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Dynamic associations between temporal behavior changes caused by the COVID-19 pandemic and subjective assessments of policymaking: A case study in Japan

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**ABSTRACT**

To design effective policies against COVID-19, there is a need for more evidence-based research. However, associations between actual policies and temporal behavior changes have remained underexplored. To fill this important research gap, a nationwide retrospective life-oriented panel survey on individuals’ behavior changes from April to September 2020 was implemented in Japan. Reliability of information sources, risk perceptions, and attitudes toward policymaking were also investigated. Valid data were collected from 2643 respondents residing in different parts of the country. Risks were reported about general infections and public transport use. Attitudes toward policymaking were mainly about policymaking capacity and PASS-LASTING based policy measures. A dynamic structural equation model (DSEM) was developed to quantify dynamic associations between individuals’ behavior changes over time and subjective assessments (i.e., attitudes) of policymaking. Survey results revealed that behavior changes are mostly characterized by avoidance behaviors. Modeling estimation results showed a statistically-significant sequential cause-effect relationship between accumulated behavior changes in the past, subjective factors, and the most recent behavior changes. The most recent behavior changes are mostly affected by accumulated behavior changes in the past. Effects of subjective assessments of policymaking on the most recent behavior changes are significant but moderate. Among attitudes toward policymaking, attitudes toward policymaking capacity are more influential than willingness to follow PASS-LASTING based policy measures. High risks of using public transport are found to significantly influence the most recent behavior changes, together with other risk perception factors. Insights into effective COVID-19 policymaking are summarized.

1. Introduction

The COVID-19 pandemic has caused more than 100 million infections and more than 2 million deaths as of the end of January 2021.\(^1\) Before vaccinations were widely available, governments implemented various behavioral interventions, from forced lockdowns (with penalties for violations) to voluntary changes in behaviors via communication campaigns. Even though daily new cases started to decline across the world by the end of the first week of January 2021, the numbers remain higher than 600,000 cases per day. In Japan, the target country of this study, more than 370,000 cumulative infection cases were confirmed by the end of January 2021, with three peaks observed in April 2020, August 2020, and the first two weeks of January 2021. Daily new cases increased about three times from the first peak to the second peak, and about four times from the second peak to the third peak. For policy measures, Japan has mainly relied on “soft” behavioral interventions which request people to change their behaviors, particularly regarding interactions with social contacts. Strict lockdown has not been adopted. Some key measures taken from March to September 2020 are summarized below.

- **March 2**: All elementary, secondary and high schools in Japan temporarily suspended until the spring break (April 6)

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\(^1\) [https://www.worldometers.info/coronavirus/](https://www.worldometers.info/coronavirus/) (Accessed on January 31, 2021).
March 19: Governmental task force releases recommendations on behavioral changes to contain the novel coronavirus
March 25: The governor of Tokyo requests people to exercise self-restraint (e.g. limit trips outside of home) on weekends
March 30: The governor of Tokyo further requests people to exercise self-restraint on both weekends and weekdays
April 7: State of emergency declared for prefectures with major infection outbreaks
April 9: Government requests companies to telework and stagger commuting times
April 11: Government requests people to reduce trips by at least 70%
April 12: Avoid 3Cs (Closed spaces, Crowded places, and Close-contact settings) at workplace
April 16: State of emergency declared for the whole country
May 4: State of emergency for the whole country extended until the end of May
May 14: State of emergency lifted for 39 prefectures
May 21: State of emergency lifted for prefectures with major outbreaks
May 25: State of emergency lifted for the whole country
May 26: Public advised to avoid unnecessary inter-prefectural travel until the end of May
June 5: Public recommended to stop overseas trips
June 18: Inter-regional travel restrictions relaxed
June 19: Government releases a smartphone app COCOA (COVID-19 Contact-Confirming Application) which informs people about physical contacts with infected persons
July 22: Go To Travel Campaign launched
August 28: Government announces goal of providing vaccines to all citizens by the first half of next year

Research has shown that human behaviors change over time. Fatigue from behavioral interventions may weaken the effects of policies. Such behavioral dynamics should be addressed in COVID-19 policymaking. However, as the review by Zhang et al. (2021) found, existing efforts are very limited. This study aims to fill this important research gap by analyzing data from a six-month life-oriented panel survey conducted in Japan using a dynamic structural equation model (DSEM). In the survey, 2,643 respondents provided valid answers about behavior changes from April to September 2020, and subjective factors that may be associated with behavior changes. Behaviors are captured based on the life-oriented approach (Zhang, 2014, 2017; Zhang and Van Anker, 2017), focusing on both intercity and intracity behaviors, which are further grouped into different life domains. Subjective factors include not only subjective evaluations of reliability of COVID-19 information and risk perceptions, but also attitudes toward policymaking. The attitudes further include subjective assessments of policymaking capacity related to governments and health professionals, and willingness to cooperate with policy measures based on the PASS approach (“Preparation-provide”, “Avoid-adjust”, “Shift-share”, and “Substitute-stop”) (Zhang, 2020) and the LASTING approach (“Life needs”, “Activity participation”, “Space”, and “Time-timing”) (Zhang, 2021). The PASS approach argues that COVID-19 policies should be made in a seamless and comprehensive way and the LASTING approach emphasizes the role of people’s willingness to cooperate with policymaking via voluntary behavioral changes. Before and during the period of April–September 2020, many policies were implemented, which may or may not have affected the respondents’ behaviors and attitudes. This study focuses on individual persons, but it is unknown how every individual perceived all of these policies. Therefore, instead of directly focusing on actual policies common to everybody, the study asked each respondent to report how he/she perceived existing policies that are classified based on the PASS and LASTING approaches, i.e., PASS-LASTING policies.

The rest of this paper is structured as follows. Section 2 briefly reviews existing studies. Section 3 proposes a conceptual framework for this study. Section 4 describes the survey and data. Section 5 estimates a dynamic structural equation model based on the conceptual framework and describes modeling estimation results. Finally, this study is concluded in Section 6 with a summary of major research findings and discussion of key policymaking recommendations.  

2. Literature review

2.1. Behavior changes during the COVID-19 pandemic

In order to control the spread of COVID-19, governments in different countries have taken various countermessages, such as travel restrictions and social distancing. Abu-Rayash and Dincer (2020) established a model with four indicators (transport efficiency, technology integration, traffic congestion rate, and accessibility ratio) to analyze changing trends in global aviation and travel in selected cities worldwide, and found dramatic declines in global mobility caused by the various restrictions imposed by authorities. It was further revealed that the transportation sector was virtually non-existent in some cities at certain periods. Shamshiripour et al. (2020) conducted a panel data based research on the relationships between travel behaviors and the COVID-19 pandemic. They found that since the outbreak of COVID-19, lots of Americans have cancelled their airline travels, and some tried to shift their mobility styles from public transport and carsharing to active transport (i.e., cycling and walking) and cars. However, not everyone can work at home or have access to alternative travel modes. If policymakers effectively restricted the use of public transport, users would have to face a higher risk of exposure to the virus, but if policymakers closed down public transport, travel or commuting would become inaccessible for people without a car or bike (Brooks et al., 2020). Holte et al. (2020) showed that most people intended to seek safety in life. People who are infected want to avoid spreading the virus, while people who are not infected want to reduce exposure. Males are less likely to alter their travel patterns in response to spreading the virus or increasing exposure. The perception of a high-level risk at one’s workplace does not significantly reduce travel. Stavrinos et al. (2020) analyzed the driving behavior changes of adolescents during the pandemic in the USA. They found that driving time per week and vehicle miles driven (VMD) declined after the COVID-19 restrictions from March 14 to April 22, 2020. The range of driving time and VMD declined by more than one third compared to previous levels, and this trend was especially remarkable for younger teens, non-minorities, females, non-working teens, and those with higher prosocial tendencies. Moreover, Katrakazas et al. (2020) observed that with the decrease in the number of running cars, people prefer to drive faster and make more sudden accelerations.

Activity-travel behavior changes might have negative impacts on people’s psychological states. COVID-19 caused a career shock for many people around the world, forcing people to adapt as travel restrictions made it difficult to commute to jobs and companies are closed (Akkermans et al., 2020), while isolation at home led to a lack of social interactions and self-development, resulting in stress and depression. Marroquin et al. (2020) investigated whether the policy of stay-at-home orders and individuals’ personal distancing behaviors are related to mental problems (e.g. depression, generalized anxiety disorder (GAD), intrusive thoughts, insomnia, and acute stress). They found that most people have an increasing GAD and feelings of depression during the period when they had to stay at home and maintain social distancing. What’s worse, the proliferation of online information sources further instigated negative impacts and as a result, some unusual behaviors (e.g., unusual purchases) occurred (Miri et al., 2020; Laato et al., 2020a). Another study in China showed that every time important negative news about COVID-19 is released, individuals’ negative emotions will increase (Li et al., 2020). Furthermore, De Vos (2020, 2013) revealed that stay-at-home threatened individuals’ subjective well-being, resulting in limited physical activities and social isolation. During the COVID-19 pandemic, people travelled less but performed more recreational activities and deliberately travelled shorter distances.
2.2. The roles of information reliability in affecting behavior changes

When individuals face a perceived gap in their knowledge, they have a desire to seek additional information (Cho et al., 2015: p.103). After seeking the information, people also need to process it. The reliability of information will influence the extent to which a person will seek out risk information in daily life and the extent to which he/she will spend on analyzing the risk information critically (Newirth, 1999). For information seeking and processing, the reliability of information sources is highly associated with one’s perceptions and behavior. During a new pandemic, different information sources will provide various information to the public, such as people’s vulnerability to the virus, the probability of infection or the sequela of disease. Receiving information from different sources influences the public’s knowledge about the risks, thereby changing their decisions (Smith, 2006). The reliability of information sources can affect people’s risk communication with external environment and then affect their behaviors (Williams, 1998). Due to various factors, such as the spread of media, individuals’ attributes and risk experience, the reliability of information sources may be distorted (Cho et al., 2015: p.233). Zhao et al. (2020) conducted a study to test whether COVID-related behaviors will change according to trust in left-leaning (e.g., CNN) or right-leaning media (e.g., Fox News) sources. They used panel data in the USA to examine how the preventive and risky behaviors of people, who trust different media sources, changed from March 10 to June 9. Their results indicated that false information can be easily disseminated to the public by the media, and that individuals made different behavioral responses according to the different levels of trust in the media. Individuals clearly do not have equal beliefs in information from different sources. Lu et al. (2020) analyzed the relationship between the trust of different COVID-19 information sources (health professionals, academic institutions, government agencies, news media, social media, family, and friends) and individuals’ information sharing behaviors in China. Their results showed that people are prone to exchange the information from media or social networks to share their feelings with each other. Meanwhile, individuals prefer to improve their knowledge about COVID-19 prevention based on information from authoritative sources, reflecting a higher trust in these sources.

2.3. The role of risk perceptions in affecting behavior changes

Individuals’ risk perceptions may affect behavior changes during pandemics. In general, the likelihood of people following policy measures of protection may be associated with their risk perceptions (Leppin and Aro, 2009; Sadique et al., 2007). When perceiving a risk, people will make a behavior decision based on their own beliefs and attitudes (Fischer, 2017). A higher risk perception of exposure to a virus may result in a higher likelihood to change travel behaviors (Pennington-Gray et al., 2011). Furthermore, Ibuka et al. (2010) conducted a survey in the United States during the H1N1 pandemic and found that people’s perceptions of risk regarding the pandemic increased over time; on the contrary, some protection behaviors such as the intention to vaccinate decreased.

As in the case of previous pandemics, people’s risk perceptions have had a similar effect on behavior changes during the COVID-19 pandemic. Hoile et al. (2020) used an ordered logit regression model to analyze the risk perceptions and risk mitigation decisions with or without infection of COVID-19 across the USA. They stated that individuals’ knowledge about COVID-19 has a larger impact on reducing travels than the recent influenza experience, and people will reduce travel to non-work locations in which they perceived medium or high risk. In the context of non-binding self-restriction requests in Japan, Parady et al. (2020) conducted a panel web-survey to target the travel behavior changes of individuals in the Kanto Region during the COVID-19 pandemic. They used a regression model and a discrete choice model to estimate the behavioral changes for shopping, eating-out and leisure. The results showed that people’s decline in shopping travels, eating-out and leisure activities are associated with other people’s perceptions of self-restriction. Moreover, they suggested that policymakers should report more information about the seriousness of COVID-19 and emphasize the behaviors of others to the public.

2.4. The role of attitudes toward policymaking in affecting behavior changes

COVID-19 policymaking aims to change people’s various behaviors. Pandemics may change people’s attitudes toward policymaking (Van Bavel et al., 2020). When people face an external threat (e.g., pandemics, natural disasters), they are likely to show an increasing cohesion in their groups (e.g., nations), and have a higher trust in government staff (Greenaway and Cruwys, 2019; Sibley et al., 2020; Toya and Skidmore, 2014; Li and Brewer, 2004; Postmes et al., 2013). However, with the increase of financial problems (e.g., unemployment) and psychological problems (e.g., depression), the level of trust for institutions and government staff may decrease (Bangert et al., 2012; Quinl, 2013; Meltzer et al., 1999). However, one coin has two sides: some people may become more suspicious about the institutions and fall into the trap of conspiracy theories (Dussaillant and Guzman, 2014; Van Prooijen and Van Dijk, 2014).

Not only attitudes toward governments (Min et al., 2020; Blendon et al., 2008; Taylor et al., 2009; Vinck et al., 2019), but also attitudes toward medical institutes (Gilles, 2011) may have a significant influence on people’s decisions to follow recommended protection measures (e.g., social distancing, washing hands, wearing a mask) during the current pandemic. Some studies showed that recommended protection behaviors are more likely to happen when there is a positive attitude toward policymaking (Wong et al., 2020; Laato et al., 2020b). Chan et al. (2020) argued that the attitudes toward governments and the attitudes toward health care systems may have a contradictory influence on following the recommended policy measures. Some scholars found that attitudes toward governments may be more influential than that of central governments (Shaw et al., 2020). In addition, when attitudes affect behavior changes, the attitudes are also associated with individuals’ risk perceptions (Prati et al., 2011). A trust in institutions can affect people’s judgments about risks and benefits, and consequently can affect their behaviors (Siegrist et al., 2003).

2.5. PASS-LASTING based policymaking

Considering the severity of threats from this virus, it is crucial to make policy decisions in a seamless and comprehensive way. In this regard, Zhang (2020) proposed a PASS approach for COVID-19 policymaking, especially in relation to the transport sector. The PASS approach emphasizes the different roles of various stakeholders and argues that COVID-19 policies should be proposed from the following four perspectives, i.e., Prepare-protect-provide (P), Avoid-adjust (A), Shift-share (S), and Substitute-stop (S). More than 100 policy measures are proposed by Zhang (2020). As discussed previously, behavioral interventions are an important category of COVID-19 policies. Related to this, Zhang (2021) conducted a nationwide retrospective panel survey in Japan at the early stages of the COVID-19 pandemic and revealed that better communication design is crucial to encourage behavior changes for mitigating the pandemic. To encourage voluntary behavior changes, Zhang (2021) further argued that a LASTING approach is needed, which involves modifying people’s needs in life (L) and performing the resulting activities (A) at places with proper spaces (S) at the proper time and with the proper timing (TING), as much as possible.
3. Conceptual framework: A dynamic structural equation model

In this study, a dynamic structural equation model (DSEM) is developed, as shown in Fig. 1. It is assumed that accumulation of changes in behaviors in the past (ACCU_CHANGE) first affects the formation of various attitudes, and then the attitudes further affect the most recent changes in behaviors (RECENT_CHANGE). ACCU_CHANGE is further assumed to influence RECENT_CHANGE, i.e., the existence of state dependence is assumed. In other words, a sequential cause-effect relationship is assumed. This assumption reflects the decision-making mechanisms related to human choice behaviors. Looking at existing studies in the general literature, almost all of them only investigated a limited number of behaviors while studies in the field of transportation mainly investigated travel behaviors. As revealed by Zhang (2014, 2017) from both conceptual and empirical perspectives, people’s various life choices (e.g. residence, neighborhood, health, education, work, family life, leisure and recreation, finance, and travel behavior) are interdependent. As a part of life choices, travel behavior is associated with other life choices (Zhang and Van Acker, 2017; Zhang and Jiang, 2020). Capturing changes in various life behaviors caused by the COVID-19 pandemic, it is better to break the existing boundaries of behavior research between different disciplines. The life-oriented approach provides a theoretical framework for people-centered cross-sectoral policymaking. In this analysis, ACCU_CHANGE is measured as the sum of 0–1 variables from April to August 2020 with respect to each behavior. RECENT_CHANGE indicates a change in September 2020. Among the different types of attitudes, first, reliability of COVID-19 information sources (RELIABILITY) is assumed to influence risk perceptions about the virus infection (RISK_PERCEPT). This is straightforward because human judgement/perception relies on information searching. Next, attitudes toward COVID-19 policymaking capability (ATTD_CAPACITY) are assumed to be associated with RISK_PERCEPT. This is because if people think policymakers are capable of dealing with COVID-19, then they may think COVID-19 is under better control and therefore feel a higher level of safety. Furthermore, ATTD_CAPACITY is assumed to influence attitudes toward PASS and LASTING based policy measures (ATTD_PASS_LASTING) from an individual perspective. This final assumption is made by considering that if people think policymakers are capable of dealing with COVID-19, they are more likely to cooperate in changing their behaviors voluntarily.

4. Survey and data

A life-oriented retrospective panel survey was implemented online with respect to 2643 respondents living across the whole of Japan, who reported changes in their various life behaviors between April and September 2020, various attitudinal attributes and individual socio-demographic attributes. The collected samples approximately reflect the distributions of age and gender as well as 47 prefectures, covering the whole population of Japan, based on data from the Statistics Bureau of Japan (2021). Table 1 shows the differences between the shares of respondents in the survey and those of the population by regions of Japan. The population in Kanto and Hokkaido are over-represented by 5.9 and 4.4 percentage points, while the population in Chubu and Kinki are under-represented by 4.1 and 3.3 percentage points, respectively. The other differences are all within 2.0 percentage points.

4.1. Respondents

Regarding the location of survey respondents, 41.2% resided in megalcity regions (e.g., Tokyo, Nagoya, and Osaka), 29.3% in ordinance-designated cities, and the remaining in local cities. Among all 47 prefectures of Japan, the respondents from Tokyo accounted for the biggest share of 19.3%, followed by those from Kanagawa Prefecture (10.4%) and Hokkaido (8.6%). As shown in Table 2, the proportion of female respondents (52.8%) is a little higher than that of males (47.2%). More than half of the respondents were aged between 30 and 60 years old, 18.2% were less than 30 years old, while the share of the respondents aged 60+ years old was 23.8%. Most participants were company employees or self-employed (40.2%), followed by housewives with the second biggest share of 17.1%. Only 7.5% of the respondents were students. Respondents with a university education background (graduated or in school) and high school (graduated or in school) accounted for 43.3% and 28.3%, respectively.
4.2. Data by survey contents

The second part of the questionnaire focuses on individuals’ changes in various behaviors and subjective attributes. The former is captured based on the life-oriented approach, while the latter includes the reliability of major COVID-19 information sources, risk perceptions about the COVID-19 virus, and attitudes toward policymaking in terms of ability of major COVID-19 information sources, risk perceptions about the virus infection, and risk perceptions about the whole country. Only 29.5% perceived the risk of infections for them changes. Only 28.9% share (60.1%) of respondents reported that the risk of infection in a whole country, only 29.5% perceived the risk level in the whole of Japan to be increasing, while 66.9% thought the COVID-19 virus is very horrific. But the share of respondents who perceived an increasing level of infection risk in the residence municipality is more than 26 points lower than those perceiving an increasing level across the whole country. Only 28.9% think that places they visit frequently are risky. As expected, a large share (60.1%) of respondents reported that the risk of infection in a crowded train or bus is high. In spite of widespread infections across the whole country, only 29.5% perceived the risk of infections for themselves as being high.

4.2.2. Risk perceptions about the virus infection (RISK_PERCEPT)

Risk perceptions about the virus infection are evaluated by asking each respondent to report how much he/she agrees with each of the following eight questions: (1) the risk of infection in the whole of Japan is increasing; (2) the risk of infection in the residence prefecture is increasing; (3) the risk of infection in the residence municipality is increasing; (4) the risk of infection in the place that he/she frequently visits (workplaces, schools, supermarkets, restaurants, gyms, etc.) is increasing; (5) the risk of infection in a crowded train or bus is high; (6) the virus is a very horrific disease; (7) the risk of infection of COVID-19 for himself/herself is high; and (8) he/she is susceptible to seasonal flu. Similarly, the assessment was done based on a 5-point scale (1: strongly disagree, 2: somewhat disagree, 3: neither, 4: somewhat agree, 5: strongly agree). It is revealed (see Table 4) that 67.9% of respondents perceived the risk level in the whole of Japan to be increasing, while 66.9% thought the COVID-19 virus is very horrific. But the share of respondents who perceived an increasing level of infection risk in the residence municipality is more than 26 points lower than those perceiving an increasing level across the whole country. Only 28.9% think that places they visit frequently are risky. As expected, a large share (60.1%) of respondents reported that the risk of infection in a crowded train or bus is high. In spite of widespread infections across the whole country, only 29.5% perceived the risk of infections for themselves as being high.

Table 3 Evaluation of reliability of COVID-19 information sources.

| Reliability | Mean | Low or very low | Neither | High or very high |
|-------------|------|----------------|---------|-----------------|
| The information announced by the central government (homepage information, news, public relations magazines, etc.) | 3.5 | 11.9% | 31.2% | 56.9% |
| The information announced by local governments (homepage information, news, public relations magazines, etc.) | 3.6 | 9.6% | 30.1% | 60.3% |
| Experts’ opinions (through various channels) | 3.2 | 14.3% | 47.6% | 38.1% |
| Domestic news | 3.5 | 10.9% | 34.5% | 54.6% |
| Overseas news | 3.0 | 19.4% | 56.1% | 24.5% |
| Medical institutes | 3.7 | 6.4% | 29.2% | 64.4% |
| Workplaces/schools | 3.0 | 16.8% | 59.7% | 23.5% |
| SNS (Social Networking Service): Facebook, LINE, Twitter, WhatsApp, etc. | 2.6 | 41.0% | 48.5% | 10.5% |
| Search engines: Google, Yahoo, etc. | 2.9 | 23.6% | 56.8% | 19.6% |
| Personal social network: acquaintances, colleagues, etc. | 2.9 | 23.2% | 62.2% | 14.6% |

Table 4 Risk perceptions about the virus infection.

| Risk perceptions | Mean | Somewhat or strongly disagree | Neither | Somewhat or strongly agree |
|------------------|------|------------------------------|---------|---------------------------|
| The risk of infection in the whole of Japan is increasing | 3.7 | 12.2% | 19.9% | 67.9% |
| The risk of infection in the residence prefecture is increasing | 3.5 | 19.2% | 26.0% | 54.8% |
| The risk of infection in the residence municipality is increasing | 3.2 | 25.7% | 32.8% | 41.5% |
| The risk of infection in the frequently-visited places (workplaces, schools, supermarkets, restaurants, gyms, etc.) is increasing | 3.0 | 31.3% | 39.8% | 28.9% |
| The risk of infection in a crowded train or bus is high | 3.6 | 13.6% | 26.3% | 60.1% |
| The COVID-19 virus is a very horrific disease | 3.8 | 12.3% | 20.8% | 66.9% |
| The risk of infection of the COVID-19 virus for oneself is high | 3.1 | 22.6% | 47.9% | 29.5% |
| The respondent is susceptible to seasonal flu | 2.3 | 62.0% | 25.3% | 12.7% |
4.2.3. Attitudes toward COVID-19 policymaking capability (ATTDD_CAPACITY)

Attitudes toward policymaking capability were investigated by asking respondents to evaluate the levels of expertise, enthusiasm, competence, and trust of governments and health/medical institutes, based on a 5-point scaling method (1: strongly disagree, 2: somewhat disagree, 3: neither, 4: somewhat agree, 5: strongly agree). These attributes are closely related to the capacity of policymakers and health professionals. Unfortunately, as shown in Table 5, only 21.3% and 48.1% of respondents thought policymakers and health professionals are capable of dealing with COVID-19. The trust level in governments is less than 30% and the perceived competence level of governments is only about 20%. Health and medical institutes were perceived to be capable in terms of trust (48.1%) and expertise (40.7%). It is therefore logical to interpret this lower level of capacity assessment as being related to the increasing trend of infections in Japan since July 2020.

Table 5
Attitudes toward COVID-19 policymaking capability.

| Attitude | Mean | Somewhat or strongly disagree | Neither | Somewhat or strongly agree |
|----------|------|--------------------------------|---------|----------------------------|
| (Expertise) Japanese health and medical institutions have sufficient expertise for COVID-19 | 3.1 | 26.3% | 33.0% | 40.7% |
| (Expertise) Japanese government has sufficient expertise for COVID-19 | 2.8 | 36.3% | 38.1% | 25.6% |
| (Expertise) The local government in the residence municipality has sufficient expertise for COVID-19 | 2.9 | 31.5% | 44.0% | 24.5% |
| (Enthusiasm) Can feel the central government’s enthusiasm in preventing the spread of COVID-19 | 2.7 | 41.3% | 33.3% | 25.4% |
| (Enthusiasm) Can feel the residence local government’s enthusiasm in preventing the spread of COVID-19 | 2.9 | 32.7% | 39.2% | 28.1% |
| (Competence) The central government has a competent management system and measures to prevent the spread of COVID-19 | 2.7 | 41.2% | 37.5% | 21.3% |
| (Competence) The local government in the residence municipality has a competent management system and measures to prevent the spread of COVID-19 | 2.8 | 33.6% | 43.1% | 23.3% |
| (Trust) Can trust that Japanese health and medical institutions can prevent the spread of COVID-19 | 3.3 | 18.5% | 33.4% | 48.1% |
| (Trust) Can trust that the central government can prevent the spread of COVID-19 | 2.8 | 36.7% | 37.2% | 26.1% |
| (Trust) Can trust that the local government in the residence municipality can prevent the spread of COVID-19 | 3.0 | 27.6% | 43.4% | 29.0% |

4.2.4. Attitudes toward PASS and LASTING based policy measures (ATTDD_PASS_LASTING)

Considering the severity of the threat of this virus, COVID-19 policies should be made in a seamless and comprehensive way. In line with such considerations, two types of COVID-19 policymaking methodologies have been proposed in the literature: one is based on the PASS approach (Zhang, 2020) and the other is the LASTING approach (Zhang, 2021). The PASS approach argues that COVID-19 policymaking should be made from Prepare-protect-produce (P), Avoid-adjust (A), Shift-share (S), and Substitute-stop (S) perspectives with respect to various stakeholders. The LASTING approach targets individual persons and suggests the importance of individuals to adapt needs in life (L) and consequently participate in activities (A) at locations with proper space (S) and at proper time and timing (T), based on individuals’ voluntary behavioral changes. In theory, both approaches are applicable not only to the transport sector but also other sectors. Here, respondents were asked to report their attitudes toward such policies from their personal viewpoints using a 5-point scaling method (1: strongly disagree, 2: somewhat disagree, 3: neither, 4: somewhat agree, 5: strongly agree). The questions of PASS and LASTING policy measures are shown in Table 6.

Table 6 shows that there are more respondents showing a positive attitude than a negative attitude. The largest group of respondents prefer “avoid” measures (66.7%) and “stop” measures (65.0%), followed by “substitute” (58.7%), “adjust” (54.8%), and “protect” measures (50.9%). Even though “prepare” measures are less preferred, the share is still larger than 30%. The other three types of PASS measures are preferred by more than 40% of respondents, respectively. Related to the LASTING policies, about half of respondents are willing to change the needs in life and lifestyles and the resulting daily activities, places and time/timing of activity participation. For both PASS and LASTING policies, the gaps between agreements and disagreements are between 21.9 and 59.0 points, except in the case of the “prepare” measures (only 8.6 points). All these data suggest that a large number of respondents recognize the importance of PASS and LASTING policies and are willing to cooperate with COVID-19 policy making and implementation. Even though preparedness is extremely important in the fight against pandemics, there are still 23.0% of respondents who dislike the “prepare” measures. Information sharing is also important to control the current pandemic; 19.5% of respondents are totally not reluctant to share their behavior histories and health status information with others. With regard to social interactions, negative attitudes may further affect other persons’ behaviors. Thus, it is not unrealistic to assume that such reluctance has strongly hindered the progress of flattening the pandemic curve.

4.2.5. Changes in behaviors

Changes in behaviors were investigated by asking respondents to report whether they changed a certain behavior in each month of April to September 2020 (during the pandemic), compared with the corresponding month in 2019 (before the pandemic).

These collected behavior changes come from different domains in life. For instance, the question “Whether have more teleworking and studying at home” belongs to the domain of work. The life choices also include the behavior changes of social life (avoid having visitors from places with severe infection), family life (avoid visiting family), leisure/recreation (domestic/overseas travel decreased), three Cs behavior (avoid going out to a crowded place; avoid activities in a closed space where there is contact with people; avoid talking to people at a close distance) and daily travel behavior (attendance/leaving time of work became more flexible; travel by public transport decreased; travel by car increased; travel by walking and biking increased; fewer detain behaviors after leaving workplace or school; less shopping in stores). The trends of behavior changes targeted in this study are shown in Fig. 2.

Fig. 2 reveals a decreasing trend from April to September for most behaviors, indicating that individuals’ willingness to cooperate in preventing the virus spread declined over time. In other words, fatigue from
Table 6
Attitudes toward PASS and LASTING based policy measures.

| Policy measures | Positive (strongly or somewhat agree) | Negative (strongly or somewhat disagree) |
|-----------------|---------------------------------------|------------------------------------------|
| **PASS**        |                                       |                                          |
| Prepare         | 31.6%                                 | 23.0%                                    |
| Protect         | 50.9%                                 | 10.4%                                    |
| Provide         | 46.7%                                 | 17.8%                                    |
| Avoid           | 66.7%                                 | 7.7%                                     |
| Adjust          | 54.8%                                 | 10.8%                                    |
| Shift           | 41.9%                                 | 14.1%                                    |
| Share           | 41.4%                                 | 19.5%                                    |
| Substitute      | 58.7%                                 | 9.3%                                     |
| Stop            | 65.0%                                 | 7.2%                                     |
| **LASTING**     |                                       |                                          |
| Life needs      | 49.5%                                 | 13.1%                                    |
| Activity, Space, Time and Timing | 49.3% | 13.4% |

behavioral interventions probably occurred. The behavior change percentage of “Domestic travel decreased” has the largest gap between April and September with 18.5 points, followed by “Travel by public transport decreased” with a gap of 11.6 points. Even though some behavior changes only showed a small gap (e.g., “Avoid having visitors from places with severe infection”: 0.9 points; “Travel by walking and biking increased”: 1.8 points), it should be noted that they increased first and then peaked in May: this fluctuating trend led to a very small change, which shouldn’t be ignored. More than three quarters of respondents chose the three Cs activities (“Avoid going out to a crowded place” from 90.0% to 80.2%, “Avoid activities in a closed space where there is contact with people” from 89.8% to 80.4%; “Avoid talking to people at a close distance” from 81.8% to 76.2%). Other behavior changes also showed a relatively high change ratio ranging between 20.7% and 62.4%. For instance, “Domestic travel decreased” and “Travel by public transport decreased” declined from 58.8% to 40.3% and from 61.4% to 49.8%, respectively. Unexpectedly, “More flexible commuting time” (from 23.8% to 20.7%) and “More teleworking” (from 26.1% to 20.2%) were less preferred.

5. Results

The DSEM model in this study was estimated using IBM SPSS Amos Ver 24. In total, 2643 respondents were included in the analysis. The generalized least squares (GLS) approach was used for estimation. The RMSEA is 0.054, which is below 0.08 showing a good fit. If there are various variables included in a structural equation model, it may be difficult to achieve a GFI (goodness-of-fit) bigger than 0.9; the threshold of GFI can therefore be loosened to 0.8 (Doll et al., 1994; Seyal et al., 2002). For example, some scholars also used a result with a threshold of 0.8 for GFI to make excellent studies on transport policy analysis (Zhang et al., 2019; Ona et al., 2013). The GFI in this study is 0.804, showing an acceptable fit for the data.

5.1. Standardized direct effects between latent variables

RECENT_CHANGE was originally assumed to be affected by
ACCU_CHANGE. However, introducing such state dependence did not work, in the sense that converged estimation results could not be obtained. Therefore, the influence of state dependence is ignored. Table 7 shows the results of standardized direct effects between latent variables, without the effects of state dependence. It is found that all these direct effects are statistically significant at 1% or 5% level. This confirms that all the assumptions made in Fig. 1 hold in this study. In other words, the conceptual framework formed in Fig. 1 is empirically applicable.

First, concerning the influence of ACCU_CHANGE on other latent variables, it is found that it is most influential to RISK_PERCEPT (0.785) and ATTD_CAPACITY (0.718), in a direct way. The direct effect of ACCU_CHANGE on ATTD_PASS-LASTING is smallest and the effect on RELIABILITY is moderate. Second, as for RISK_PERCEPT, there are three direct effects from RELIABILITY, ATTD_CAPACITY, and ACCU_CHANGE. ACCU_CHANGE shows the largest influence (0.785), followed by ATTD_CAPACITY (0.517) and RISK_PERCEPT (0.155). Third, two direct effects are confirmed on ATTD_PASS-LASTING. ACCU_CHANGE shows a larger direct effect (0.423) than ATTD_CAPACITY (0.102). Finally, among all the direct effects, RECENT_CHANGE is mostly affected by ATTD_CAPACITY (0.493), followed by RISK_PERCEPT (0.329), and RELIABILITY (0.262). ATTD_PASS-LASTING shows the smallest influence but is still significant.

5.2. Standardized total effects between latent variables

Table 8 shows the results of standardized total effects between latent variables. First, RECENT_CHANGE is mostly influenced by ACCU_CHANGE (0.640). Thus, even though the direct effect from ACCU_CHANGE on RECENT_CHANGE could not be observed, the influence of state dependence (i.e., the influence of the previous behaviors on the present behavior) exists, but in an indirect way via attitudinal factors. This result further supports the developed sequential modeling structure. The second largest total effects on RECENT_CHANGE come from ATTD_CAPACITY (0.331) and RISK_PERCEPT (0.329), where RISK_PERCEPT is mostly affected by ATTD_CAPACITY (−0.517). This suggests that policymaking capacity is most influential in inducing changes...
in behaviors. ATTD_PASS-LASTING, mostly affected by ACCU_CHANGE, is estimated to be least (but significantly) influential for RECENT_CHANGE.

The direct effects shown in Table 7 indicate that ACCU_CHANGE mostly affects RISK_PERCEPT and ATTD_CAPACITY with similar influencing sizes. However, the total effects suggest that the influencing size of ACCU_CHANGE on ATTD_CAPACITY is 0.718, which is 2.2 times larger than the size on RISK_PERCEPT (just 0.323). Concerning ATTD_PASS-LASTING, relative influences of ACCU_CHANGE and ATTD_CAPACITY do not change when reflecting indirect effects: the influencing size of ACCU_CHANGE is more than 4.0 times higher than that of ATTD_CAPACITY. ACCU_CHANGE shows the least direct effect on ATTD_PASS-LASTING; however, its total effect on ATTD_PASS-LASTING becomes larger than RISK_PERCEPT. Regarding RISK_PERCEPT, it is not mostly affected by ACCU_CHANGE, as suggested by indirect effects; instead, it is mostly influenced by ATTD_CAPACITY.

5.3. Features of latent variables

Estimation results about the relationships between latent variables and observed variables (i.e., estimation results of the measurement equations) are shown in Table 9 with standardized values. All the measurement parameters are statistically significant at 1% level (note: one parameter is fixed to be 1 when estimating other measurement parameters for each latent variable).

5.3.1. Changes in behaviors (ACCU_CHANGE & RECENT_CHANGE)

As for changes in behaviors in each month, both ACCU_CHANGE and RECENT_CHANGE are characterized by “avoid going out to a crowded place” (0.691 | 0.637), “avoid activities in a closed space where there is contact with people” (0.684 | 0.642), and “avoid talking to people at close distance” (0.677 | 0.615). As shown in Fig. 2, these behaviors show larger changes over the survey period, whose shares range between 76.2% and 90.0%. There are four other observed variables with larger standardized parameter values, including “travel by public transport has decreased” (0.614 | 0.607), “avoid visiting family” (0.574 | 0.580), “less shopping in stores” (0.565 | 0.496) and “avoid having visitors from places with severe infection” (0.551 | 0.550).

5.3.2. Attitudinal attributes

In the case of ATTD_PASS-LASTING, the standardized parameters range between 0.538 (“prepare” measure) and 0.770 (“adjust” measure). This latent variable ATTD_PASS-LASTING is mostly featured by people’s attitudes toward “adjust” measure (0.770), “avoid” measure (0.764), and “protect” measure (0.700). The second group with larger parameter values include “substitute” measure (0.697), “stop” measure (0.649), “life needs” measure (0.668), “activity, space, time” measure (0.681), and “shift” measure (0.633). The third group includes “share” measure (0.572), “provide” measure (0.563), and “prepare” measure (0.537). Concerning attitudes toward policymaking capacity (ATTD_CAPACITY), all observed variables of expertise, competence, enthusiasm, and trust related to governments and health professionals are significantly large: i.e., their standardized parameters range between 0.676 and 0.890. This suggests that all these variables can better represent how people perceive the policymaking capacity of governments and health professionals. Looking at risk perceptions about the virus infection (RISK_PERCEPT), RISK_PERCEPT seems to effectively capture them, with “the risk of infection in the whole of Japan is increasing” (0.902), “the risk of infection in the prefecture where you live is increasing” (0.873), and “the risk of infection in the municipalities where you live is increasing” (0.897). Furthermore, focusing on reliability of COVID-19 information sources (RELIABILITY), RELIABILITY well presents the reliability of “the information announced by the central government” (0.880) and “the information announced by local governments” (0.882).

5.4. Associations of observed variables with latent variables

It is important to rebuild confidence in using public transport; however, as shown in Table 4, more than 60% of respondents perceive the use of public transport to be risky. The parameter of the influence of RISK_PERCEPT on “the risk of infection in a crowded train or bus is high” is 0.433. This value is not that large; however, it sufficiently shows that perceptions of higher risk in using public transport not only lead to a decline in public transport ridership (as measured by “travel by public transport has decreased”), but is also associated with major avoidance behaviors, including “avoid going out to a crowded place”, “avoid activities in a closed space where there is contact with people”, “avoid talking to people at close distance”, and “avoid visiting family”. A statistically significant connection with “avoid having visitors from places with severe infection” further suggests that risk perceptions about public transport are not independent of other types of risk perceptions.

Even though ATTD_PASS-LASTING has the least influence on RECENT_CHANGE, it is statistically significant. The standardized parameter values indicate that policy measures of “avoid”, “adjust”, “protect”, “substitute”, “stop”, and LASTING are mainly attributable to the above avoidance behaviors.

Furthermore, the above avoidance behaviors are more likely to result from people’s perceptions about the competence of local governments and their trust in both local and central governments. This observation reaffirms the importance of communication between governments and the general public. Enhancing the reliability of the information announced by both local and central government seems necessary. The largest influence of ACCU_CHANGE on RECENTCHANGE may suggest that policy interventions should be made as early as possible. Early interventions may help people to form new habits under the current pandemic. Such new habits may help COVID-19 policymaking work more effectively.

6. Conclusions

Scientifically-sound evidence is crucial to support COVID-19 policymaking. However, existing studies have neglected the dynamic associations between policymaking and temporal behavior changes. This study has made one of the first attempts in the literature to fill this important research gap. It used a nationwide retrospective life-oriented panel survey with respect to 2643 individuals’ various behavior changes from April to September 2020 in Japan. The collected data had a similar age-gender-region distribution to that of the whole population.

A dynamic structural equation model was developed to quantify the
Table 9
Standardized effects between latent variables and observed variables.

| Parameter | std. err. | t value | sig. |
|-----------|-----------|---------|------|
| RELIABILITY | | | |
| The information announced by the central government (homepage, news, public relations magazines, etc.) | 0.880 | | |
| The information announced by local governments (homepage information, news, public relations magazines, etc.) | 0.882 0.021 44.599 *** | | |
| Experts’ opinions (through various channels) | 0.501 0.022 22.764 *** | | |
| Domestic news | 0.446 0.022 19.991 *** | | |
| Overseas news | 0.414 0.023 17.023 *** | | |
| Medical institutes | 0.537 0.021 25.448 *** | | |
| Workplaces/schools | 0.403 0.021 16.874 *** | | |
| SNS (Social Networking Service): Facebook, LINE, Twitter, WhatsApp, etc. | 0.070 0.024 2.994 *** | | |
| Search engines: Google, Yahoo, etc. | 0.212 0.022 8.805 *** | | |
| Personal social network: acquaintances, acquaintances, colleagues, etc. | 0.159 0.021 6.793 *** | | |
| RISK PERCEPT | | | |
| The risk of infection in the whole of Japan is increasing | 0.902 | | |
| The risk of infection in the residence prefecture is increasing | 0.873 0.038 28.662 *** | | |
| The risk of infection in the residence municipality is increasing | 0.897 0.042 26.614 *** | | |
| The risk of infection in the frequently-visited places (workplaces, schools, supermarkets, restaurants, gyms, etc.) is increasing | 0.529 0.039 15.778 *** | | |
| The risk of infection in a crowded train or bus is high | 0.433 0.030 16.628 *** | | |
| COVID-19 is a very horrific disease | 0.464 0.031 17.282 *** | | |
| The risk of infection of COVID-19 for oneself is high | 0.434 0.028 16.968 *** | | |
| The respondent is susceptible to seasonal flu | 0.212 0.027 9.667 *** | | |
| ATTD_CAPACITY | | | |
| (Expertise) Japanese health and medical institutions have sufficient expertise for COVID-19 | 0.722 | | |
| (Expertise) The central government of the residence municipality has sufficient expertise for COVID-19 | 0.808 0.031 38.021 *** | | |
| (Expertise) The local government in the residence municipality place has sufficient expertise for COVID-19 | 0.796 0.030 37.810 *** | | |
| (Enthusiasm) Can feel the central government’s enthusiasm in preventing the spread of COVID-19. | 0.836 0.047 28.777 *** | | |
| (Enthusiasm) Can feel the residence local government’s enthusiasm in preventing the spread of COVID-19. | 0.838 0.045 30.404 *** | | |
| (Competence) The central government has a competent management system and measures to prevent the spread of COVID-19. | 0.839 0.044 29.898 *** | | |
| (Competence) The local government in the residence municipality has a competent management system and measures to prevent the spread of COVID-19. | 0.890 0.044 31.745 *** | | |

Table 9 (continued)

| Parameter | std. err. | t value | sig. |
|-----------|-----------|---------|------|
| municipality can prevent the spread of COVID-19 | | | |
| ATTND_PASS-LASTING | | | |
| L Activity, Space, Time and Timing | 0.668 | 0.021 48.215 *** | |
| P Prepare | 0.537 0.034 23.362 *** | |
| Protect | 0.700 0.033 29.392 *** | |
| Provide | 0.563 0.038 24.308 *** | |
| Adjust | 0.764 0.035 28.862 *** | |
| S Shift | 0.501 0.036 22.707 *** | |
| Share | 0.572 0.039 23.772 *** | |
| Substitute | 0.697 0.036 27.711 *** | |
| Stop | 0.649 0.036 25.353 *** | |
| ACCU_CHANGE | | | |
| Attendance/leaving time (commuting/returning time) became more flexible | 0.210 | | |
| Decreased detour behavior after leaving company or school | 0.417 0.435 5.957 *** | |
| More teleworking and studying at home | 0.290 0.280 5.638 *** | |
| Less shopping in stores | 0.565 0.903 5.393 *** | |
| Avoid going out to a crowded place | 0.691 0.746 5.484 *** | |
| Avoid participating in activities at a closed space where there are direct contacts with people | 0.684 0.716 5.472 *** | |
| Avoid talking to people at a close distance | 0.677 0.801 5.450 *** | |
| Avoid visiting family | 0.574 0.860 5.416 *** | |
| Avoid having visitors from places with severe infection | 0.551 0.709 5.404 *** | |
| Travel by public transport decreased | 0.614 0.864 5.434 *** | |
| Travel by car increased | 0.408 0.494 5.040 *** | |
| Travel by walking and biking increased | 0.441 0.555 5.136 *** | |
| Domestic travel decreased | 0.378 0.516 5.098 *** | |
| Overseas travel decreased | 0.196 0.242 3.927 *** | |
| RECENT_CHANGE | | | |
| Attendance/leaving time (commuting/returning time) became more flexible | 0.230 | | |
| Decreased detour behavior after leaving company or school | 0.379 0.355 6.092 *** | |
| More teleworking and studying at home | 0.290 0.275 5.652 *** | |
| Less shopping in stores | 0.496 0.723 5.693 *** | |
| Avoid going out to a crowded place | 0.637 0.758 5.848 *** | |
| Avoid participating in activities at a closed space where there are direct contacts with people | 0.642 0.740 5.853 *** | |
| Avoid talking to people at a close distance | 0.615 0.719 5.778 *** | |
| Avoid visiting family | 0.580 0.813 5.783 *** | |
| Avoid having visitors from places with severe infection | 0.550 0.671 5.785 *** | |
| Travel by public transport decreased | 0.607 0.677 5.810 *** | |
| Travel by car increased | 0.433 0.464 5.349 *** | |
| Travel by walking and biking increased | 0.441 0.462 5.292 *** | |
| Domestic travel decreased | 0.322 0.439 5.120 *** | |
| Overseas travel decreased | 0.171 0.218 3.697 *** | |

The effects of reliability of information sources, risk perceptions, attitudes toward COVID-19 policymaking capability and PASS-LASTING based policies on the most recent changes in behaviors. The above subjective factors were further explained by accumulated behavior changes in the past. Capturing such dynamic relationships, and the focus on policymaking, differentiates the current study from existing studies on COVID-19. The major findings are summarized as follows:

1. More than 60% of respondents perceived that the risk of infection was increasing across the whole country, and that risk of infection in a crowded train or bus is high. Even though about 70% of respondents perceived that the COVID-19 virus is very horrific, less
than 30% reported that they felt the places they frequently visited were risky, and less than 40% perceived that the risk in their residence municipalities is increasing. Such a low perception ratio may be because less than 30% of respondents think the risk of infection of the COVID-19 virus for themselves is high.

[2] The DSEM estimation results confirmed a statistically-significant sequential cause-effect relationship between accumulated behavior changes in the past, subjective factors, and the most recent behavior changes. In other words, accumulated behavior changes in the past affect all the subjective factors, which further influence the most recent behavior changes. Such sequential dynamics reflect human decision-making mechanisms.

[3] The DSEM estimation results indicate that the various behavior changes are mostly characterized by avoidance behaviors: avoid going out to a crowded place; avoid participating in activities at a closed space where there are direct contacts with people; avoid talking to people at a close distance; and avoid visiting family.

[4] The most recent behavior changes are most affected by accumulated behavior changes in the past, in an indirect way, because the direct effects are not observed but the largest total effects are confirmed. This observation further supports the assumed sequential relationships in Fig. 1.

[5] Effects of subjective assessments of policymaking on the most recent behavior changes are significant but moderate. Within the attitudes toward policymaking, attitudes toward policymaking capacity are more influential than willingness to follow PASS-LASTING based policy measures. At the same time, it is also estimated that people who perceive policymakers to have higher expertise level, be more enthusiastic and competent, and to be more trusted, are more likely to follow PASS-LASTING based policy measures.

[6] High risks of using public transport are found to have a significant influence on the most recent behavior changes, together with other risk perception factors. Meanwhile, a large association between accumulated behavior changes and risk perceptions is also revealed.

[7] The information announced by authorities (i.e., central/local governments, experts, medical institutes) has the most influence on people’s perception of information reliability. Individuals’ risk perceptions at the country and city levels are more likely to affect whether people change their behaviors.

The above findings suggest that the following policies should be recommended in response to the COVID-19 pandemic.

[1] All categories of the PASS-LASTING based policy measures should be taken to effectively control the COVID-19 pandemic. The PASS-LASTING based policy measures appear to be widely accepted and followed by individuals during the COVID-19 pandemic, proving that PASS-LASTING based policy measures (Zhang, 2020, 2021) are rational and effective. In particular, the “Avoid” measures show a significant impact on people’s behavior changes. Some measures such as avoiding inconsistent information, avoiding crowded platforms and vehicles of public transport systems, and avoiding activities/trips involving close physical distance should be strongly recommended. Such measures are not only feasible but also less costly. The importance of such avoidance measures is also consistent with the observations by Shimizu and Negita (2020), who studied Japanese people’s responses to the first wave of the COVID-19 pandemic.

[2] Governments should ensure that the information they provide is reliable. The more authoritative the government is, the more likely it is that people will cooperate in making behavior changes which will prevent the spread of the virus. Communications between governments and the general public should be better designed by reflecting the up-to-date insights from social psychological research. Governments also need to build a channel to receive feedback from the public about perceptions of the reliability of their information and address any concerns in a timely way. The above policy recommendations are in line with the argument by Hyland-Wood et al. (2021), who stated that government policymakers should promote widespread public participation by involving diverse communities and using digital technologies in communication and engagement activities.

[3] Government (especially local governments) should pay more attention to the public’s attitudes to them and take some feedback to improve people’s feelings about governments’ expertise, enthusiasm, competence and trust. In this regard, Kim and Kreps (2020) showed a similar observation that effective risk communications can improve the public’s attitudes to governments. Both central and local governments should ensure the consistency of policymaking. After the central government takes policy measures, local governments should take subsequent measures, accordingly. Ren (2020) compared COVID-19 policymaking in China, Italy, and the US to examine how crisis responses in each country are shaped by its central-local government relations and concluded that central governments should play the key role in controlling the current pandemic. To guarantee such policymaking consistency, the COVID-19 policymaking headquarters in the central government should involve key members from local governments. As behavioral interventions have to be made with respect to various behaviors across life domains, a cross-sectoral and interdisciplinary policymaking framework should be established as the most fundamental framework to support effective policymaking. It is already very obvious that public health authorities cannot stop the pandemic by themselves. The importance of such a cross-sectoral policymaking system is strongly supported by Mei’s (2020) research.

[4] COVID-19 policymakers should pay more attention to people’s time-varying behaviors by encouraging behavior changes that are helpful in controlling the pandemic, while at the same time restricting behavior changes which worsen the pandemic. Acuña-Zegarra et al. (2020) also revealed that individuals’ intentions to follow preventive measures change over time. Co-changes in various behaviors and fatigue of behavior changes caused by continuous interventions should be addressed. It seems important to figure out several key behavior changes that may trigger other changes automatically without further interventions. In other words, intervention policymaking should have clear targets in order to avoid unnecessary pressures on people and to enhance policymaking efficiency. This is because when a policy is implemented for a long time, people will inevitably show policy fatigue, which may weaken the effects of the policy (Rahmandad et al., 2021; Petherick et al., 2021).

The COVID-19 pandemic is a disaster for all humankind. Every country has to take decisive measures to combat the virus. The above analysis results and recommended policies may help policymakers to improve their policymaking processes and instruments. Having emphasized the significant findings from this study, its shortcomings and corresponding improvements for the future should be mentioned. First, as this case study was conducted in Japan, the findings may be specific to Japan. It is desirable to conduct further studies in other countries in order to make international comparisons. Second, this study adopts a sampling-based analysis and as a result, the findings may not be generalizable. Accordingly, it is important to integrate this sampling-based analysis with Big Data and Open Data based analyses. Third, policymaking is addressed in this study via the help of subjective assessments, which are crucial to better reflect personal feelings about policymaking processes. However, detailed policy measures should be directly examined, even though this involves the difficult task of assessing the impacts of policy decisions, made at an aggregate level, on
every individual. Last but not least, different countries have taken various policy measures. Some measures are common, but there are also many unique measures. Broad international comparative research should be promoted, with the support of sufficient research funds. Such investments in scientific research are crucial to prevent and control future pandemics.

Declaration of competing interest

There is no conflict of interest.

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