on integrative health behavior theory [27] by conducting a longitudinal study among Japanese people, who have low confidence in vaccines and tend to be hesitant to be vaccinated [2,5]. This study provides important findings based on three hypotheses.

4.1. Psychological processes leading to the formation of vaccination intentions in COVID-19

First, we found that by applying the integrated health behavior theory proposed by Chu and Liu [27], it is possible to explain not only the psychological process that leads to the formation of the intention to receive vaccinations but also vaccination behavior two months later. The results obtained from this study support H1 and suggest that integrative health behavior theory can explain the psychological processes that lead to the formation of vaccination intention for the COVID-19 vaccine even in Japanese people. Japanese people were found to have a high level of vaccine hesitancy before the COVID-19 pandemic [5], and some findings indicate that this tendency was similar during the pandemic. Prior to the implementation of vaccination programs, experimental research on hypothetical vaccines revealed obstacles to the evaluation of their effectiveness and concerns regarding their safety [9]. Additionally, survey research indicated that the perceived susceptibility to infection, the perceived severity of the disease, and the perceived community benefit of vaccination influence individuals'

Table 3
Types of information about COVID-19 vaccination available on the internet.[54]

Items	Factor 1 Expertise in effects	Factor 2 Availability for individuals	Factor 3 National and international dissemination	*M*	*SD*
- Information indicating that the vaccine is not effective	**.91**	-.01	-.08	2.17	1.14
- Problems related to the domestic vaccine development process	**.78**	.14	-.02	2.29	1.15
- Information suggesting that there is a connection between government and corporate agendas regarding the spread of the vaccine	**.70**	.01	.19	2.34	1.15
- Information indicating that there are no side effects of vaccination	**.64**	.22	.00	2.30	1.17
- Current status of domestic vaccine development and approval	**.60**	.18	.14	2.36	1.11
- Expert knowledge of vaccines	**.57**	.13	.22	2.35	1.14
- A case of vaccination causing serious consequences	**.57**	-.03	.33	2.44	1.15
- Warning about fake news regarding vaccines	**.54**	.19	.13	2.37	1.14
- Evoking anxiety and fear about the vaccine	**.52**	-.03	.37	2.52	1.16
- Current status of vaccine development overseas	.50	.00	.40	2.40	1.16
- Domestic vaccination operations on track	**.46**	.36	.08	2.42	1.15
- Information on types and characteristics of the vaccine	**.40**	.21	.32	2.46	1.12
- Information on what to do in case of side effects	.38	.29	.26	2.48	1.15
- Difficulties in getting vaccinated	.38	.26	.24	2.45	1.17
- Operational problems and difficulties related to domestic vaccination	.37	.27	.29	2.46	1.13
- Vaccination timing and schedule	.01	**.85**	.02	2.58	1.18
- When people might be able to get vaccinated	.12	**.79**	-.03	2.54	1.21
- Specific information needed for vaccination (vaccination location, etc.)	.14	**.68**	.11	2.55	1.19
- Trends of vaccination in each municipality and region	.00	**.66**	.24	2.56	1.18
- Estimates and forecasts of vaccine distribution in Japan	.19	**.43**	.32	2.54	1.14
- Information indicating that the vaccine is effective	.14	.40	.40	2.58	1.15
- Rapid spread of the vaccine overseas	.07	.02	**.79**	2.59	1.18
- Vaccination trends overseas	.32	-.10	**.68**	2.47	1.13
- Delay in the domestic distribution of the vaccine	-.06	.27	**.66**	2.72	1.19
- Mismanagement of domestic vaccine operations	.00	.24	**.62**	2.62	1.13
- Information indicating that there are side effects of vaccination	.10	.21	**.58**	2.44	1.15
- Experts' opinions and views on vaccines	.13	.24	**.56**	2.57	1.16
- Public reaction and opinion about vaccines	.19	.18	**.55**	2.59	1.14
- Vaccination trends in Japan	.14	.37	**.43**	2.59	1.15
- Vaccination experience stories	.26	.24	.38	2.49	1.13

intentions to receive the COVID-19 vaccine [29]. The findings of this study are meaningful because they correspond to the results of previous studies and indicate that the integrated health behavior model is a useful framework for explaining vaccination even in Japan, where vaccine hesitancy is stronger than in other countries.

Moreover, this study provides new findings based on a three-wave longitudinal study. First, this study showed that among the factors of the integrative health behavior model that impact the intention to receive the COVID-19 vaccine, some factors change depending on the period. This was observed especially with regard to risk perception and emotional responses regarding COVID-19 infection. Although susceptibility influenced vaccination intention and fear lowered vaccination behavior at T1, immediately after the start of the general vaccination program, only fear continued to have a significant effect on vaccination intention at T2. At 4 months after the start of the vaccination program (T3), there was a weak significant effect of severity. These findings align with previous studies showing that the impact of each factor on health behavior changed between periods during the COVID-19 pandemic [56, 57]. Furthermore, a systematic review of studies conducted in the period around T1 of this study suggested that susceptibility was associated with vaccination intentions [58]. Notably, the present study showed similar findings. However, at T1, fear of COVID-19 inhibited vaccination behavior. This result may be related to the situation in Japan in 2021, when individuals and employers were intermittently requested to refrain from unnecessary activities and outings throughout the country to reduce the risk of infection. At the same time, there were long lines at

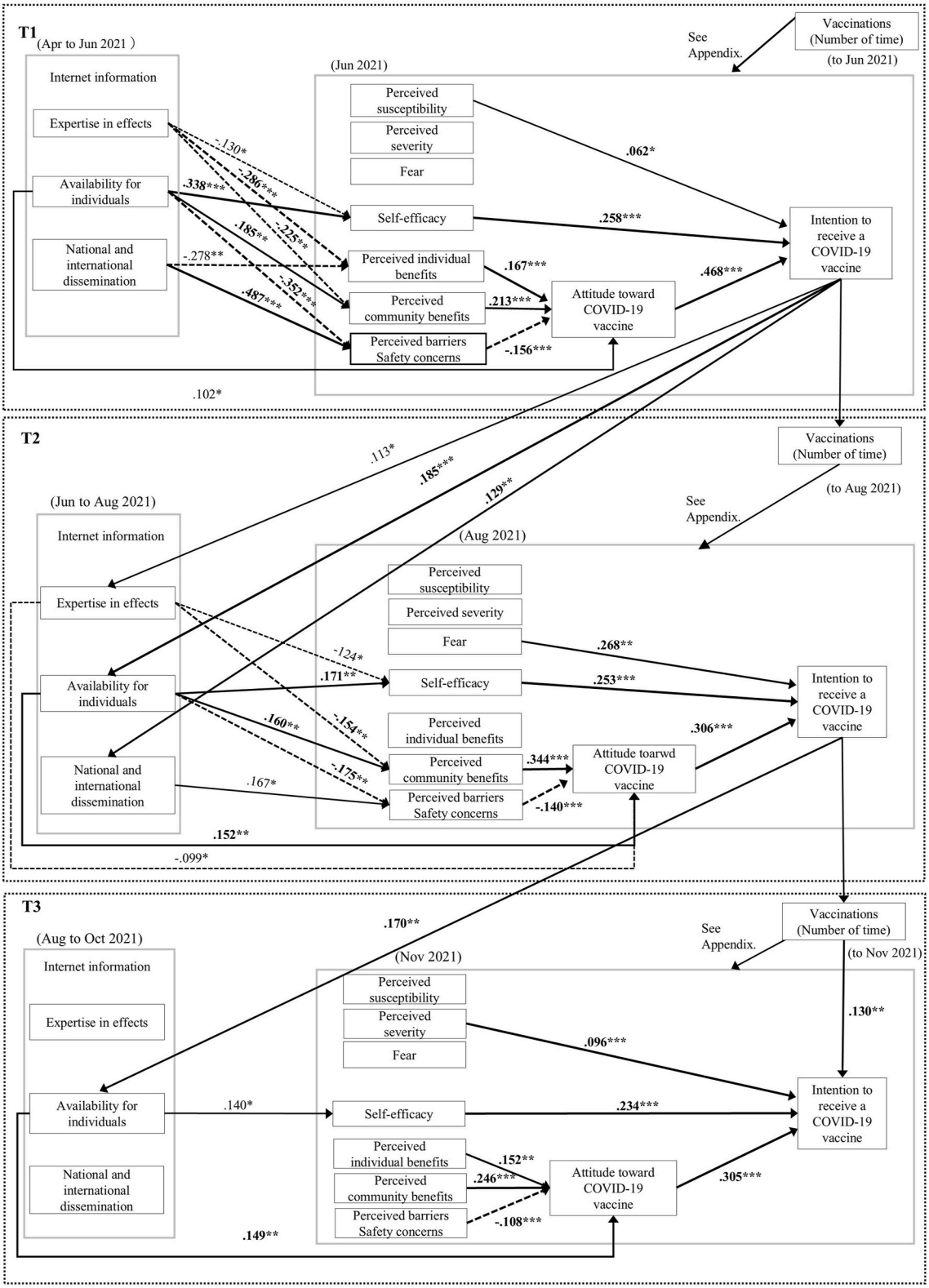

Fig. 4. Structural equation model of the cyclical influence of information about COVID-19 vaccination available on the internet on variables.
Note. This structural equation model is based on a hypothesis model (Fig. 3). The model is depicted with significant paths in bold and path estimates. $*p < .05$, $**p < .01$, $***p < .001$.

mass vaccination centers, and many people attempted to be vaccinated at the same time at T1 [59,60]. Under these circumstances, a strong fear of the virus may have increased people's desire to avoid the possibility of infection and to avoid being vaccinated in large groups. However, at T2, the Delta strain, which was feared to cause severe illness, was prevalent [61]. Fear of this version of the virus that carried a high risk of severe disease may have been the driving factor behind vaccination intentions. Finally, in T3, the number of new infections decreased, behavioral

restrictions ceased, and the resumption of economic activities was emphasized [62]. In other words, societal trends at that time were moving toward a return to pre-pandemic daily life while taking into consideration the possibility of COVID-19 infection. Under these circumstances, only the severity of COVID-19 may have influenced vaccination intentions during this period since there was widespread awareness of the need to avoid severe symptoms rather than fear and avoidance of COVID-19 infection itself. Thus, the results of this study indicate that changes in circumstances in society can affect individuals' vaccination intention, but the psychological mechanisms involved change from time to time. In other words, this study also demonstrates that integrative health behavior theory is useful in examining how psychological processes that influence vaccination intentions change in response to changes in social context over time.

Second, this study reveals the existence of factors that continue to influence COVID-19 vaccination intention despite changes in the social context. In this study, subjective norms impacted individual and community benefits at all time points, strengthened positive attitudes toward vaccines, and increased self-efficacy to vaccinate. This finding corresponds with a meta-analysis of studies conducted prior to the COVID-19 pandemic that found that subjective norms and behavioral efficacy had a strong effect on vaccination [63]. Additionally, throughout the entire period, safety concerns had a negative impact on vaccination attitudes and reduced vaccination intentions. It has been noted that Japanese people have strong concerns about the safety of vaccines [2,15,50,64], and this finding is consistent among previous studies. This study found that these factors, which have shown strong effects in previous studies, were also found to be influential in the new context of the COVID-19 pandemic. Among the variables included in integrative health behavior theory, cognitive and emotional responses to viruses may change with social contexts, but beliefs about vaccines themselves, such as norm consciousness, self-efficacy, and safety concerns, may be less affected by a change of situation.

Similar to the findings of Chu and Liu [27], this study revealed that integrative health behavior theory is an effective model for explaining vaccination intentions. Furthermore, this longitudinal study is the first to show that some factors that determine vaccination intentions change under the influence of social and environmental conditions, while others do not. The findings of this study can be used to understand the psychological processes involved in COVID-19 vaccination intentions in Japan. Integrative health behavior theory also has the potential to provide a useful framework for examining aversion to the HPV vaccine, which currently has a low vaccination rate in Japan, as well as vaccines against unknown viruses that may emerge in the future.

4.2. Influence of internet information on vaccination intentions and beliefs about the COVID-19 vaccine

The results of this examination of vaccination intentions found that information about COVID-19 vaccination available on the internet also influences COVID-19 vaccination attitudes and intentions. It has been shown that internet information influences intentions and that this influence depends on the content of the information [38–40], consistent with the findings of previous studies.

In the present study, the results of the factor analysis showed that information obtained from the internet about the COVID-19 vaccine was classified into three categories. Among these categories, we found that information on the availability of COVID-19 vaccination influenced self-efficacy and COVID-19 vaccination attitudes and increased the intention to vaccinate at all time points (T1-T3). These results are consistent with the finding that obtaining information about the availability and schedule of vaccination increases vaccination intention [40,65,66] as well as the results of a meta-analysis showing that self-efficacy, the feeling that one can control one's own vaccination behavior, promotes vaccination intentions [63]. In particular, it has been noted that Japanese people are afraid of the unknown and tend to take action to avoid uncertainty [67]. Therefore, information on availability, which can reduce uncertainty about vaccines, may play an important role for Japanese people.

However, expertise information was found to have different effects. In the early period (T1), this information was found to lower self-efficacy and perceived benefits. However, this effect eventually faded, and after four months (T3), no significant effect was found. Expertise information is disseminated to provide relief in making vaccination decisions and is thought to have a positive influence on vaccination intentions. Why does it have a negative function? Experts usually explain both positive information, such as efficacy, and negative information, such as side effects, based on scientific evidence. However, it has been suggested that people are more likely to focus on the negative, and negative information tends to exhibit more power and contagion than positive information [68,69]. It is possible that this effect was particularly enhanced in the early stages of the pandemic, when many people lacked knowledge about the COVID-19 vaccine and when detailed information, both positive and negative, was more readily available in the media.

It is interesting to note that individuals' decision to vaccinate are influenced not only by domestic information about the vaccine itself but also by information about the development and dissemination of the vaccine at the global level. Since the development and approval process for the COVID-19 vaccine was rapid, some studies have suggested that this perception of exceptional speed may have generated serious concerns [70]. Therefore, it is likely that the Japanese, who are sensitive to uncertainty, perceived the vaccine as being imported to Japan without sufficient safety assessment in other countries. This may have increased Japanese people's safety concerns [15,50,64], reduced their perceived benefit, and negatively impacted their perception of the vaccine.

In summary, internet information influences beliefs and intentions toward the COVID-19 vaccine. However, the influence differs depending on the information. This result supports H2. Information on availability had a consistent positive influence on vaccination intentions, while expertise information and information on foreign approval had a negative impact at certain times. This result implies that changes in the social context can play a crucial role, similar to the findings from the examination of H1. Therefore, the results also suggest that information on availability that has a positive impact regardless of the time of year should be disseminated consistently regardless of social conditions. In contrast, expertise information that may have a negative impact should be disseminated cautiously and with careful consideration, especially during the start of a pandemic.

4.3. Cyclical influence of vaccination intentions and internet information on COVID-19 vaccine

This study showed that information gathered from the internet and individuals' beliefs affect each other similar to an echo chamber. Specifically, increased vaccination intention encourages people to seek information on availability via the internet. Moreover, exposure to this information increases beliefs and intentions in favor of vaccination. This process of reciprocal influence was observed from T1 to T3. Based on these findings, H3 is supported. These results are consistent with pre-COVID-19 pandemic theories of information-seeking behavior and the cyclical influence of attitudes [47], confirmation bias to obtain positive internet information related to positive vaccine beliefs [71], and attitudes and beliefs that govern the collection of health information online [72]. In addition, vaccines are a controversial topic that is susceptible to the echo chamber effect [42]. This study demonstrates that previous theory is equally applicable in the unprecedented situation of the COVID-19 pandemic and provides new empirical findings that extend the theory through an examination of the cyclical influence of positive beliefs about vaccines and information on availability. This cyclical influence depends on the content of the information, similar to the findings from the examination of H2.

However, this study also showed for the first time that this cyclical influence, like an echo chamber, weakens over time. It has been observed that information seeking is more active during periods of extreme interest, such as the early stages of a pandemic as in T1, and during periods of high uncertainty when there is insufficient information to support decision-making [73,74]. However, after T2, information on vaccination was being disseminated by local governments in Japan, and vaccination coupons were delivered to all people. People were increasingly reassured as others around them were vaccinated and as they gained experience with vaccination. Therefore, it is possible that as people progressed from T2 to T3, they may have been less strongly motivated to search for information, and the coefficient value may have decreased.

In summary, this study revealed the important empirical finding that not all types of information produce a reciprocal influence process, nor do they continue to be selected and influenced as social contexts change over time. Therefore, this study provides new insights into existing theories on the need to consider both the content and timing of vaccination information depending on the beliefs and attitudes already held by the public.

4.4. Practical implications

The results of this study provide practical suggestions for promoting vaccination programs during the COVID-19 pandemic. It is necessary to implement interventions and measures that take into account both the psychological process of vaccination, as indicated by integrated health behavior theory, and the social context. In particular, as shown in the present study, because cognitive and emotional responses to the virus are likely to change depending on the infection situation and social conditions, the implementation of different interventions and measures and switching between them at different times is likely to be effective. However, given that subjective norms and self-efficacy show consistent effects regardless of the social context, it may be effective to implement interventions and measures that communicate the effectiveness of vaccines and focus on these factors.

The influence of information that people may access on the internet is also important in combating vaccine hesitancy. This study suggests that Japanese people, who strongly desire to avoid uncertainty amid the global scientific uncertainty of a pandemic, could overcome vaccine hesitancy if they have specific information on availability for individuals, such as when, where, and for whom vaccinations are available. As suggested by Phillip et al. [75], developing a digital strategy that provides information that is tailored to each individual's specific situation and is useful to the individual, in collaboration with local governments and medical institutions, would make a tremendous contribution to promoting vaccination. Similarly, the actions of health care providers, such as pharmacists, who can communicate in a familiar manner and provide specific information to individuals may also be effective in promoting vaccination. In fact, studies during the pandemic showed that working with pharmacists, who are accessible to the general public, have long been a source of information about vaccination and other public health activities, and are central to the local community, is also effective [76,77]. Pharmacists' ability to provide specific information is promising.

Caution is necessary, however, when considering that expertise in the effects of vaccination and information on the dissemination of vaccines outside the country may lead to negative attitudes in the early stages of primary vaccination, when vaccine information is lacking. Furthermore, it is important to note that during a pandemic, information disseminated by experts has various influences, and accurate information is required amid scientific uncertainty [78,79]. In such a situation, it is increasingly important for science communicators to disseminate to the public not only negative information on effects but also positive information in an easily understood manner while effectively explaining information on availability [78]. Furthermore, while exposure to a variety of types of digital media information has been shown to influence perceptions of vaccine efficacy [80], it would be useful to educate people on how to gather a wide range of information rather than relying on exposure to information from specific experts.

It is also important to understand that the impact of the information gathering discussed in this study is a cyclical process of influence that is driven by pre-existing attitudes, including people's own vaccination experience. In line with the findings of this study, it would be beneficial to provide consistent information to promote vaccination behavior and on an ongoing basis after vaccination given the cyclical influence of pre-existing attitudes and information. Furthermore, the provision of information on availability that does not undermine the echo chambers that support positive attitudes toward vaccines and vaccination intentions can promote stable vaccination behavior and is expected to be effective in preventing dropouts from vaccination programs that require multiple doses.

The combination of these approaches suggested by this study may help to reduce the reluctance to use newly developed vaccines in countries that, like Japan, are reluctant to vaccinate. These approaches can also minimize the threat of further unknown pandemics in the future, should they occur.

4.5. Limitations and future study

This study has several limitations. First, this study was conducted only in Japan. Thus, further development and generalization of the model is required for validation and confirmation in other countries with various levels of pandemic experience. Second, the amount of information obtained from the internet was assessed subjectively by each respondent. Even when the respondents were asked what kind of information made a strong impression on them, it was unclear to what extent and how they were objectively exposed to each type of information. In the future, a more detailed verification process will be necessary, including the use of actual internet access records. Third, as the results of this study indicate, vaccination intentions should be examined in more detail to understand how they are influenced by changes in public health with regard to infection, information dissemination, and a wide range of social factors. Thus, the continued monitoring of vaccination coverage, attitudes, and intentions is needed.

5. Conclusion

As expectations for the spread of the vaccine increased during the COVID-19 pandemic, people were exposed to a variety of information on the internet. This study applied integrative health behavior theory to determine how information on the internet influences the process of forming vaccination intentions. The results of this longitudinal study allowed us to explain vaccination intentions based on integrative health behavior theory. We found that perceptions of the virus changed with the social context, while the effects of subjective norms, self-efficacy, and safety concerns remained unchanged. Furthermore, while all information influenced beliefs at a time when information was scarce, information on availability for individuals continued to have a positive effect in the process of vaccine dissemination. This occurred through a cyclical effect, similar to an echo chamber, with information influencing beliefs about vaccines and vice versa. On the other hand, expert information on the effects of the vaccine outside of the country was found to negatively affect vaccination intentions. The effects varied according to the content of the information and as the timing of the information changed. The results of this study suggest that although information disseminated by experts does not necessarily have a positive effect, exposure to information on vaccine availability from the early stages may reduce individuals' anxiety about vaccines and lead to confidence in vaccination, even among Japanese people who have strong vaccine hesitancy.

CRediT authorship contribution statement

Sanae Inoue: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Visualization, Writing – original draft. **Kei Fuji:** Conceptualization, Project administration, Supervision, Writing – review & editing.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.techsoc.2024.102776.

Data availability

The data that has been used is confidential.

References

[1] World Health Organization, Report of the SAGE Working Group on Vaccine Hesitancy, WHO, Geneva, Switzerland, 2024.
[2] A. de Figueiredo, C. Simas, E. Karafillakis, P. Paterson, H.J. Larson, Mapping global trends in vaccine confidence and investigating barriers to vaccine uptake: a large-scale retrospective temporal modelling study, Lancet (London, England) 396 (2020) 898–908, https://doi.org/10.1016/S0140-6736(20)31558-0.
[3] N.E. MacDonald, Vaccine hesitancy: definition, scope and determinants, Vaccine 33 (2015) 4161–4164, https://doi.org/10.1016/j.vaccine.2015.04.036.
[4] World Health Organization, Ten Threats to Global Health in 2019, WHO, Geneva, Switzerland, 2019.
[5] S.J.B. Hanley, E. Yoshioka, Y. Ito, R. Kishi, HPV vaccination crisis in Japan, Lancet 385 (2015) 2571, https://doi.org/10.1016/s0140-6736(15)61152-7.
[6] S. Kreps, S. Prasad, J.S. Brownstein, Y. Hswen, B.T. Garibaldi, B. Zhang, D. L. Kriner, Factors associated with US Adults' likelihood of accepting COVID-19 vaccination, JAMA Netw. Open 3 (2020) e2025594, https://doi.org/10.1001/jamanetworkopen.2020.25594.
[7] M. Schwarzinger, V. Watson, P. Arwidson, F. Alla, S. Luchini, COVID-19 vaccine hesitancy in a representative working-age population in France: a survey experiment based on vaccine characteristics, Lancet Public Health 6 (2021) e210–e221, https://doi.org/10.1016/S2468-2667(21)00012-8.
[8] M. Motta, Can a COVID-19 vaccine live up to Americans' expectations? A conjoint analysis of how vaccine characteristics influence vaccination intentions, Soc. Sci. Med. 272 (2021) 113642, https://doi.org/10.1016/j.socscimed.2020.113642.
[9] K. Kawata, M. Nakabayashi, Determinants of COVID-19 vaccine preference: a survey study in Japan, SSM Popul, Health 15 (2021) 100902, https://doi.org/10.1016/j.ssmph.2021.100902.
[10] S. Nomura, A. Eguchi, D. Yoneoka, T. Kawashima, Y. Tanoue, M. Murakami, H. Sakamoto, K. Maruyama-Sakurai, S. Gilmour, S. Shi, H. Kunishima, S. Kaneko, M. Adachi, K. Shimada, Y. Yamamoto, H. Miyata, Reasons for being unsure or unwilling regarding intention to take COVID-19 vaccine among Japanese people: a large cross-sectional national survey, Lancet Reg. Health West. Pac. 14 (2021) 100223, https://doi.org/10.1016/j.lanwpc.2021.100223.
[11] K. Muto, I. Yamamoto, M. Nagasu, M. Tanaka, K. Wada, Japanese citizens' behavioral changes and preparedness against COVID-19: an online survey during the early phase of the pandemic, PLoS One 15 (2020) e0234292, https://doi.org/10.1371/journal.pone.0234292.
[12] S. Cato, T. Iida, K. Ishida, A. Ito, H. Katsumata, K.M. McElwain, M. Shoji, The bright and dark sides of social media usage during the COVID-19 pandemic: survey evidence from Japan, Int. J. Disaster Risk Reduct. 54 (2021) 102034, https://doi.org/10.1016/j.ijdrr.2020.102034.
[13] S.K. Chandan, S. Deepti, C.K. Gaurav, N. Waqar, S. Arti, Facade of media and social media during COVID-19: a review, Int. J. Res. Pharm. Sci. 11 (2020) 142–149, https://doi.org/10.26452/ijrps.v11ispl1.2288.
[14] A. Çal, M.K. Yıldız, İ.A. Avci, The effect of health-related media messages on fear and uncertainty about the COVID-19 pandemic, Disaster Med. Public Health Prep. 18 (2024) e129, https://doi.org/10.1017/dmp.2024.124.
[15] T. Yoda, H. Katsuyama, Willingness to receive COVID-19 vaccination in Japan, Vaccines 9 (2021) 48, https://doi.org/10.3390/vaccines9010048.
[16] F. Raza, J.D. Lantos, Promoting COVID-19 vaccination on social media, Pediatrics 147 (2021) e2021050049, https://doi.org/10.1542/peds.2021-050049.
[17] Q. Niu, J. Liu, M. Kato, Y. Shinohara, N. Matsumura, T. Aoyama, M. Nagai-Tanima, Public opinion and sentiment before and at the beginning of COVID-19 vaccinations in Japan: twitter analysis, JMIR Infodemiol 2 (2022) e32335, https://doi.org/10.2196/32335.
[18] G. Muric, Y. Wu, E. Ferrara, COVID-19 vaccine hesitancy on social media: building a public Twitter data set of antivaccine content, vaccine misinformation, and conspiracies, JMIR Public Health Surveill 7 (2021) e30642, https://doi.org/10.2196/30642.
[19] R.M. Wolfe, L.K. Sharp, Anti-vaccinationists past and present, BMJ 325 (2002) 430–432, https://doi.org/10.1136/bmj.325.7361.430.
[20] H.J. Larson, C. Jarrett, E. Eckersberger, D.M.D. Smith, P. Paterson, Understanding vaccine hesitancy around vaccines and vaccination from a global perspective: a systematic review of published literature, 2007–2012, Vaccine 32 (2014) 2150–2159, https://doi.org/10.1016/j.vaccine.2014.01.081.
[21] P. Schmid, D. Rauber, C. Betsch, G. Lidolt, M.L. Denker, Barriers of influenza vaccination intention and behavior - a systematic review of influenza vaccine hesitancy, 2005 - 2016, PLoS One 12 (2017) e0170550, https://doi.org/10.1371/journal.pone.0170550.
[22] I. Ajzen, The theory of planned behavior, Organ. Behav. Hum. Decis. Process. 50 (1991) 179–211, https://doi.org/10.1016/0749-5978(91)90020-t.
[23] I.M. Rosenstock, V.J. Strecher, M.H. Becker, Social learning theory and the health belief model, Health Educ. Q. 15 (1988) 175–183, https://doi.org/10.1177/109019818801500203.
[24] K. Witte, Putting the fear back into fear appeals: the extended parallel process model, Commun. Monogr. 59 (1992) 329–349, https://doi.org/10.1080/03637759209376276.
[25] S.M. Noar, R.S. Zimmerman, Health behavior theory and cumulative knowledge regarding health behaviors: are we moving in the right direction? Health Educ. Res. 20 (2005) 275–290, https://doi.org/10.1093/her/cyg113.
[26] M.A. Gerend, J.E. Shepherd, Predicting human papillomavirus vaccine uptake in young adult women: comparing the health belief model and theory of planned behavior, Ann. Behav. Med. 44 (2012) 171–180, https://doi.org/10.1007/s12160-012-9366-5.
[27] H. Chu, S. Liu, Integrating health behavior theories to predict American's intention to receive a COVID-19 vaccine, Patient Educ. Couns. 104 (2021) 1878–1886, https://doi.org/10.1016/j.pec.2021.02.031.
[28] J.W.J. Ng, S. Vaithilingam, M. Nair, L.A. Hwang, K.I. Musa, Key predictors of COVID-19 vaccine hesitancy in Malaysia: an integrated framework, PLoS One 17 (2022) e0268926, https://doi.org/10.1371/journal.pone.0268926.
[29] M. Machida, I. Nakamura, T. Kojima, R. Saito, T. Nakaya, T. Hanibuchi, T. Takamiya, Y. Odagiri, N. Fukushima, H. Kikuchi, S. Amagasa, H. Watanabe, S. Inoue, Acceptance of a COVID-19 vaccine in Japan during the COVID-19 pandemic, Vaccines 9 (2021) 210, https://doi.org/10.3390/vaccines9030210.
[30] K.O. Kwok, K.-K. Li, W.I. WEI, A.Tang, S.Y.S.Wong, S.S.Lee, Influenza vaccine uptake, COVID-19 vaccination intention and vaccine hesitancy among nurses: A survey, Int. J. Nurs. Stud. 114 (2021), https://doi.org/10.1016/j.ijnurstu.2020.103854.
[31] L. An, D.M. Russell, R. Mihalcea, E. Bacon, S. Huffman, K. Resnicow, Online search behavior related to COVID-19 vaccines: infodemiology study, JMIR Infodemiol 1 (2021) e32127, https://doi.org/10.2196/32127.
[32] S. Vosoughi, D. Roy, S. Aral, The spread of true and false news online, Science 359 (2018) 1146–1151, https://doi.org/10.1126/science.aap9559.
[33] S. Loomba, A. de Figueiredo, S.J. Piatek, K. de Graaf, H.J. Larson, Measuring the impact of COVID-19 vaccine misinformation on vaccination intent in the UK and USA, Nat. Hum. Behav. 5 (2021) 337–348, https://doi.org/10.1038/s41562-021-01056-1.
[34] C. Pires, What is the state-of-the-art in clinical trials on vaccine hesitancy 2015-2020? Vaccines 9 (2021) 348, https://doi.org/10.3390/vaccines9040348.
[35] J. Roozenbeek, C.R. Schneider, S. Dryhurst, J. Kerr, A.L.J. Freeman, G. Recchia, A. M. van der Bles, S. van der Linden, Susceptibility to misinformation about COVID-19 around the world, R. Soc. Open Sci. 7 (2020) 201199, https://doi.org/10.1098/rsos.201199.
[36] M. Uehara, S. Fujita, N. Shimizu, K. Liew, S. Wakamiya, E. Aramaki, Measuring concerns about the COVID-19 vaccine among Japanese internet users through search queries, Sci. Rep. 12 (2022) 15037, https://doi.org/10.1038/s41598-022-18307-4.
[37] Ministry of Internal Affairs and Communications, Information and communications in Japan white paper 2021. https://www.soumu.go.jp/johotsusintokei/whitepaper/eng/WP2021/2021-index.html, 2021. (Accessed 22 September 2023).
[38] C. Betsch, F. Renkewitz, T. Betsch, C. Ulshöfer, The influence of vaccine-critical websites on perceiving vaccination risks, J. Health Psychol. 15 (2010) 446–455, https://doi.org/10.1177/1359105309353647.
[39] X. Nan, K. Madden, HPV vaccine information in the blogosphere: how positive and negative blogs influence vaccine-related risk perceptions, attitudes, and behavioral intentions, Health Commun. 27 (2012) 829–836, https://doi.org/10.1080/10410236.2012.661348.
[40] R.K. Goel, M.A. Nelson, COVID-19 internet vaccination information and vaccine administration: evidence from the United States, J. Econ. Finance 45 (2021) 716–734, https://doi.org/10.1007/s12197-021-09551-x.
[41] C.R. Sunstein, Republic.com, Princeton University Department of Art & Archaeology, New Jersey, 2001.
[42] M. Cinelli, G.D.F. Morales, A. Galeazzi, W. Quattrociocchi, M. Starnini, The echo chamber effect on social media, Proc. Natl. Acad. Sci. U. S. A. 118 (2021) e2023301118, https://doi.org/10.1073/pnas.2023301118.

[43] A.L. Schmidt, F. Zollo, A. Scala, C. Betsch, W. Quattrociocchi, Polarization of the vaccination debate on Facebook, Vaccine 36 (2018) 3606–3612, https://doi.org/10.1016/j.vaccine.2018.05.040.
[44] M. Del Vicario, G. Vivaldo, A. Bessi, F. Zollo, A. Scala, G. Caldarelli, W. Quattrociocchi, Echo chambers: emotional contagion and group polarization on Facebook, Sci. Rep. 6 (2016) 37825, https://doi.org/10.1038/srep37825.
[45] N. Ahmed, S.C. Quinn, G.R. Hancock, V.S. Freimuth, A. Jamison, Social media use and influenza vaccine uptake among White and African American adults, Vaccine 36 (2018) 7556–7561, https://doi.org/10.1016/j.vaccine.2018.10.049.
[46] J. Keelan, V. Pavri-Garcia, G. Tomlinson, K. Wilson, YouTube as a source of information on immunization: a content analysis, JAMA 298 (2007) 2481, https://doi.org/10.1001/jama.298.21.2482.
[47] T.D. Wilson, Information behaviour: an interdisciplinary perspective, Inf. Process. Manag. 33 (1997) 551–572, https://doi.org/10.1016/s0306-4573(97)00028-9.
[48] Prime Minister's Office of Japan, COVID-19 vaccines. https://japan.kantei.go.jp/ongoingtopics/vaccine.html. (Accessed 14 July 2023).
[49] D. Wild, A. Grove, M. Martin, S. Eremenco, S. McElroy, A. Verjee-Lorenz, P. Erikson, Principles of good practice for the translation and cultural adaptation process for patient-reported outcomes (PRO) measures: report of the ISPOR task force for translation and cultural adaptation, Value Health 8 (2005) 94–104, https://doi.org/10.1111/j.1524-4733.2005.04054.x.
[50] R. Okubo, T. Yoshioka, S. Ohfuji, T. Matsuo, T. Tabuchi, COVID-19 vaccine hesitancy and its associated factors in Japan, Vaccines 9 (2021) 662, https://doi.org/10.3390/vaccines9060662.
[51] P.M. Podsakoff, S.B. MacKenzie, J.Y. Lee, N.P. Podsakoff, Common method biases in behavioral research: a critical review of the literature and recommended remedies, J. Appl. Psychol. 88 (2003) 879–903, https://doi.org/10.1037/0021-9010.88.5.879.
[52] T.D. Little, Longitudinal Structural Equation Modeling, Guilford Press, New York, 2013.
[53] J. Pallant, SPSS survival manual—a step by step guide to data analysis using SPSS for windows. https://www.scirp.org/(S(351jmbntvnsjt1aadkozje))/reference/referencespapers.aspx?referenceid=771114, 2007. (Accessed 18 July 2023).
[54] S. Inoue, K. Fuji, An exploratory study of information on COVID-19 vaccines obtained by Japanese working adults through social media, in: The Asian Conference on Psychology & the Behavioral Sciences (ACP2022), 2022. Tokyo, Japan.
[55] J.F. Hair, W.C. Black, B.J. Babin, E. Rolph, The Statistical Analysis of Multivariate Failure Time Data, Pearson Prentice, England, 2019.
[56] H. Zhou, D. Cárdenas, K.J. Reynolds, Norms and COVID-19 health behaviours: a longitudinal investigation of group factors, Eur. J. Soc. Psychol. 53 (2023) 720–731, https://doi.org/10.1002/ejsp.2932.
[57] R. Liu, G.M. Li, Hesitancy in the time of coronavirus: temporal, spatial, and sociodemographic variations in COVID-19 vaccine hesitancy, SSMSSM Popul, Health 15 (2021) 100896, https://doi.org/10.1016/j.ssmph.2021.100896.
[58] R. Al-Amer, D. Maneze, B. Everett, J. Montayre, A.R. Villarosa, E. Dwekat, Y. Salamonson, COVID-19 vaccination intention in the first year of the pandemic: a systematic review, J. Clin. Nurs. 31 (2022) 62–86, https://doi.org/10.1111/jocn.15951.
[59] NHK (Japan Broadcasting Corporation), People crowded the large vaccination center for vaccination tickets, starting from 18 to 64 years old. https://www3.nhk.or.jp/news/html/20210617/k10013090251000.html. (Accessed 13 November 2024).
[60] T. Okubo, A. Inoue, K. Sekijima, Who Got Vaccinated for COVID-19? Evidence from Japan, Vaccines, vol. 9, 2021, p. 1505, https://doi.org/10.3390/vaccines9121505.
[61] National Institute of Infectious Diseases, New mutant strain of a novel coronavirus (SARS-CoV-2) of concern for increased infection and transmissibility and antigenic changes (report 12). https://www.niid.go.jp/niid/ja/diseases/ka/corona-virus/2019-ncov/2484-idsc/10554-covid19-52.html, 2019. (Accessed 13 November 2024).
[62] Cabinet Secretariat, COVID-19] press conference by the prime minister. https://japan.kantei.go.jp/99_suga/statement/202101/_00005.html. (Accessed 13 November 2024).
[63] X. Xiao, R.M. Wong, Vaccine hesitancy and perceived behavioral control: a meta-analysis, Vaccine 38 (2020) 5131–5138, https://doi.org/10.1016/j.vaccine.2020.04.076.
[64] M. Lelliott, E. Sahker, H. Poudyal, A review of parental vaccine hesitancy for human papillomavirus in Japan, J. Clin. Med. 12 (2023) 2004, https://doi.org/10.3390/jcm12052004.
[65] P.F. Burke, D. Masters, G. Massey, Enablers and barriers to COVID-19 vaccine uptake: an international study of perceptions and intentions, Vaccine 39 (2021) 5116–5128, https://doi.org/10.1016/j.vaccine.2021.07.056.
[66] Q. Niu, J. Liu, M. Kato, M. Nagai-Tanima, T. Aoyama, The effect of fear of infection and sufficient vaccine reservation information on rapid COVID-19 vaccination in Japan: evidence from a retrospective Twitter analysis, J. Med. Internet Res. 24 (2022) e37466, https://doi.org/10.2196/37466.
[67] G.J. Hofstede, Cultures and Organizations: Software of the Mind: Intercultural Cooperation and its Importance for Survival, McGraw-Hill, New York, United States, 1991.
[68] R.F. Baumeister, E. Bratslavsky, C. Finkenauer, K.D. Vohs, Bad is stronger than good, Rev. Gen. Psychol. 5 (2001) 323–370, https://doi.org/10.1037//1089-2680.5.4.323.
[69] P. Rozin, E.B. Royzman, Negativity bias, negativity dominance, and contagion, Pers. Soc. Psychol. Rev. 5 (2001) 296–320, https://doi.org/10.1207/s15327957pspr0504_2.
[70] P. Brown, F. Waite, M. Larkin, S. Lambe, H. McShane, A.J. Pollard, D. Freeman, "It seems impossible that it's been made so quickly": a qualitative investigation of concerns about the speed of COVID-19 vaccine development and how these may be overcome, Hum. Vaccines Immunother. 18 (2022) 2004808, https://doi.org/10.1080/21645515.2021.2004808.
[71] C.S. Meppelink, E.G. Smit, M.L. Fransen, N. Diviani, "I was right about vaccination": confirmation bias and health literacy in online health information seeking, J. Health Commun. 24 (2019) 129–140, https://doi.org/10.1080/10810730.2019.1583701.
[72] J. Wang, G. Xiu, F. Shahzad, Exploring the determinants of online health information-seeking behavior using a meta-analytic approach, Sustainability 11 (2019) 4604, https://doi.org/10.3390/su11174604.
[73] S.A. Rains, Health information seeking and the world wide web: an uncertainty management perspective, J. Health Commun. 19 (2014) 1296–1307, https://doi.org/10.1080/10810730.2013.872731.
[74] S. Chowdhury, F. Gibb, M. Landoni, Uncertainty in information seeking and retrieval: a study in an academic environment, Inf. Process. Manag. 47 (2011) 157–175, https://doi.org/10.1016/j.ipm.2010.09.006.
[75] R.K. Philip, M. Shapiro, P. Paterson, S. Glismann, P. Van Damme, Is it time for vaccination to "go viral", Pediatr. Infect. Dis. J. 35 (2016) 1343–1349, https://doi.org/10.1097/inf.0000000000001321.
[76] T. Pantasri, Expanded roles of community pharmacists in COVID-19: a scoping literature review, J. Am. Pharm. Assoc. 62 (2022) 649–657, https://doi.org/10.1016/j.japh.2021.12.013.
[77] K. Hess, A. Bach, K. Won, S.M. Seed, Community pharmacists roles during the COVID-19 pandemic, J. Pharm. Pract. 35 (2020) 469–476, https://doi.org/10.1177/0897190020980626.
[78] B. León, I. López-Goñi, R. Salaverría, The COVID-19 catastrophe: a science communication mess? Church, Commun. Cult. 7 (2022) 6–22, https://doi.org/10.1080/23753234.2022.2031236.
[79] L. Provenzi, S. Barello, The science of the future: establishing a citizen-scientist collaborative agenda after COVID-19, Front. Public Health 8 (2020) 282, https://doi.org/10.3389/fpubh.2020.00282.
[80] H. Chen, Y. Chen, X. Xu, D. Atkin, Diversity of digital media exposure, information verification and vaccination intention: an empirical study in China, Inf. Technol. People (2024), https://doi.org/10.1108/ITP-04-2023-0390.