Behavioral research for pandemic policymaking: Focusing on activity-travel behavior and social contact decisions under the impacts of COVID-19

D200978

HONGXIANG DING

A Dissertation Submitted to
the Graduate School of Advanced Science and Engineering
of Hiroshima University in Partial Fulfillment
of the Requirement for the Degree of
Doctor of Philosophy in Engineering

March 2023

ABSTRACT

Research background and motivation

The Coronavirus disease (COVID-19) is an infectious disease, predominantly transmitted from person to person. As of January 2023, globally, more than 670 million infections and more than 6.7 million deaths were observed, without any clear sign of stopping in the growth trend. The risk of COVID-19 is still a threat to human beings. To fight against COVID-19, various pharmaceutical and non-pharmaceutical measures have been taken, such as lockdown, restrictions of activity participation and trip making, physical distancing, mask wearing, and hand disinfection. These measures played their rightful roles in pandemic control on one hand, while they also brought about various negative impacts on the other. After suffering from COVID-19 for nearly three years, it becomes more and more important how to balance the control of the COVID-19 pandemic and the maintenance of economic activities and daily life activities. However, there is a serious lack of scientifically sound evidence for supporting pandemic policymaking, especially based on understanding of people's decision-making mechanisms related to those behaviors that are closely related to the virus transmission. For addressing the above research gap, this study focuses on people's daily activity participation and trip making as well as social contact (referring to offline social contact) before and during the COVID-19 pandemic.

Research questions and objectives

This dissertation aims to provide a comprehensive investigation of people's behavioral decisions on daily activity participation and trip making as well as social contact under the impacts of COVID-19, for providing behavioral insights into pandemic policymaking. The investigation is done from various angles by answering the following different but connected research questions related to individual-level decision-making mechanisms.

First, COVID-19 has brought about various changes in people's behaviors; however, the following question has remained under-explored.

> ***Q-1*** *How do people's daily activity-travel and social contact behaviors change over time by considering the risk of COVID-19 and the influences of psychological factors?*

Second, trip making is one of the virus transmission channels; however, the following questions have not been investigated by existing studies in a satisfactory way.

> ***Q-2*** *How are travel mode choices associated with risk perception in different spatial scales, trust in stakeholders' policymaking capabilities, and cultural risk factors?*

Q-3 *How did people prepare for such a pandemic like COVID-19 and how the preparedness affects travel mode choices under the impacts of COVID-19?*

Q-4 *How the performing factors of travel behavior (e.g., travel time, travel companion, travel habit) affect people's travel mode choice during the COVID-19 pandemic with individuals' taste variations?*

Third, individuals' social contacts with others during activity participation and travelling are one of the main channels of virus transmission; however, the following questions have not been well examined.

Q-5 *How are changes in the number of social contacts heterogeneous depending on demographic characteristics and attributes of activity-travel behavior?*

Q-6 *How do people behave social contact in different contact modes, including not only physical or direct contact but also non-physical or indirect contact?*

Q-7 *Whether and how do people make joint decisions on choices of social contact modes and the number of contacted persons during the COVID-19 pandemic, and what are the roles/influences of various factors, including demographic attributes, psychological factors, and attributes of activity-travel behavior?*

Fourth, decisions on trip making behavior and social contact may vary across activity settings; however, such setting-sensitivity analyses have been neglected in existing studies, leading to the following unresolved research question.

Q-8 *How do travel mode choice and social contact decisions differ across activity settings, especially related to leisure?*

Methodology

Large-scale nationwide questionnaire surveys with a total of 9,888 respondents were implemented in six developed countries (Australia, Canada, Japan, New Zealand, United States, and United Kingdom), followed by extensive descriptive analyses. And models with temporal dynamics and choice decision-making mechanisms were built, where respondents were recruited from the whole territory of each country by reflecting population distributions in terms of age, gender and region.

Two types of questionnaire surveys were conducted online. The first type is a life-oriented panel survey, where respondents in Japan reported their various daily life behaviors between April and September 2020, month by month, in a retrospective way, where several ten behaviors were jointly investigated. In this survey, 2,643 respondents provided valid data about both behaviors and potential influential factors (both objective and subjective factors), in comparison with the behaviors before the COVID-19 pandemic. The second type is a comparative questionnaire survey about both activity-travel and social contact by comparing the current pandemic period and influenza seasons before the pandemic,

where social contact was investigated with respect to both activity participation and trip making. It was carried out in all the six developed countries (Australia, Canada, Japan, New Zealand, United States, and United Kingdom) form March to May 2021 and collected valid data from 7,245 respondents (Australia: 1125, Canada: 1176, Japan: 1169, New Zealand: 1193, United Kingdom: 1305, United States: 1297). Question items include social contact information (e.g., contact modes, number of contacted persons), activity participation attributes (e.g., frequency, duration, travel modes), and various psychological factors when doing different daily activities and using different transport vehicles before (influenza season in 2019) and during (March 2020 to May 2021) the pandemic.

Models include, (1) a dynamic structural equation model (DSEM) that is developed to investigate the relationship between the latent psychological/cultural variables and individuals' life behavior changes over time, (2) a mixed hybrid choice model (XHCM) with correlated latent variables is developed to reveal individuals' travel mode choice behaviors with unobserved heterogeneities, and (3) a copula-based model is applied to estimate the joint distribution and dependency between individuals' contact modes (based on multinomial logit model) and the number of contacted persons (based on an ordered logit model).

Main findings

First (answer Q-1), people's accumulated behavior changes in the past can affect their psychological factors (e.g., the reliability of information sources, the risk perceptions, the attitudes toward COVID-19 policymaking capability, the attitudes toward PASS-LASTING based policies) and then further influence the most recent behavior changes. People's behavior changes are obviously represented by avoiding social contacts with others. And there is a strong relationship between different psychological factors during the process that accumulated past behavior changes affect the recent behavior changes dynamically.

Second (answer Q-2, Q-3, Q-4, Q-8), people are less likely to change travel mode choices for commuting than other travel purposes. The impacts of latent psychological/cultural factors on travel mode choice show an obvious diversity across different travel purposes in direct and indirect way simultaneously. Risk perception is found to be more remarkable at larger spatial scales than inside crowded public transport vehicles. The effect of the cultural orientations on travel mode choices can be divided into two dimensions: hierarchism-egalitarianism and individualism-fatalism because of the higher similarities in each pair. The preparedness focusing on risk-concerned travel habits formed before the COVID-19 pandemic shows a significant impact on travel mode choices, but the influences are not consistent across travel purposes.

Third (answer Q-5, Q-6, Q-8), there is an obvious heterogeneity of the number of social contacts and its changes across the targeted attributes and contact settings, the pandemic policymaking could focus on the protection of specific group with higher danger level of social contacts. People's contact modes and the taken protecting measures are associated with the number of social contacts during the

pandemic and show different features across the contact settings. On one hand, most both physical and non-physical contacts occurred in work/study setting and party setting, while the most non-physical contacts contact (with the physical presence of others) occurred in shopping setting and public transport setting. On the other hand, protecting measures are well implemented for work/study setting and shopping settings during the pandemic.

Fourth (answer Q-6, Q-7, Q-8), the joint estimation of people's different indexes of social contact behaviors is possible via the copula approach. A significant joint correlation between the non-physical contact mode and the number of social contacts is found indicating that people trend to simultaneously increase the number of contacted persons and the probability of having non-physical contacts with others under the influence of common unobserved factors during the COVID-19 pandemic. Not only individuals' demographic attributes but also the psychological factors and activity participation attributes have a diversified influence on people's joint choice of social contact behaviors. Having contacts with others doesn't means people would consequentially contact more people. The additional psychological variables in copula analysis highlight that people' risk-related psychological factors surely have the significant impact on the a certain behavior change too. And it is reasonable to include risk perception with different spatial scales in a certain behavior analysis like social contact because of the obvious difference among them. The joint analysis of social contact also indicates that the difference of behavioral mechanisms for different contact settings can be reflected not only in the difference of positive-negative effects but also in different sensitivity to influencing factors.

Contributions

The contributions of this study are summarized in academic level and practical level respectively.

(1) Academic contributions

Academic contribution on research framework:

1) A seamless framework of individuals' pandemic activity-travel behaviors mechanisms with social contacts is built.

Academic contributions on research contents based on data:

1) The cultural risk factors basing on the cultural theory of risk are the first time to be applied for the analysis of individuals' travel mode choices.

2) The leisure related travel purposes/contact settings for choice analysis are specifically classified into eating out, physical exercise, party, and cultural leisure in the comparative survey data of activity-travel and social contact before-during COVID-19 of this study.

3) The heterogeneities of the changes in the number of social contacts are revealed not only across personal attributes but also across individuals' participation attributes of activity-travel behaviors for different contact settings.

4) In addition to the close contact (direct physical contacts or close conversation) behavior, individuals' behavioral mechanisms for other contact modes (e.g., only non-physical contacts without direct physical contacts or close conversation) are also investigated in a comprehensive perspective.

Academic contributions on modeling approach:

1) The dynamic associations between individuals' behavior changes over time and psychological factors is the first time to be quantified by a developed dynamic structural equation model (DSEM).

2) Individuals' taste variations related to preparedness (travel mode choices corresponding to different risk levels) and key travel attributes are incorporated into the mixed hybrid choice model with correlated latent variables for travel mode choice analysis.

3) The copula-based approach is first time to be used for the exploration of the joint behavioral mechanisms of different indexes for social contacts under the effect of personal attributes, activity participation attributes and psychological factors.

(2) Practical contributions

1) The complementary relationship between policymaking for different kinds of activity-travel and social contact is revealed.

2) A comprehensive perspective on the dynamic effect between people's recent behaviors and the behaviors in the past across the psychological factors is provided indicating a necessity of the timely adjustment for pandemic policymaking.

3) The important impact of the risk perception in different spatial scales and the attitudes to policymaking capacity on the change of the activity-travel behaviors with social contacts is highlighted for the pandemic policymaking.

4) The logical relations between different psychological factors related to the pandemic policymaking across multiple daily behavior changes and across travel mode choice behaviors are confirmed.

5) The pandemic policymaking approach that could influence different aspects of social contact behaviors simultaneously has been proven to be necessary and possible in this study. And the policymaking for activity-travel behavior with social contact which is tailored to specific situations is recommended.

ACKNOWLEDGEMENTS

3 years in Japan passed in the blink of an eye, I'm about to finish my PhD and feel like a dream. Here, I would like to express my heartfelt thanks to all those who have helped me.

My sincere and hearty thanks and appreciations go firstly to my main supervisor, Prof. Junyi Zhang and his wife Ziying Jiang. Getting PhD is a road full of thorns, it would have been hard for me to stick it out without their support in life and research. It is my great fortune to study under the supervision of such kinds of Prof. All things are difficult before they are easy, I'm going to take the next step in my life, but I believe that the Prof. Zhang's serious academic attitude and life attitude will continue to encourage me to face the challenges in my future life.

Excellent scholars are the face of excellent university. I would like to extremely grateful to each of the members of my dissertation committee. Profs. Akimasa Fujiwara, Tao Feng, Masaaki Fuse, Makoto Chikaraishi, Saori Kashima have provided me extensive professional guidance on the revision of my dissertation via their rich research experience. Their kind help and guidance opened my eyes to see the endless possibilities of learning in life.

A friend in need is a friend indeed, I am so lucky to make lots of true friends in these short three years. Hence, I would like to show my sincere gratitude to Rui Liu, Wenhao Li, Wenhui Huang, Hongyang Du, Lin Liao, Baoxin Zhai, Hyewon Namgung, Fuyo (Jenny) Yamamoto, Baraa Alhakim for their generous tolerance and help to me during the worst period of my life. Life without a friend is death without a witness, I am also extremely grateful to the new friend I met in 2021-2022 in Mobilities and Urban Policy Lab (Yueou Li et al.), Urban and Data Science Lab (Mengxia Li et al.), Transport Engineering Lab (Iqbal Muhammad Yousaf et al.), Infrastructure Planning and Urban Risk Management Lab (Maya Safira et al.). And I must show my apologies for can't writing all the names at here due to the word limitation.

Although I didn't get much support from my family during my PhD, I am still grateful to them for making me become a mature man. As the saying goes, "He who makes constant complaint gets little compassion". Thank you for making me comprehend what are "The Unbearable Lightness of Being" in life.

Finally, adversity reveals genius, prosperity conceals it. I am not the genius, but you are the blessed person. I hope the people I'm grateful for can live life without regrets, with my best wishes.

HONGXIANG DING (丁 泓翔)

March 2023

Hiroshima, Japan

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 Introduction

1.1 Background and motivation

The Coronavirus disease (COVID-19) is an infectious disease caused by the SARS-CoV-2 virus. The virus of COVID-19 can spread from an infected person's mouth or nose in small liquid particles when they cough, sneeze, speak, sing or breathe. These particles range from larger respiratory droplets to smaller aerosols. Anyone can get sick with COVID-19 and become seriously ill or die at any age[1].

As of 2022.11.21, the global cumulative number of the COVID-19 cases has exceeded 635 million. And more than 6 million of people have lost their life due to the impact of the SARS-CoV-2 virus. As seen in Figure 1.1, even though the number of new daily cases started to decrease dramatically across the world since the February 2022, more than 2 million infection cases are newly reported in the world during the last week before 2022.11.21[2].

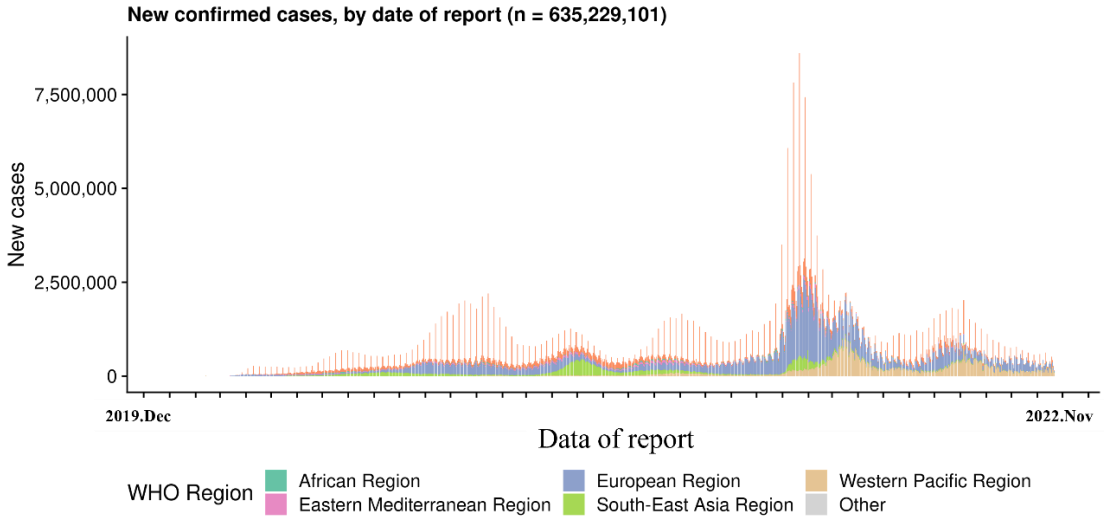

Figure 1. 1. Newly reported cases of the COVID-19 across the world (Source: WHO COVID intel database https://worldhealthorg.shinyapps.io/covid/)

In addition to vaccination, the governments across the world have implemented various behavioral interventions and policies from the strictest lockdowns (with penalties for violations) to the soft

[1] WHO: Health topics/Coronavirus disease (COVID-19) https://www.who.int/health-topics/coronavirus#tab=tab_1

[2] WHO Coronavirus (COVID-19) Dashboard: https://covid19.who.int/data

proposing changes in behaviors to control the current COVID-19 pandemic. The compulsory social distancing policy (e.g., lockdown) has been conducted by some governments in the initial phase of the COVID-19 pandemic and been proven to be effective for controlling the pandemic. However, it might lead to a serious damage to the economies and people's well-being. The COVID-19 pandemic is still risky to people' safety but it is difficult to sustain such kind of strict behavioral interventions and polices due to people's policy fatigue after the COVID-19 pandemic has lasted more than two years.

Under this background, it is crucial to find a sensible pandemic policymaking approach for prompting people to make proposing behavior changes. Exploring individual's behavioral mechanisms contributes to the reasonable pandemic policymaking which would protect people from the infection effectively by the soft non-pharmaceutical interventions (NPIs) instead of the strict lockdown. Meanwhile, the transmission of the COVID-19 pandemic mainly relies on individual's (offline) social contacts with others in daily life, hence, to explore individual's behavioral mechanisms during the pandemic, a seamless behavioral study focusing on people's activity-travel behaviors with social contacts in the process of travels and daily activity is needed.

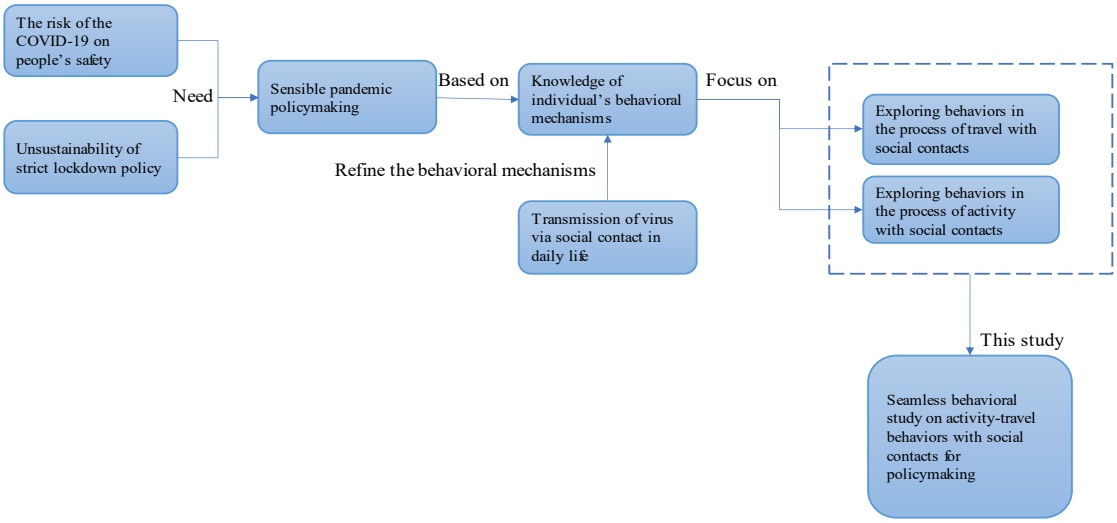

Figure 1. 2. Background and motivation of this study

1.2 Research questions and objectives

This dissertation aims to investigate individuals' behavioral mechanism of activity-travel behavior and social contact (referring to offline social contact) under the impacts of COVID-19 in the case of six developed countries, and to provide the scientific evidence for further pandemic policymaking, hoping improving the efficiency of pandemic policymaking by decreasing the risk of infection and prompting people to follow the policy. The investigation is done from various angles by answering the following

different but connected research questions related to individual-level decision-making mechanisms.

First, COVID-19 has brought about various changes in people's behaviors; however, the following question has remained under-explored.

> ***Q-1*** *How do people's daily activity-travel and social contact behaviors change over time by considering the risk of COVID-19 and the influences of psychological factors?*

Second, trip making is one of the virus transmission channels; however, the following questions have not been investigated by existing studies in a satisfactory way.

> ***Q-2*** *How are travel mode choices associated with risk perception in different spatial scales, trust in stakeholders' policymaking capabilities, and cultural risk factors?*
>
> ***Q-3*** *How did people prepare for such a pandemic like COVID-19 and how the preparedness affects travel mode choices under the impacts of COVID-19?*
>
> ***Q-4*** *How the performing factors of travel behavior (e.g., travel time, travel companion, travel habit) affect people's travel mode choice during the COVID-19 pandemic with individuals' taste variations?*

Third, individuals' social contacts with others during activity participation and travelling are one of the main channels of virus transmission; however, the following questions have not been well examined.

> ***Q-5*** *How are changes in the number of social contacts heterogeneous depending on demographic characteristics and attributes of activity-travel behavior?*
>
> ***Q-6*** *How do people behave social contact in different contact modes, including not only physical or direct contact but also non-physical or indirect contact?*
>
> ***Q-7*** *Whether and how do people make joint decisions on choices of social contact modes and the number of contacted persons during the COVID-19 pandemic, and what are the roles/influences of various factors, including demographic attributes, psychological factors, and attributes of activity-travel behavior?*

Fourth, decisions on trip making behavior and social contact may vary across activity settings; however, such setting-sensitivity analyses have been neglected in existing studies, leading to the following unresolved research question.

> ***Q-8*** *How do travel mode choice and social contact decisions differ across activity settings, especially related to leisure?*

1.3 Research framework

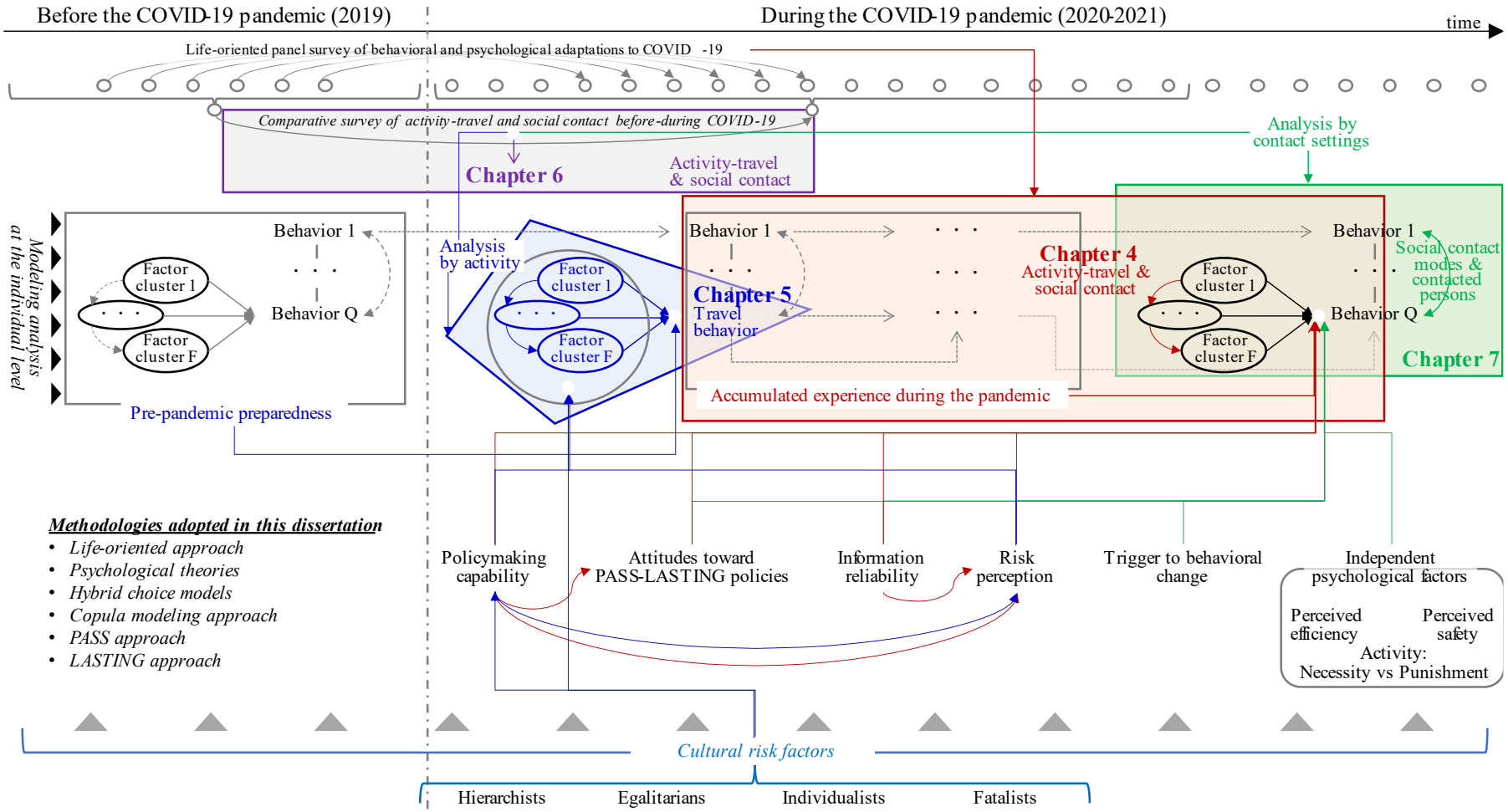

Figure 1. 3. Research framework

Figure 1.3 shows the conceptual framework of this study. This study has investigated people's activity-travel and social contact behaviors before (2019) and during (2020-2021) the COVID-19 pandemic based on a life-oriented panel survey and a comparative survey of behaviors. The solid line in the framework shows the analysis that has been implemented in this study and the dashed line is the analysis to be implemented for future study. For the methodologies, the life-oriented approach, psychological theories, hybrid choice models, copula modeling approach, PASS approach, and LASTING approach have been adopted in this dissertation.

A descriptive analysis of social contact across different activity-travel settings is conducted in Chapter 6. While the modeling analysis at the individual level are conducted in Chapters 4, 5 and 7. The influencing factors are collected in different cluster, the factors contained not only the COVID-related psychological factors (e.g., policymaking capability, attitudes toward PASS-LASTING policies, information reliability, risk perception, trigger to behavioral change) but also the independent psychological factors and cultural risk factors. There are some associations between different factor clusters, meanwhile, these factor clusters could impact the activity-travel and social contact decision making in direct and indirect ways. People's behaviors in pre-pandemic are treated as the preparedness for individuals' behaviors during the COVID-19 pandemic.

The multiple behaviors analysis of travel behaviors and social contact behaviors in chapter 4 has examined the impact of people's psychological factors about the COVID-19 infection risk on their behavior changes in daily life and verified the dynamic associations between individuals' accumulated experience during the pandemic, current behaviors and subjective assessments (i.e., attitudes) of policymaking. The modeling analysis in Chapter 5 has examined the the impact of psychological factors on travel mode choice behaviors across different activity settings (or travel purposes) with individuals' taste variations. While people's social contact modes and number of contacted persons are investigated jointly in Chapter 7. The analysis by contact settings in Chapter 7 has shown people's average performance of social contact behaviors under the influence of factor clusters.

In addition, the difference of behaviors for different travel purposes/different contact settings are examined for the travel mode choice behavior and the changes of the number of social contacts directly, while the joint choice analysis indicates the difference of behaviors across different contact settings by evaluating the sensitivity of social contact choice to influencing factors.

1.4 Contributions of dissertation

The contributions of this study are summarized in academic level and practical level respectively.

(1) Academic contributions

Academic contribution on research framework:

1) A seamless framework of individuals' pandemic activity-travel behaviors mechanisms with social contacts is built.

Academic contributions on research contents based on data:

1) The cultural risk factors basing on the cultural theory of risk are the first time to be applied for the analysis of individuals' travel mode choices.

2) The leisure related travel purposes/contact settings for choice analysis are specifically classified into eating out, physical exercise, party, and cultural leisure in the comparative survey data of activity-travel and social contact before-during COVID-19 of this study.

3) The heterogeneities of the changes in the number of social contacts are revealed not only across personal attributes but also across individuals' activity participation attributes for different contact settings.

4) In addition to the close contact (direct physical contacts or close conversation) behavior, individuals' behavioral mechanisms for other contact modes (e.g., only non-physical contacts without direct physical contacts or close conversation) are also investigated in a comprehensive perspective.

Academic contributions on modeling approach:

1) The dynamic associations between individuals' behavior changes over time and psychological factors are the first time to be quantified by a developed dynamic structural equation model (DSEM).

2) Individuals' taste variations related to preparedness (travel mode choices corresponding to different risk levels) and key travel attributes are incorporated into the mixed hybrid choice model with correlated latent variables.

3) The copula-based approach is first time to be used for the exploration of the joint behavioral mechanisms of different indexes for social contacts under the effect of personal attributes, activity participation attributes and psychological factors.

(2) Practical contributions

1) The macroscopic policymaking for multiple behaviors and the microscopic policymaking for single behavior are complementary to each other. This study has provided a comprehensive policymaking approach based on findings of behavioral analysis.

2) The strong dynamic effect between people's recent behaviors and the behaviors in the past indicate a necessity of the timely adjustment for pandemic policymaking.

3) Individuals' psychological factors of their risk perception in different spatial scales and their attitudes to policymaking capacity play an important role in changing the activity-travel behaviors with social contacts. They are often ignored in the policymaking process, while this study highlights their significance with the scientific evidence in the case of six developed countries.

4) This study confirmed the logical relation between different psychological factors related to the pandemic policymaking across daily behavior changes and travel mode choice behaviors. Further pandemic policymaking could refer to this logical relation.

5) This study has revealed the necessity and possibility of the simultaneous impact of pandemic policymaking approach on different aspects of social contact behaviors. And the policymaking approach for activity-travel behavior with social contact which is tailored to specific situations has been provided in this study.

1.5 Outline of dissertation

This dissertation consists of eight chapters.

Chapter 1 introduces the background, motivation, research questions, objectives, research framework, contributions, and outline of this dissertation.

Chapter 2 presents the literature reviews of the focused research contents in this dissertation: behavioral and psychological adaptations to COVID-19, travel mode choice behavior and social contact behaviors during the COVID-19 pandemic.

Chapter 3 introduces the survey data and modeling approach that used in the methodologies of this study.

Chapter 4 provides a behavior analysis of activity-travel behavior changes during the pandemic in Japan. The life-oriented panel data of behavioral and psychological adaptations to COVID-19 collected from April to September 2020 in Japan is used. And a dynamic structural equation model (DSEM) is developed to quantify the dynamic associations between individuals' reliability of information sources, risk perceptions, attitudes toward COVID-19 policymaking capability, attitudes toward PASS-LASTING based policies and the behavior changes over time.

Chapter 5 provides a behavior analysis of individuals' travel mode choice behaviors during the

COVID-19 pandemic via the travel data in a comparative survey of activity-travel and social contact before-during COVID-19 conducted in six developed countries (Australia, United States, New Zealand, Canada, United Kingdom, Japan) in 2021. The latent impacts of risk perception at different spatial scales, trust toward governments/medical agencies' capacity to control the pandemic and the cultural orientations related to risk on individuals' travel mode choices across different travel purposes are quantified by a mixed hybrid choice model (XHCM). The unobserved heterogeneities related to pre-pandemic preparedness induced by experiencing influenza (measured by risk-concerned travel habits formed during influenza seasons before the pandemic) and during-pandemic travel attributes are reflected in the mixed logit form as well.

Chapter 6 shows the descriptive analysis of the changes of the number of social contacts before and during the COVID-19 pandemic. The social contact data for different contact settings (in activity locations and public transport vehicle) in the comparative survey of activity-travel and social contact before-during COVID-19 is used to explore the changes of social contacts in the mentioned six developed countries. The changes of the number of social contacts are obtained by calculating the total number of social contacts for all participants and the mean number of social contacts for people who have maintained their daily social contacts before and during the pandemic. The heterogeneities of social contacts across personal attributes and key activity participation attributes are revealed.

Chapter 7 provides a quantitative behavior analysis of people's joint social contact behaviors in six developed countries during the pandemic. This chapter used the same social contact data for daily activities in chapter 6. A joint copula-based model is developed to estimate people's social contact behaviors represented by the unordered choice of contact modes and ordered choice of the number of contacted persons simultaneously. The impacts of people's demographic attributes, activity participation attributes and risk-related psychological factors on social contact behaviors are quantified in the joint copula-based model. Not only people's average performance of social contact for daily activities but also the different sensitivity levels of social contact choice to influencing factors across different contact settings are estimated.

Chapter 8 provides the conclusions in this dissertation.

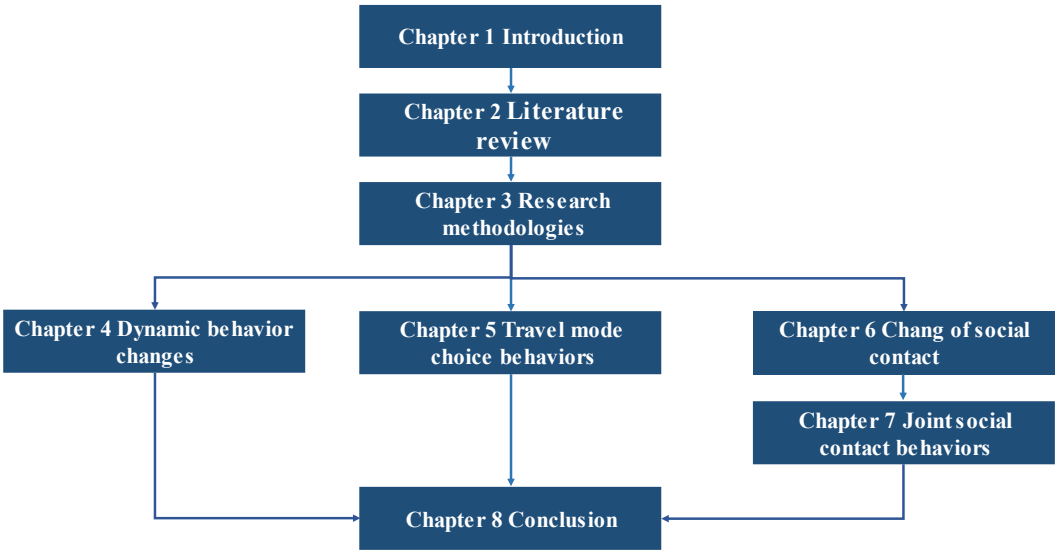

Figure 1. 4. Outline of dissertation

CHAPTER 2 Literature review

This chapter provides the literature review of the pandemic-related activity-travel behavior with social contacts focused by this study. First, individuals' behavioral changes for daily activity-travel behaviors during the pandemic and the corresponding influence of psychological factors on behavioral changes in previous studies are summarized in section 2.1 to give an overview of the impact of the COVID-19 pandemic on people's activity-travel behaviors. Then, the literature reviews focusing on people's travel mode choice behaviors and social contact behaviors, which are two single aspects of the activity-travel behaviors, are provided in section 2.2 and section 2.3 respectively. Finally, the research gaps of previous studies are summarized in section 2.4.

2.1 Behavioral and psychological adaptations to COVID-19 for multiple behaviors

2.1.1 Activity-travel behavior changes during the COVID-19 pandemic

In order to control the spread of COVID-19, governments in different countries have taken various countermeasures, 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). Hotle 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. Marroquín 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.

2.1.2 The roles of information reliability in affecting activity-travel 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 (Neuwirth, 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 sequelae 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.

2.1.3 The role of risk perceptions in affecting activity-travel 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. Hotle 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.

2.1.4 The role of attitudes toward policymaking in affecting activity-travel 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 (Bangerter et al., 2012; Quinn, 2013; Meltzer et al., 1999). Nevertheless, 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. (2020a) 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 are strongly associated with adherence to health guidelines (Prati et al., 2011; Quinn, 2013). The effect of local 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).

2.1.5 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.

2.2 Travel mode choice behavior during the COVID-19 pandemic

2.2.1 Travel mode choices under the impacts of COVID-19

As stated by WHO, "the virus spreads mainly between people who are in close contact with each other, for example at a conversational distance."[3] In line with such existing evidence, it is reasonably argued that travel for leisure involving more person-to-person conversation, such as party and eating out, may by riskier than travel for other purposes. However, as evidenced by the following literature review, there are limited studies on travel mode choices for leisure purposes and differences of factors (e.g., especially risk-related factors) affecting travel mode choices for different detailed travel purposes have further remained unknown.

As shown in the definition of the pandemic risk given by Zhang et al. (2021a), trip making and activity participation are a key part of the whole virus spread process, in the form of exposure and transmission. Thus, it is necessary to investigate travel mode choices together with activity participation (i.e., travel purposes). Affected by the fear of infection, people may shift from public transport to private car, walk and/or cycling (De Vos, 2020, Chen et al., 2022, Zhu et al., 2022). Although travel mode choices were researched with respect to commuting (Bhaduri et al., 2020; Cusack, 2021; Das et al., 2021) and shopping (Zannat et al., 2021; Shaer et al., 2021) and by classifying travel purposes into commute, shopping, and other non-commuting purpose (Thombre et al., 2021; Tarasi et al., 2021; Abdullah et al., 2021a), comparative studies on travel mode choices for more detailed travel purposes (especially for leisure activities) during the COVID-19 pandemic are still very limited.

What kinds of changes in travel mode choices have been revealed

The COVID-19 virus spreads fast from people to people via daily trip making (Hendrickson et al., 2020;

[3] https://www.who.int/news-room/questions-and-answers/item/coronavirus-disease-covid-19-how-is-it-transmitted (Accessed on May 22, 2022)

Abdullah et al., 2021b). As a result, people may have to change some of their travel modes for avoiding being infected. Shakibaei et al. (2021) revealed that about one-third of the respondents in Istanbul shifted from public transport to private cars. Zhu et al (2022) found an obvious shift from subways to walking for commuting in 58 cities of 31 countries across the continents of America, Asia, Europe, and Oceania. De Vos (2020) and Zhu et al. (2022) observed that people increased walking or cycling for recreational purposes, such as enjoying the sensation of speed or exposure to the natural environment. Cusack (2021) found that the essential workers in USA increased active transport for commuting, even though they were less satisfied with community support (e.g., safety in busy roads, lack of bicycle lanes) for active transport choices. Das et al. (2021) showed that an increasing infection risk of shared travel modes might result in a systematic shift from public transport to car commuting in India, leading to worsened traffic congestion. Abdullah et al. (2021a) confirmed that people in Pakistan significantly shifted from public transport to private car for long-distance travel (>5 km). Eisenmann et al. (2021) revealed that during the strictest period of lockdown (i.e., April 2020) in Germany, the share of public transport decreased, while the share of car users remained stable, indicating that private card became more important during the pandemic. Przybylowski et al. (2021) found that people in Gdańsk, Poland shifted from public transport and shared mobility to cars, bicycles and walking significantly during a lockdown period, while about 75% of the respondents who stopped or restricted the use of public transport planned to return to using public transport when the infections became stabilized. Focusing on the post-pandemic transformation in transport systems in Europe and North America, Ciuffini et al. (2021) showed that active transport is required for reinforcing the resilience of urban transport.

Differences in travel mode choices across travel purposes

Using data collected in Istanbul, Turkey, Shakibaei et al. (2021) found that more people began to shift from public transport to private car for commuting trips from February 25 to April, 2020 when people became more sensitive to the virus infection risk and took actions against the pandemic; the decrease of public transport was more obvious than that of private car and walking from February 25 to April 24, 2020 for social/recreational/leisure travels; and private car and walking are the most common modes being used for social/recreational/leisure travels and shopping travels from March 23 to April 24 when people took actions against the pandemic. Shaer et al. (2021) showed that older adults in Isfahan, Iran increased the use of active transport for shopping and aimless recreational travels. Targeting India, Bhaduri et al. (2020) observed that personal vehicles (car and motorbike) experienced the biggest decrease for commuting, probably because of the shift to telework, and the use of personal vehicles showed the biggest increase for shopping and other travel purposes, followed by active transport (walk and cycle).

Factors associated with travel mode choices under the context of the pandemic

Psychological factors and travel attributes could lead to tremendous changes in travel mode choices during the COVID-19 pandemic (Chan et al., 2020b; Ding and Zhang, 2021; Zhang, 2021). Among the psychological factors, risk perception in vehicle is one of the most popular factors to explain travel mode choices in such a context (Zafri et al., 2022; Chen et al., 2022; Abdullah et al., 2021b). The risk perception at a larger spatial scale was confirmed to be influential to changes in various behaviors in daily life (Ding and Zhang, 2021). In Ding and Zhang's study, respondents were asked about whether they thought the infection risk increased at four spatial levels (the whole country, residence prefecture, residence municipality, the often-visited places) or not. Another important psychological factor is people's trust in policymakers, Ding and Zhang (2021) found that higher trust in policymakers could encourage people to reduce the use of public transport and increase the use of car and active transport in Japan. For travel attributes, travel time (Chen et al, 2022; Aaditya & Rahul, 2021), travel habit (Gao et al., 2020; Bhaduri et al., 2020; Ding and Zhang, 2021) were found to affect travel mode choices. Aaditya et al., (2021) further observed that when choosing public transport, people are willing to spend more time to ensure their personal safety.

2.2.2 Influences of risk perception and trust in policymakers on travel mode choice

Risk perception is a typical factor to describe human behaviors under the threat of risk (Aaditya et al., 2021; Chen et al., 2022), while trust in policymakers determines how people respond to policies (Wong et al., 2020; Laato et al., 2020b). Travel mode choices during the COVID-19 pandemic are found to be affected by risk perception inside vehicles (Chen et al., 2022; Zafri et al., 2022), risk perception at activity destinations (Ding and Zhang, 2021; Zhang, 2021), and trust in governments and health/medical agencies (Sibley et al., 2020; Wong et al., 2020; Laato et al., 2020b; Ding and Zhang, 2021; Zhang, 2021).

Zafri et al. (2022) analyzed perceived risks of viral transmission in different travel modes in Bangladesh and identified influential factors based on an ordinal logistic regression model. It is found that people perceived a high risk of viral transmission in bus, moderate risk in shared modes (rickshaw, auto-rickshaw, ridesharing), and low risk in private modes (private car, motorcycle/scooter, walking, cycling). It is further stated that risk perception about the use of public transport might encourage people to shift to private modes, which would worsen urban transport problems and undermine sustainable transportation goals. Targeting travel mode choices in the Netherland, Chen et al. (2022) measured risk perception using the following three questions based on a five-point Likert scale: whether people think it is unsafe in public transport, whether people want to share with others in public transport, and whether people think it unsafe to share with others in public transport. Chen et al. showed that people were prone to perceive public transport as a riskier mode, in comparison with private modes. Abdullah et al. (2021b)

evaluated the risk perception inside transport vehicles by asking questions about whether safety precautions (social distancing, wearing a facemask, use of hand sanitizers) were taken inside public transport vehicles, using a five-point Likert scale. They revealed that perceived safety precaution was significantly related to people's willingness to choose a public transport.

At the level of activity destinations, risk perception has been measured at levels of country, residence perfection, and residence municipality, also using a Likert scale (Zhang, 2021; Ding and Zhang, 2021). Zhang (2021) estimated a structural equation model based on data collected in Japan to investigate the associations between five latent variables (changes in daily life, reliability of information, risk perception, triggers of behavioral changes, and attitudes) during the COVID-19 pandemic. Zhang (2021) found that if people perceived a higher level of risk perception (inside transport vehicles and at other spatial scales, they were more likely to reduce the use of public transport and increase car trips or walking/cycling trips. The study conducted by Ding and Zhang (2021) also presented similar findings.

People's trust in governments and health/medical agencies may change during the COVID-19 pandemic (Sibley et al., 2020). Some studies revealed that people may easily follow those recommended behaviors by governments and health/medical agencies, if people highly trusted them (Wong et al., 2020; Laato et al., 2020b). Ding and Zhang (2021) used a dynamic structural equation model to examine the effects of subjective factors on individuals' behavior changes over time and found that higher trust in policymakers could encourage people to make more behavior changes during the pandemic. However, the study by Ding and Zhang (2021) did not incorporate the decision-making mechanisms related to travel mode choices and the analysis of travel modes did not pay attention to potential differences caused by travel purposes.

2.2.3 Influences of cultural risk factors on transportation field

As for cultural risk factors, the cultural theory of risk, which was first proposed by Douglas (1970), has been regarded to be a key theory. The cultural theory of risk treats risk perception as a social process and argues that the perceived level of risk is affected by underlying cultural biases associated with one's worldview (i.e., values and preferred form of social order): i.e., the perceived risk is primarily explained by the socio-cultural context (Douglas, 1992). The cultural theory of risk emphasizes two dimensions of group and grid, where group refers to "the degree to which an individual is bonded into social groups" (e.g., "who am I" or "who am I with") and grid is "the degree to which social interactions should be constrained by rules and norms" (e., "how should I behave"), where if an individual faces a threat to his/her ideal cultural cognition or social order, he/she will perceive a higher level of risk (Jenkins-Smith et al., 2009/2019; Kahan et al., 2006; Lodge et al., 2010; McEvoy et al., 2017; Nan et al., 2014; Ripberger et al., 2012; Silva et al., 2007; Song et al., 2014a,b; Thompson et al., 2018; Wildavsky et al., 1987; Wildavsky et al., 1990).

As stated in the above references about the two dimensions of group and grid, people can be classified into four cultural orientations: hierarchism, egalitarianism, individualism, and fatalism.

Hierarchism corresponds to a high-level group and a high-level grid. Hierarchists prefer strong group attachment and clear obedience of social rules, and as a result, they often trust the authority in society and insist on the contribution to the whole society. Egalitarianism corresponds a high-level group and a low-level grid. Egalitarianists think that social relationship in a group is very important, but they do not trust or want to follow the rules proposed by the authorities unless these social rules are decided by all group members. Individualism is weak in both grid and group dimensions. Individualists, who enjoy an untrammeled and self-regulated life, prefer competition with an equal opportunity rather than solidarity in the society and dislike the regulations from the authorities. Finally, fatalism has a high level in the grid dimension but a low level in the group dimension. Fatalists think that most things in life are totally out of their control and the fate or luck plays the dominant role in their life. They are not interested in the social relations in group/society and tend to avoid the social rules if possible.

In the transportation field, there are limited applications related to road traffic safety, but not focusing on the whole picture of the above four types of cultural orientations. Gaygısız (2010) revealed that hierarchism is positively associated with traffic fatalities, while egalitarianism shows a negative influence. Atchley et al. (2014) found similar associations of hierarchism and egalitarianism, not only related to facilities but also related to traffic crashes and injuries. Solmazer et al. (2016) investigated whether and how hierarchism and egalitarianism are associated with fatality rates and law enforcements and confirmed that hierarchism is positively associated with traffic fatality rates and negatively associated with law enforcements, which are opposite the results of egalitarianism. Üzümcüoglu et al. (2018) investigated the associations of not only hierarchism and egalitarianism but also individualism with traffic law enforcements and drivers' violation behaviors and found that non-speeding traffic violations (e.g., aggressive violations, tailgating, and using a mobile phone without a hands-free kit) are positively correlated with hierarchism and negatively with egalitarianism and individualism.

2.2.4 Influences of preparedness on under-pandemic travel mode choices

COVID-19 should be regarded as an unpreceded event for most people. Thus, it is difficult to say that people could prepare for it. On the other hand, because some measures against COVID-19 (e.g., mask wearing, hand washing) are similar to those against influenza. Travel habits formed during influenza seasons before the COVID-19 pandemic could play a similar role of preparedness for COVID-19.

About the effect of preparedness on people's travel mode behavior, Gao et al. (2020) investigated the influences of travel habit, as a proxy variable of preparedness, on travel mode choices. The following eight questions are used to measure travel habits: (1) I have frequently used car/metro in commuting for a long time, (2) I habitually used car/metro for commuting, (3) I commute by car/metro without having to consciously remember, (4) It makes me feel weird if I do not use car/metro in commuting, (5) Besides car/metro, I do not think about other options for commuting, (6) I would find hard not to commute by car/metro, (7) Commuting by car/metro belongs to my daily routine, and (8) I commute by car without thinking. Obviously, travel habits are measured without distinguishing between different

travel modes. Bhaduri et al. (2020) defined travel habit as the most frequently used travel mode before the pandemic and found a positive effect on travel mode choices during the pandemic. Unfortunately, it is unclear whether the period before the pandemic included any risky environment. In other words, only travel habits without paying special attention to any risky choice environments were targeted.

During the COVID-19 pandemic, people may also try to form a kind of risk-concerned or virus-sensitive travel habit. From such a perspective, Ding and Zhang (2021) incorporated people's accumulated behavior changes during the pandemic, as a kind of preparedness, to explain the recent changes in various behaviors (including travel mode choices) based on a dynamic structural equation model.

2.2.5 Applications of hybrid choice models in the COVID-19 context

Hybrid choice model (HCM) is an expanded choice model consisting of structural equations and measurement equations as well as a utility equation, where latent variables are included. HCM has a flexible choice structure, which can accommodate a probit-based or logit-based structure (Bhat et al., 2016). Bhat (2015) formulated a generalized heterogeneous data model (GHDM) with a probit-based structure to jointly estimate mixed types of dependent variables (ordinal/binary variables for occurrences of weekly non-commute travel, nominal variables for travel mode and residential location choices, continuous variables for commute distance). Kang et al. (2021) used the above GHDM to investigate how people simultaneously choose five binary variables related to pooled ride-hailing. In comparison with the probit-based model, the logit-based HCM is more widely applied in the transportation field (Ben-Akiva et al, 2002; Hess et al., 2018; Scagnolari et al., 2015; Thorhauge et al., 2019; Vij and Walker, 2016; Walker et al., 2002). Thus, in this study, we adopt the logit-based HCM. There are also a lot of applications to the analysis of travel mode choices (Borriello et al., 2019; Hess et al., 2018; Huan et al., 2021; Ingvardson et al., 2021; Kamargianni et al., 2015; Kim et al., 2017; Mehdizadeh et al., 2019). However, the applications to travel mode choices in the COVID-19 context are very limited. Only two studies have been found. The first study was done by Aaditya et al., (2021), who focused on two latent variables of the safety perception about public transport (related to three measures of sanitization, crowd management, social distancing) and attitude towards public transport (i.e., whether people believe using a motorized travel mode is a symbol of prosperity, in comparison to public transport). Aaditya et al. revealed that attitude towards public transport did not influence people's willingness to choose a public transport, while the safety perception showed a dominant effect on the choice of public transport. The second study was conducted by Chen et al. (2022), who targeted four latent variables of social responsibility, risk perception (using three questions about the perceived risk in public transport, measured in a five-point Likert scale: 1) travel by public transport during the COVID-19 pandemic is not safe; 2) I do not like sharing space with strangers in using public transport; 3) sharing space with strangers in public transport during the pandemic is unsafe)), fear of infection (using two questions about physiological manifestation of fear, measured in a five-point Likert scale: 1)

my heart races or palpitates when I think about getting COVID-19; 2) my hands become sweaty when I think about COVID-19) and travel anxiety. Chen et al. incorporated four travel purposes (i.e., work, shopping, leisure, and social purposes), as a dummy variable, respectively, into a travel mode choice model and confirmed the statistical significance of all the latent variables. It is observed that the fear of infection was positively related with choosing private cars and shared E-bikes, as well as walking, and people were more likely to perceive public transportation as a more dangerous mode than private modes.

2.3 Social contact behaviors during the COVID-19 pandemic

2.3.1 Ignorance of indirect social contact

As stated by WHO[4], COVID-19 spread between people mainly in three ways: (1) through close contact with each other (e.g., at a conversational distance), (2) in poorly ventilated and/or crowded indoor settings, and (3) when touching eyes, nose, or mouth after touching surfaces or objects that have been contaminated by the virus. Thus, both direct and indirect social contacts could spread the virus. However, existing studies only focus on skin-to-skin touch and face-to-face conversation (Fadilah et al., 2020; Latsuzbaia et al., 2020; Zhang et al., 2020a; Trentini et al., 2022; Zhang et al., 2021b), by following the definition for previous infectious respiratory diseases (Mossong et al., 2008; Hoang et al., 2019; Leung et al., 2017). Existing studies (Brooks-Pollock et al., 2020; Dorélien et al., 2021; Wong et al., 2022; Tomori et al., 2021; McCarthy et al., 2020; Tizzani et al., 2022; Jarvis et al., 2020) have mainly cited the definition given by the POLYMOD (Improving Public Health Policy in Europe through Modelling and Economic Evaluation of Interventions for the Control of Infectious Diseases) (Akakzia et al., 2007; Mossong et al., 2008), which adopts the mean number of contacted persons. As confirmed by other existing studies on COVID-19, the COVID-19 virus (i.e., SARS-CoV-2) can travel more than six feet through people's aerosols (Ge et al., 2020) and infect people by their indirect contact with virus-infected surfaces (Daraei et al., 2020; Cai et al., 2020; Zhang, Z. et al., 2020). Hence, focusing only on close or direct contact is insufficient and biased, and it is necessary to also accommodate indirect contact. McCreesh et al. (2022) implemented one of the few studies investigating people's indirect contact with others. However, they only used the contact time and ignored the number of contacted persons because of the unavailability of casual contact data.

In summary, most previous studies only focus on close contact (skin-to-skin touch or face-to-face conversation) behaviors but neglect individuals' indirect contacts, which could also transmit the virus [Research gap 1].

[4] https://www.who.int/news-room/questions-and-answers/item/coronavirus-disease-covid-19-how-is-it-transmitted (accessed on December 15, 2022)

2.3.2 Lack of the representation of joint social contact decisions

After the restrictions from the government were lifted gradually in many countries, social contact have shown an increasing trend, but it is still difficult to return to the pre-pandemic levels (Wong et al., 2022; Liu et al., 2021; Latsuzbaia et al., 2020). For instance, Zhang et al. (2021b) used the social contact data collected on March 1-20, 2020 in Shanghai, Shenzhen, Changsha, and the data on May 7-15, 2020 in Wuhan (about one month after the lockdown was lifted) to compare the changes in contact patterns across the pre-pandemic, lockdown and post-lockdown periods. The mean number of contacts increased from 5% to 17% after lockdowns in these cities. Although the intracity mobility has rebounded to pre-pandemic levels, the number of contacts only recover from one-seventh to one-third of the pre-pandemic level.

Such a mean number of contacts have been further investigated by associating with different demographic attributes (e.g., age, gender, household size, occupation) and contact settings/locations (household/home, workplace, school, community, leisure activity, transport, shopping). To be specific, Tomori et al., (2021) applied a self-reported contact survey data and mobility data (from Google and Apple) in German from April to June, 2020 to investigate the reduction of the mean number of social contacts over time via the age-specific social contact matrices of direct social contacts. Respondents were asked about the age and sex of their social contacts, the duration they spend with each contact and the contact setting (household, school, work, transport). In their results, most of the social contacts occurred in household. After the lockdown measures were relaxed in German, people's mobility behavior went back to pre-pandemic levels almost instantly, while the degree of contacts still maintains a persistent reduction because people may reduce close contacts outside home and keep the social distance deliberately. Sypsa et al. (2020) conducted a social contact survey in Greece from March 31 to April 7, 2020, which is during the lockdown in Greece. They collected information about people's social contacts approximately two months earlier than the lockdown and during the lockdown. They found that daily contacts were reduced by 86.9% during the lockdown. The decrease in contact during lockdown is most obvious in a household, the school closure measure may lead to an increase in leisure contact or a decline in work contact. People are prone to contact peers when doing leisure activities, while that phenomenon is not obvious in other contact settings before the lockdown. Trentini et al. (2021) collected individuals' social contact data in the South West Shewa Zone (SWSZ) of Ethiopia from November 2019 to December 2019 when schools were open as usual. And they explored the impact of socio-demographic factors and observed mixing patterns on the COVID-19 disease burden in three spatial scales: remote settlements, rural villages, and urban neighborhoods. For each spatial scale, there are three contact settings: households, schools, and the general community. Their results show that the mean number of social contacts (excluding school contacts) is higher in both urban neighborhoods and remote settlements, but lower in rural villages, especially for these old people who are over 60 years old. Nevertheless, the mean number of social contacts in school did not show obvious differences across these three spatial scales. For the mixing patterns, these people aged below 30 years

old (especially between 10 to 19 years) are more likely to contact their peers in a general community across the three spatial scales. McCarthy et al. (2020) compared the average number of contacts per day of one random individual during the pandemic (from January to May 2020) in Ontario, Canada with the mean value of contacts in POLYMOD survey data before the pandemic to explore the age-specific susceptibility of daily contact mixing patterns in workplace, household, school, and community settings. They found an obvious reduction in the average contact rate (for total contact in all contact settings) following the implementation of control measures, but the contacts in households increased 13% after school closure, 45% after the additional physical distancing measures, and 51% after the closure of non-essential businesses. Tizzani et al. (2022) used the CoMix social contact data (a multi-country social contact survey started in March 2020 and conducted in 19 European countries including respondents' information on social contact in the contact settings of home, work, school, leisure activities, other places (Verelst et al., 2021)) and POLYMOD data in Italy to investigate the impact of tiered restrictions on social contacts between December 2020 and April 2021. Tizzani et al. summarized the differences in the mean number of contacts by waves for CoMix and Polymod from the perspective of age, gender, and household size, and provided an analysis of the difference in the mean number of contacts by age for different contact settings of home, work, other. Their results show that NPIs reduced the number of contacts significantly across the age groups and contact settings. Elderly people aged over 60 had a lower number of contacts and a lower decrease of contacts than other age groups. Household contact did not show obvious differences across the regions with different levels of non-pharmaceutical interventions. While the other contacts (such as leisure contact) are more likely to be affected by the strictness of interventions, especially for younger people. Kiti et al. (2020) used online social contact survey data obtained from 304 employees of three U.S. companies between April to June 2020 to analyze the changes in daily contact among workforces. In their study, the collected contacts are classified into different modes: conversation only (54 %), physical contact only (12 %), both conversation and physical contact (34 %). The descriptive analysis shows that most contacts of employees occurred at home (64 %), followed by shopping contacts (14 %). Most daily contacts lasted more than 4 hours (38 %). The long-lasting contacts occurred at the respondent's home, while short-lasting contacts occurred outside. More than 60% of the daily contacts are repeated contacts over days.

In summary, previous studies only investigated the number of social contacts (especially only the average values) as the indicator of social contact behaviors, and there is no study on social contact mode choices, except the study by Kiti et al. (2020). Some studies explored the changes in the number of social contacts for different contact settings, but they tend to categorize the shopping and leisure settings into "other", probably leading to seriously biased findings. These are Research gap 2.

2.3.3 Lack of modeling approaches with the dependence of social contact behaviors

Concerning the modeling approaches of social contact behaviors, existing studies have mainly focused

on the number of contacted persons, based on regression models.

Wong et al. (2022) estimated a generalized additive mixed regression model to investigate factors affecting changes in average daily contacts by country and by contact settings (e.g., at home, at work) based on a repeated cross-sectional survey implemented in 21 European countries between March 2020 and March 2022, where a zero-inflated Poisson distribution is assumed. Influences of age, household size, gender, risk perception, measures taken against COVID-19 were quantified.

Latsuzbaia et al. (2020) applied a Poisson regression model to investigate influential factors to the number of social contacts, where data were collected in Luxembourg during the lockdown (from March 25 to May 1) and after the lockdown (from June 12 to June 25), with respect to the number of social contacts in different contact settings (home, work, leisure place, shopping places, etc.). They examined the influences of age, nationality, and the survey period. To overcome the shortcomings of the Poisson regression model, which allows for overdispersion (i.e., enables to model data exhibiting more variance), Zhang et al. (2020a) estimated a negative binomial regression model by conducting social contact surveys in Wuhan and Shanghai, China on February 1-10, 2020 to investigate the change in people's social contacts. The baseline of the number of contacts is defined as people's contacts before the pandemic. Gender, age, occupation, and household size are examined. Similarly, Feehan et al. (2021) also applied a negative binomial regression model to analyze the number of daily contacts in the USA between March 22 and September 26, 2020. Age, education, ethnicity, household size, residential location, and gender are incorporated in the analysis. Dorélien et al. (2021) used a negative binomial regression model to evaluate the number of social contacts from April to May 2020 in Minnesota, USA, where age, gender, race/ethnicity, region, and other demographic characteristics are included as explanatory variables. Using data collected in Milan, Italy between July 2020 and March 2021, Trentini et al. (2022) also estimated a negative binomial regression model by targeting the number of daily contacts, but under different levels of restrictions.

In summary, the previous social contact modeling methods are only based on the regression approaches. As a result, the dependence between the number of social contact and contact mode choices have been ignored. Furthermore, existing modeling analyses only focus on the effects of demographic characteristics, and the impacts of people's psychological factors have been ignored. These are the Research gap 3 that is identified from the above literature review.

2.4 Summary

This chapter summarized the research background of the dynamic activity-travel behavior changes and the behaviors of travel mode choice and social contacts related to the COVID-19 pandemic in previous studies. Based on the literature review, the research gaps need to be resolved are found as follows.

1) Behavioral and psychological adaptations to COVID-19

The dynamic association between people's behavior changes and their psychological factors related to the pandemic policymaking haven't been explored.

2) Travel mode choice behavior during the COVID-19 pandemic

Limited research efforts were made to compare factors affecting travel mode choices for different travel purposes, especially related to leisure. The studies focusing on the impact of people's risk perception at different spatial scales and the trust in governments and health/medical agencies on travel mode choices are limited. the cultural risk factors have been recognized to determine people's responses of travel mode choices to the risks of the COVID-19 pandemic. Preparedness averts peril; however, it has remained under-explored how people prepared for such a pandemic of COVID-19 and how preparedness affects travel mode choices under the impacts of COVID-19. Previous studies about the applications of HCM did not consider individuals' taste variations and the associations between latent factors for travel mode choices during the COVID-19 pandemic simultaneously.

3) Social contact behaviors during the COVID-19 pandemic

Most previous studies only focused on the close contact (physical contact or direct conversation) behaviors but neglected individuals' social contact behaviors in the forms of other contact modes, such as the non-close contact, or both of them. Previous studies only studied on the number of social contacts (especially for the changes of the mean numbers) as the indexes of social contact behaviors, the analysis on people's contact mode is very limited. Meanwhile, some studies explored the changes of the number of social contacts for different contact settings, while they tend to categorize the shopping and leisure settings into "other", the classification of settings is rough. The previous modeling methodology used for analyzing social contact is only restricted to the regression approach, so the coupling relationship between the number of social contact and contact mode haven't been explored in previous studies. And the most previous modeling approach only focused on the effect of demographic characteristics on social contact, the impact of people's psychological factors was ignored in the modeling process.

CHAPTER 3 Pandemic-responsive methodologies

This chapter introduces the methodology used in this study. A life-oriented panel online survey is conducted in Japan at the end of October 2020 to collect people's behavior changes under the impact of the COVID-19 pandemic before September 2020. And an online comparative survey of activity-travel and social contact before-during COVID-19 is conducted in six developed countries (Australia, Canada, Japan, New Zealand, the US, and the UK) form March to May 2021 to collect people's behavior information before May 1st, 2021. Figure 3.1 shows the trend of new daily confirmed cases in Australia (AU), United States (US), New Zealand (NZ), Canada (CA), United Kingdom (UK) and Japan (JP) from April 2020 to May 2021 and targeted survey period of behaviors in this study. It shows that the number of new daily confirmed cases in latest wave of the pandemic before the survey declined after January 2021 and remain stable since the end of February 2021. And most of the strict lockdown measures have been lifted in these six countries before March 2021. The data in life-oriented panel survey is used for the analysis in chapter 4, while the data in comparative survey of activity-travel and social contact before-during COVID-19 is used in chapter 4-7. First, the details of surveys are introduced in section 3.1, then the applied modeling approaches in this study are introduced in section 3.2.

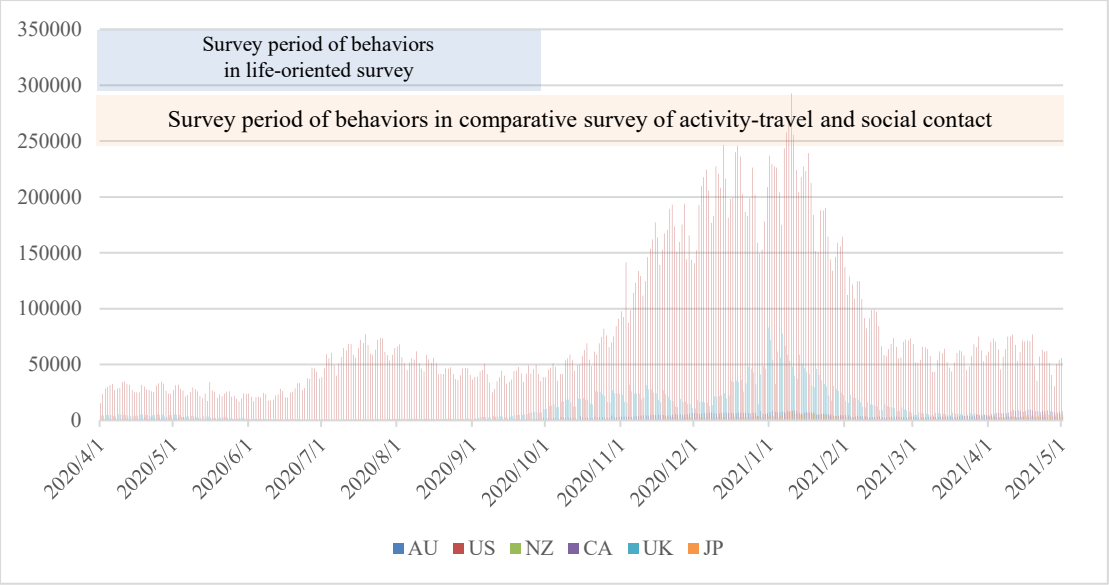

Figure 3. 1. Targeted survey period of behaviors in two surveys

3.1 Nationwide behavioral surveys

3.1.1 Life-oriented panel survey of behavioral and psychological adaptations to COVID-19

1) Survey design

The questionnaire of life-oriented panel survey has two parts. The first part includes the questions about individual and household attributes. The second part of the questionnaire focuses on individuals' changes in various behaviors from April 2020 to September 2020 and people's subjective psychological attributes. The former of second part 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 policymakers and health professionals as well as PASS-LASTING based policy measures in a 5-point Likert scale. The behaviors included in the survey contain not only travel behaviors but also other life choices and activities, within cities and across cities. More details of the questionnaire can be found in Appendix 1.

2) Survey implementation

A life-oriented retrospective panel survey was implemented online with respect to 2,643 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 3.1 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.

Table 3. 1. Share differences of respondents in the survey and the population by regions

Regions	Shares of respondents in the survey (%) (A)	Shares of the population (B)	A – B
Hokkaido	8.6	4.2	4.4
Tohoku	6.2	7.0	-0.8
Kanto	40.3	34.4	5.9
Chubu	12.7	16.8	-4.1
Kinki	14.2	17.5	-3.3
Chugoku / Shikoku	7.1	8.7	-1.6
Kyushu / Okinawa	10.9	11.4	-0.5

3) Respondents

Regarding the location of survey respondents, 41.2% resided in megacity 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 3.2, 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. Detailed questionnaire items are explained in chapter 4.

Table 3. 2. Socio-demographic attributes of the survey respondents

Attributes	Definition	N	%
Gender	Male	1247	47.2
	Female	1396	52.8
Age	Below 30 years old	480	18.2
	Between 30 and 60 years old	1534	58.0
	Over 60 years old	629	23.8
Occupation	Company employee/self-employed	1062	40.2
	Civil servants / organizational employees	89	3.4
	Faculty and staff of educational institutes such as schools and universities	33	1.2
	Housewife	452	17.1
	Part-time job	356	13.5
	Student	197	7.5
	Other unemployed (including pensioners)	366	13.8
	Others	88	3.3
Education background	Junior high school	58	2.2
	High school	749	28.3
	Specialized training college	278	10.5
	Junior college / technical college	268	10.2
	University	1144	43.3
	Graduate School	146	5.5

3.1.2 Comparative survey of activity-travel and social contact before and during the COVID-19 pandemic

1) Survey design

The questionnaire of comparative survey of activity-travel and social contact before-during COVID-19 consists of four parts.

The first part collects individual and household attributes (e.g., gender, age, resident region, occupation, household size, marital status, education background and annual household income).

The second part collected people's social contact information (e.g., contact mode, number of contacted persons), average performance information (e.g., frequency, duration), and psychological factors for doing different daily activities before (influenza season in 2019) and during (March 2020 to May 2021) the pandemic. In this part, seven contact settings are designed to show the heterogeneities of the social contacts occurred in different locations of the daily activities (working/studying in company/school, shopping in supermarket/shopping mall, eating out in restaurant, doing exercise/sports in indoor places like gym, joining the party in indoor places like bar, culture leisure in indoor places like cinema, doing medical activities in indoor places like hospital).

The third part of the questionnaire collects people's social contact information, average performance information and psychological factors in different transport vehicle types before (influenza

season in 2019) and during (March 2020 to May 2021) the pandemic.

The final part collects people's subjective statements to the reliability of COVID-19 information sources, risk perceptions about the COVID-19, triggers of the behavior change, attitudes toward policymakers/health professionals, attitudes toward PASS-LASTING based policy measures, and the cultural risk factors based on cultural theory of risk in a 5-point Likert scale.

The questionnaires can be found in Appendix 2 and 3.

2) Survey implementation

In this study, the retrospective survey was conducted online in six developed countries (Australia: AU, United States: US, New Zealand: NZ, Canada: CA, United Kingdom: UK, and Japan: JP) from March to May 2021. With the assistance of a major international survey company, the online questionnaires were distributed to respondents by keeping the sample distributions of age, gender and regions within each country to be consistent with the corresponding population distributions[5]. More than 1,000 respondents in each country (AU: 1125, US: 1297, NZ: 1193, CA: 1176, UK: 1305, JP: 1169) provided valid information about activity and travel behaviors during and before the COVID-19 pandemic, various psychological factors, and individual/household attributes. In total, data from 7,245 respondents are used in this study.

Regarding the distribution of survey data by regions, most respondents in six countries resided in megacity regions such as the New South Wales/Australian Capital Territory in AU (32.8%), California in US (12.1%), Auckland/Northland in NZ (32.2%), Ontario in CA (35.5%), Greater London in UK (12.2) and Kanto in JP (34.1%). Table 3.3 shows the differences between the regional shares of respondents in the sample and in each country (at the time of February 2021). The shares of population in Auckland, Northland (NZ), Ontario (CA), North West, North East and South East (UK) are under-represented by 4.6, 3.5 and 2.2 percentage points, respectively, while the gaps between the sample and the population in other areas are all less than 2.0 percentage points. Note that the sample representativeness could also be defined using other sample attributes. Thus, it can be said that the current survey sample roughly represents the whole population in these six countries.

[5] Australian Bureau of Statistics: https://www.abs.gov.au/ (2020)
U.S. Census Bureau: https://www.census.gov/ (2020)
Stats NZ: https://www.stats.govt.nz/ (2018)
Statistics Canada: https://www.statcan.gc.ca/en/start (2020)
Office for National Statistics - GOV.UK: https://www.gov.uk/government/organisations/office-for-national-statistics (2020)
Statistics Bureau of Japan: https://www.stat.go.jp/english/ (2020)

Table 3. 3. The shares of respondents and population by regions

Country	Regions	Shares of respondents in the survey (%) (A)	Shares of the population (%) (B)	Deviation of share (%) (A – B)
Australia (AU)	New South Wales, Australian Capital Territory	32.8	33.7	-0.9
	Queensland	19.9	20.1	-0.2
	South Australia, Northern Territory	8.9	7.9	1.0
	Victoria, Tasmania	26.5	27.9	-1.4
	Western Australia	11.9	10.4	1.5
US	Arizona, New Mexico, Colorado	6.5	5.7	0.8
	Washington, Alaska, Hawaii, Oregon, Wyoming, Montana, Idaho, Nevada, Utah	6.5	5.8	0.7
	California	12.1	12.3	-0.2
	Texas	8.3	8.5	-0.2
	Florida	6.6	6.6	0.0
	North Carolina, South Carolina, Georgia	8.3	8.5	-0.2
	Virginia, West Virginia, Maryland, Delaware, Washington, D.C., Tennessee, Kentucky	8.5	8.8	-0.3
	Arkansas, Mississippi, Oklahoma, Louisiana, Alabama	6.2	6.1	0.1
	New York, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, Maine	9.3	9.6	-0.3
	New Jersey, Pennsylvania	6.9	6.9	0.0
	Wisconsin, Illinois, Indiana	7	8.2	-1.2
	Michigan, Ohio	7.2	6.7	0.5
	Minnesota, North Dakota, South Dakota, Missouri, Kansas, Nebraska, Iowa	6.6	6.3	0.3
New Zealand (NZ)	Auckland, Northland	32.2	36.8	-4.6
	Bay of Plenty, Gisborne	8.8	7.7	1.1
	Canterbury	13.7	13.0	0.7
	Manawatu-Wanganui, Taranaki, Hawke's Bay	11.6	10.8	0.8
	Marlborough, Nelson, Tasman, West Coast, Southland, Otago	12.6	11.6	1.0
	Waikato	9.9	9.4	0.5
	Wellington	11.2	10.7	0.5
Canada (CA)	Alberta, Northwest Territories	12.3	11.3	1.0
	British Columbia, Yukon	14.9	14.6	0.3
	Manitoba, Nunavut, Saskatchewan	8.1	6.3	1.8
	New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador	7.8	6.2	1.6
	Ontario	35.5	39.0	-3.5
	Quebec	21.4	22.6	-1.2
UK	Scotland	8.7	8.5	0.2
	Northern Ireland, Wales	9.0	7.5	1.5
	North West, North East	12.8	15.0	-2.2
	Yorkshire and The Humber	9.2	8.4	0.8
	West Midlands	8.8	8.9	-0.1
	East Midlands	8.5	7.1	1.4
	South West	9.4	8.5	0.9
	South East	11.7	13.9	-2.2

Country	Regions	Shares of respondents in the survey (%) (A)	Shares of the population (%) (B)	Deviation of share (%) (A – B)
	East of England	9.7	9.1	0.6
	Greater London	12.2	13.1	-0.9
Japan (JP)	Hokkaido	4.5	4.4	0.1
	Tohoku	7.7	7.4	0.3
	Kanto	34.1	34.5	-0.4
	Chubu	16.6	16.9	-0.3
	Kinki	18.6	18.2	0.4
	Chugoku , Shikoku	7.3	6.7	0.6
	Kyushu , Okinawa	11.2	11.9	-0.7

3) Respondents

Table 3.4 shows the attributes of all respondents in the six countries. The percentage of female (51.0%) is slightly higher than that of male (49.0%), which is consistent with the population percentages (i.e., female: 50.7%, male: 49.3%). Almost half of the respondents were between 30 and 59 years old (49.6%). As the evidence of population aging in some developed countries, the share of respondents aged 60 or above 60 years old (29.6%) was bigger than the share of young respondents below 30 years old (20.8%). The sample in each country has similar distributions of gender and age to the whole population. Company employees, self-employed and other unemployed (including pensioners) account for more than half of all the respondents (total: 64.0%). Most of the respondents have an education background of undergraduate/bachelor (total: 32.9%), followed by college and vocational school (total: 22.5%), and high school and senior high school (total: 19.8%).

Table 3. 4. Distribution of attributes for all respondents in six developed countries

Attributes	Definition	AU (%)	US (%)	NZ (%)	CA (%)	UK (%)	JP (%)	Total (%)
Gender	Male	49.0	49.0	48.5	48.6	49.9	48.6	49.0
	Female	51.0	51.0	51.5	51.4	50.1	51.4	51.0
Age	< 30 years old	23.6	20.7	22.4	20.6	19.3	18.5	20.8
	30–59 years old	49.7	50.1	50.4	51.1	52.7	42.9	49.6
	60 years old or above	26.7	29.2	27.2	28.3	28.0	38.6	29.6
Occupation	Company employee/self-employed	38.3	36.1	39.3	38.4	43.8	40.2	39.4
	Civil servants / organizational employees	6.5	3.6	6.5	4.7	6.5	3.3	5.2
	Faculty and staff of educational institutes such as schools and universities	3.0	4.0	4.4	3.6	3.1	0.7	3.1
	Housewife	7.9	6.5	6.4	5.7	5.9	18.4	8.3
	Part-time job	12.4	8.3	10.0	8.0	7.0	10.5	9.3
	Student	3.3	4.8	4.4	5.5	3.9	3.2	4.2
	Other unemployed (including pensioners)	23.6	27.8	23.9	28.7	23.6	19.8	24.6
	Others	5.0	8.9	5.1	5.4	6.2	3.9	5.9
Education background	No formal qualification	0.2	0.5	2.8	0.1	1.4	0.1	0.8
	Elementary school	2.5	0.5	1.9	0.7	0.5	0.0	1.0
	Middle school/ Junior high school/Secondary school	13.6	0.5	13.1	1.4	20.2	2.2	8.6
	High school/ Senior high school	14.6	20.4	14.4	20.2	20.2	29.0	19.8
	College/ Vocational school	26.2	27.8	20.1	31.0	12.1	18.3	22.5
	Undergraduate/ Bachelor	26.7	26.0	35.2	33.7	30.4	46.1	32.9
	Master degree	14.1	19.9	10.6	11.3	13.0	3.3	12.1
	Doctoral degree	2.1	4.4	1.9	1.6	2.2	1.0	2.3

3.2 Modeling application

The dynamic structural equation model and mixed hybrid choice model are developed and applied in chapter 4 and chapter 5 for the behaviors analysis of dynamic activity-travel behavior changes and travel mode choice respectively, while the Copula model is used in chapter 7 for the joint analysis of the social contact behaviors.

3.2.1 Modeling of temporal dynamics of behavioral and psychological adaptations to COVID-19: Dynamic structural equation model (DSEM)

Structural equation models (SEM) are the models that reveal the association between latent variables by observable indicators (Bielby et al., 1977; Bagozzi et al., 1988; Duncan, 2014). It can help people to measure the latent variables indirectly. However, the traditional SEM can't indicate the dynamic relationship between individuals' behavior changes over time. Hence, a dynamic structural equation model (DSEM) is developed in this study to show how the accumulation of changes in behaviors in the past could affect the most recent changes in behaviors directly or indirectly through other latent variables.

3.2.2 Hybrid choice modeling of heterogeneous preparedness and correlated cultural and psychological factors in response to COVID-19: Mixed hybrid choice model (XHCM)

Hybrid choice model (HCM) is a widely used model for transport studies that can indicate the impact of the latent variables on the discrete choice (Vij et al., 2014; Kim et al., 2017; Aadity et al., 2021). However, the HCM structure in previous studies usually ignore the association between latent variables or the influence of the unobserved heterogeneities caused by individuals' taste variations. to resolve this problem, a mixed hybrid choice model with the association between latent variables (XHCM) is developed in this study. To the best of the authors knowledge, this study is the first time to use a hybrid choice model to investigate the travel mode choice behaviors with the association between latent

variables and individuals' taste variations simultaneously.

3.2.3 Dependence modeling of multi-faceted social contact decisions under the impacts of COVID-19: Copula model

The copula-based model is a multivariate functional form to derive the joint distributions of given marginal distributions (Trivedi et al., 2007). The term copula is first proposed by Sklar (1973) in English, and the applications of copula have been widely extended to other fields of economic research since the beginning of 21st century (Nelsen, 2007; Trivedi et al., 2007; Schmidt, 2007). The copula approach could form the joint distribution and estimate the dependency between random variables without restrictive distribution assumptions for the specific univariate marginal distributions (Irannezhad et al., 2017; Trivedi et al., 2007; Schmidt, 2007; Meloni et al., 2011). Moreover, compared with other multivariate correlation methods (e.g., Pearson, Kendall's tau, Spearman's rho), copulas can obtain nonlinear central dependence and tail dependence in both symmetric and asymmetric forms (Frey et al., 2001; Trivedi et al., 2007).

CHAPTER 4 Capturing temporal dynamics of behavioral and psychological adaptations to COVID-19

4.1 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.[6] 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)*
- *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*

[6] https://www.worldometers.info/coronavirus/ (Accessed on January 31, 2021)

- *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. (2021a) found, existing efforts are very limited. This chapter aims to fill this important research gap by analyzing data from a six-month life-oriented panel survey of behavioral and psychological adaptations to COVID-19 conducted in Japan using a dynamic structural equation model (DSEM). The latent psychological factors of the reliability of major COVID-19 information sources, risk perceptions about the COVID-19, attitudes toward policymakers and health professionals and attitudes toward PASS-LASTING based policy measures are considered in the structure of DSEM.

4.2 Data and descriptive analysis

In the survey, 2,643 respondents provided valid answers about behavior changes from April to September 2020, and psychological 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. Psychological 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 (“Prepare-protect-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 descriptive analysis of modeling factors is introduced as follows.

1) Reliability of COVID-19 information sources (RELIABILITY)

10 questions were included to evaluate the reliability of major COVID-19 information sources: i.e., official sources from the central government and local governments, authoritative sources from experts and medical institutes, domestic and overseas news on mass media, sources of SNS (Facebook, Twitter, etc.), search engines (e.g., Google, Yahoo), and information from personal social networks. The reliability degree is assessed via a 5-point scaling method (1: very low, 2: low, 3: neither, 4: high, 5: very high). As shown in Table 4.1, the information from medical institutes is perceived to be reliable (4: high or 5: very high) by the largest proportion of respondents (64.4%), and the second largest group of respondents believed that the information announced by local governments (60.3%), the central government (56.9%), and domestic news (54.6%) are reliable. On the other hand, only 10.5% of respondents perceive the information from SNS to be reliable, while more than 40% think the SNS information reliability is low or very low. Experts should have played important roles in helping the control of the pandemic; however, their opinions are trusted by only 38.1% of respondents. This indirectly suggests that scientific knowledge about COVID-19 is still limited or not publicly acceptable, and as a result, is not sufficient to convince the majority of the general public.

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 often 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 4.2) 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 4. 1. 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. 2. 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%

3) Attitudes toward COVID-19 policymaking capability (ATTD_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 attribute measurements are closely related to the capacity of policymakers and health professionals. Unfortunately, as shown in Table 4.3, 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 4. 3. 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%

Attitude	Mean	Somewhat or strongly disagree	Neither	Somewhat or strongly agree
(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) Attitudes toward PASS and LASTING based policy measures (ATTD_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-provide (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 (TING), 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 4.4.

Table 4. 4. Attitudes toward PASS and LASTING based policy measures

Policy measures			Positive (strongly or somewhat agree)	Negative (strongly or somewhat disagree)
PASS	Prepare	You are well prepared for emergencies like this COVID-19 pandemic.	31.6%	23.0%
	Protect	In order to prevent yourself or others from infection, you keep your physical distance, even if you find it is very inconvenient.	50.9%	10.4%
	Provide	In order to prevent yourself or others from infection, you are willing to provide your details of behavior history to medical and government agencies.	46.7%	17.8%
	Avoid	In order to prevent yourself or others from infection, you will avoid dense activities / actions with three Cs (closed spaces, crowded places, and close contact), even if you find it is very inconvenient	66.7%	7.7%

Policy measures			Positive (strongly or somewhat agree)	Negative (strongly or somewhat disagree)
	Adjust	In order to prevent yourself or others from infection, you will adjust your activity / action schedule or plans	54.8%	10.8%
	Shift	In order to prevent yourself or others from infection, it is better to shift the work style into telework and use transportation modes other than public transportation, even if you find it is very inconvenient.	41.9%	14.1%
	Share	In order to prevent yourself or others from infection, you are totally not reluctant to share your behavior history and health status information with others	41.4%	19.5%
	Substitute	In order to prevent yourself or others from infection, it's better to switch to online activities, postpone travel, reduce the number and distances of trips, and stop unnecessary activities, even if you find it is very inconvenient.	58.7%	9.3%
	Stop	In order to prevent yourself or others from infection, it's better to stop activities that involve traveling and avoid parties at home, even if you find it is very inconvenient.	65.0%	7.2%
LASTING	Life needs	In order to keep yourself or others from infection, you totally accept changing the needs in your life, and your lifestyles, even if you find it is very inconvenient.	49.5%	13.1%
	Activity, Space, Time and Timing	In order to keep yourself or others from infection, you totally accept changing your daily activities, places and time and timing of activity participation, even if you find it is very inconvenient.	49.3%	13.4%

Table 4.4 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.

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 detour behaviors after leaving workplace or school; less shopping in stores). The trends of behavior changes targeted in this study are shown in Figure 4.1.

Figure 4.1 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 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.

Figure 4. 1. Changes in behaviors from April to September 2020

4.3 Methodology and framework

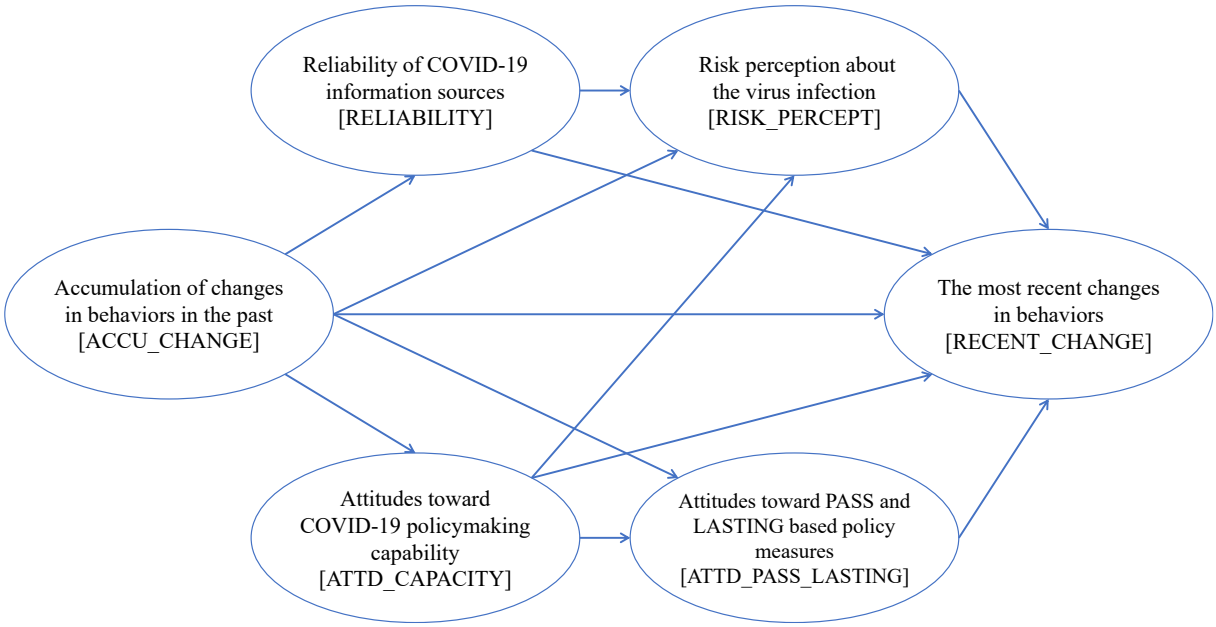

Figure 4. 2. Conceptual framework about cause-effect relationships

In this study, a dynamic structural equation model (DSEM) is developed, as shown in Figure 4.2. 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.

4.4 Result and discussion

The DSEM model in this study was estimated using IBM SPSS Amos Ver 24. In total, 2,643 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, C. and Liu et al., 2019; Oña et al., 2013). The GFI in this study is 0.804, showing an acceptable fit for the data.

4.4.1 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 4.5 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 Figure 4.2 hold in this study. In other words, the conceptual framework formed in Figure 4.2 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 (-0.519) and RELIABILITY (-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.

4.4.2 Standardized total effects between latent variables

Table 4.6 shows the results of standardized total effects between latent variables. First, RECENT_CHANGE is mostly influenced by ACCU_CHANGE (0.648). 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.

Table 4. 5. Standardized direct effects between latent variables

Relationships	Parameter	Std. err.	t value	sig.
Influence of ACCU_CHANGE on				
RELIABILITY	0.587	0.592	5.315	***
ATTD_CAPACITY	0.718	0.540	5.259	***
RISK_PERCEPT	0.785	0.947	4.601	***
ATTD_PASS-LASTING	0.423	0.371	4.622	**
Influence of RELIABILITY				
RISK_PERCEPT	-0.155	0.047	-3.441	***
RECENT_CHANGE	0.262	0.003	4.385	***
Influence of ATTD_CAPACITY on				
RISK_PERCEPT	-0.517	0.101	-7.144	***
ATTD_PASS-LASTING	0.102	0.046	2.288	***
RECENT_CHANGE	0.493	0.006	5.173	***
Influence of RISK_PERCEPT on RECENT_CHANGE	0.329	0.003	4.796	***
Influence of ATTD_PASS-LASTING on RECENT_CHANGE	0.069	.002	2.024	**

Note: ** significant at 5% level and *** significant at 1% level.

Table 4. 6. Standardized total effects between latent variables

Exogenous variables / Endogenous variables	ACCU_CHANGE	ATTD_CAPACITY	RELIABILITY	ATTD_PASS-LASTING	RISK_PERCEPT
ATTD_CAPACITY	0.718				
RELIABILITY	0.587				
ATTD_PASS-LASTING	0.497	0.102			
RISK_PERCEPT	0.323	-0.517	-0.155		
RECENT_CHANGE	0.648	0.331	0.211	0.069	0.329

The direct effects shown in Table 4.5 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_CPACITY. 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.

4.4.3 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 4.7 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).

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 Figure 4.1, 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).

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).

Table 4. 7. Standardized effects between latent variables and observed variables

	Parameter	std. err.	t value	sig.
RELIABILITY				
The information announced by the central government (homepage information, 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	8.855	***
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	16.62	***

		Parameter	std. err.	t value	sig.
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	***
(Trust) Can trust that Japanese health and medical institutions can prevent the spread of COVID-19		0.676	0.034	31.501	***
(Trust) Can trust that the central government can prevent the spread of COVID-19		0.864	0.047	29.849	***
(Trust) Can trust that the local government in the residence municipality can prevent the spread of COVID-19		0.860	0.043	31.331	***
ATTD_PASS-LASTING					
L	Life needs	0.668			
ASTING	Activity, Space, Time and Timing	0.681	0.021	48.215	***
	Prepare	0.537	0.034	23.362	***
P	Protect	0.700	0.033	29.392	***
	Provide	0.563	0.038	24.308	***
	Avoid	0.764	0.035	28.862	***
A	Adjust	0.770	0.036	30.207	***
	Shift	0.633	0.039	25.241	***
S	Share	0.572	0.039	23.772	***
	Substitute	0.697	0.036	27.711	***
S	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	***

	Parameter	std. err.	t value	sig.
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	***

4.4.4 Associations of observed variables with latent variables

It is important to rebuild confidence in using public transport; however, as shown in Table 4.2, 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 RECENT_CHANGE 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.

4.5 Conclusion

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 chapter 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 of behavioral and psychological adaptations to COVID-19 with respect to 2,643 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 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 psychological 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, psychological factors, and the most recent behavior changes. In other words, accumulated behavior changes in the past affect all the subjective psychological 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 Figure 4.2.

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.

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 psychological factors, 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.

CHAPTER 5 Influences of preparedness and correlated cultural and psychological factors on choice behaviors in response to COVID-19: A case study on travel mode choices

5.1 Introduction

The COVID-19 pandemic has caused various changes to the transport sector and as a result, enormous efforts have been made to address such changes (e.g., Rothengatter et al., 2021; Zhang et al., 2021b; Zhang and Hayashi, 2022a,b). Even though there are a rich body of studies on transport and COVID-19, there are still many unresolved research issues, among which travel mode choices are an under-researched topic. Therefore, this study focuses on the travel mode choices under the COVID-19 pandemic.

Decline in public transport and increase in car and active transport have been commonly observed in countries all over the world on one hand, while existing studies have mainly targeted a specific country on the other, leading to the observed factors affecting travel mode choices to be largely dependent on the targeted country. The risk of COVID-19 infection is obviously the key factor that should be influential to travel mode choices; however, the reality suggests that the risk perception is not always the same among people. Unfortunately, such a heterogeneity has not been well investigated from perspectives of theoretical thinking and improvements of both survey and modeling methods. To enhance people's proper perception about infection risk, efforts of both health/medical agencies and governments are crucial but unfortunately, such efforts have not been always highly evaluated by general public (Zhang, 2021). In this regard, the role of trust in health/medical agencies and governments has remained ill explored. Risk communication is essential to the pandemic policymaking; however, existing communication practices are often ineffective and sometimes even improper (Zhang, 2021). There are various reasons for such an inconvenient practice, among which the ignorance or disrespect of cultural aspects related to people's decisions on the way to be involved in the pandemic policymaking process may be one of the reasons. While preparedness is crucial to survive from pandemics (Zhang, 2020; Zhang et al., 2021b), it is unclear whether preparedness is helpful or not. In the case of travel mode choices, travel habit has been long recognized to be a key factor affecting travel

behavior. Such a habit, especially formed during influenza seasons is a kind of preparedness; however, such during-influenza risk-concerned travel habits formed before the COVID-19 pandemic have not been investigated in the context of COVID-19.

Keeping the above unresolved research issues in mind, this study makes several initial attempts to revisit factors affecting the travel mode choices under the COVID-19 pandemic, to the best of authors' knowledge. First, this chapter examines the factors to travel mode choices by combining data (valid sample: 7,245 respondents) collected from six developed countries (Australia, Canada, Japan, New Zealand, the US, and the UK) in March-April 2021. Second, cultural risk factors, classifying people into four types, are introduced to the analysis. Third, the travel habits (corresponding to different risk levels) formed for the survival during influenza seasons before the COVID-19 pandemic are incorporated into the analysis. Fourth, the "risk perception" – "trust" – "cultural risk factors" relationships are jointly reflected in the representation of travel mode choices based on a mixed hybrid choice model, where a mixed logit model is adopted to properly reflect the influences of unobserved heterogeneities (or taste variations) related to key travel attributes. Combining data from the six countries is expected to better capture the role of cultural risk factors in people's decisions on travel mode choices. The above modeling analysis is conducted with respect to major travel purposes (work/study, shopping, eating out, physical exercise, party, cultural leisure, and medical activities).

5.2 Data and descriptive analysis

A comparative survey of activity-travel and social contact before-during COVID-19 was conducted in all the six developed countries (Australia, Canada, Japan, New Zealand, the US, and the UK), which includes daily travel mode choices with respect to the following main travel purposes (or activities): work/study, shopping (at supermarket/shopping mall), eating out (at restaurants), physical exercise (at indoor places (e.g., gym)), party (at indoor public places (e.g., bar)), cultural leisure (e.g., visiting cinema, concert hall, etc.), and medical activities (e.g., see a doctor, purchase medicine). Travel mode choices are asked with respect to both before and during the COVID-19 pandemic. The before-pandemic period refers to popular influenza seasons when people may also need to pay attention to be infected by influenza viruses. Travel modes contain shared mobility (Uber/DiDi/Grab, etc.), taxi, bus, rail (train, metro, street car, etc.), private car, and active transport (walk, bicycle).

During the COVID-19 pandemic, some individuals may totally stop several activities as a protective measure (Zhang, 2020). Because this study investigates travel mode choices, data without out-of-home activities are excluded. As a result, the sample sizes for different travel purposes are 3,776 respondents for work/study; 7,042 for shopping; 4,412 for eating out; 3,366 for physical exercise; 2,998 for party; 3,039 for cultural leisure; and 5,545 for medical activities. Obviously, during the pandemic, there were more people who worked/studied from home and reduced the participation to party, cultural leisure and physical exercise. The smallest reduction was shopping. In this study, travel mode choices

are analyzed for different travel purposes, separately.

Table 5.1 shows the distributions of respondents' gender, age, and number of household members by travel purpose. Male respondents performed more daily activities than female during the COVID-19 pandemic, except shopping and medical activities. Among all age groups, young adults (20–29 years old) showed the largest share of participating in out-of-home activities, followed by the 30–39 group. The traveling share was the smallest for the 15–19 group, followed by the groups aged 60 and above. Among all household groups, the respondents living in a two-member household account for the largest share of the participation in out-of-home activities, while the one-member, three-member and four-member households have similar shares.

Table 5. 1. The sample distributions of gender, age, and number of household members by travel purposes

Individual and household attributes \ Travel purpose		Work/ Study (%)	Shopping (%)	Eating out (%)	Physical exercise (%)	Party (%)	Cultural leisure (%)	Medical activities (%)
Gender	Female	46.3	51.0	48.5	45.2	44.7	45.3	50.6
	Male	53.7	49.0	51.5	54.8	55.3	54.7	49.4
Age	15–19	2.9	1.9	2.3	2.6	2.5	2.4	1.9
	20–29	26.8	18.8	23.3	26.7	27.9	27.6	19.1
	30–39	21.8	16.7	19.3	21.7	22.1	22.3	16.7
	40–49	19.9	16.2	17.0	17.2	18.3	17.3	15.7
	50–59	16.2	16.8	14.9	13.3	13.1	13.1	15.9
	60–64	4.7	7.1	5.1	4.3	3.7	4.1	6.7
	65–69	3.5	8.3	6.4	5.4	4.6	4.3	8.5
	70 and above	4.3	14.1	11.8	8.8	7.9	8.9	15.3
Number of household members	1	21.0	21.0	18.3	17.0	16.8	20.0	20.5
	2	27.0	36.0	33.8	30.2	30.5	27.9	36.1
	3	20.9	19.2	20.3	21.5	21.4	21.4	19.1
	4	20.7	15.7	18.3	20.6	20.8	20.2	16.2
	5	6.8	5.3	6.0	6.5	6.5	6.4	5.3
	6 and above	3.5	2.9	3.3	4.2	4.0	4.1	2.9

The descriptive analysis of modeling factors is introduced in subsequent sections.

5.2.1 Choices of travel modes

In this retrospective survey, respondents were asked to report their main travel modes for different travel purposes (=activities), including shared mobility (Uber/ DiDi/ Grab, etc.) and taxi, bus, rail (train, metro, streetcar, etc.), private car, and active transport (walk, bicycle) for both before and during the COVID-19 pandemic.

Figure 5.1 shows the travel mode choice shares during the pandemic. Private car accounts for a preponderant share of 59.0% or above for all travel purposes, where the share even reaches 73.1% for shopping. The second largest shares are observed with respect to active transport, between 11.0% (for party) and 19.6% (for physical exercise), which are however much smaller than the car shares. The third

largest shares are related to rail, ranging between 3.6% (for shopping) and 10.6% (cultural leisure). The shares of shared mobility and taxi and bus are similar.

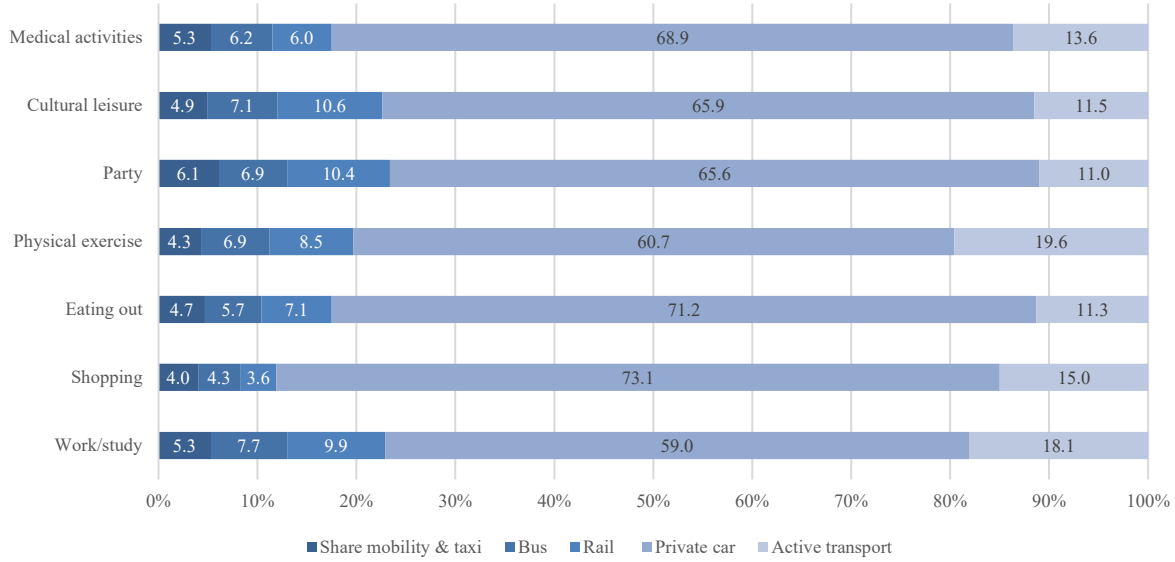

Figure 5. 1. Choices of travel modes by travel purpose during the COVID-19 pandemic

Table 5.2 shows the changes (measured by a percentage value) in travel mode choices and trip reductions before and during the COVID-19 pandemic. It is found that the pandemic led to an obvious reduction of people's daily trips, especially for leisure purposes (cultural activities: -31.6%, eating out: -29.8%, party: -29.4%, physical exercise: -22.4%). The shopping trips show the least decline (-6.0%), followed by medical activities (-9.1%) and work/study (-9.4%). Trips of shopping, commuting and medical activities decreased less than other leisure trips, which may be because these three kinds of trips are essential to people. About the travel mode changes, it is observed that the largest decline in mode choice shares was the use of rail for cultural leisure (-51.6 percentage points) and the least changes were the use of private car for work/study (-1.8 points) and shopping (+1.8 points). Larger declines were found with respect to private car for cultural leisure (-48.4), bus for cultural leisure (-46.4), shared mobility and taxi for party (-45.2) and rail for party (-45.0). Among all travel modes, public transport modes (bus and rail) showed the largest declines. Comparing all travel purposes, cultural leisure and party showed the largest declines in all travel modes. Looking at those travel modes with an increased share, they are active transport for shopping (+10.8) and for work/study (+8.3) and shared mobility and taxi for medical activities.

Table 5. 2. Changes in travel mode choices and trip reduction before and during the COVID-19 pandemic

Travel purpose	Shared mobility & taxi (%)	Bus (%)	Rail (%)	Private car (%)	Active transport (%)	Trip reduction (%)
Work/study	-17.4	-36.5	-36.6	-1.8	8.3	-9.4
Shopping	-18.2	-24.2	-28.6	1.8	10.8	-6.0
Eating out	-31.9	-43.9	-27.8	-31.6	-21.6	-29.8
Physical exercise	-15.2	-34.5	-22.0	-27.9	-20.6	-22.4
Party	-45.2	-32.5	-45.0	-41.6	-39.6	-29.4
Cultural leisure	-34.8	-46.4	-51.6	-48.4	-36.5	-31.6
Medical activities	5.4	-27.8	-24.6	-12.2	-17.3	-9.1

Note: The values (percentage points) are the shares during COVID-19 minus those before COVID-19.

5.2.2 Psychological risk factors

1) Risk perception

Risk perception has been revealed to affect people's various behaviors performed during the COVID-19 pandemic (e.g., Chan et al., 2020; Ding and Zhang, 2021; Zhang, 2021). In the survey, individuals' risk perceptions about the infection of COVID-19 are measured at the following four spatial levels: (1) in the whole country, (2) in the residence municipality, (3) at respondents' frequently-visited places (e.g., workplaces, schools, supermarkets, restaurants, gyms), and (4) inside crowded public transport vehicles, by asking the following question, where a five-point Likert scale (i.e., 1: strongly disagree, 2: somewhat disagree, 3: Neither agree nor disagree, 4: somewhat agree, 5: strongly agree) is adopted.

To what extend do you agree or disagree to each of the following statements related to COVID-19?

1. The COVID-19 outbreak in your residence country is severe than many other countries.
2. The infection risk of COVID-19 in your residence country is high
3. The infection risk of COVID-19 in your residence region (prefecture, province, state) is high
4. The infection risk of COVID-19 in your residence municipality is high
5. The infection risk of COVID-19 in the place where you often go (workplaces, schools, supermarkets, restaurants, gyms, etc.) in your daily life is high
6. The infection risk of COVID-19 in crowded train or bus is high

To ensure the fit of model, only the question 2, 4, 5 and 6 are included in the model, the

distributions of these questions are summarized in Figure 5.2.

As shown in Figure 5.2, most of the respondents thought that the infection risk in crowed public transport vehicles increased when performing all types of activities during the COVID-19 pandemic (the "agree" (strongly agree or somewhat agree) responses range from 59.9% to 66.8%). The "agree" shares for high-risk perception in the whole country are from 43.7% to 50.7% (especially for work/study). The "agree" shares are obviously higher than the shares of "disagree" (strongly disagree or somewhat disagree) in crowed public transport vehicles and the whole country; however, the differences between "agree" and "disagree" are minor in the residence municipality or those frequently visited places in people's daily lives. The respondents who had a travel for work/study (agree: 41.2%, disagree: 35.5%) and physical exercise (agree: 39.5%, disagree: 39.1%) thought the risk of infection in the residence municipality increased. However, for respondents travelling for other purposes, more people disagree that the risk of infection increased during the pandemic (agree: from 34.7% to 38.2%, disagree: from 41.2% to 44.1%). More respondents who had a travel for work/study (agree: 43.2%, disagree: 31.9%), physical exercise (agree: 39.8%, disagree: 35.4%), party (agree: 40.0%, disagree: 36.8%) and cultural leisure (agree: 40.6%, disagree: 36.1%) thought that their frequently-visited places were riskier during the COVID-19 pandemic, while interestingly, those people travelling for eating out are less likely to think that it is riskier at the restaurants they often visited (agree: 34.7%, disagree: 40.2%). The shares of "agree" and "disagree" for the risk in frequently visited places do not show significant differences for shopping and medical activities. Thus, both similarities and dissimilarities are observed with respect to the risk perception at the four spatial scales, which motivated us to make use of all of them in the modeling modeling analysis.

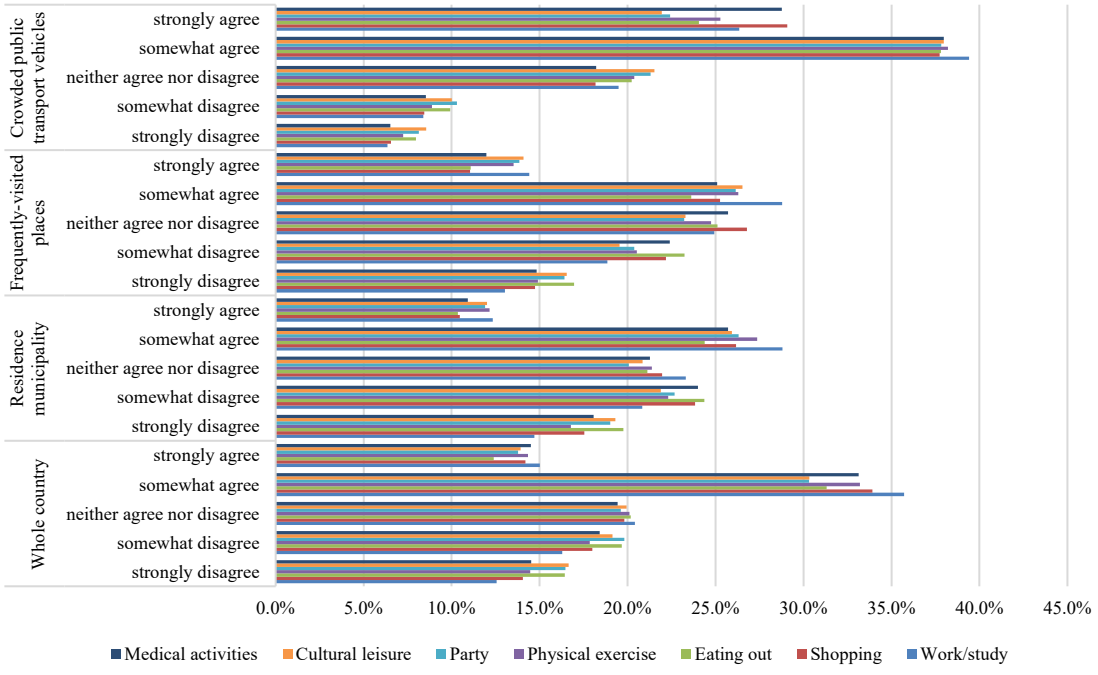

Figure 5. 2. The distributions of risk perception scores

2) Trust in governments and health/medical agencies

Governments and health/medical agencies are the key decision makers in the fight against COVID-19. People's trust in these decision makers has been influential to behavioral adaptation to the COVID-19 pandemic (Laato et al., 2020b; Sibley et al., 2020; Zhang, 2021). In this survey, the following question is prepared to measure people's trust in governments and health/medical agencies, using the same five-point Likert scale, as described above.

To what extend do you agree or disagree to each of the following statements related to COVID-19?

1. You can trust your residence country's health and medical institutions in preventing the spread of COVID-19.
2. You can trust your residence country's central government in preventing the spread of COVID-19.
3. You can trust your residence municipality's local government in your residence place in preventing the spread of COVID-19.

As shown in Figure 5.3, most of the respondents agreed that they trusted governments and health/medical agencies in preventing the spread of COVID-19 in the sense that the "agree" shares related to health/medical agencies range from 63.6% to 67.7%, central government from 59.7% to 64.4%, and local government from 59.9% to 64.2%. Only less than 20% of the respondents had a negative attitude (distrust) to governments and health/medical agencies. The "agree" shares of the trust in health/medical agencies are slightly higher than that to central and local governments, while the distrust in central government (from 15.7% to 20.3%) is slightly more obvious than that to local government (from 14.6% to 16.2%). People who had a travel for shopping (agree: 66.7%) and eating out (agree: 66.3%) have a slightly bigger share of trust in health/medical agencies than people with other travel purposes. People who traveled for party (central government: 64.4%; local government: 64.2%) and cultural leisure (central government: 63.8%; local government: 63.7%) are more likely to show a trust in governments.

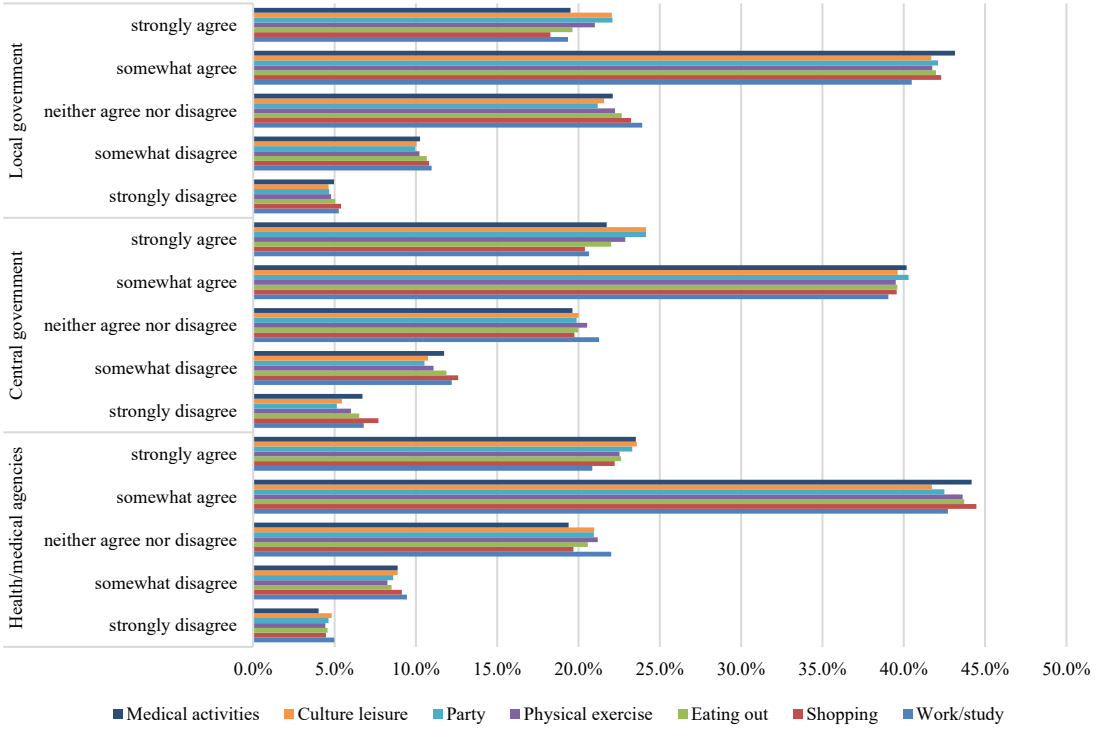

Figure 5. 3. The distributions of trust scores

5.2.3 Cultural risk factors

To mitigate the impacts of risk perception on people's behavioral adaptions to the COVID-19 pandemic, it is necessary to recognize the existence of people's various heterogeneities related to risk, especially knowing the empirical evidence that differentiated risk communication is crucial for controlling the pandemic effectively (Zhang, 2021). In this regard, the grid-group cultural theory of risk (Thompson et al., 2018; Wildavsky et al., 1987; Wildavsky et al., 1990) becomes relevant to this study, which classifies people into four types: hierarchist, egalitarian, individualist, and fatalist. Previous research assumed that an individual should belong to one of these four types; however, in reality, it may be difficult to classify him/her into one type. Instead of identifying one specific type, this study asked respondents to judge by themselves. To this end, the following question is asked in this study to capture such cultural risk factors, using the same five-point Likert scale, as described above, where the first statement is about hierarchist, the second about egalitarian, the third about individualist, and the last about fatalist.

To what extend do you agree or disagree to each of the following statements related to COVID-19?

1. You are a person who leaves important decisions to experts or government and support the social order.
2. You agree with that everyone is equal and the good of the many people comes before the good of any individual, the risk decision should be made by all people instead of a small elite or authority.
3. You agree with that individual freedom is absolutely important, and individual choices should not be constrained by society and other people?
4. You agree with that there is little you can do to control the environment so that you will receive whatever fate throws at you and try not to know or worry about it.

Figure 5.4 shows the shares of the four types of cultural risk factors or cultural orientations. There are more respondents showing a tendency of being an egalitarian (66.6%–69.3%) or a hierarchist (57.6%–60.0%) than those being an individualist (46.6%–54.5%) or a fatalist (42.2%–52.0%). Hierarchists and egalitarians have no obvious differences across travel purposes (less than 4 percentage point). In contrast, individualists and fatalists are mainly observed with respect to party (individualists: 54.5%; fatalists: 52.0%). Similar distributions of "agree" and "disagree" are found for the pairs of egalitarians-hierarchists and individualists-fatalists. Thus, there are more respondents showing a group/altruism orientation than those with ego-oriented cultural risk factors. On the other hand, egalitarians and hierarchists should be opposite to each other, as argued in the grid-group cultural theory of risk; however, the response overlaps between egalitarians and hierarchists were found, suggesting that a person can be an egalitarian and a hierarchist simultaneously. It is hard to define a boundary between egalitarians and hierarchists, or between individualists and fatalists in reality. It is therefore important to conduct more comprehensive analyses of the cultural theory of risk. This study attempts to provide additional insights related to the cultural risk factors in the context of COVID-19 and transport.

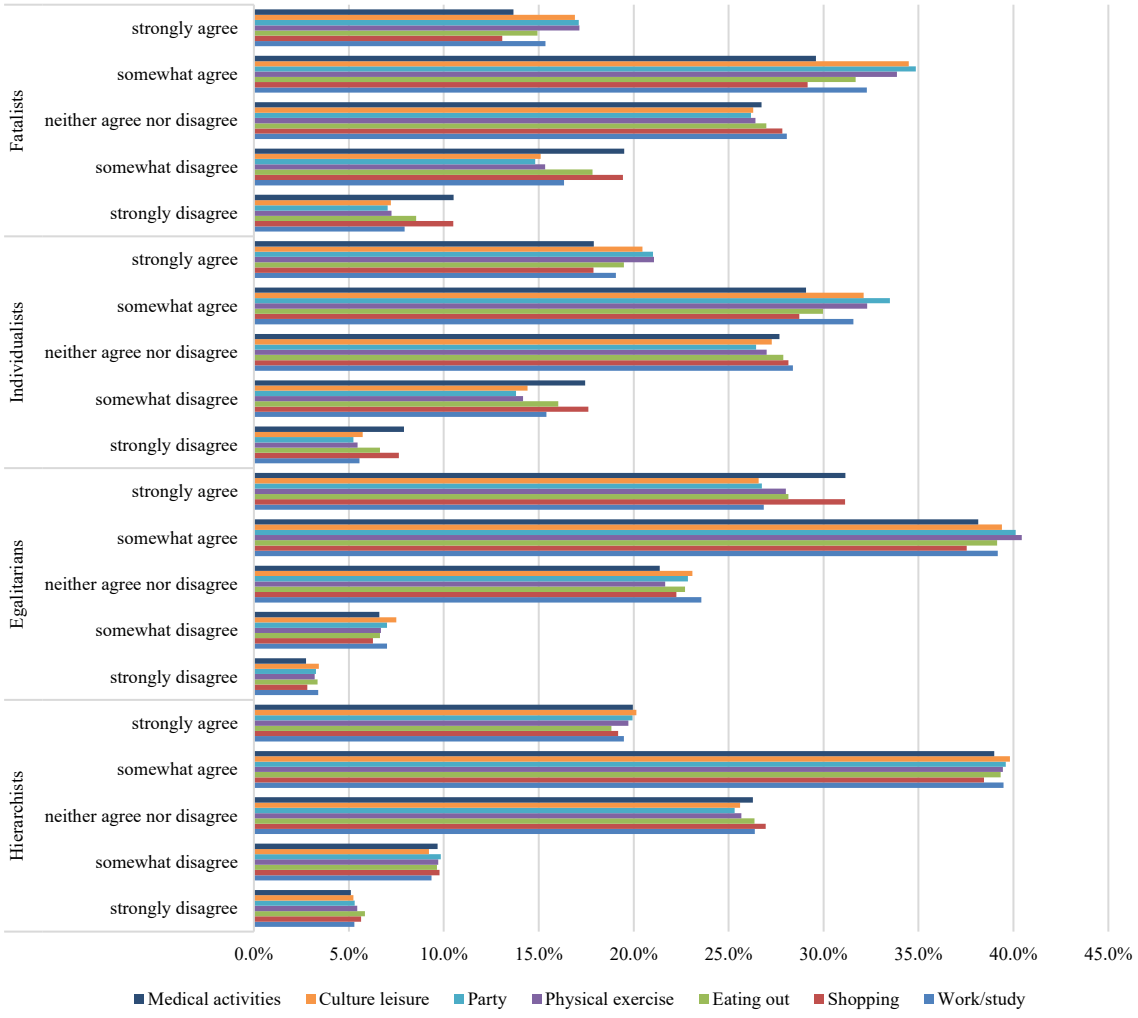

Figure 5. 4. The distributions of cultural risk factors by travel purpose

5.2.4 Pre-pandemic preparedness

Travel mode choices made before the pandemic are regarded as an indicator of travel habit, which is expected to affect travel behavior in the present. Generally speaking, people tend to avoid extra thinking and repeat some travel behaviors (e.g., travel mode choices) in daily life (González et al., 2017, Gao et al., 2020; Haggar et al., 2019). This kind of phenomenon is known as travel habit (Gärling & Axhausen, 2003, Lanzini & Khan, 2017), which is a spontaneous behavioral reaction caused by individuals' psychological inertia (Sommer, 2011; Haggar et al., 2019). Such an inertia is built by people's travel experience for a long time (Kitamura & Van Der Hoorn, 1987). As a result, the inertia is difficult to change and plays a crucial role in affecting individuals' choices of travel modes (Cherchi & Manca, 2011; Gao et al., 2020; González et al., 2017).

To analyze the effects of pre-pandemic preparedness on individuals' travel mode choices during the pandemic, risk-concerned travel mode choices made before the pandemic (i.e., during influenza

seasons) are classified into three types: the travel habits with high risk, middle risk, and low risk (Zafri et al., 2022). Public transport (bus and rail) is regarded to have high risk because people may have numerous direct or indirect contacts with others in the same vehicle. Shared mobility and taxi are classified to have middle risk because even though users may contact some others, but the number of in-vehicle social contacts can be controlled. Using a private car, an individual does not need to contact any others expect their companions they know. Active transport (walk, cycling) is conducted in an open outdoor environment. Hence, private car and active transport are regarded to have low risk. Figure 5.5 shows the distribution of travel habits. It is found that most people have a travel habit with low risk before the pandemic for all travel purposes. This is most obvious for shopping (83.7%) and medical activities (82.2%). The travel habit with high risk accounts for a bigger share in the cases of work/study (21.3%), cultural leisure (17.4%), party (17.5%) and physical exercise (16.4%).

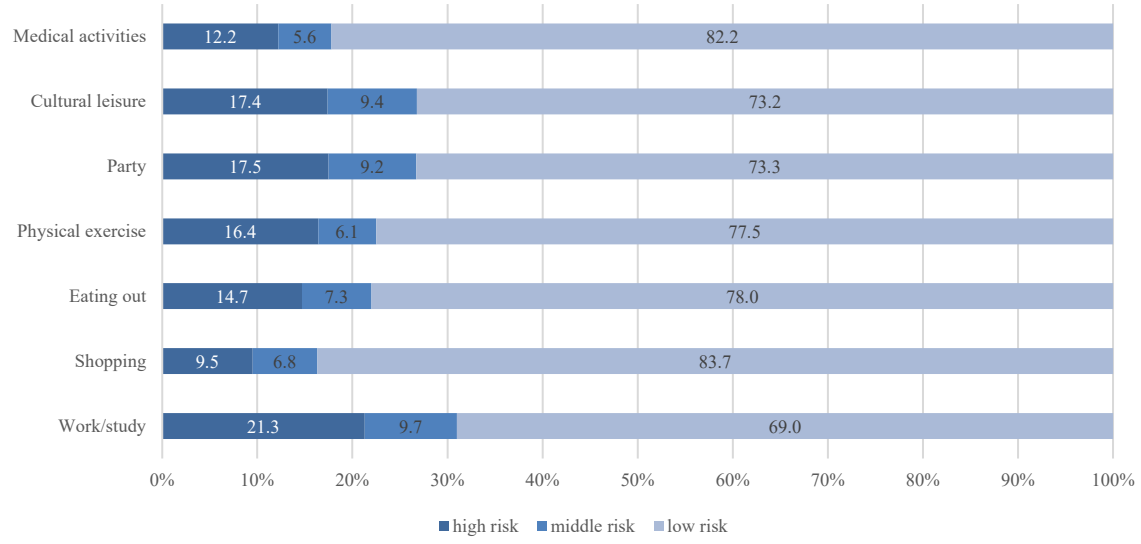

Figure 5. 5. The distributions of risk-concerned travel habits (or pre-pandemic preparedness) by travel purpose

5.2.5 Travel attributes

For a proper understanding of travel mode choices, travel time and travel companion are further investigated in the survey, by reflecting the findings from existing references (Chen et al, 2022; Efthymiou et al., 2016; Guo et al., 2020; Ho and Mulley, 2015; Weiss and Habib, 2020; Wu et al., 2011).

1) Travel time

In the survey, travel time was measured using the following four categorical scales: (1) less than 10 mins, (2) 10 mins – 30 mins, (3) 30 mins – 1 hour, and (4) 1 hour or longer. The distribution of travel

time is shown in Table 5.3. The second category shows the largest shares for all travel purposes, following by the first category for the travel purposes other than party and cultural leisure. There are more than 10% of respondents who had to take 1 hour or longer to go to workplace or go to school. There are more medical activities conducted within a travel time less than 10 minutes than the travel time between 30 minutes and 1 hour. Activities mainly conducted within a travel time less than 30 mins were shopping (82%), medical activities (74.1%) and eating out (73.2%). Activities needing a travel time longer than 30 mins include work/study (36.1%), party (36%) and cultural leisure (37.9%). In the modeling analysis of this study, each category of travel time was transformed into a continuous value for the chosen travel mode and for the unchosen travel modes, their travel times were calculated as the mean of travel time of all other respondents who lived in same area with him/her.

Table 5. 3. The distribution of travel time during the COVID-19 pandemic

Travel time categories	Work/ Study (%)	Shopping (%)	Eating out (%)	Physical Exercise (%)	Party (%)	Cultural leisure (%)	Medical activities (%)
Less than 10 mins	26.5	35.7	23.9	27.7	20.9	17.0	28.5
10 mins – 30 mins	37.4	46.3	49.3	42.1	43.1	45.1	45.6
30 mins – 1 hour	25.5	14.6	21.6	23.4	27.0	29.4	18.5
1 hour or longer	10.6	3.4	5.2	6.8	9.0	8.5	7.4

2) Travel companion

Travel companions include three types: travel with family (including spouse/couple, children/grandchildren, parents/grandparent), travel with friends (including close friend, other acquaintances), and travel alone. Respondents need to make a choice from these three options. As shown in Figure 5.6, during the COVID-19 pandemic, 60.1% of the respondents traveled alone for medical activities (60.1%) and 50.6% traveled alone for shopping, while 62.0% traveled with family for eating out. Other larger shares of traveling with family are cultural leisure (51.5%) and party (48.9%), followed by traveling with family for shopping (42.0%) and traveling alone for physical exercise (41.3%). As for traveling with friends, the largest share was found with respect to party (33.8%), while the smallest share was travel for shopping. Comparing all types of travel companions, traveling with family is more popular during the pandemic.

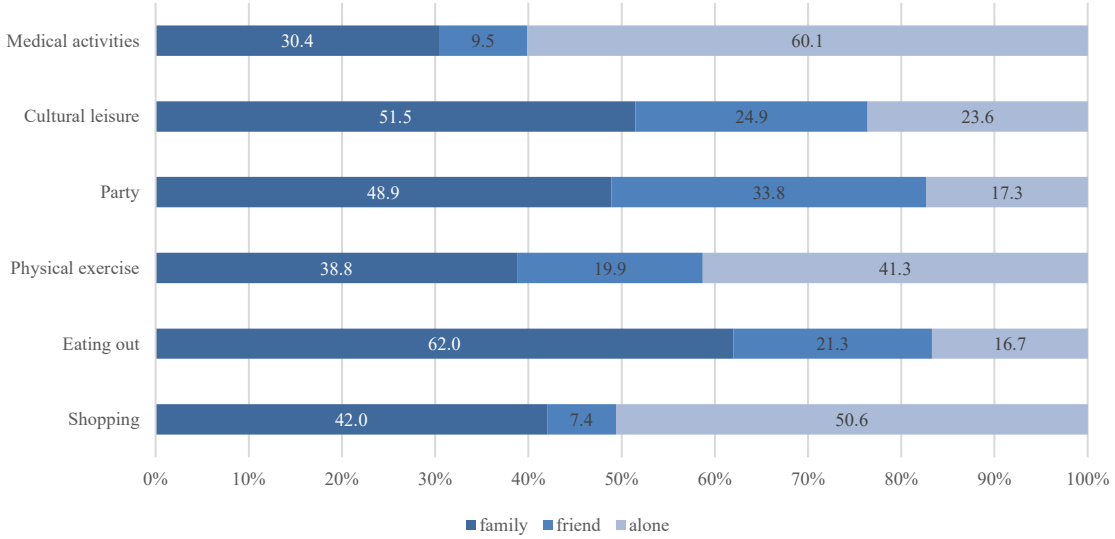

Figure 5. 6. The distributions of travel companions by travel purpose during the COVID-19 pandemic

5.3 Methodology and framework

5.3.1 Framework of XHCM

Here, a hybrid choice model (HCM) with three correlated latent variables (risk perception, trust, and cultural risk factors) is built to analyze travel mode choices under the impacts of COVID-19, where the structural equations represent the endogenous relations between the three latent variables are introduced to the utility equation together with during-pandemic travel attributes, pre-pandemic preparedness and individual/household attributes. To capture heterogenous influences of preparedness and travel attributes, a mixed logit model is adopted in HCM. As a result, a mixed hybrid choice model (XHCM) is built in this study, as shown in Figure 5.7, where both direct and indirect effects of the latent variables are incorporated.

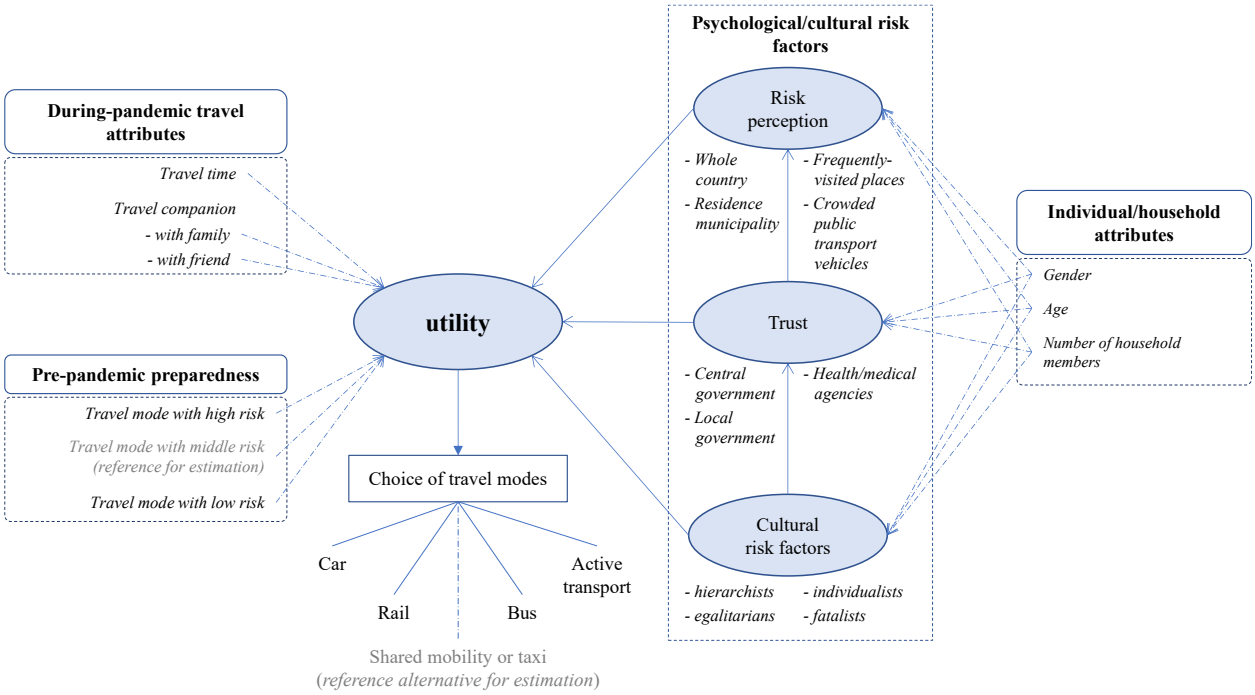

Figure 5. 7. A mixed hierarchical hybrid choice model (XHCM)

Existing studies showed that individuals' attitude factors are affected by cultural variables (Verweij, 2005; Nan et al., 2014; Atchley et al., 2014), and people's attitude toward agency is significantly associated with risk perception (Ding and Zhang, 2021; Prati et al., 2011; Siegrist et al., 2003). Considering the above existing evidence and its unconfirmed effects in the case of travel mode choices under the COVID-19 pandemic, Figure 5.7 adds a link from cultural risk factors to trust and a link from trust in risk perception. Thus, the structure of HCM is used to capture the endogenous relations between these three psychological/cultural risk factors.

Risk perception and trust in agency's risk management are two crucial components of the psychological analysis of risk (Slovic et al., 1991; Slovic, 1993; Dedeoğlu et al., 2021; Liu et al., 2020; Alaszewski, 2003). Trust and risk perception are the mirror image to each other (Das et al., 2004). In this study, risk perception is represented by four observed variables measured at four spatial levels: the whole country, residence municipality, frequently visited places, inside public transport vehicles. Trust is measured as attitudes toward central government, local government, and health/medical agencies, etc. Cultural risk factors are measured using four questions about how much a respondent think that he/she is a person of hierarchists, egalitarians, individualists, and fatalists, respectively, based on the cultural theory of risk (Thompson et al., 2018; Douglas, 1970; Douglas, M. 1982). The three latent variables of risk perception, trust and cultural risk factors are further explained by respondents' individual and household attributes (i.e., age, gender, and number of household members).

Because travel time (Molin & Timmermans, 2010; Guo et al., 2020; Chen et al., 2022), travel companion (LaMondia et al., 2010; Thrane et al., 2015; Böcker et al., 2016), travel habit (González et al., 2017; Lanzini & Khan, 2017; Gao et al., 2020) are crucial to travel mode choice decisions, all these variables are also introduced into the XHCM.

5.3.2 Equations included in the XHCM

1) Structural and measurement equations

The structural equations in the XHCM are defined as follows:

$$LV_{n,cul} = \sum_k \Upsilon_{cul,k} X_{n,k} + \eta_{n,cul}, \quad \eta_{n,cul} \sim N(0, \sigma^2_{\eta_{cul}}) \tag{5-1}$$

$$LV_{n,tu} = \sum_k \Upsilon_{tu,k} X_{n,k} + \Upsilon_{ct} LV_{n,cul} + \eta_{n,tu}, \quad \eta_{n,tu} \sim N(0, \sigma^2_{\eta_{tu}}) \tag{5-2}$$

$$LV_{n,rp} = \sum_k \Upsilon_{rp,k} X_{n,k} + \Upsilon_{tr} LV_{n,tu} + \eta_{n,rp}, \quad \eta_{n,rp} \sim N(0, \sigma^2_{\eta_{rp}}) \tag{5-3}$$

where $LV_{n,cul}$, $LV_{n,tu}$, and $LV_{n,rp}$ [$\boldsymbol{LV_{n,l}}$] are individual *n*'s latent variables representing risk perception (*rp*), trust (*tu*), and cultural risk factors (*cul*), respectively; $X_{n,k}$ is individual *n*'s *k*th attribute (e.g., age, gender, and the number of household members), and $\Upsilon_{cul,k}$, $\Upsilon_{tu,k}$, and $\Upsilon_{rp,k}$ [$\boldsymbol{\Upsilon_{l,k}}$] are the unknown parameters associated with the three latent variables; Υ_{ct} is the coefficient describing the influence of cultural risk factors on trust and Υ_{tr} is the coefficient indicating the influence of trust on risk perception [$\boldsymbol{\Upsilon_r}$: Υ_{ct}, Υ_{tr}]; $\eta_{n,cul}$, $\eta_{n,tu}$, $\eta_{n,rp}$ are the error terms of the three latent variables, respectively, each of which follows a normal distribution [$\boldsymbol{\eta_{n,l}}$].

A latent variable usually represents a common factor behind two or more some observed variables. Such a relationship is expressed as the following measurement equation:

$$I_{n,l,q} = \zeta_{l,q} LV_{n,l} + \delta_n, \quad \delta_n \sim N(0, \sigma^2_{\delta}) \tag{5-4}$$

where, $I_{n,l,q}$ is individual *n*'s *q*th observed variable corresponding to the *l*th latent variable $LV_{n,l}$ (*l* = *rp*, *tu*, *cul*) and $\zeta_{l,q}$ is the unknown parameter representing an association degree of $LV_{n,l}$ with $I_{n,l,q}$, and δ_n is a normally-distributed error term.

2) Utility equation

In addition to the above three latent variables, there are also other factors that are used to directly explain the choice utility. Such a utility function is expressed below.

$$U_{n,m} = \sum_s \beta_{m,s} X_{n,m,s} + \lambda_{rp,m} LV_{n,rp} + \lambda_{tu,m} LV_{n,tu} + \lambda_{cul,m} LV_{n,cul} + \varepsilon_{n,m} \tag{5-5}$$

Here, $U_{n,m}$ is the utility that individual *n*'s chooses travel mode *m*, $X_{n,m,s}$ indicates *n*'s *s*th variable that is used to directly explain the choice utility of travel mode *m* (as shown in Section 6, individual attributes are excluded from Equation (5-5) by referring to existing studies (e.g., Gao et al., 2020; Kamargianni et al., 2015; Kim et al., 2017; Scagnolari et al., 2015; Thorhauge et al., 2019)). $\lambda_{rp,m}$, $\lambda_{tu,m}$, and $\lambda_{cul,m}$ [$\boldsymbol{\lambda_{l,m}}$] represent the influences of the three latent variables $LV_{n,rp}$, $LV_{n,tu}$, and $LV_{n,cul}$ on the utility of travel mode *m*. And $\varepsilon_{n,m}$ is an error term, which is assumed to follow an

independent and identical Gumbel distribution. This distribution results in the so-called multinomial logit (MNL) model under the random utility maximization principle.

In this study, travel time, travel companion and pre-pandemic travel habits (i.e., preparedness) formed to avoid being infected are used as $X_{n,m,s}$. To capture the unobserved heterogeneities in these three observed travel-related attributes, each of them is assumed to have a random parameter $\beta_{m,s}$, which follow a normal distribution with mean $\beta^0_{m,s}$ and standard deviation σ_s. Related to travel time, such a normal distribution assumption allows the co-existence of negative and positive parameters. The logit model with unknown randomly distributed parameters related to explanatory variables is called mixed logit model. The model consisting of equations (5-1) – (5-5) with a mixed logit structure is called mixed hybrid choice model (i.e., XHCM).

5.3.3 Estimation

In this study, the above-built mixed hybrid choice model (XHCM) is estimated based on a maximum likelihood method, where the likelihood function is expressed as follows:

$$L_n = \int_{LV_{n,l}} \prod_m f_Y\left(y_{n,m}\middle|\begin{matrix}X_{n,m,s},\ \boldsymbol{LV_{n,l}};\\ \beta_{m,s},\ \boldsymbol{\lambda_{l,m}}\end{matrix}\right) \prod_q f_I\left(I_{n,l,q}\middle|LV_{n,l};\ \zeta_{l,q}\right) \prod_l f_L\left(LV_{n,l}\middle|\mathrm{X}_{n,k}, LV_{n,j}; \Upsilon_{l,k}, \Upsilon_j\right) dLV_{n,l} \tag{5-6}$$

where, *l* indicates one of the three latent variables of risk perception, trust and cultural risk factors; Υ_j refers to Υ_{ct} or Υ_{tr}; $f_Y(\cdot)$ (equation (5-7)) indicates the probability that individual *n* chooses travel mode *m* under the influences of explanatory variables $X_{n,m,s}$ and latent variables $\boldsymbol{LV_{n,l}}$; $f_I(\cdot)$ (equation (5-8)) is the joint density function related to each measurement equation, $f_L(\cdot)$ (function (5-9)) represents the joint density function of each structural equation, and $y_{n,m}$ (equation (5-10)) is a dummy variable indicating whether individual *n* chooses travel mode *m* or not (yes: 1, no: 0).

$$f_Y(\cdot) = \left(\frac{exp(\sum_s \beta_{m,s}X_{n,m,s} + \lambda_{rp,m}LV_{n,rp} + \lambda_{tu,m}LV_{n,tu} + \lambda_{cul,m}LV_{n,cul})}{\sum_{h\in H} exp(\sum_s \beta_{h,s}X_{n,h,s} + \lambda_{rp,h}LV_{n,rp} + \lambda_{tu,h}LV_{n,tu} + \lambda_{cul,h}LV_{n,cul})}\right)^{y_{n,m}} \tag{5-7}$$

$$f_I(\cdot) = \frac{1}{\sigma_{\delta,q}}\Phi\left(\frac{I_{n,l,q} - \zeta_{l,q}LV_{n,l}}{\sigma_{\delta,q}}\right) \tag{5-8}$$

$$f_L(\cdot) = \frac{1}{\sigma_{\eta,l}}\Phi\left(\frac{LV_{n,l} - \sum_k \Upsilon_{l,k}X_{n,k}}{\sigma_{\eta,l}}\right) \ \{\text{corresponding to equation (5-1)}\} \tag{5-9a}$$

$$f_L(\cdot) = \frac{1}{\sigma_{\eta,l}}\Phi\left(\frac{LV_{n,l} - \sum_k \Upsilon_{l,k}X_{n,k} - \Upsilon_r LV_{n,j}}{\sigma_{\eta,l}}\right) \ \{\text{corresponding to equations (5-2) and (5-3)}\} \tag{5-9b}$$

$$y_{n,m} = \begin{cases} 1, & if \quad U_{n,m} = \max_h \{U_{n,h}\} \\ 0, & otherwise \end{cases} \tag{5-10}$$

Here, $\Phi(\cdot)$ is the probability density function of a standard normal distribution.

As for the identification issues of the above XHCM, details refer to existing studies (e.g., Vij et al., 2014; Walker et al., 2004). To estimate this model, the software Apollo (Hess et al., 2019) was used, where a simulated estimation approach is generated by random Halton draws (Train, 2009).

5.4 Result and discussion

To run the above XHCM, 100 Halton draws were applied for each random parameter. For each activity category, the calculation time ranged between 31.82 min and 93.83 min, using a desktop PC (Inter ® Core™ i7-9700 / 14 Core / 3.00GHz). Tables 5.4–5.6 shows the modeling estimation results with respect to the following seven trip purposes: work/study, shopping, eating out, physical exercise, party, cultural leisure, and medical activities. As shown in Table 5.4, the Rho-squared values of the XHCM models range from 0.47 to 0.62, indicating that the modeling accuracy is sufficiently high. There are totally 502 unknown parameters in Tables 5.4-5.6, among which 304 parameters (60.6%) are statistically significant. Concerning trip purposes, the model for medical activities has the largest share (77.0%) of significant parameters, while the model for work/study has the smallest share (41.4%). As for structural parameters of latent variables, even though there are more insignificant parameters representing the direct effects of risk perception, trust and cultural risk factors, there are more significant parameters indicating the influence of cultural risk factors on trust and the influence of trust on risk perception. All the above observations suggest that the adopted XHCM is acceptable to conduct analyses for achieving the research purpose of this study.

Table 5. 4. Estimation results of mixed hybrid choice model: Utility equation

Explanatory variables \ Travel purposes			Work/Study		Shopping		Eating out		Physical exercise		Party		Cultural leisure		Medical activities	
			Est.	t-val.	Est.	t-val.	Est.	t-val.	Est.	t-val.	Est.	t-val.	Est.	t-val.	Est.	t-val.
Travel time	Bus	Mean μ	-0.05	-3.50	-0.06	-4.04	-0.09	-4.70	0.02	0.85	-0.13	-4.57	-0.05	-1.14	-0.24	-6.60
		STDEV σ	0.12	7.76	0.08	8.63	0.16	6.73	0.15	8.33	0.19	5.94	0.13	3.59	0.41	8.18
	Rail	Mean μ	-0.02	-2.35	-0.07	-3.12	-0.06	-2.94	0.01	0.09	-0.04	-2.41	0.03	2.88	-0.03	-3.12
		STDEV σ	0.08	8.42	0.10	4.64	0.09	4.48	0.15	10.03	0.08	5.07	0.07	8.23	0.06	5.52
	Car	Mean μ	0.01	2.12	-0.01	-4.14	-0.01	-2.75	-0.06	-5.07	0.01	0.61	0.01	0.79	0.01	-0.37
		STDEV σ	0.01	2.22	0.01	0.41	0.01	2.64	0.23	8.17	0.01	1.06	0.01	2.73	0.01	1.26
	Active transport	Mean μ	-0.17	-7.55	-0.24	-5.50	-0.12	-5.84	0.03	1.51	-0.11	-4.96	-0.11	-6.73	-1.69	-5.29
		STDEV σ	0.20	8.37	0.22	6.00	0.13	11.55	0.10	5.07	0.15	7.24	0.13	7.42	1.32	5.33
	Bus	Mean μ	-	-	-0.75	-2.25	-0.81	-1.81	-2.18	-1.82	1.92	2.46	-0.73	-1.59	-1.41	-3.13
		STDEV σ	-	-	0.96	1.61	0.87	1.53	3.54	2.94	3.24	3.00	0.05	0.06	1.23	2.55
	Rail	Mean μ	-	-	-0.75	-1.79	-0.35	-0.72	-3.01	-2.53	-1.18	-1.23	-0.66	-1.70	-0.67	-1.98
		STDEV σ	-	-	2.69	4.78	2.16	4.39	4.29	3.89	2.35	2.73	0.79	1.34	0.45	0.83

Explanatory variables \ Travel purposes			Work/Study		Shopping		Eating out		Physical exercise		Party		Cultural leisure		Medical activities	
			Est.	t-val.	Est.	t-val.	Est.	t-val.	Est.	t-val.	Est.	t-val.	Est.	t-val.	Est.	t-val.
Travel companion of family	Car	Mean μ	-	-	-1.13	-1.07	-0.76	-2.04	-3.22	-1.70	-1.54	-2.05	-0.50	-1.67	-1.54	-6.38
		STDEV σ	-	-	1.27	3.06	2.40	6.49	5.07	4.33	4.23	5.45	1.05	2.39	0.30	0.76
	Active transport	Mean μ	-	-	-1.66	-5.61	-1.05	-2.51	-4.09	-3.21	-2.17	-2.33	-0.71	-1.95	1.84	1.07
		STDEV σ	-	-	0.41	1.10	0.45	1.10	3.90	3.12	1.57	1.68	1.40	2.26	7.20	3.33
Travel companion of friend	Bus	Mean μ	-	-	-49.60	-7.85	-0.01	-0.02	-2.04	-1.65	1.91	2.28	-0.22	-0.42	9.18	5.16
		STDEV σ	-	-	41.79	8.86	0.53	0.76	3.18	2.45	3.33	2.96	0.59	0.66	15.28	6.06
	Rail	Mean μ	-	-	-0.54	-1.01	0.91	1.40	-2.64	-2.13	-0.55	-0.53	-0.24	-0.58	-3.76	-4.96
		STDEV σ	-	-	2.50	2.67	1.30	1.75	3.99	3.44	2.27	2.29	0.54	0.65	3.72	4.62
	Car	Mean μ	-	-	-0.52	-1.12	-0.33	-0.64	-2.79	-2.27	-1.28	-1.35	-0.34	-1.04	1.36	0.96
		STDEV σ	-	-	2.43	3.26	1.69	2.75	4.72	3.72	3.71	3.30	0.76	1.35	28.75	6.54
	Active transport	Mean μ	-	-	-6.36	-4.30	-0.03	-0.05	-3.61	-2.94	-1.46	-1.40	-0.28	-0.68	-47.43	-7.98
		STDEV σ	-	-	3.83	2.98	0.07	0.10	2.94	2.44	0.85	0.77	0.72	1.11	58.84	9.40
Pre-pandemic preparedness: Travel habit with high risk	Bus	Mean μ	3.00	5.33	4.31	11.71	4.84	6.02	1.71	3.72	2.45	5.61	2.89	4.61	11.18	8.38
		STDEV σ	4.34	4.50	0.75	0.94	5.99	5.03	2.36	2.20	2.58	2.75	4.30	6.41	14.33	8.10
	Rail	Mean μ	2.24	5.19	5.72	12.45	3.96	4.84	2.09	4.62	3.42	6.91	1.85	3.83	4.14	4.77
		STDEV σ	3.38	3.84	4.14	4.36	1.79	1.45	1.60	1.56	0.80	0.91	5.52	7.06	3.22	2.76
	Car	Mean μ	1.17	3.52	1.47	4.03	1.91	2.55	0.84	1.50	2.16	3.04	0.24	0.65	1.00	1.28
		STDEV σ	1.91	2.07	0.55	0.63	3.18	2.94	1.86	1.60	3.59	2.31	0.52	0.78	3.87	2.72
	Active transport	Mean μ	2.52	4.76	4.92	10.78	3.67	4.83	0.77	1.02	3.39	6.17	1.74	3.99	14.48	5.82
		STDEV σ	3.27	3.48	3.04	3.63	4.14	4.03	0.13	0.10	4.77	4.22	1.77	2.69	7.79	3.84
Pre-pandemic preparedness: Travel habit with low risk	Bus	Mean μ	15.14	4.24	4.80	3.82	3.43	4.23	1.02	1.70	0.91	0.69	1.20	2.21	6.95	9.10
		STDEV σ	6.17	3.74	1.07	0.95	6.16	11.21	1.70	1.42	2.27	2.64	3.95	10.36	14.48	8.82
	Rail	Mean μ	13.83	3.92	7.01	5.86	3.51	4.81	1.77	3.40	3.33	2.08	0.34	0.67	1.82	4.76
		STDEV σ	5.23	3.21	6.97	6.44	0.75	2.01	1.51	1.28	0.52	0.39	4.39	11.03	2.30	5.08
	Car	Mean μ	17.98	5.05	7.54	6.29	5.72	8.76	4.96	7.56	5.67	4.07	2.70	9.32	4.21	13.6
		STDEV σ	9.65	5.15	3.19	3.33	3.87	8.48	2.18	1.86	5.20	4.99	1.50	7.95	0.31	1.27
	Active transport	Mean μ	18.83	5.17	9.15	6.82	6.29	9.58	3.34	3.95	6.06	4.38	3.28	11.09	16.72	6.12
		STDEV σ	7.53	4.44	5.11	4.93	4.22	9.15	0.36	0.26	5.47	5.16	1.69	9.30	7.11	6.19
Direct effect of risk perception (*rp*)		Bus	0.33	0.06	-5.62	-1.52	-10.27	-0.58	-10.13	-0.83	-3.30	-0.18	-0.89	-0.20	34.26	2.91
		Rail	0.23	0.06	-12.86	-7.12	-14.29	-0.94	-15.21	-0.73	-1.83	-0.03	10.79	3.44	7.41	1.69
		Car	0.16	0.03	0.28	0.17	18.63	1.36	-58.95	-3.07	8.08	0.17	-9.76	-3.03	-11.53	-1.96
		Active transport	0.33	0.06	-1.63	-0.55	-6.46	-0.39	-33.02	-1.98	3.94	0.06	-4.34	-1.39	-13.63	-0.45
Direct effect of trust (*tu*)		Bus	-2.10	-0.09	15.66	0.93	36.02	0.55	-5.31	-0.54	-1.50	-0.19	2.60	0.20	-45.70	-1.90
		Rail	-1.22	-0.09	17.68	2.02	50.23	0.85	4.08	0.51	-1.05	-0.05	-30.87	-2.94	-9.84	-1.41
		Car	-1.36	-0.08	2.23	0.24	-65.29	-1.14	-8.15	-0.22	2.49	0.17	28.04	2.66	15.15	1.57
		Active transport	-1.49	-0.08	11.41	0.73	23.23	0.40	-13.07	-0.55	1.06	0.05	12.48	1.39	18.16	0.45
Direct effect of cultural risk factors (*cul*)		Bus	-0.23	-0.28	5.62	1.33	1.58	0.58	4.98	0.40	0.03	0.03	-0.43	-0.50	-6.34	-3.51
		Rail	-0.22	-0.40	25.61	6.71	2.47	0.84	15.57	0.90	0.11	0.04	0.69	0.09	-1.38	-1.78
		Car	-0.28	-0.42	-2.72	-1.04	-3.66	-1.22	42.97	1.36	-0.88	-0.48	-1.59	-0.23	1.95	2.07
		Active transport	-0.35	-0.47	-2.94	-0.82	0.58	0.17	18.20	0.69	-0.61	-0.22	-0.73	-0.24	2.58	0.51
Structural equation: Influence of cultural risk factors on trust (*ct*)			-0.61	-0.72	-0.34	-4.00	-0.47	-3.41	-1.69	-9.07	-1.69	-4.21	3.81	2.90	1.02	2.32
Structural equation: Influence of trust on risk perception (*tr*)			1.58	0.70	2.87	13.88	1.94	2.21	0.24	1.11	1.02	1.17	2.64	8.49	0.92	3.07
AIC			123876.3		228759.8		142787.1		109941.8		97181.7		98947.6		180531	
BIC			124478		229554.1		143541.6		110673.3		97903.4		99670.5		181304.9	
LL(0, choice)			-6077.2		-11333.7		-7100.8		-5417.4		-4825.1		-4891.1		-8924.3	
LL(final, choice)			-3222.4		-4255.5		-2897.9		-2847.9		-2422.7		-2469.1		-3460.3	
Rho-squared			0.47		0.62		0.59		0.47		0.50		0.50		0.61	

Note: The values shown in grey indicate insignificant parameters and the other values represent significant parameters with the significance level of 5% or lower.

Table 5. 5. Estimation results of mixed hybrid choice model: Measurement equations

Latent variables	Observed variables	Work/ study		Shopping		Eating out		Physical exercise		Party		Cultural leisure		Medical activities	
		Est.	t-val.	Est.	t-val.	Est.	t-val.	Est.	t-val.	Est.	t-val.	Est.	t-val.	Est.	t-val.
Risk perception (*rp*)	whole country	0.57	0.83	0.29	8.64	0.46	2.77	1.04	6.15	3.15	0.94	0.07	2.90	0.34	3.92
	Residence municipality	0.59	0.83	0.30	8.68	0.49	2.76	1.12	6.10	3.35	0.94	0.07	2.89	0.35	3.86
	frequently-visited places	0.55	0.83	0.27	8.52	0.44	2.75	1.04	6.09	3.11	0.94	0.07	2.90	0.32	3.86
	crowded public transport vehicles	0.35	0.83	0.16	7.73	0.28	2.71	0.59	5.69	1.91	0.94	0.04	2.91	0.20	3.92
Trust (*tu*)	Health/medical agencies	-1.12	-0.45	-0.87	-8.26	-0.86	-3.76	0.68	3.41	0.62	1.74	-0.10	-3.37	-0.23	-4.80
	central government	-1.33	-0.45	-1.05	-8.29	-0.98	-3.80	0.76	3.41	0.64	1.74	-0.10	-3.35	-0.28	-4.62
	local government	-1.07	-0.45	-0.89	-8.30	-0.84	-3.75	0.65	3.36	0.54	1.75	-0.08	-3.28	-0.23	-4.67
Cultural risk factors (*cul*)	Hierarchists	0.01	0.10	-0.26	-11.09	-0.08	-1.66	-0.16	-4.76	-0.05	-1.32	-0.12	-3.69	-0.01	-0.95
	Egalitarians	0.01	1.19	-0.15	-6.97	-0.09	-2.02	-0.14	-3.91	-0.07	-1.98	-0.12	-3.79	-0.02	-2.30
	Individualists	0.07	1.68	0.02	0.95	0.15	6.84	0.10	2.33	0.13	5.98	0.12	5.46	0.09	7.16
	Fatalists	0.09	1.72	-0.01	-0.33	0.17	8.09	0.09	2.47	0.19	8.91	0.16	7.38	0.11	8.42

Note: The values shown in grey indicate insignificant parameters and the other values represent significant parameters with the level of 5% or lower.

Table 5. 6. Estimation results of mixed hybrid choice model: Structural equations

Latent variables	Explanatory variables	Work/ study		Shopping		Eating out		Physical exercise		Party		Cultural leisure		Medical activities	
		Est.	t-val.	Est.	t-val.	Est.	t-val.	Est.	t-val.	Est.	t-val.	Est.	t-val.	Est.	t-val.
Risk perception (*rp*)	Gender	0.41	0.76	0.08	1.56	0.23	1.69	0.15	3.53	0.13	1.09	0.12	0.32	0.41	6.88
	Age	-0.08	-0.47	-0.01	-1.43	-0.06	-1.69	-0.03	-4.30	-0.03	-2.05	-0.04	-0.28	-0.12	-6.39
	Number of household members	0.04	0.23	0.05	2.45	0.08	1.80	0.01	1.20	0.02	0.91	-0.01	-0.07	0.13	4.33
Trust (*tu*)	Gender	1.88	0.66	0.09	3.09	0.54	3.31	0.19	3.73	1.75	2.54	-1.99	-1.70	-2.24	-2.23
	Age	-0.53	-0.60	-0.02	-4.78	-0.14	-2.99	-0.03	-2.31	-0.49	-2.72	0.72	1.89	0.72	2.70
	Number of household members	0.47	0.55	0.02	1.96	0.16	2.77	0.04	2.39	0.43	2.22	-0.80	-1.91	-0.98	-2.78
Cultural risk factors (*cul*)	Gender	3.06	1.46	0.09	2.71	1.07	4.53	0.16	3.60	1.07	3.68	0.77	3.65	2.23	7.87
	Age	-0.91	-1.34	-0.04	-6.26	-0.28	-4.12	-0.02	-2.58	-0.30	-3.76	-0.24	-4.87	-0.67	-9.04
	Number of household members	0.84	1.27	0.02	1.82	0.31	3.52	0.03	2.19	0.26	2.75	0.24	4.70	0.90	7.44

Note: The values shown in grey indicate insignificant parameters and the other values represent significant parameters with the significance level of 5% or lower.

5.4.1 Features of psychological factors

The estimation results of the measurement equations for the three types of psychological factors (i.e., risk perception, trust, and cultural risk factors) are shown in Table 5.5. In total, there are 54 parameters that are estimated to be significant (71.1% of the 77 unknown parameter), indicating that the constructed three latent variables are suitable to capture risk perception, trust, and cultural risk factors.

Looking at the estimated parameters of the four observed variables for all the seven trip purposes,

even though the correlations between the risk perception at the four spatial scales are between 0.72 and 0.82, all the estimated parameters with respect to all the seven trip purposes are positive, and no contradictory or irrational results are obtained. This supports the joint use of the four measurements of risk perception. The latent variable "risk perception" is obviously characterized by people's perception of the infection risks at a relatively large area (the whole country, the residence municipality, and a frequently visited place), rather than within a crowded public transport vehicle (Shopping: 0.16; Eating out: 0.28; Physical exercise: 0.59; Cultural leisure: 0.04; Medical activities: 0.20).

As for the latent variable "trust", its three observed variables have similar parameter values, indicating that people's trust related to COVID-19 policy measures comes from not only governments but also medical agencies.

In the case of the latent variable "cultural risk factors", comparing the four observed variables "hierarchists", "egalitarians", "individualists", and "fatalists" (correlations: two correlations are less than 0.10, two are less than 0.20, and the remaining two are less than 0.45), the former two variables with significant parameters have negative parameter values, while the latter two with significant parameters all have positive parameter values. Comparing the parameter values, "hierarchists" (high-level group and high-level grid: experts and government are trusted, and the social order is supported) and "egalitarians" (high-level group and low-level grid: equality of all people and the risk decision by all people are emphasized) mainly represent the cultural risk factors of shopping (hierarchists: -0.26; egalitarians: -0.15) and physical exercise (hierarchists: -0.16; egalitarians: -0.14), where the role of group is strong. In contrast, "individualists" (low-level group and low-level grid: the individual freedom is highly prioritized) and "fatalists" (low-level group and high-level grid) mainly explain the cultural risk factors of eating out (individualists: 0.15; fatalists: 0.17), party (individualists: 0.13; fatalists: 0.19) and medical activities (individualists: 0.09; fatalists: 0.11), where the role of group becomes weak. As for cultural leisure, the cultural risk factors are mainly featured by "fatalists" (0.16): the respondents of "fatalists" believe in fate, because he/she think there is little he/she can do to control the environment, and they think that socially defined aspects (social classification, regulation or other external constraints) impost more on an individual.

5.4.2 Influences of individual and household attributes on psychological factors

Table 5.6 shows that 39 parameters of gender, age and number of household members are statistically significant. These three individual and household attributes are influential to all the three latent variables of risk perception, trust and cultural risk factors for medical activities, but are not influential in the case of work/study. These three individual and household attributes affect trust when travelling for shopping, eating out, physical exercise, and party, and cultural risk factors when travelling for eating out, physical exercise, party, and cultural leisure. Differently, these three individual and household attributes are not that influential to risk perception in the sense that there are only seven significant parameters out of 21 relevant parameters (and there is no significant parameter for work/study and eating out). In the case of

cultural risk factors, they are further affected by gender and age when travelling for shopping.

As for the influences of individual and household attributes on risk perception, people living in a household with more members are mostly likely to perceive a higher level of infection risk at various spatial levels in the cases of participating in shopping (0.05) and medical activities (0.13), than those living together with a smaller number of household members. Male respondents tend to perceive a higher level of infection risk at various spatial levels in the cases of physical exercise (0.15) and medical activities (0.41). Younger respondents perceive a higher level of risk at various spatial levels when participating in physical exercise (-0.03), party (-0.03), and medical activities (-0.12), than older respondents.

About the influences of individual and household attributes on trust, because the result in Table 5.5 shows a heterogeneity of the meaning of latent variable across travel purposes (Shopping, Eating out, Cultural leisure and Medical activities have negative sign, but Physical exercise has opposite sign), we need to state the influence of individual and household attributes on trust by combining the results in Table 5.5 and Table 5.6. For instance, the estimated coefficients of physical exercise in Table 5.5 have opposite signs to other activities but the results of physical exercise in Table 5.6 are same with other activities. Meanwhile, the estimated coefficients of medical activities in Table 5.5 have same signs with other activities but its results in Table 5.6 are opposite to other activities. Thus, physical exercise and medical activities show similar results of the influence of individual and household attributes on trust, which are opposite to other activities. Based on that, we can find people living in a household with more members and male persons tend to show a higher level of trust in governments and health/medical agencies in the cases of physical exercise (0.19/0.04 in Table 5.6, positive in Table 5.5) and medical activities (-2.24/-0.98 in Table 5.6, negative in Table 5.5), while people living in a household with more members and male persons demonstrate less trust in governments and health/medical agencies in the cases of shopping and eating out. On the other hand, higher trust is observed with respect to older persons when traveling for shopping and eating out, while less trust is further observed for older persons when participating in physical and medical activities.

Concerning the influences of individual and household attributes on cultural risk factors, female persons are more likely to be a hierarchist in the cases of physical exercise and cultural and an egalitarian in the cases of eating out, physical exercise, party, cultural leisure, and medical activities, but less likely to be an individualist and a fatalist in the cases of eating out, physical exercise, party, cultural leisure, and medical activities.

Older persons tend to be a hierarchist in the cases of physical exercise and cultural leisure and an egalitarian when participating in eating out, physical exercise, party, cultural leisure, and medical activities; however, older persons are less likely to be an individualist and a fatalist in the cases of eating out, physical exercise, party, cultural leisure, and medical activities.

People living together with a smaller number of household members are more likely to be a hierarchist in the cases of physical exercise and cultural leisure and an egalitarian in the cases of eating out, physical exercise, party, cultural leisure, and medical activities, but less likely to be an individualist

and a fatalist in the cases of eating out, physical exercise, party, cultural leisure, and medical activities.

5.4.3 Influences of psychological factors on travel mode choices

The correlations between latent variables are considered via a hierarchical structure in the XHCM of this study. Hence, expect the direct effects (see Table 5.4), some latent variables may have indirect effects on travel mode choice through other latent variables. Here, the latent variables "trust" can affect the utility function indirectly through "risk perception", while the latent variables "cultural risk factors" show indirect impact on utility through "risk perception" and "trust". To investigate the influences of psychological/cultural factors on travel mode choices, the total effect (the sum of direct effect and indirect effect) of each latent variable is calculated via the equation (5-1) (5-2) (5-3) and (5-5) as the evidence of quantitative analysis. The result of total effect is summarized in Table 5.7.

As observed in Table 5.7, risk perception is only assumed to have a direct effect on travel mode choices during the COVID-19 pandemic, while the other two latent variables "trust" and "cultural risk factors" are assumed to have not only a direct effect but also indirect effect(s) on travel mode choices. Observing the total effects shown in Table 5.7, about half of their parameters are statistically significant in either a direct or an indirect way. As shown in Table 5.4, trust affects risk perception positively for all trip purposes. All observed variables related to risk perception have positive parameters. Except physical exercise, all other observed trust-related variables have negative parameters (see Table 5.5). The above results indicate that higher distrust in governments and medical agencies leads to a higher-level of perception about the infection risk. This is consistent with the observation by Ding and Zhang (2021). For the trip purpose "work/study", both direct and indirect effects are not significant, meaning that neither of risk perception, trust and cultural risk factors does not affect the travel mode choice for work/study. Considering that we collected data from six developed countries in March-April 2022, this observation is surprising. Note that respondents were asked to compare travel mode choices before and during the COVID-19 pandemic, where the pandemic period covered the whole period up to the end of the survey. Thus, the travel mode choices during the pandemic indicate people's average choices. The above observation means that when people have to go to work/study on average days, they will choose whatever travel mode without considering any psychological factors. This is probably due to the essential feature of work/study for most people's daily lives, at least in part. In other words, if psychological factors may matter to commuting/school mode choices, they may only work tentatively for a certain period, but not over a long period. This needs to be further confirmed based on a panel survey of travel mode choices over a long period, which should be left as an important research issue for the future.

Influences of the three types of psychological factors on travel mode choices for the trip purposes other than work/study are analyzed below.

Table 5. 7. Total effects of trust and cultural risk factors on the utility of travel mode choice

Latent variables	Travel modes	Work/ Study	Shopping	Eating out	Physical exercise	Party	Cultural leisure	Medical activities
Risk perception (*rp*)	Bus	0.33	-5.62	-10.27	-10.13	-3.30	-0.89	34.26
	Rail	0.23	-12.86	-14.29	-15.21	-1.83	10.79	7.41
	Car	0.16	0.28	18.63	-58.95	8.08	-9.76	-11.53
	Active transport	0.33	-1.63	-6.46	-33.02	3.94	-4.34	-13.63
Trust (*tu*)	Bus	-1.6	-0.5	16.1	-7.7	-4.9	0.3	-14.2
	Rail	-0.9	-19.2	22.5	0.4	-2.9	-2.4	-3.0
	Car	-1.1	3.0	-29.1	-22.3	10.7	2.3	4.5
	Active transport	-1.0	6.7	10.7	-21.0	5.1	1.0	5.6
Cultural risk factors (*cul*)	Bus	0.7	5.8	-6.0	18.1	8.3	0.5	-20.8
	Rail	0.3	32.1	-8.1	14.8	5.0	-8.4	-4.5
	Car	0.4	-3.8	10.0	80.7	-19.0	7.1	6.6
	Active transport	0.2	-5.2	-4.4	53.7	-9.2	3.2	8.3

[Note] Grey-colored: none of the parameters related to the total effect is statistically significant.

Risk perception

In the case that the parameter of an observed risk perception variable and that representing the effects of the latent variable "risk perception" on a travel mode have a different sign (or a same sign), if an individual perceives a higher risk of infection, he/she is less likely (or more likely) to choose the travel mode, in comparison to shared mobility and taxi. Concretely speaking, during the COVID-19 pandemic, considering that shared mobility and taxi are given as a reference for mode choices, rail is not preferred for shopping (-12.86), but preferred for cultural leisure (10.79), while bus is preferred for medical activities (34.26). These observations may be due to that cultural leisure and medical activities are generally less frequent than shopping, and/or the places of performing cultural leisure and medical activities are located in a convenient built environment to use rail and bus. Unexpectedly, car is not more attractive than shared mobility and taxi for physical exercise (-58.95), cultural leisure (-9.76), and medical activities (-11.53) during the pandemic. This result is not intuitive, but probably due to the places of performing these three activities are not convenient to use a car (e.g., lack of parking slots or expensive parking fees).

Trust

It is assumed that trust not only directly affects travel mode choices but also indirectly affects through risk perception. Similar to the above case of risk perception, the parameters of observed trust variables and those representing the effects of the latent variable "trust" on travel modes have both consistent and inconsistent signs. If the parameter signs are consistent (or inconsistent) for a certain travel mode, in the case that an individual trusts governments and/or health/medical agencies, he/she is more likely (or

less likely) to choose the travel mode, by comparing with shared mobility and taxi. Concretely speaking, if an individual trusts governments and/or health/medical agencies, he/she is more likely to use rail for shopping and cultural leisure as well as medical activities, bus for shopping and medical activities, car for eating out; in contrast, he/she is less likely to use active travel modes for all trip purposes except party, car for the trip purposes other than eating out, rail and bus for eating out, and bus for cultural leisure, because of the opposite signs of the result in Table 5.7 and Table 5.5. Even though up to the survey period, the governments of the targeted six countries had taken various protective measures (e.g., requirements of wearing mask, disinfection, and keeping social distance) for all types of travel modes, the above seemingly contradictory observations suggest different trip makers' complicated responses to the pandemic, involving both logical and illogical perception about the infection risk, which is significantly associated with the trust in governments and medical agencies. The above observations re-confirm the importance of differentiated risk communication with respect to different activities, where different stakeholders should play different roles in the communication, as evidenced by Zhang (2021).

Cultural risk factors

Cultural risk factors are assumed to not only directly affect travel mode choices but also indirectly affect through trust and further risk perception. Most of the observed variables of cultural risk factors are statistically significant, among which "hierarchists" and "egalitarians" have negative parameters and "individualists" and "fatalists" have positive parameters.

Respondents who highly think that important decisions should be made by experts/governments (hierarchists) and/or by all people (egalitarians) are less likely to choose rail and bus for shopping, physical exercise and party, but they are more likely to choose rail and bus for eating out and medical activities. Those of "hierarchists" and "egalitarians" also prefer the use of rail for cultural leisure. For the use of rail and bus, "individualists" and "fatalists" show a completely opposite preference for all trip purposes other than work/study.

Concerning car and active travel mode, they are preferred by "individualists" and "fatalists" for physical exercise, cultural leisure, and medical activities, where car is also preferred by "individualists" and "fatalists" for eating out. Car and active travel mode are further preferred by "hierarchists" and "egalitarians" for shopping and party, where active travel mode for eating out is also preferred by "hierarchists" and "egalitarians". Individualists and fatalists pay more attention to their own benefits and convenience than the benefit and convenience of the whole society: this can better explain why they prefer the use of car and active travel mode more than other modes.

In the cases of shopping, eating out, physical exercise and party, individualists/fatalists (rather than hierarchists/egalitarians) are more likely to have higher distrust in governments and health/medical agencies. In contrast, if people travel for cultural leisure and medical activities, individualists/fatalists would highly distrust governments and health/medical agencies.

The above differences in preference between hierarchists/egalitarians and individualists/fatalists

obviously come from the feature that hierarchists/egalitarians are more likely to follow the social order and respect equality among people (e.g., to obey social/physical distancing rules during the pandemic for avoiding the infection), while individualists/fatalists concern too much about themselves.

5.4.4 Influences of pre-pandemic preparedness on travel mode choices

Pre-pandemic preparedness, i.e., risk-concerned travel habits formed before the COVID-19 pandemic, is measured using three dummy variables: travel habit with high risk (i.e., public transport: rail and bus), travel habit with middle risk (i.e., shared mobility and taxi), and travel habit with low risk (i.e., car and active travel mode), where the travel habit with middle risk is treated as a reference during the modeling estimation. In other words, the XHCM model only includes the travel habit with high risk and that with low risk. It is found that most of the travel habit parameters (both high risk and low risk) (49 parameters) are statistically significant, re-confirming the role of past choice behaviors in explaining the current travel mode choices, but in the context of COVID-19.

Looking at the interval estimates of travel habit parameters (see Table 5.8), the only consistently positive parameter of travel habit with high risk is observed with respect to the use of bus for shopping (2.840, 5.780). Those consistently positive parameters of travel habit with low risk are related to the use of bus for work/study (3.047, 27.233) and shopping (2.703, 6.897) , rail for work/study (3.579, 24.081) and eating out (2.040, 4.980) as well as party (2.311, 4.349), car for shopping (1.288, 13.792) and physical exercise (0.687, 9.233) as well as medical activities (3.602, 4.818), and active transport for work/study (4.071, 33.589), physical exercise (2.634, 4.046) and medical activities (2.784, 30.626). A positive parameter of travel habit means that the corresponding travel habit (either high or low risk) is associated with the use of one of the above-mentioned travel mode choices.

Even though preparedness with respect to any infection risk level is, on average, positively related to choices of a majority of travel modes, there are surely a not small portion of respondents who dislike traveling by a certain travel mode if they experienced some infection risks of influenza viruses before the COVID-19 pandemic.

5.4.5 Influences of other factors on travel mode choices

Travel time

In the survey, travel time was only collected with respect to the chosen travel modes. Thus, it is necessary to be included into the travel mode choice model. Here, the travel time of those unchosen travel modes was imputed using that of other respondents who lived in the same residence region and chose the same travel mode, with respect to each activity category, separately.

Concerning the modeling results, a majority of mean parameters of travel time are statistically significant and have a logical negative sign, indicating that trip makers dislike longer travel time, on

average. This result is consistent with existing studies in the COVID-19 context (Aaditya & Rahul, 2021; Sun et al., 2020). Unfortunately, travel time does not affect travel mode choices for participating in physical exercise (except private car: -0.511, 0.391), cultural leisure (except rail: -0.107, 0.167, active transport: -0.365, 0.145), and it does not affect choice of private car for medical activities. On the other hand, looking at the interval estimates of travel time parameters with 95% confidence level (see Table 5.8), it is found that a value range from negative to positive is observed for all relevant parameters. Positive values of travel time parameters mean that during the COVID-19 pandemic, some people had to choose some travel modes with a longer travel time. The mean travel time parameters of private car for work/study (mean: 0.01, see Table 5.4) and rail for cultural leisure (mean: 0.03, see Table 5.4) are also positive, while their interval estimates also include negative parameter values.

It should be noted that all the above observations show significant unobserved heterogeneities, as shown by those significant standard deviation parameters of travel time.

Travel companion

Among all the 48 mean parameters of travel companion (family and friends) introduced in the XHCM, 21 are statistically significant. Among these 21 significant parameters, 18 have a negative value, meaning that when traveling together with family/friends, people tend to avoid using the corresponding travel modes. Active transport is not preferred in the case of travelling together with family and/or friends for shopping (mean: -1.66/-6.36, see Table 5.4), physical exercise (mean: -4.09/-3.61), travelling with family for eating out (mean: -1.05) and party (mean: -2.17), and travelling with friends for medical activities (mean: -47.43). In the cases of active travel for shopping (-2.464, -0.856) and eating out (-1.932, -0.168), the interval estimates with 95% confidence level (see Table 5.8) only include negative values, which further support the above observations. The use of bus (rail) is not preferred by people traveling with family/friends for shopping (mean: -0.75 for family; -49.60 for friend, see Table 5.4) and physical exercise (mean: -3.01 for family; -2.64 for friend). People travelling with family dislike the use of private car for eating out (mean: -0.76), party (mean: -1.54) and medical activities (mean: -1.54), while private cars are not preferred by people travelling with friends for physical exercise (mean: -2.79). Looking at the three positive and significant mean parameters, when travelling with family/friends for participating in a party, people are more likely to use a bus (mean: 1.92/1.91), while people traveling with friends for medical activities also tend to use a bus (mean: 9.18).

It should be noted that most of the above observations show significant unobserved heterogeneities, as shown by those significant standard deviation parameters of travel companion.

Table 5. 8. Interval estimates (95% confidence level) of the parameters of travel attributes and pre-pandemic preparedness

Parameters following a normal distribution		Work/study	Shopping	Eating out	Physical exercise	Party	Cultural leisure	Medical activities
Travel time	Bus	(-0.285, 0.185)	(-0.217, 0.097)	(-0.404, 0.224)	(-0.274, 0.314)	(-0.502, 0.242)	(-0.305, 0.205)	(-1.044, 0.564)
	Rail	(-0.177, 0.137)	(-0.266, 0.126)	(-0.236, 0.116)	(-0.284, 0.304)	(-0.197, 0.117)	(-0.107, 0.167)	(-0.148, 0.088)
	Private car	(-0.010, 0.030)	(-0.030, 0.010)	(-0.030, 0.010)	(-0.511, 0.391)	(-0.010, 0.030)	(-0.010, 0.030)	(-0.010, 0.030)
	Active transport	(-0.562, 0.222)	(-0.671, 0.191)	(-0.375, 0.135)	(-0.166, 0.226)	(-0.404, 0.184)	(-0.365, 0.145)	(-4.277, 0.897)
Travel companion of family	Bus	-	(-2.632, 1.132)	(-2.515, 0.895)	(-9.118, 4.758)	(-4.430, 8.270)	(-0.828, -0.632)	(-3.821, 1.001)
	Rail	-	(-6.022, 4.522)	(-4.584, 3.884)	(-11.418, 5.398)	(-5.786, 3.426)	(-2.208, 0.888)	(-1.552, 0.212)
	Private car	-	(-3.619, 1.359)	(-5.464, 3.944)	(-13.157, 6.717)	(-9.831, 6.751)	(-2.558, 1.558)	(-2.128, -0.952)
	Active transport	-	(-2.464, -0.856)	(-1.932, -0.168)	(-11.734, 3.554)	(-5.247, 0.907)	(-3.454, 2.034)	(-12.272, 15.952)
Travel companion of friend	Bus	-	(-131.508, 32.308)	(-1.049, 1.029)	(-8.273, 4.193)	(-4.617, 8.417)	(-1.376, 0.936)	(-20.769, 39.129)
	Rail	-	(-5.440, 4.360)	(-1.638, 3.458)	(-10.460, 5.180)	(-4.999, 3.899)	(-1.298, 0.818)	(-11.051, 3.531)
	Private car	-	(-5.283, 4.243)	(-3.642, 2.982)	(-12.041, 6.461)	(-8.552, 5.992)	(-1.830, 1.150)	(-54.990, 57.710)
	Active transport	-	(-13.867, 1.147)	(-0.167, 0.107)	(-9.372, 2.152)	(-3.126, 0.206)	(-1.691, 1.131)	(-162.756, 67.896)
Pre-pandemic preparedness: Travel habit with high risk	Bus	(-5.506, 11.506)	(2.840, 5.780)	(-6.900, 16.580)	(-2.916, 6.336)	(-2.607, 7.507)	(-5.538, 11.318)	(-16.907, 39.267)
	Rail	(-4.385, 8.865)	(-2.394, 13.834)	(0.452, 7.468)	(-1.046, 5.226)	(1.852, 4.988)	(-8.969, 12.669)	(-2.171, 10.451)
	Private car	(-2.574, 4.914)	(0.392, 2.548)	(-4.323, 8.143)	(-2.806, 4.486)	(-4.876, 9.196)	(-0.779, 1.259)	(-6.585, 8.585)
	Active transport	(-3.889, 8.929)	(-1.038, 10.878)	(-4.444, 11.784)	(0.515, 1.025)	(-5.959, 12.739)	(-1.729, 5.209)	(-0.788, 29.748)
Pre-pandemic preparedness: Travel habit with low risk	Bus	(3.047, 27.233)	(2.703, 6.897)	(-8.644, 15.504)	(-2.312, 4.352)	(-3.539, 5.359)	(-6.542, 8.942)	(-21.431, 35.331)
	Rail	(3.579, 24.081)	(-6.651, 20.671)	(2.040, 4.980)	(-1.190, 4.730)	(2.311, 4.349)	(-8.264, 8.944)	(-2.688, 6.328)
	Private car	(-0.934, 36.894)	(1.288, 13.792)	(-1.865, 13.305)	(0.687, 9.233)	(-4.522, 15.862)	(-0.240, 5.640)	(3.602, 4.818)
	Active transport	(4.071, 33.589)	(-0.866, 19.166)	(-1.981, 14.561)	(2.634, 4.046)	(-4.661, 16.781)	(-0.032, 6.592)	(2.784, 30.626)

Note: The values shown in grey indicate insignificant parameters and the other values represent significant parameters with the significance level of 5% or lower.

5.5 Conclusion

This research has revealed how psychological/cultural risk factors and pre-pandemic preparedness are associated with individuals' travel mode choices during the COVID-19 pandemic, by estimating a mixed hybrid choice model with correlated latent variables. Risk perception and trust as well as cultural risk factors are especially emphasized, where correlations between these factors are jointly incorporated through the concept of the latent variable. Preparedness is reflected in the modeling analysis in the form of risk-concerned travel habits formed to survive from influenza before the COVID-19 pandemic. The modeling results are compared across travel purposes. Here, main findings are summarized.

First, the use of public transport decreased significantly due to the shock of COVID-19 pandemic for all daily travel purposes. This observation is consistent with existing studies (e.g., Eisenmann et al., 2021; Abu-Rayash et al., 2020; Crowley et al., 2021). While public transport is preferred for shopping and medical activities in a pandemic era with the lowest decrease. Shared mobility and taxi are less preferred for leisure activities when comparing with pre-pandemic era with a higher decrease. Travel mode choices for commuting during the pandemic are considerably different from those for other travel purposes in the sense that people are less likely to change their travel mode choices for commuting.

Second, risk perception, trust, and cultural risk factors are influential to travel mode choices for shopping, physical exercise, cultural leisure and medical activities; however, their influences cannot be confirmed with respect to work/study. Party-related travel mode choices are only affected by cultural risk factors (Egalitarians: coefficient (-0.07), t-value (-1.98); Individualists: coefficient (0.13), t-value (5.98); Fatalists: coefficient (0.19), t-value (8.91)) and travel mode choices for eating out are not affected by risk perception. These three latent factors affect travel mode choices in both direct and indirect ways and both expected and unexpected influences are detected, where there are more significant indirect effects of trust and cultural risk factors than direct effects.

Third, risk perception is found to be more remarkable at larger spatial scales (coefficient: from 0.07 to 1.12) than inside crowded public transport vehicles (coefficient: from 0.04 to 0.59). Such a joint reflection of different types of risk perception presents a more reliable understanding of risk perception for supporting effective pandemic policymaking. People perceiving a higher level of infection risk are more likely to reduce the use of public transport for some high-frequency daily activities (e.g., shopping) during the COVID-19 pandemic (-12.86). On the other hand, public transport is preferred for some low-frequency activities (e.g., cultural leisure, medical activities) by some people with a higher-level of risk perception (10.79/34.26). In the cases of cultural leisure, medical activities and physical exercise, shared mobility and taxi are more preferred than car by people having a higher-level of risk perception.

Fourth, travel mode choices are affected by trust in both governments and health/medical agencies in a similar way, where trust is positively influential to risk perception (from 0.92 to 2.89). People who trust governments and health/medical agencies prefer the use of rail for shopping and cultural leisure as

well as medical activities, bus for shopping and medical activities and car for eating out, but do not prefer the use of active travel modes for all trip purposes (except party), rail and bus for eating out, and bus for cultural leisure.

Fifth, the four types of cultural orientations affect travel mode choices in two differentiated ways. Concretely, the group-oriented hierarchism and egalitarianism are a pair with higher similarities, which influences are very different from the pair of individualism and fatalism. The two ways of the influences of cultural orientations show diverse influencing directions and magnitudes depending on travel modes and purposes. Hierarchists and egalitarians are mainly reflected in travel mode choices for shopping and physical exercise, while individualists and fatalists are dominating in travel mode choices for other travel purposes. Hierarchists and egalitarians are less likely to choose public transport mode for shopping, physical exercise and party, but they are more likely to choose rail and bus for eating out and medical activities. Meanwhile, car and active travel mode are further preferred by hierarchists and egalitarians for shopping and party, where active travel mode for eating out is also preferred by hierarchists and egalitarians. Individualists and fatalists show a completely opposite preference for all trip purposes except work/study. Car and active travel mode are preferred by individualists and fatalists for physical exercise, cultural leisure, and medical activities, where car is also preferred by individualists and fatalists for eating out.

Sixth, different from existing studies, this research has examined the role of preparedness by focusing on risk-concerned travel habits formed before the COVID-19 pandemic, which were used to survive from influenza viruses. Such a focus on influenza allows us to better capture the influences of preparedness on travel mode choices during the pandemic. As a result, preparedness is surely influential to travel mode choices, but the influences are not consistent across a majority of travel purposes.

This research has investigated travel mode choices with respect to different travel purposes, separately, where for each purpose, the samples without the purpose have been excluded from the modeling analysis. Such a kind of analysis has its own rationality, because the purpose of this research is to clarify influential factors to travel mode choices. Representing choices of different travel modes is also for a better understanding about how people attempt to avoid being infected. From such a consideration, avoiding the participation in out-of-home activities is probably a much more effective way to keep away from viruses. Thus, it is also worth analyzing travel mode choices by incorporating their interactions with choices of activities, as argued by the popular activity-based approach. In addition, in relation to the virus infection, a proper understanding of social contact cannot be neglected: for example, how and how long to contact with other persons during travel and during performing an activity, and how many persons are involved in social contact, etc. Furthermore, more importantly, it is necessary to accumulate more data about the infection risk levels within different types of transport vehicles (e.g., bus, subway, ridesharing vehicle, taxi), allowing policymakers to make scientifically sound and practically effective/efficient policies to control the ongoing COVID-19 pandemic and prepare well for future pandemics. Last but not the least, more countries should be added for deriving more general findings based on cultural factors and social norms.

CHAPTER 6 Differences of social contacts by activity settings before and during the COVID-19 pandemic and associational analysis

6.1 Introduction

Social contact is an important route of transmission for the SARS-CoV-2. The mechanism of transmission of the COVID-19 pandemic can be expressed by the changes of individuals' social contacts. As the COVID-19 pandemic has been lasting for more than two years, more and more countries begin to lift restriction measure of COVID-19 since 2021 gradually. People must get used to living in life with the pandemic. As a result, to prepare for the complete end of the epidemic in the near future, it is necessary to focus on people's behavioral changes of social contacts between the pre-pandemic and pandemic era so as to provide more scientific evidence for further academic research or policymaking.

Previous studies only focused on the heterogeneities of social contacts across a few limited individuals' attributes (e.g., age, gender), the heterogeneities across activity participation attributes (e.g., frequency, duration) are still unknown. To resolve that question, firstly, this chapter calculates the total number of social contacts and the mean number of social contacts for people who have performed their daily social contacts before or during the pandemic (as see in Appendix 4 and Appendix 5; total number = sample* mean number) across the options of different individual/household attributes and key activity participation attributes. The trend and heterogeneity of the number of individual's social contact for different groups are revealed. Secondly, this chapter calculates people's changes of the number of social contacts before (2019: during the Influenza season) and during the pandemic (2020 – 2021. May) basing on that obtained total number and mean number of social contacts. In the end of this chapter, the circumstances with high risk of infection via social contacts is stated and some recommendations for target circumstances are proposed. The contents of this chapter have provided a reference for further social contact research and scientific evidence for policy making in the pandemic era.

6.2 Data

Most precious studies used POLYMOD data as the baseline of individuals' social contacts before the

pandemic, and mainly focus on the changes of the number of social contacts between the pre-pandemic and during the lockdown. However, POLYMOD data only shows people's social contacts in a normal daily life (not during influenza season), people's social contact is obviously different from the social contact during an infectious disease period (such as the influenza). Hence, except the difference of social contact between during normal daily life in pre-pandemic and during the pandemic, the difference of that between during the influenza season in pre-pandemic and during the pandemic should not be ignored as well. This chapter used the social contact data in comparative survey of activity-travel and social contact before-during COVID-19 to investigate how individuals' number of social contacts changed after the outbreak of the COVID-19 pandemic and what is the heterogeneity of the number of social contacts across different individual/household attributes, activity participation attributes (frequency, duration, taken protecting measures) and contact modes.

In the comparative survey of activity-travel and social contact before-during COVID-19, people responded their average number of contacted persons for performing daily activities each time in an ordered sequence: (1) 1~2 persons, (2) 3~4 persons, (3) 5~6 persons, (4) 7~9 persons, (5) 10 persons or more. It is assumed that people would only have one contact with one contacted persons each time in this study. Thus, the number of social contacts is equal to the number of contacted persons at here. And because the data of the number of social contacts is in an ordered sequence, this study transfers the ordered options into numerical options with the average value of the ordered range. For example, the option of "(4) 7~9 persons" is transferred into contacting average "8" persons.

6.3 Result and discussion

Based on the social contact data introduced in previous section, this section will give a descriptive analysis of the changes of the number of contacts between the influenza season in the pre-pandemic (in 2019) and during-pandemic (since 2020). The changes of social contacts will be expressed across different variables to show the heterogeneities among their options. In this analysis, it is assumed that one person only has one contact with another person during performing the activities. Thus, the number of contacted persons from participants' responses is accounted as the number of social contacts for each contact setting.

Only the contacts with the people outside of the companion (such as family) is counted as the contacts in this analysis because people are more likely to get infected by households at home instead of in other contact settings, so it is meaningless to talk about the contacts between families outside home, and we didn't include the household contacts at here.

The total number of social contacts and the mean value of social contact for each person are calculated to show the changes of social contact behaviors between pre-pandemic and during-pandemic from the perspective of different demographic attributes (age, gender, country, occupation, household size, education, income), activity participation attributes (frequency, duration, protecting measures) and

contact mode. The total number of social contacts can indicate the total change of social contacts in the population, while the mean number of social contacts can explore the average change of social contacts only for these people who still perform the according activities.

The results in Figure 6.1 and Figure 6.2 show the changes of the total number and mean number of social contacts for each contact setting, respectively. Readers can find more details of the number of contacts in different contact settings in appendix and calculate the results in Figure 6.1 and Figure 6.2 by themselves. For the total samples in targeted countries, although the restrict lockdown measures have been lifted and most indoor places were allowed to reopen gradually since 2021, we can find the total number of social contact still maintained a low level during the pandemic compared with that in influenza season of pre-pandemic (as highlighted by Wong et al., 2022; Liu et al., 2021; Latsuzbaia et al., 2020; Zhang, J. and Litvinova, M. et al., 2021; Tomori et al., 2021). Associated with common sense, the mean number of social contacts is largest in workplace/school (pre-pandemic: mean: 8.85, 95%CI: 8.67-9.03; during-pandemic: mean: 7.42, 95%CI: 7.22-7.62). The mean numbers of social contact happened in Party (pre-pandemic: mean: 7.21, 95%CI: 7.05-7.37; during-pandemic: mean: 5.68, 95%CI: 5.5-5.86), Cultural leisure (pre-pandemic: mean: 6.32, 95%CI: 6.16-6.48; during-pandemic: mean: 5.29, 95%CI: 5.1-5.48), and Public transport (pre-pandemic: mean: 6.96, 95%CI: 6.77-7.15; during-pandemic: mean: 5.96, 95%CI: 5.74-6.18) are also in a high level. On the contrary, people only contact less than 4 persons during the medical activities on average (pre-pandemic: mean: 3.66, 95%CI: 3.56-3.76; during-pandemic: mean: 3.34, 95%CI: 3.24-3.44). And the most obvious decrease of number of social contacts is found for Party (change of total number of contacts: -57.6%; change of mean number of contacts: -1.53) and Cultural leisure (change of total number of contacts: -58.4%; change of mean number of contacts: -1.03). They are followed by the decrease of contacts in public transport (change of total number of contacts: -48.2%; change of mean number of contacts: -1.00). The reasons for these dramatic changes would be that some venues are still closed (including bankruptcy), and less people want to do these activities for the benefit of safety or money. The total number of social contacts decreased obviously for Eating out (-44.6%) and Physical exercise (-45.2%), but for these people who still do these activities, the decrease of the mean number of social contacts is limited (Eating out: -0.59; Physical exercise: -0.97). In contrast, it seems that most people have resumed their essential social contacts in places of work/study (change of total number of contacts: -34.0%), shopping (change of total number of contacts: -22.1%), medical activities (change of total number of contacts: -28.4%) after the initial lockdown in pervious waves of pandemic, while the average social contacts at workplace or school decreased more obviously (change of mean number of contacts: -1.43). The descriptive analysis of the number of contacts for different variables are summarized in subsequent sections.

6.3.1 Social contacts across individual and household attributes and its changes before and during the COVID-19 pandemic

1) Social contacts across age

More than 70% of the social contacts were made by the people aged between 20 ~ 60 years.

For the work/study setting, among the working ages (20~64 years), the mean number of social contacts increased with people's age. That is sensible because when people getting older, they are more likely to get a higher position for the work and have more works to contact with others. The most obvious decrease of the mean value of work contact between pre-pandemic and during-pandemic is found for the people aged from 20 to 39 year (more than -1.5). The study contacts for the students less than 19 years show a dramatic decrease with the value of -40.7% compared to pre-pandemic, which may because the offline lecture wasn't recovered totally, some student can still study online.

The mean value of social contacts during shopping activities begin to decrease gradually when people are over 60 years. More young people aged less than 19 years have decreased their total shopping contacts during the pandemic (-31.4%). Among these people who still have shopping contacts, the people with a middle-age (40~49) seems to pay more attention to decreasing the mean value of contacting others when shopping (-0.73).

The mean number of social contacts in eating out setting is negatively associated with people's age both in pre-pandemic and during-pandemic. For people with the working ages (20~64 years), the change of the total number of contacts increased with people's age, indicating that older people are prone the decrease the number of social contacts for eating out. The total number of social contacts in eating out setting have decreased more than 50% for all people aged over 50 years. And people aged 50 ~ 59 years contacted less people for each eating out behavior than other age groups (change of mean: -0.8).

The mean number of social contacts during physical exercise is high for young people less than 19 years (pre-pandemic: mean: 6.01, 95%CI: 5.02-7; during-pandemic: mean: 5.69, 95%CI: 4.39-6.99). A sharp decrease of the mean number is found between the age group of less than 19 years and 20~29 years, which may because more people begin to work since 20 years old and have less time to do physical exercise with others. However, that mean number increased again with the raise of people's age after 30 years, and the mean number returns to the level of the group of "less than 19 years" when people are over 70 years (pre-pandemic: mean: 6.45, 95%CI: 5.83-7.07; during-pandemic: mean: 5.78, 95%CI: 4.96-6.6). Social contact during physical exercise decreased obviously for all people aged over 40 years, especially for people aged between 60 and 69 years (change of total number of contacts: -59.8%; change of mean number of contacts: -0.98).

Young people less than 19 (pre-pandemic: mean: 8.06, 95%CI: 7-9.12; during-pandemic: mean:

6.74, 95%CI: 5.39-8.09) are more likely to contact more people during the party than other age group. Fortunately, the total number of social contacts have decreased obviously from -41.1% to -75.6% for all age groups. The impact of the COVID-19 pandemic on the social contacts during party is especially obvious for people aged from 40 to 49 years with the decrease of mean number (-1.72).

The mean number of social contacts during cultural leisure didn't show obvious heterogeneities across the age. During the pandemic, the total number of social contacts have decreased from -46.7% to -67.6%, although these entertainment venues have been reopened after the lockdown.

During the pandemic, the mean number of contacts during medical activities is negatively associated with people's age for the people aged between 20 to 70. While that mean number is highest for the age groups between 20 to 40 years, which may because these people aged between 20 to 40 years are more likely to be the parents who need to take care of their children during the during medical activities. Because of the bad health status of the elderly, it is difficult for them to decrease the social contacts even during the pandemic, that phenomenon is especially obvious for the people over 70 years with the smallest decrease of total number (-17.3%) and mean number (-0.08) of contacts.

The mean number of contacts in public transport setting during the pandemic is the issue ranking only second to work/study setting with value ranging from 5.47(95%CI: 5.12-5.82) to 6.6 (95%CI: 5.2-8). If people are older, they are more likely to decrease more social contacts in public transport, which may because they have more access to use a private car to avoid the risk of infection. These people aged between 60 and 65 years have the biggest decrease of the total number of contacts in public transport because they are more rich and more dangerous to the virus. Conversely, it is difficult for the people aged between 30 and 39 years to decrease the total number of contacts, but they could try to decrease the average number of contact each time (-1.14), such as avoiding traveling during rush hour.

2) Social contacts across gender

The share of males' social contacts increased during the pandemic for all contact settings. It seems that females decreased more social contacts than males (both the total number and mean number), especially for shopping setting, eating out setting and cultural leisure setting. As a result, the shares of females' contacts were surpassed by males' contacts for these settings during the pandemic.

Males have more contacts than females in physical exercise setting, party setting and public transport setting whether in pre-pandemic or in during-pandemic. Oppositely, females always have more contacts than males during the medical activities.

3) Social contacts across countries

We collected the data in six countries from March 2021 to May 2021, the data from these countries help us to conduct a cross-countries comparison of the social contact behaviors before and during the pandemic.

In the survey period, only a few new daily cases occurred in AU and NZ and the strict lockdown in AU and NZ had been lifted for a long time. The new daily cases were high in US, but the strict lockdown measures had been lifted for a long time in US as well. Thus, the data from AU, NZ and US belong to the same stage, which people had lived with the COVID-19 virus in a normal life for a long time during the pandemic. UK and CA had just eased the intervention of strict lockdown for not a long time during the survey period. The data from these two countries can indicate the social contact behaviors under stronger intervention. JP hadn't taken strict lockdown measure in 2021, for example, the restaurants were allowed to open from 5 a.m. to 20 p.m. every day, so the data in JP can show the people's social contacts behaviors with a persistent soft intervention to the COVID-19 pandemic.

The results show that the mean number of contacts for work/study setting, and shopping setting fluctuated across six countries during the pandemic, but the mean number of contacts for leisure settings (including eating out, physical exercise, party, cultural leisure) in AU, US, NZ (almost no interventions) is obviously higher than CA and UK (strong intervention), especially higher for cultural leisure setting (AU: mean: 5.49, 95%CI: 5.09-5.89; US: mean: 5, 95%CI:4.6-5.4; NZ: mean: 6.06, 95%CI: 5.65-6.47; CA: mean: 4.24, 95%CI: 3.77-4.71; UK: mean: 3.82, 95%CI: 3.44-4.2). Nevertheless, the mean number and total number of contacts during medical activities in AU, US, NZ were much higher than other countries as well, whether there is an increase in the contacts during medical activity led by the infection of the coronavirus needs further discussion. It seems that the total number and mean number of social contacts in JP (county with soft interventions) for different settings are at the same level with that in AU, US, NZ (almost no intervention countries) during the COVID-19 pandemic.

As expected, the decrease of the total number and mean number of social contacts between pre-pandemic and during-pandemic is most obvious in CA and UK (countries with stronger interventions). And most people hadn't recovered their daily social contacts especially for party setting (CA: change of total number: -81.2%, change of mean number: -2.93; UK: change of total number: -80.8, change of mean number: -2.53).

4) Social contacts across occupation

We try to investigate individuals' risky social contact behaviors outside home and found that more than 40% of social contacts were conducted by company employee / company officer or self-employed people for all contact settings (excluding home).

The staff in government (pre-pandemic: mean: 9.97, 95%CI: 9.31-10.63; during-pandemic: mean: 8.49, 95%CI: 7.76-9.22) or educational institution (pre-pandemic: mean: 10.42, 95%CI: 9.61-11.23; during-pandemic: mean: 8.82, 95%CI: 7.91-9.73) have a much higher mean number of work contacts than other occupations revealed that they are more likely to contact more people than others during their work.

During the pandemic, the mean numbers of social contacts made by housewife/househusband and other unemployed people (including retired) were obviously lower than other occupations, although

their mean numbers in pre-pandemic were at the same level with other occupations for some contact settings. The unemployed people (including retired) have an especially lower mean contacts with others during the medical activities than other occupations during the pandemic (mean: 2.51, 95%CI: 2.36-2.66).

Housewife/househusband (change of total number: -55.0%; change of mean number: -1.27) and other unemployed people (including retired) (change of total number: -61.9%; change of mean number: -1.01) have decreased their contacts in public transport most obviously between pre-pandemic and during-pandemic. An obvious decline of contacts in shopping setting (change of total number: -33.3%; change of mean number: -0.96) and eating out setting (change of total number: -49.4; change of mean number: -1.21) is found for student exploring that the students have much lower resistance to the close of shopping and eating out venues.

5) Social contacts across household size

About 70% of the social contacts were made by the people with a household size ranging from 2 persons to 4 persons (including themselves). And a two-person household (such a couple without children) have much lower life pressure and higher intention to enjoy life than others, their social contacts account for about one third of the total social contacts for all people. Interestingly, the mean number of social contacts (excluding work/study contacts) is obviously lower for these people who live alone, it seems that the social network of single people living alone is much simpler, as a result, they have fewer social contacts no matter in pre-pandemic or in during-pandemic.

The mean number of work/study contacts didn't show obvious heterogeneities across different household size. However, the mean number of contacts in other settings increased with rising household size and got the peak point at the household size of 5 persons. The reason may be that if people live with more persons, they are more likely to join the activities outside home, and the household size of 5 can guarantee traveling together without too many troubles.

The decrease of work/study contacts (whether for total number or for mean number) between pre-pandemic and during-pandemic is negatively associated with household size, which may because if people have more economic pressures, they must earn more money and are difficulty to decreased work contacts. People are prone to decrease more shopping contacts and medical activities contacts if they have larger household size, which could avoid bringing the virus home from the activity venues.

6) Social contacts across education background

The mean number of party contacts during the pandemic is obvious higher for low educated people (elementary school: mean: 6.49, 95%CI: 5.36-7.62; middle school/ junior high school: 6.22, 95%CI: 5.47-6.97) than high educated people (master's degree: mean: 5.59, 95%CI: 5.17-6.01; doctor degree: mean: 5.87, 95%CI: 4.68-7.06). The reason might be that most low educated people are young student,

they have less risk to the virus and have plenty of time to join the party. The low educated people have a higher dependence on the use of public transport for daily travels, as a result their mean number of social contacts in public transport have increased slightly during the pandemic (elementary school: 0.03; middle school/ junior high school: 0.05). The work/study contacts have decreased more for the people with the master's degree (change of total number: -38.4%; change of mean number: -1.82), which may because they have more access to conduct online work or study during the pandemic.

7) Social contacts across income level

The mean number of social contacts occurred at work/study, shopping and leisure venues increased with people's household income since 25,000 USD both in pre-pandemic and during-pandemic. It is easy to understand that if people have more money, they have better access to work/study, shopping and leisure activities and contacts with others.

The people with low income (under 34,999 USD per year) have the smallest decrease of work contacts between pre-pandemic and during-pandemic (under 24,999 USD: change of total number: -32.7%, change of mean number: -0.92; 25,000 to 34,999 USD: change of total number: -26.0%, change of mean number: -0.79). That means the poor people's work don't allow them to work online, the risk of infection via work contacts would be still higher for them. Meanwhile, the poor people (under 34,999 USD per year) also show a smaller decrease of shopping contacts than others (under 24,999 USD: change of total number: -11.0%, change of mean number: -0.13; 25,000 to 34,999 USD: change of total number: -16.6%, change of mean number: -0.11). In fact, the total number of shopping contacts for the people with a low income is at the same level with that for people with more money. Fewer poor people have shopping contacts, and each poor people have a higher average number of contacts, if they have shopping activities, so they have a higher risk of infection than other people with higher income.

6.3.2 Social contacts across activity participation attributes and its changes before and during the COVID-19 pandemic

1) Social contacts across frequency

Consistent with common sense, the mean number of social contacts is positively associated with the frequency of the performing the activities. However, during the pandemic, the contacts with the frequency of daily or almost daily have decreased for all contact settings. For instance, more than 80% of the work/study contacts occurred with the frequency of daily or almost daily in pre-pandemic, while the total number of work/study contacts decreased -44.7% accompanied by the decrease of the mean number with the value of -1.23, which may because there were fewer work opportunities due to the

pandemic. Simultaneously, the work/study contacts with lower frequency increased, the total number of work/study contacts for the frequency of "Once or twice a month" and "Once or twice a week" have increased with the value of 29.5% and 17.1% respectively. Nevertheless, the mean number of work/study contact with low-frequency decreased during the pandemic indicating that people would contact fewer others for work/study in low frequency as well.

In a similar way, the low-frequency shopping contacts increased compared to pre-pandemic (Less than once a month: 72.7%, Once or twice a month: 19.6%). About 70% of the shopping contacts occurred once or twice a week in pre-pandemic, while during the pandemic the shopping contacts with the frequency of once or twice a week decreased 33.4%, and the mean number of contact decreased -0.44.

In addition, because of the dramatic decrease of the use of public transport, the social contact in public transport decreased without the impact of the frequency.

2) Social contacts across duration

The duration of social contact is assumed as the average performing time of the activities in venues in these chapter. The results show that the mean number of social contacts would increase with the extend of duration. And comparing with the pre-pandemic, the contact with long duration decreased obviously during the pandemic. In the case of work/study setting, about 70% of the work/study contacts have a duration more than 4 hours each time in pre-pandemic, however, the total number of that contacts decreased -39.0%, and the mean value declined -1.25 during the pandemic.

More than half of the shopping contacts have the duration between 15 mins and 1 hour, their total number and mean number decreased -14.0% and -0.47 respectively. Meanwhile, the number of shopping contact with long duration (more than 1 hour) decreased more than -40%, whereas the number of contacts with the duration less than 5 mins increased (change of total number: 23.8%, change of mean number: 0.24). About 80% of social contacts for eating out setting will continue 15 mins - 4 hours in the influenza season before the pandemic. However, after the outbreak of the COVID-19 pandemic, the eating out contacts continuing 15 mins -1 hour decreased -27.5% (change of mean number: -0.48), the contacts continuing 1 hour - 4 hours decreased -59.6% (change of mean number: -0.47), while more people prefer eating out less than 5 mins (change of total number of contacts: 7.4%, change of mean number of contacts: -0.38).

To avoid the infection from the COVID-19, the social contacts with short duration (less than 5 mins) during medical activities increased 10.0%, and that mean number of contacts increased 0.23 as well.

3) Social contacts across protecting measures

Three protecting measures of wearing mask, disinfecting hands, keeping a proper distance with others

are included in this analysis. The results indicated that the total number of these contacts taking protecting measures increased obviously compared to pre-pandemic, and the contacts without protecting measures decreased more than -90%.

The total number of contacts wearing a mask increased most obviously when working/studying (138.9%), doing medical activities (127.8%) and travelling in public transport (122.3%). The social contacts with disinfecting hands increased most obviously for the contact setting of shopping (108.3%), while it only increased 20.7% in the public transport. The obvious increase of the social contacts with keeping a proper distance with others is found for work/study setting (172.3%) and shopping setting (173.8%).

It is gratifying that people have taken more protecting measures (the total number with protecting measures increased) and contact fewer others (the mean number decreased) for the contact setting of shopping, leisure activities and medical activities during the pandemic. And it is reasonable for people to contact more people for work/study setting and public transport setting during the pandemic if they have taken enough protecting measures. However, it should be noted that some people haven't taken any protecting measures neither in pre-pandemic nor in during-pandemic, the mean number of contacts without any protecting measures in the location of shopping, cultural leisure and medical activities had increased during the pandemic as well.

6.3.3 Social contacts across contact modes and its changes before and during the COVID-19 pandemic

There are three contact modes defined in this chapter: (1) ONPC: Only non-physical contacts (in the physical presence of another person in same space without face to face conversation, skin-to-skin touching or other indirect physical contacts); (2) OPC: Only physical contacts (having a face to face conversation or, skin-to-skin touching or other indirect physical contacts); (3) PCNPC: both non-physical and physical contacts. In addition, it is important to note that the virtual social contact without the physical presence of social contact object in same space (e.g., online contact through SNS) is not included in the targeted non-physical contacts of this study. This classification contains not only close contacts but also indirect contacts providing a comprehensive overview for the social contact analysis.

About the relationship between number of contacts and contact mode, the results show that the mean number of social contacts increased with the risk level across the contact modes (risk level: ONPC < OPC < PCNPC). The number of contacts for medical activities setting is minimal among all settings, and the mean number didn't show obvious heterogeneities across the contact modes. The decreasing value of the total number of social contacts is associated with risk levels of contact modes, namely, PCNPC has the larger decrease of the total number of social contacts than OPC, and OPC has larger decrease than ONPC for all contact settings.

Obviously, people have more direct conversations with others when working/studying or joining the party. Thus, most of the contacts occurred in work/study setting (55%) and party setting (45.2%) have both non-physical and physical contacts. And that total number (work/study: -45.9%; party: -67.7%) and mean number of contacts (work/study: -1.07; party: -1.51) in PCNPC mode show an obvious decrease during the pandemic.

When people are shopping or traveling in public transport, they are usually in the physical presence of others but don't need to talk with them. As a result, the main contact mode for shopping and public transport is only non-physical contacts (shopping: 42.2%; public transport: 45.4%). The shopping contacts only showed a slightly decrease for the total number (-1.1%) and mean number (-0.48) of contacts, while the decrease of ONPC in public transport is obvious (change of total number: -40.5%; change of mean number: -0.93)

The mean number of contacts is average across three contact modes for cultural leisure, eating out, physical exercise, medical activities. Because if people doing these activities with companion, some people might only have conversations their companion. For these people they are more likely to have contacts in ONPC mode.

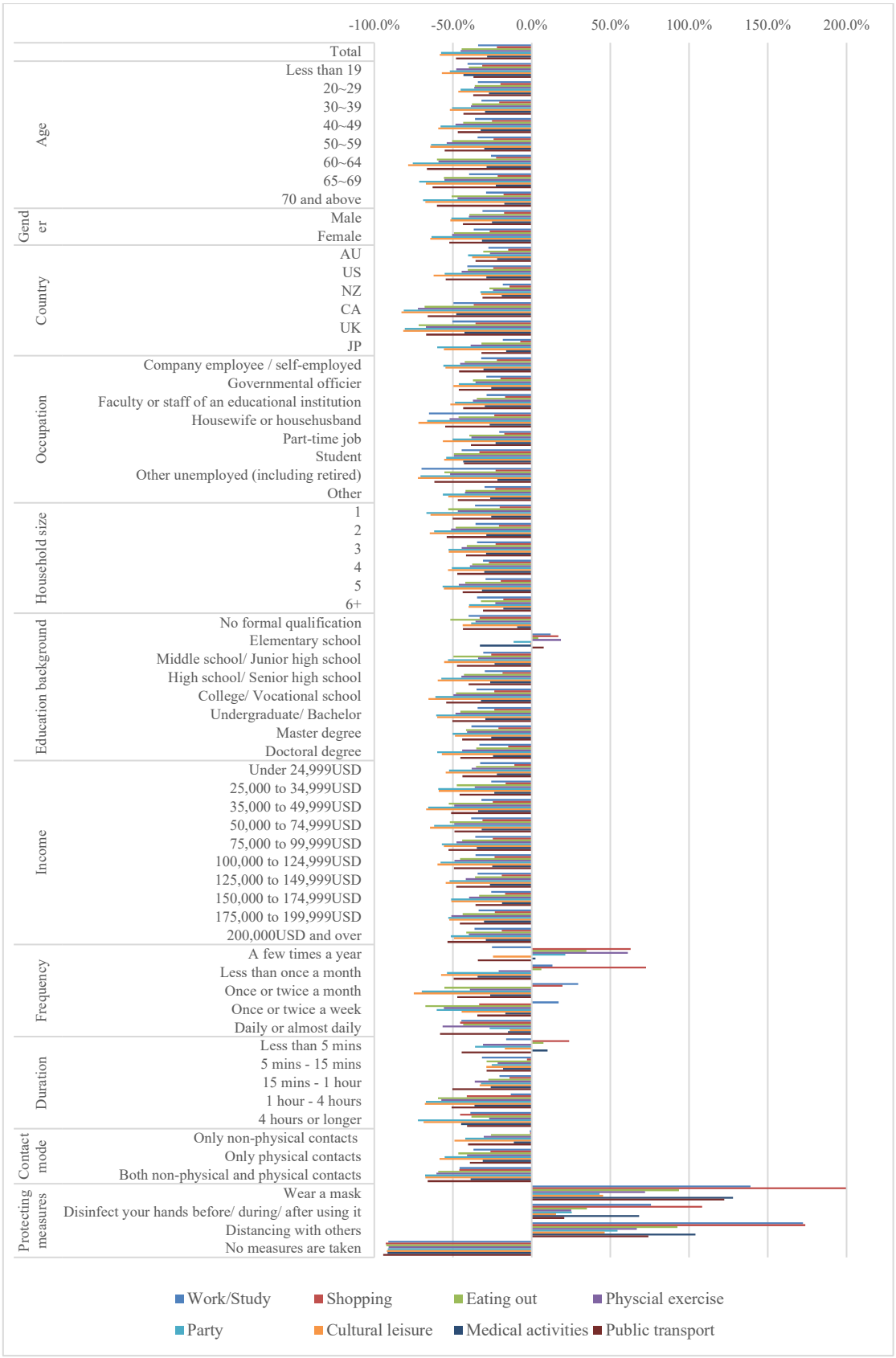

Figure 6. 1. The changes of total number of social contacts between pre-pandemic and during-pandemic

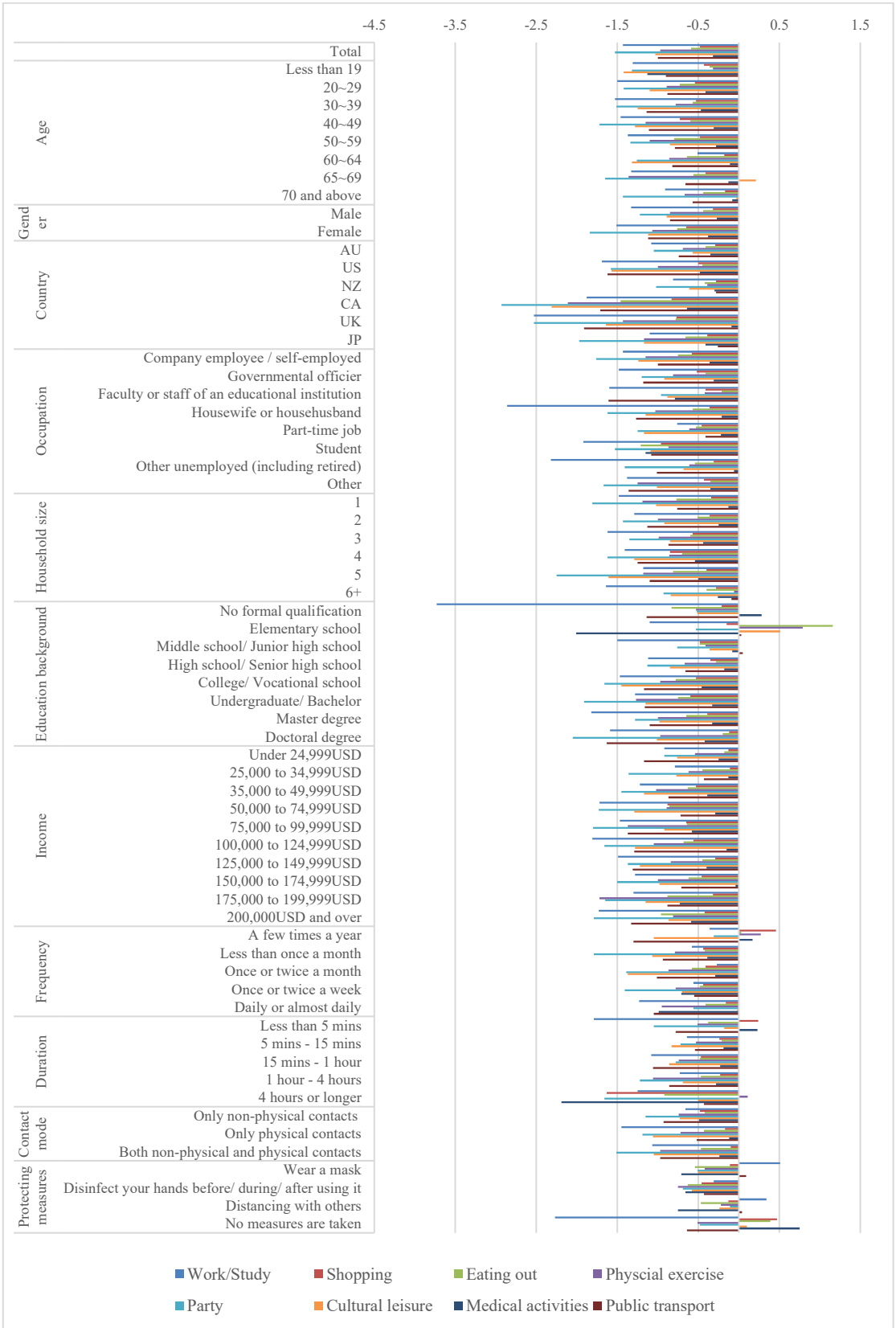

Figure 6. 2. The changes of the mean number of social contacts between pre-pandemic and during-pandemic

6.4 Conclusion

In this chapter, the descriptive analysis of the changes of people's social contact behaviors between during the influenza season in pre-pandemic and during the COVID-19 pandemic is conducted for eight contact settings from the perspectives of different individual/household attributes, activity participation attributes and contact modes. Not only the close contacts but also the indirect contacts are included in this analysis expressed into three contact modes: only non-physical contacts, only physical contacts, both of them. Two indicators were calculated to estimate the general changes of the total number of social contacts and the average changes of social contacts for people who still continue daily social contacts with others during the pandemic. The study findings are summarized as follows.

Obvious heterogeneities of social contacts were found across individual and household attributes and contact settings. After the lockdown were lifted, essential social contacts in places of work/study, shopping and medical activities would recover faster than the contacts for leisure activities, however, it is difficult to return to the normal level before the pandemic (Wong et al., 2022; Latsuzbaia et al., 2020; Zhang, J. and Litvinova, M. et al., 2021). The mean number of contacts is especially higher in work/study setting and public setting.

During the pandemic, older people are prone to have more contacts during work and fewer contacts during eating out. Young people are more likely to contact more people during the party. Older people (less than 70 years) had tried to decrease the mean number of contacts more if they have to perform medical activities. But it is difficult for the elderly (over 70 years) to decrease the social contacts during the medical activities. Females have decreased more social contacts than males during the pandemic. In countries with the ease of interventions for a long time, the mean number of contacts for these people who still perform leisure activities during the pandemic was obviously higher than that in other countries. However, the social contact during medical activities were high which could be led by the infection of the coronavirus. If country have taken soft interventions, the negative impact of pandemic on the economy could be likely to be smaller, but these interventions have only a slight impact on the decrease of the mean contacts. The people work for school/university and government are more likely to contact more people than other occupations when they are working. Housewife/househusband and other unemployed people (including retired) had decreased their contacts in public transport most obviously. Most of the social contact is made by the two-person household. These people who live alone have fewer intentions to make social contacts whether in pre-pandemic or during-pandemic. If people have a larger household size with more economic pressures, they are less likely to decrease the number of contacts when working. The low educated people have a higher dependence on the use of public transport for daily travels during the pandemic. The people with low income have an obvious higher social contact with others for work/study setting and shopping setting.

When people have contacts with others during the pandemic, their number of social contacts is

positively associated with the frequency and duration for performing the activities. The social contacts occurred with high-frequency and long-duration had decreased significantly during the pandemic. Meanwhile, the low-frequency contacts increased for work and shopping, and the short-duration contacts increased for medical activities, shopping and eating out settings. The social contacts with the contact mode of PCNPC (both physical contacts and non-physical contacts) show the most obvious decrease during the pandemic, while the social contacts with the mode of ONPC (only indirect non-physical contacts) have the smallest decrease. The social contacts for work/study setting and party setting are most both non-physical and physical contacts. The social contacts for shopping setting and public transport setting are most indirect non-physical contacts. The social contacts without protecting measures have decreased more -90%. The social contacts with wearing a mask increased most obviously for work/study setting, medical activities setting and public transport setting. The social contacts with disinfecting hands increased most obviously when shopping. The social contacts with social distancing measures increased obviously for work/study setting and shopping setting.

This chapter provides a glimpse on the heterogeneity of the number of social contact and its changes across the demographic attributes, activity participation attributes and contact modes. However, the obtained results in this chapter need to be combined with statistically significant results by modeling approach for persuasive evidence. And due to the limitation of the length of the chapter, the differences across some psychological variables that included in the multiple behaviors analysis are not reflected in this part. The modeling analysis of social contact behaviors would be conducted by the research in next chapter.

CHAPTER 7 Investigation of multi-faceted social contact decisions under the impacts of COVID-19: Joint analysis of contact mode choices and the number of contacted persons

7.1 Introduction

Individuals' social contacts with others during activity participation and travelling are one of the main channels of virus transmission (e.g., Mossong et al., 2008; Akakzia et al., 2007; Latsuzbaia et al., 2020; Li et al., 2020; Colomer et al., 2021; Mikszewski et al., 2022; Zhang et al., 2021a). To restrain the spread of COVID-19, various non-pharmaceutical interventions have been implemented. For example, strict lockdowns (Abouk et al., 2021; Sypsa et al., 2020; Tomori et al., 2021; Latsuzbaia et al., 2020; Lv et al., 2022) dramatically reduced the reproduction number (Brooks-Pollock et al., 2020; Zhang et al., 2021b; Tizzani et al., 2022; Trentini et al., 2022). Physical distancing measures and infection prevention measures (e.g., wearing a mask) have also been proven to be effective for the pandemic control (Haug et al., 2020; Islam et al., 2020; López et al., 2020; Thu et al., 2020; Huang et al., 2021). However, these measures also caused various negative impacts on economic activities and people's daily lives (involving various social contacts), which should be well addressed (Chakraborty and Maity, 2020; Guan et al., 2020; Oraby et al., 2021; Li et al., 2022; Nelson et al., 2022).

Social contact includes direct and indirect contacts between people. Because of the experiences during lockdowns, people have learned to change the way of social contact and activity-travel behaviors as well as to behave protectively for avoiding virus transmission (Wong et al., 2022; Liu et al., 2021; Latsuzbaia et al., 2020; Zhang et al., 2021b; Tomori et al., 2021) and mitigating the COVID-19 impacts on mental health (e.g., Pouso et al., 2020; Melnyk et al., 2022). However, it is not always successful to rely on changes in social contact behaviors, as evidenced by the repeated peaks of new infection cases. Thus, it is necessary to have a better understanding of social contact patterns and provide more reliable input data for assessing various policies. At the aggregated level, consequences from such efforts could offer valuable insights for improving the total environment, e.g., the reduced number of trips and activities because of social contacts may lead to less carbon emissions. However, existing knowledge

regarding the changes in social contact behaviors and its associated influential factors is rare, leading to various unknowns about social contacts and consequent misleading policymaking. As reviewed later, we have identified three key research gaps.

[1] Close contacts have been mainly investigated, because of the popular 1.0m or 2.0m distancing rule, as recommended by WHO and the US Centers for Disease Control and Prevention as well as many other countries. Studies on early stages of the pandemic already showed that the maximum transmission distance of SARS-CoV-2 aerosol might reach 4.0m (e.g., Guo et al. 2020) and modeling studies further confirmed that even the 2 m rule is not adequate for protecting people, especially in an indoor environment (e.g., Bazant and Bush, 2021). In other words, indirect social contacts may also transmit the virus. However, existing studies have neglected the investigation of indirect social contacts.

[2] Existing studies have widely investigated the average number of contacted persons during the COVID-19 pandemic but neglected the analysis of social contact mode choices (including physical (or direct) and non-physical (or indirect) contacts). More importantly, no study has been done to examine the association between social contact modes and the number of contacted persons, not mentioning about heterogeneities of social contacts across activity settings.

[3] As for modeling approaches, regression-type models have been mainly applied, where behavioral mechanisms have been beyond the scope of modeling framework. Concerning the two key social contact behaviors (i.e., choices of contact modes and the number of contacted persons), no relevant modeling effort has been made. In other words, the representation of the dependence between the two contact behaviors have been fully ignored.

This study aims to fill the above research gaps from the following aspects.

(1) A multi-country questionnaire survey was conducted in March-May 2021, from which valid answers were collected from more than 7000 respondents in six developed countries of Australia, Canada, Japan, New Zealand, the USA, and the UK. All data are pooled for this study for deriving cross-country common findings.

(2) Social contact mode choices and the number of contacted persons are jointly represented by building a copula-based model that combines a multinomial logit model and an ordered logit model, where utility-based behavioral decision-making mechanisms are reflected.

(3) Influences of seven key activity settings (work/study, shopping, eating out, physical exercise, parties, cultural leisure, medical activities) are simultaneously incorporated into the utility functions of the two contact behaviors. By doing so, observed heterogeneities of the influences of activity settings can be revealed in a comparative way.

(4) In addition to respondents' individual attributes, this study especially investigates the influences of factors related to social contact settings (both objective and subjective factors) and risk-related psychological factors (e.g., reliability of risk information, risk perceptions) as well as triggers (e.g., from government and workplace) for behavioral changes.

The rest of this study is structured as follows. Section 2 briefly summarizes the findings of previous studies related to social contacts. Section 3 describes the survey data. Section 4 discusses the copula-

based model used in this study. Section 5 shows the model results and discussion, and Section 6 provides the conclusion.

7.2 Survey and Data

7.2.1 Survey design

Based on the life-oriented approach (Zhang, 2017), a retrospective questionnaire survey was designed, where social contact behaviors during the COVID-19 pandemic were investigated with respect to seven representative social contact settings (work/study, shopping at supermarket/shopping mall, eating out at restaurants, physical exercise at indoor places (e.g., gym), parties at indoor public places (e.g., bar), cultural leisure (e.g., visiting cinema, concert hall, etc.), medical activities (e.g., see a doctor, purchase medicine)). Social contact behaviors refer to choices of four types of social contact modes and the number of contacted persons. The four contact modes are: (1) no contact (NC), (2) only physical contacts [OPC] (e.g., having a face-to-face conversation or, skin-to-skin touching or other indirect physical contacts), (3) only non-physical (or indirect) contacts (ONPC) (e.g., in the physical presence of another person but without face to face conversation, skin-to-skin touching or other indirect physical contacts), and (4) both physical and non-physical contacts (PCNPC). The number of persons to be contacted was measured using an ordinal scale: (1) 1–2 persons, (2) 3–4 persons, (3) 5–6 persons, (4) 7–9 persons, and (5) ten persons or more. In the case of no contact, the number was reported to be zero. Note that contacts between household members are excluded from this survey.

The survey further investigated potential determinants of social contact behaviors, including factors related to social contact settings and risk-related psychological factors as well as triggers for behavioral changes, in addition to individuals' socio-demographic attributes. As for social contact settings, both objective and subjective factors are incorporated into the modeling analysis. Objective factors include activity frequency, distance from home to activity destination, travel party, and protective measures taken for having social contacts (wear a mask, disinfect hands). Subjective factors include respondents' perceptions of contact situations at activity locations (i.e., closed spaces with poor ventilation, crowded places, and close-contact settings), perceived safety levels and protective capacities (or efficiency) (e.g., Witte and Allen, 2020) with respect to respondents themselves and their household members, and attitudes toward the necessity and publishment related to activities. Concerning risk-related psychological factors, this study focuses on the reliability of risk information, risk perceptions at different spatial scales, and acceptance of changing the duration/timing of activity participation. Triggers for behavioral changes (e.g., Sparkman and Walton, 2017) were captured from the perspectives of stakeholders and the number of infected cases.

7.2.2 Survey implementation and samples

The survey was conducted online in six developed countries (Australia, United States, New Zealand, Canada, the United Kingdom, and Japan) in March-May 2021. To roughly reflect the representativeness of the whole population in each country, the collected samples' distributions in terms of age, gender and residence region were set to be almost same as those in the whole population, based on official statistics of these countries.[7] Finally, more than 1000 samples were collected in each country: Australia (AU: 1125), United States (US: 1297), New Zealand (NZ: 1193), Canada (CA: 1176), United Kingdom (UK: 1305) and Japan (JP: 1169). In total, 7265 respondents provided valid information. The differences between the samples the whole populations are within two percentage points, respectively. Table 7.1 only shows the differences across regions in each country.

Table 7.2 shows distributions of individual attributes by country/region. The share of males (49.0%) is slightly lower than that of females (51.0%) for the whole data. These shares well matched those in the whole populations (males: 49.3%, females: 50.7%). People aged 30-60 years old account for the biggest share (49.6%). The share of old people (aged 60 or above) (29.6%) is higher than that of young people (younger than 30 or below) (20.8%). Company employees/self-employed people have the biggest share (39.4%), followed by other unemployed/retirement (24.6%). About one-third of the respondents have an educational qualification of undergraduate/bachelor (32.9%), followed by those with college/vocational qualification (22.5%) and high school or senior high school (19.8%).

[7] Australian Bureau of Statistics: https://www.abs.gov.au/ (2020); U.S. Census Bureau: https://www.census.gov/ (2020); Stats NZ: https://www.stats.govt.nz/ (2018); Statistics Canada: https://www.statcan.gc.ca/en/start (2020); Office for National Statistics - GOV.UK: https://www.gov.uk/government/organisations/office-for-national-statistics (2020); Statistics Bureau of Japan: https://www.stat.go.jp/english/ (2020)

Table 7. 1. Differences of regional distributions between samples and whole populations

Country	Regions	Shares in samples (%) (A)	Shares in whole population (%) (B)	Differences of shares (%) (A – B)
AU	New South Wales, Australian Capital Territory	32.8	33.7	-0.9
	Queensland	19.9	20.1	-0.2
	South Australia, Northern Territory	8.9	7.9	1.0
	Victoria, Tasmania	26.5	27.9	-1.4
	Western Australia	11.9	10.4	1.5
US	Arizona, New Mexico, Colorado	6.5	5.7	0.8
	Washington, Alaska, Hawaii, Oregon, Wyoming, Montana, Idaho, Nevada, Utah	6.5	5.8	0.7
	California	12.1	12.3	-0.2
	Texas	8.3	8.5	-0.2
	Florida	6.6	6.6	0.0
	North Carolina, South Carolina, Georgia	8.3	8.5	-0.2
	Virginia, West Virginia, Maryland, Delaware, Washington, D.C., Tennessee, Kentucky	8.5	8.8	-0.3
	Arkansas, Mississippi, Oklahoma, Louisiana, Alabama	6.2	6.1	0.1
	New York, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, Maine	9.3	9.6	-0.3
	New Jersey, Pennsylvania	6.9	6.9	0.0
	Wisconsin, Illinois, Indiana	7.0	8.2	-1.2
	Michigan, Ohio	7.2	6.7	0.5
	Minnesota, North Dakota, South Dakota, Missouri, Kansas, Nebraska, Iowa	6.6	6.3	0.3
NZ	Auckland, Northland	32.2	36.8	-4.6
	Bay of Plenty, Gisborne	8.8	7.7	1.1
	Canterbury	13.7	13.0	0.7
	Manawatu-Wanganui, Taranaki, Hawke's Bay	11.6	10.8	0.8
	Marlborough, Nelson, Tasman, West Coast, Southland, Otago	12.6	11.6	1.0
	Waikato	9.9	9.4	0.5
	Wellington	11.2	10.7	0.5
CA	Alberta, Northwest Territories	12.3	11.3	1
	British Columbia, Yukon	14.9	14.6	0.3
	Manitoba, Nunavut, Saskatchewan	8.1	6.3	1.8
	New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador	7.8	6.2	1.6
	Ontario	35.5	39.0	-3.5
	Quebec	21.4	22.6	-1.2
UK	Scotland	8.7	8.5	0.2
	Northern Ireland, Wales	9	7.5	1.5
	North West, North East	12.8	15.0	-2.2
	Yorkshire and The Humber	9.2	8.4	0.8
	West Midlands	8.8	8.9	-0.1
	East Midlands	8.5	7.1	1.4
	South West	9.4	8.5	0.9
	South East	11.7	13.9	-2.2
	East of England	9.7	9.1	0.6
	Greater London	12.2	13.1	-0.9
JP	Hokkaido	4.5	4.4	0.1
	Tohoku	7.7	7.4	0.3
	Kanto	34.1	34.5	-0.4
	Chubu	16.6	16.9	-0.3
	Kinki	18.6	18.2	0.4
	Chugoku, Shikoku	7.3	6.7	0.6
	Kyushu, Okinawa	11.2	11.9	-0.7

Table 7. 2. Distribution of individual attributes by country

Attributes	Definition	AU (%)	US (%)	NZ (%)	CA (%)	UK (%)	JP (%)	Total (%)
Gender	Male	49.0	49.0	48.5	48.6	49.9	48.6	49.0
	Female	51.0	51.0	51.5	51.4	50.1	51.4	51.0
Age	< 30 years old	23.6	20.7	22.4	20.6	19.3	18.5	20.8
	30–59 years old	49.7	50.1	50.4	51.1	52.7	42.9	49.6
	60 years old or above	26.7	29.2	27.2	28.3	28.0	38.6	29.6
Occupation	Company employee/self-employed	38.3	36.1	39.3	38.4	43.8	40.2	39.4
	Civil servants / organizational employees	6.5	3.6	6.5	4.7	6.5	3.3	5.2
	Faculty and staff of educational institutes such as schools and universities	3.0	4.0	4.4	3.6	3.1	0.7	3.1
	Housewife	7.9	6.5	6.4	5.7	5.9	18.4	8.3
	Part-time job	12.4	8.3	10.0	8.0	7.0	10.5	9.3
	Student	3.3	4.8	4.4	5.5	3.9	3.2	4.2
	Other unemployed (including retirement)	23.6	27.8	23.9	28.7	23.6	19.8	24.6
	Others	5.0	8.9	5.1	5.4	6.2	3.9	5.9
Education	No formal qualification	0.2	0.5	2.8	0.1	1.4	0.1	0.8
	Elementary school	2.5	0.5	1.9	0.7	0.5	0.0	1.0
	Middle school/Junior high school/Secondary school	13.6	0.5	13.1	1.4	20.2	2.2	8.6
	High school/ Senior high school	14.6	20.4	14.4	20.2	20.2	29.0	19.8
	College/ Vocational school	26.2	27.8	20.1	31.0	12.1	18.3	22.5
	Undergraduate/ Bachelor	26.7	26.0	35.2	33.7	30.4	46.1	32.9
	Master's degree	14.1	19.9	10.6	11.3	13.0	3.3	12.1
	Doctoral degree	2.1	4.4	1.9	1.6	2.2	1.0	2.3

7.2.3 Data screening

To better understand social contact decisions, here, data without out-of-home activities are excluded. As a result, samples included in the seven social contact settings are 3963 for work/study (51.8% out of all the 7265 respondents), 7245 for shopping (99.7%), 4562 for eating out (62.8%), 3518 for physical exercise (48.4%), 3044 for parties (41.9%), 3025 for cultural leisure (41.6%), and 5670 for medical activities (78.0%). The largest shares of performing no out-of-home activities are observed with respect to cultural leisure and parties, while only 0.3% did not go shopping. Stopping some out-of-home activities is probably for the consideration of protecting people from being infected (Zhang, 2020).

As shown in Table 7.3, males performed more daily activities than females during the COVID-19 pandemic, except shopping and medical activities. People aged 20–29 participated in more activities (especially for parties (28.1%) and cultural leisure (28.3%)) than other age groups. More than half of respondents lived in a household with fewer members (three members or below) and about one-third of respondents came from a two-member household. More than half of the respondents were married. Respondents with the undergraduate/bachelor qualification ranged from 32.4% to 36.7%, followed by the education qualification of college or vocational school. About 60% of respondents' income levels were between 35,000 USD and 149,999 USD.

Table 7. 3. Individual attributes by social contact setting

		Work/ Study (%)	Shopping (%)	Eating out (%)	Physical exercise (%)	Parties (%)	Cultural leisure (%)	Medical activities (%)	Total (%)
Gender	Female	46.2	51.0	48.6	45.3	44.6	44.7	50.8	48.1
	Male	53.8	49.0	51.4	54.7	55.4	55.3	49.2	51.9
Age	15~19	2.8	2.1	2.3	2.7	2.5	2.5	1.9	2.3
	20~29	27.0	18.8	23.3	26.4	28.1	28.3	19.2	23.3
	30~39	22.1	16.7	19.1	21.3	22.2	22.6	16.6	19.4
	40~49	20.2	16.2	16.9	17.0	18.1	17.7	15.5	17.1
	50~59	16.5	16.7	14.9	13.3	13.1	13.1	15.7	15.1
	60~64	4.6	7.1	5.3	4.5	3.7	3.8	6.8	5.5
	65~69	3.3	8.2	6.4	5.6	4.5	4.1	8.5	6.3
	70 and above	3.5	14.2	11.8	9.2	7.8	7.9	15.8	11.0
Number of households	1	15.9	19.1	16.3	15.4	14.1	15.1	18.1	16.8
	2	28.6	36.6	34.1	31.0	31.0	29.1	36.8	33.3
	3	22.7	19.8	20.9	21.8	22.3	22.9	19.8	21.1
	4	21.8	16.1	19.0	20.9	21.4	21.6	16.7	19.0
	5	7.3	5.4	6.1	6.6	6.7	6.8	5.4	6.1
	6 and above	3.7	3.0	3.6	4.3	4.5	4.5	3.2	3.7
Marriage	Married	55.1	55.8	58.2	57.8	59.0	57.0	58.1	57.2
	Other (including single, divorced, widowed)	44.9	44.2	41.8	42.2	41.0	43.0	41.9	42.8
Education	No formal qualification	0.5	0.8	0.8	0.7	0.9	0.9	0.9	0.8
	Elementary school	0.9	1.0	1.2	1.4	1.7	1.6	1.3	1.2
	Middle school/ Junior high school	6.0	8.6	6.9	7.0	7.2	7.3	8.3	7.6
	High school/ Senior high school	17.5	19.7	18.2	16.5	16.2	16.0	18.7	18.0
	College/ Vocational school	20.0	22.5	22.5	20.6	20.7	20.6	22.8	21.6
	Undergraduate/ Bachelor	36.7	32.9	34.2	34.7	34.0	34.5	32.4	33.9
	Master's degree	15.6	12.2	13.6	16.2	16.6	16.5	13.2	14.3
	Doctoral degree	2.8	2.3	2.6	2.9	2.7	2.6	2.4	2.6
Income	under 24,999USD	9.4	13.3	11.7	10.3	9.7	10.5	12.8	11.5
	25,000 to 34,999USD	7.9	11.1	10.2	9.2	8.4	9.1	10.8	9.8
	35,000 to 49,999USD	11.2	13.7	11.5	11.0	9.8	10.1	13.1	11.9
	50,000 to 74,999USD	16.5	17.0	16.8	16.9	17.3	16.2	17.1	16.9
	75,000 to 99,999USD	15.6	14.4	15.3	15.2	16.4	16.2	14.3	15.1
	100,000 to 124,999USD	13.7	11.1	11.7	13.0	13.6	13.4	11.6	12.3
	125,000 to 149,999USD	10.0	7.9	8.9	9.5	9.7	9.5	8.3	8.9
	150,000 to 174,999USD	7.5	5.2	6.4	6.8	6.4	6.4	5.2	6.1
	175,000 to 199,999USD	3.7	2.7	3.3	3.5	3.9	3.8	3.0	3.3
	200,000USD and over	4.5	3.6	4.2	4.6	4.8	4.8	3.8	4.2

7.3 Features of Key Variables

7.3.1 Dependent variables: Social contact behaviors

As shown in Figure 7.1, more than 60% of respondents had a certain contact with others at all contact settings, where parties have the largest contact share (75.7%), and shopping showed the smallest share of 62.3%. Among the three modes with contact, the ONPC mode (i.e., only having indirect contact) accounted for the largest share in all settings (among which, the shares during shopping and eating out were larger than 37.0%). Considering that the PCNPC mode (the shares range between 11.5% (shopping) and 25.7% (work/study)) also includes indirect contact, ignoring the indirect contact in existing studies is obviously wrong. Smaller shares of the OPC mode than the ONPC mode at all settings suggest that people surely tried to avoid close contact for safety as much as possible, but among all settings, parties, cultural leisure, and medical activities had the largest shares of close contact. Interestingly, the shares across modes during parties are similar to those during medical activities.

Figure 7.2 indicates that work/study, parties, and cultural leisure involved a larger number of contacts (at least 5 persons: 29.2%–40.3%) than in other settings, where the routine activity "work/study" should be regarded as the riskiest setting for pandemic control policymaking. Shopping, eating out and medical activities showed the largest share of 1–2 persons. The shares of 3–4 persons varied across settings slightly (11.9% (shopping) – 20.6% (eating out)), in comparison to those of 1–2 persons (16.9% (work/study) – 43.8% (medical activities)).

Concerning the relationships between social contact modes and the number of contacted persons (see Figure 7.3), it is shown that the largest number of contacted persons (i.e., at least 5 persons) was observed under both physical and non-physical contacts (i.e., PCNPC) at all settings. Thus, mixed contact modes are associated with more persons to be contacted. Compared with the non-physical contact mode (ONPC), the physical contact mode (OPC) has a higher share in the largest number of contacted persons (i.e., at least 5 persons). This is consistent with the observation that the ONPC mode is more likely to be linked with the smallest number of 1–2 persons than OPC and PCNPC. As for the medium-size of contacts (i.e., 3–4 persons), its largest shares are not necessarily associated with either PCNPC or OPC.

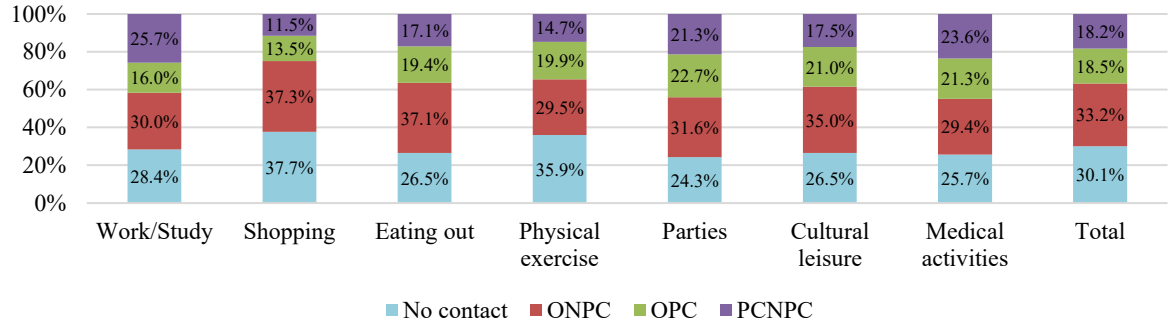

Figure 7. 1. Distributions of social contact modes by activity

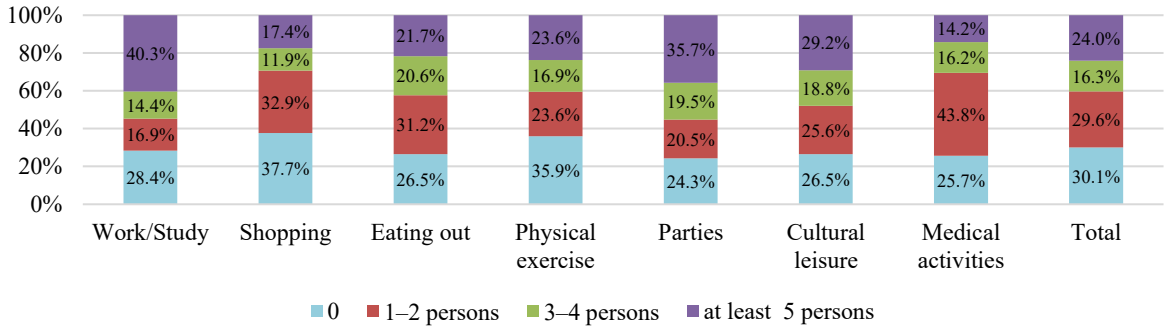

Figure 7. 2. Numbers of persons contacted by activity

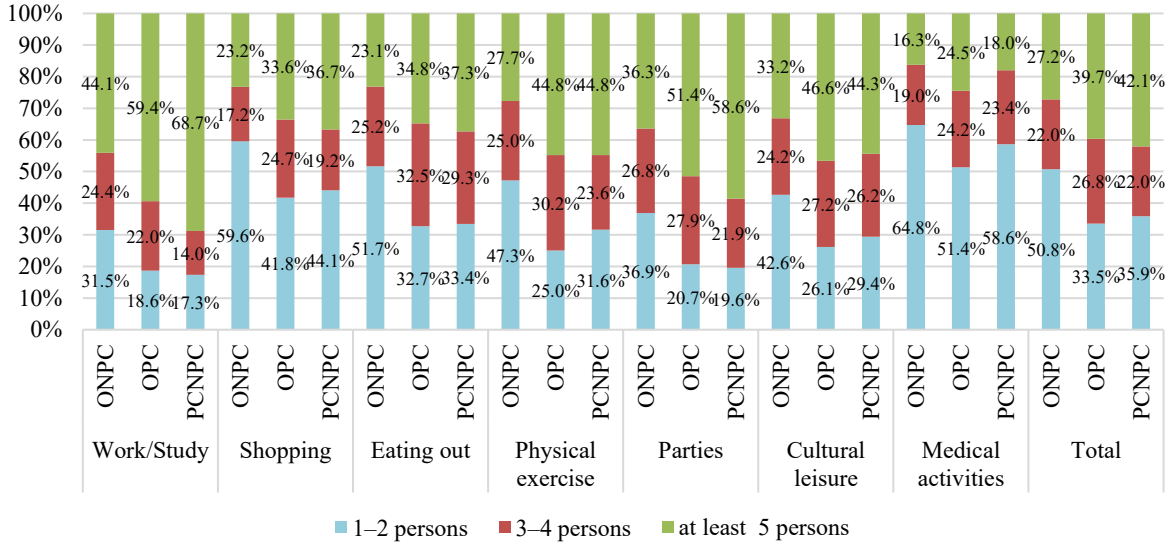

Figure 7. 3. Distributions of numbers of persons contacted under different modes by activity

7.3.2 Explanatory variables: Key candidates

7.3.2.1 Factors related to activity participation

1) Perceptions of 3Cs at activity locations

An analysis was conducted with respect to the shares of the respondents who perceived their daily activity locations to be closed spaces with poor ventilation, crowded places, or places with close contact (i.e., 3Cs). Pooling data from all social contact settings, it is found that the share perceiving closed places is only 18.5%, the share of crowded places is 30.0% and the share of close-contact settings is 34.7%. This can be interpreted that people are willing to visit places without 3Cs, especially those who hold a low tolerance to poor ventilation during the COVID-19 pandemic. Among the seven contact settings, five of them showed the highest share of having places with close contact. Crowded places were mostly perceived with respect to the settings of shopping, cultural leisure, and parties. People suffered more from poor ventilation during work/study and parties than in other settings. Details refer to the Figure 7.4 of Supplementary Information.

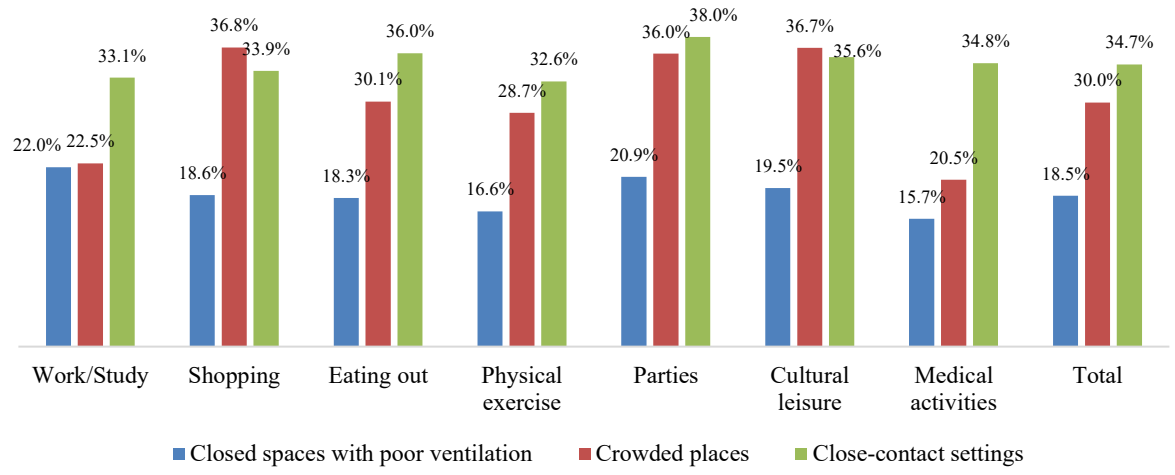

Figure 7. 4. Perceptions of 3Cs at activity locations

2) Perceived safety during activity participation

Only about half of respondents perceived that participation in activities was safe. Performing medical activities were perceived to be the safest among all social contact settings, followed by the setting of work/study. The above observations are about themselves and their companions. More or less, respondents perceived that the safety levels during parties and cultural leisure are lowest for themselves, while they perceived that participating in shopping and eating out has the least safety level for their companions. Details refer to the Figure 7.5 of Supplementary Information.

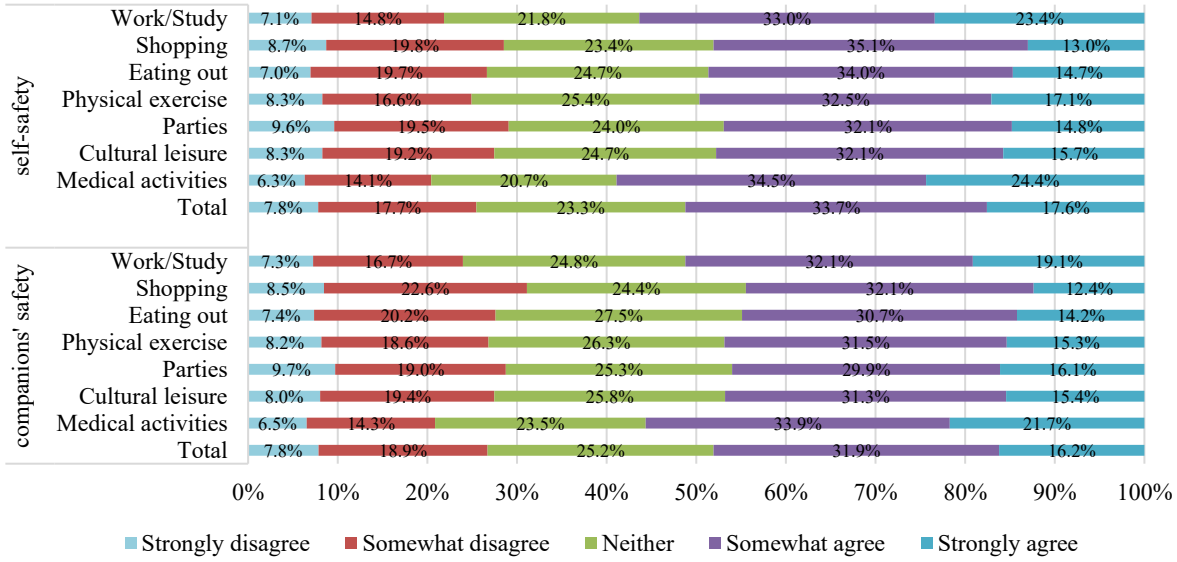

Figure 7. 5. Perceived safety during activity participation

3) Protective measures taken during activity participation

Recognizing the above perceived safety level (relatively low, on average), the shares of wearing a mask and disinfecting hands are about 60% by pooling data of all contact settings. Among all settings, the shares of taking such protective measures are highest for shopping and medical activities. This may be due to the high frequency of shopping and concerns about infection risks in hospitals. As expected, the shares of taking protective measures when participating in parties are lowest, which are however not significantly different from those for physical exercise and cultural leisure. It is further surprising that the shares for eating out are much lower than those for work/study, even though eating out is usually risker in terms of infection. Details refer to the Figure 7.6 of Supplementary Information.

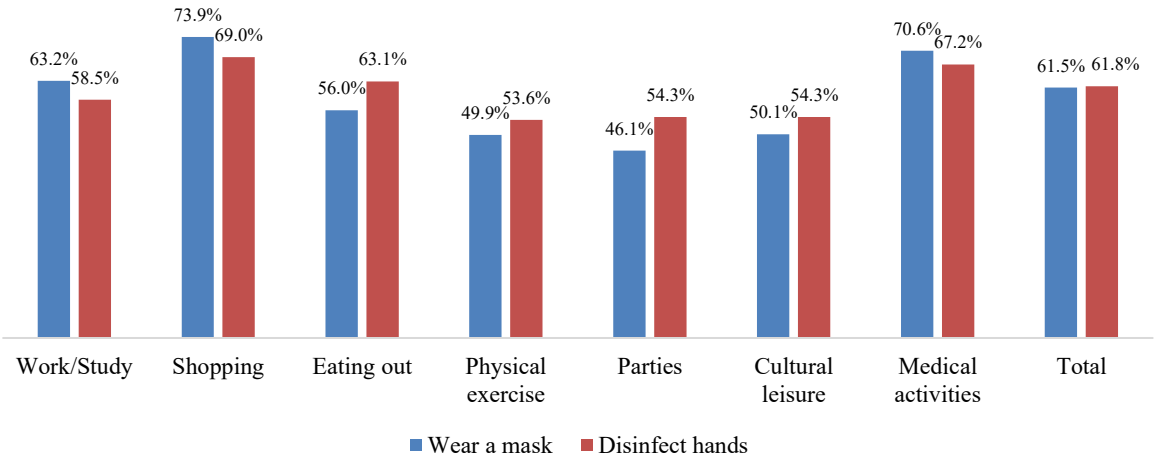

Figure 7. 6 Protective measures taken during activity participation

4) Self-efficiency and others' efficiency

In all contact settings, respondents' belief in other people's capacity to protect others (including respondents) (i.e., others' efficiency) is higher (shares of "high" and "very high") than that in their own capacity to protect themselves (i.e., self-efficiency). Respondents reported the highest capacity to protect themselves during shopping and medical activities, while reported that other people's capacity to protect others (including respondents) during medical activities is the highest, which is probably because of the higher belief in hospitals. Being aware of higher infection risks during parties and cultural leisure activities, the perceived self-efficiency and others' efficiency were lower than in other contact settings. Details refer to the Figure 7.7 of Supplementary Information.

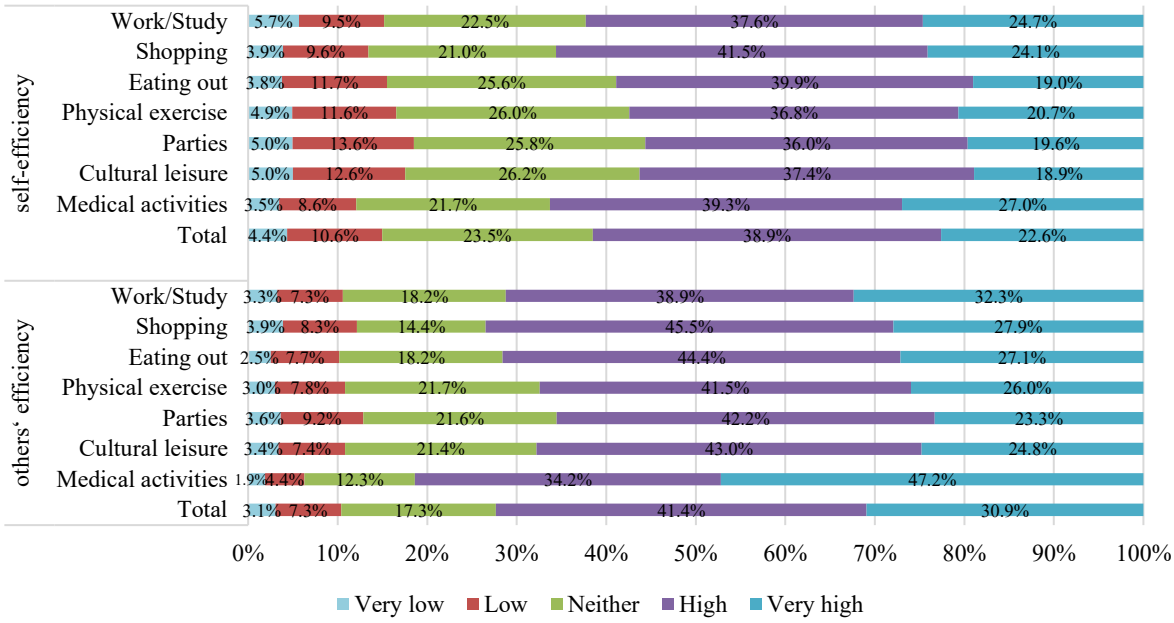

Figure 7. 7. Self-efficiency and others' efficiency

5) Attitudes toward necessity and punishment related to activity participation

An analysis was conducted about people's attitudes toward whether they think performing a certain activity during the pandemic should be published or not and whether they think performing the activity is necessary even at the infection risk or not. In the case of total data, the shares of supporting punishment and necessity are almost equally larger than 40% ("somewhat agree" and "totally agree"), which are larger than the unsupported shares. The largest support share of activity necessity is work/study (very close to 50%), while the support share of punishment to work/study is less than 40%. The second largest support share of activity necessity is participation in medical activities, for which only about 32% of respondents supported the punishment of medical activities. The largest more than 52% of respondents supported the punishment to party participation, while its necessity-support share was about 37%. But the smallest necessity-support share does not necessarily correspond to the largest punishment-support share, as shown by the shares for eating out. Details refer to the Figure 7.8 of

Supplementary Information.

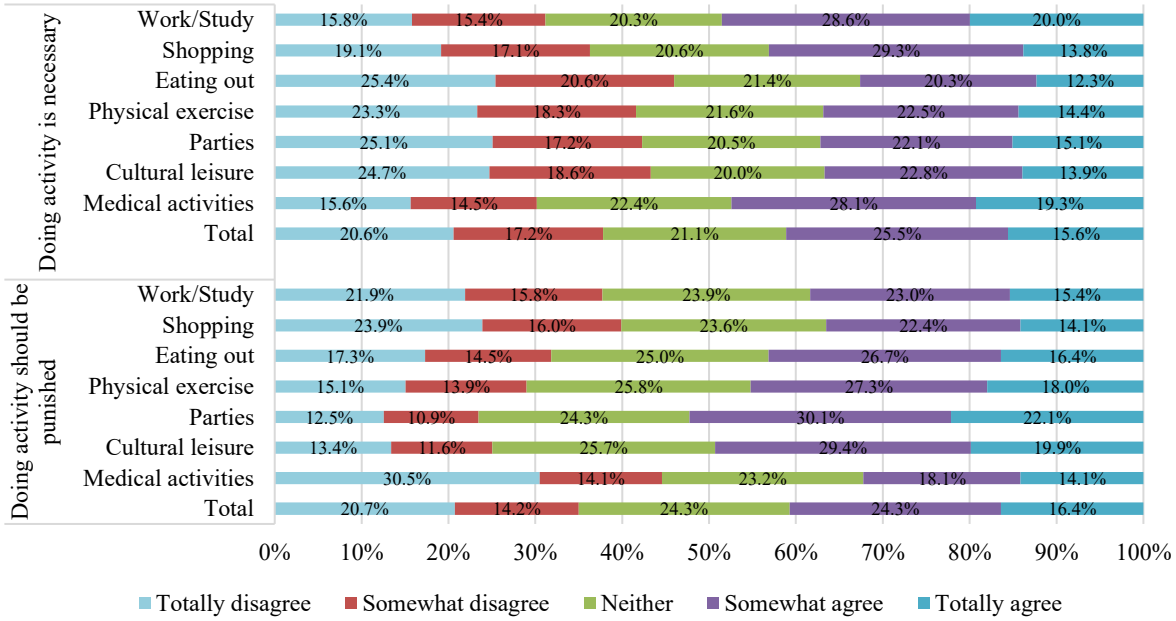

Figure 7. 8. Perceptions of activity-related necessity and punishment

6) Activity attributes

Even under the COVID-19 pandemic, about 60% of respondents had to work/study in a daily or almost daily basis. Going to shopping once or twice a week accounted for the largest share (55.7%), among all shopping frequency categories. Participation less than once a month was dominant for parties, cultural leisure, and medical activities as well as eating out. For physical exercise, less than once a month and once or twice a week are the two main activity frequencies. Details refer to the Figure 7.9 of Supplementary Information.

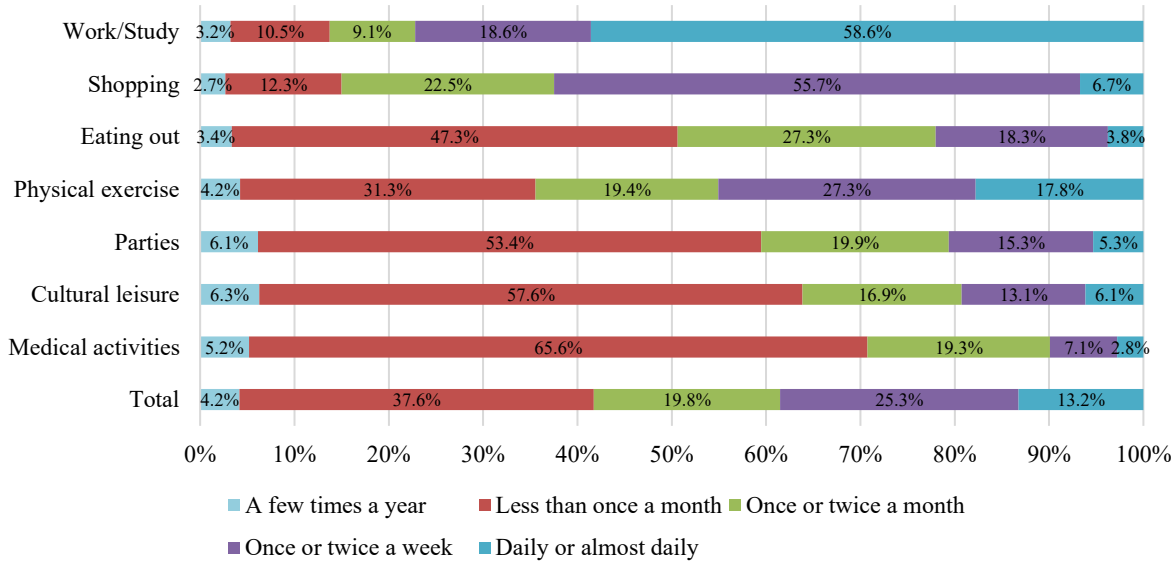

Figure 7. 9. Activity frequencies

Comparing with the travel distance for home to work/study locations that may be largely associated with people's daily action space, medical activities had a similar share of shorter distance (< 2km), while culture leisure's longer travel distance (5km or longer) is similar to that of work/study. The travel distances for shopping and physical exercise are similarly shorter than 2km. Respondents participating in cultural leisure prefer a longer distance over a shorter distance. More or less, eating out and parties showed similar distance distributions. In the case of medical activities, the shares of shorter and longer distances are very similar. Details refer to the Figure 7.10 of Supplementary Information.

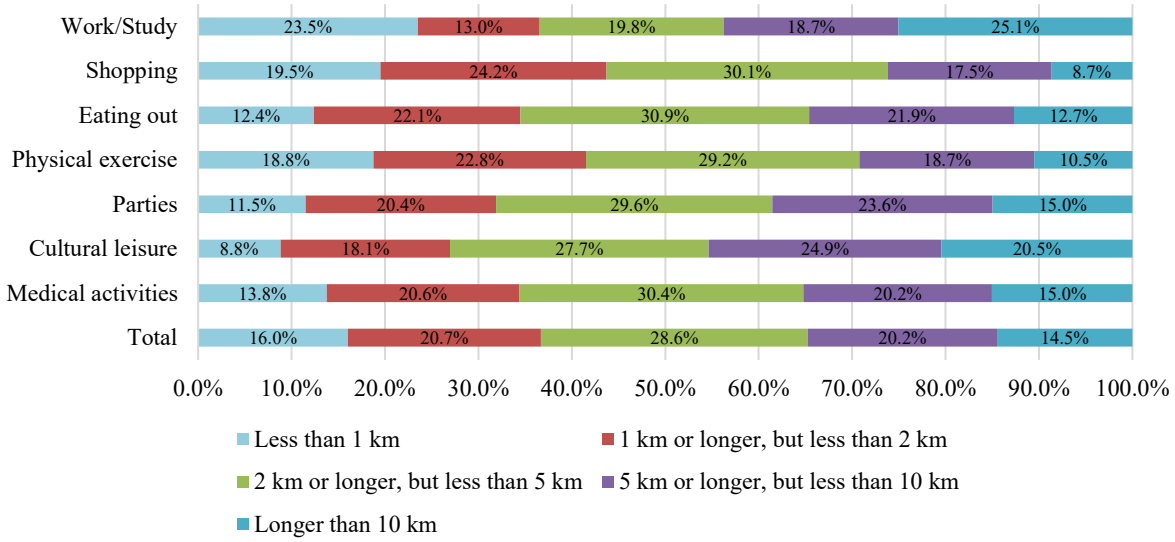

Figure 7. 10. Travel distance from home to activity locations

Concerning the shares of whether people performed a certain activity with acquaintances (including friends, but except their household members), expectedly, participating in a party had the largest share (33.7%), followed by cultural leisure, while the shares for shopping and medical activities were the lowest. Eating out and physical exercise showed similar shares (about 20%). Details refer to the Figure 7.11 of Supplementary Information.

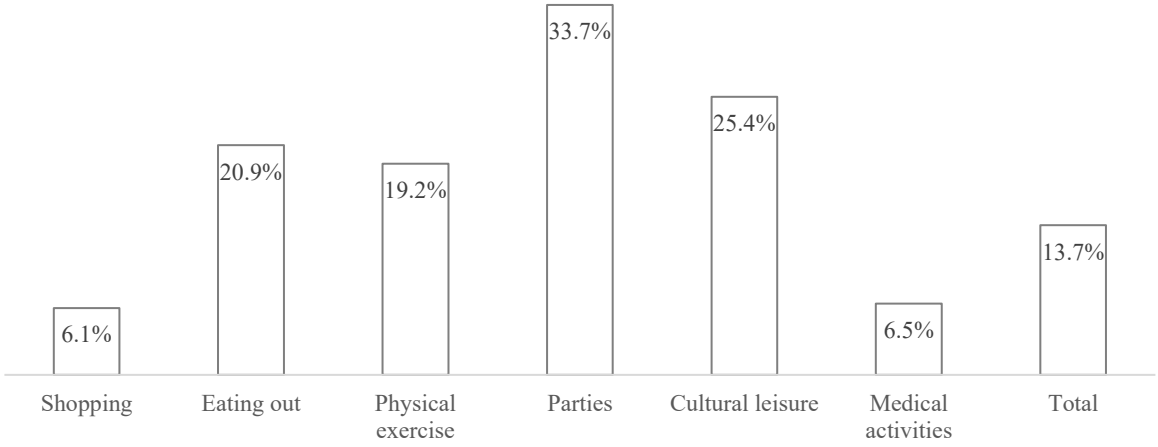

Figure 7. 11. Shares of activity participation with acquaintances

7.3.2.2 Risk-related psychological factors

1) Risk perception and reliability of information

The shares of people perceiving a higher risk in crowded trains and buses are between 60% and 70% ("somewhat agree" and "strongly agree"), which were much higher than the shares of a higher risk perceived in residence regions (more than 40%) and residence country (between 30% and 40%). Thus, it seems that people's risk perception is negatively associated with spatial scales; however, the shares of "disagree" and "agree" are almost equal for the risk perception at the level of residence region, while the "disagree" shares are larger than the "agree" shares at the level of the residence country. Concerning social contact settings, the shares of higher risk in crowded public transport are especially higher in the cases of participating in medical activities, shopping, and work/study, while there are differences across the settings, although the differences are not remarkable. For information reliability (provided by the local government), more than 65% of the respondents trusted the information, and only about 10% did not trust it, where the shares of reliability assessment are very similar across social contact settings. Details refer to the Figure 7.12 of Supplementary Information.

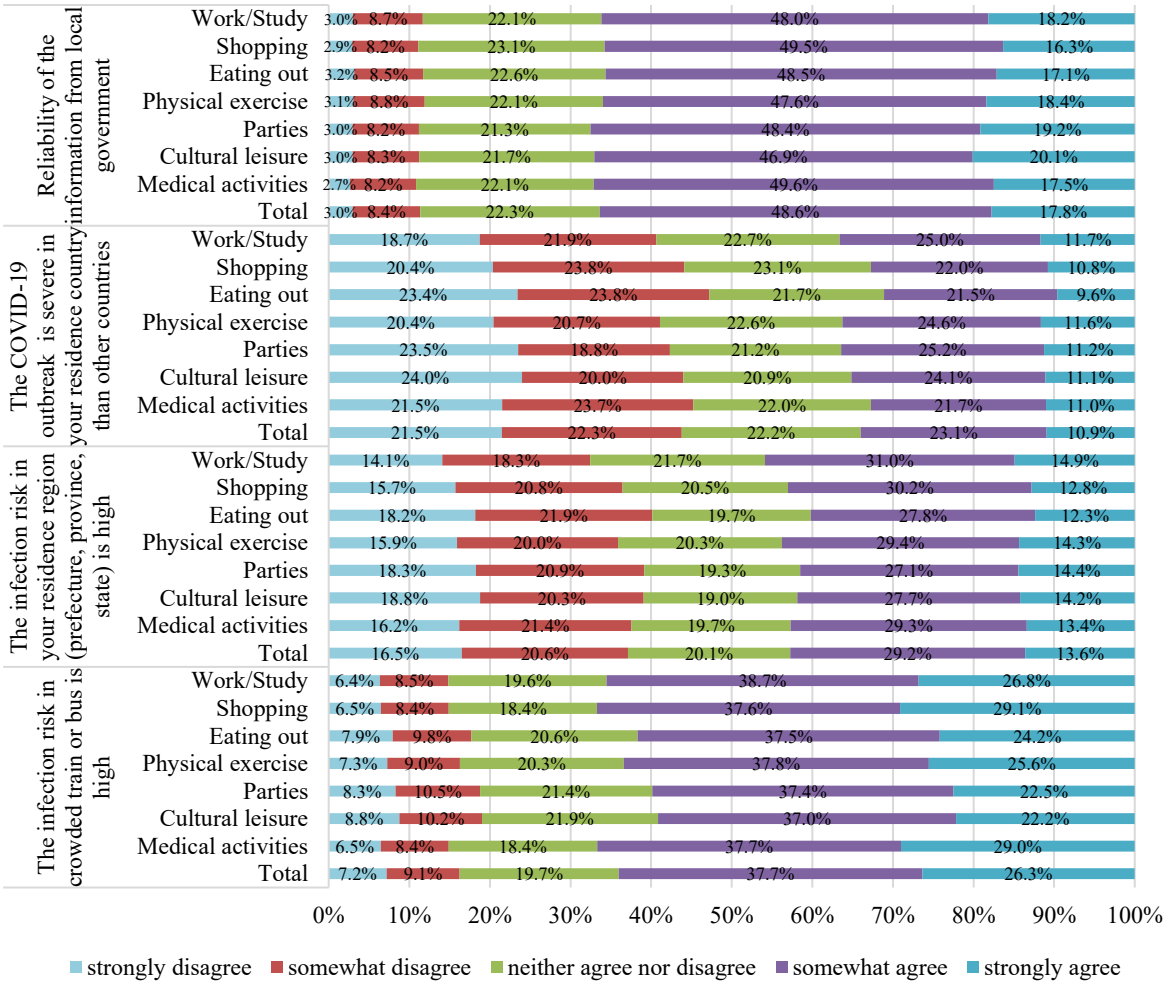

Figure 7. 12. Risk perception and reliability of risk information

2) Triggers for behavioral changes

Regarding the triggers for behavioral changes, more than 60% of respondents answered that they changed their behaviors due to the influences of multiple triggers, irrespective of social contact settings. In contrast, only less than 15% of respondents disagreed with the influences of multiple triggers. Among the three triggers investigated in the survey, people were mostly triggered by the formal rules from the government in the sense that the corresponding "agree" shares are much higher than the other two triggers: i.e., the rules from the workplace/organization and the number of infected cases. This is probably because the rules from the government are more mandatory and authoritative. The rules from the government and the number of infected cases had larger impacts on the behavioral changes of those people who had shopping and medical activities during the pandemic. The rules from the workplace/organization/affiliation especially affected the behavioral changes related to work/study. The "agree" shares for leisure activities (eating out, physical exercise, parties, cultural leisure) were not as large as the shares for mandatory/maintenance activities (work/study, shopping, medical activities). Details refer to the Figure 7.13 of Supplementary Information.

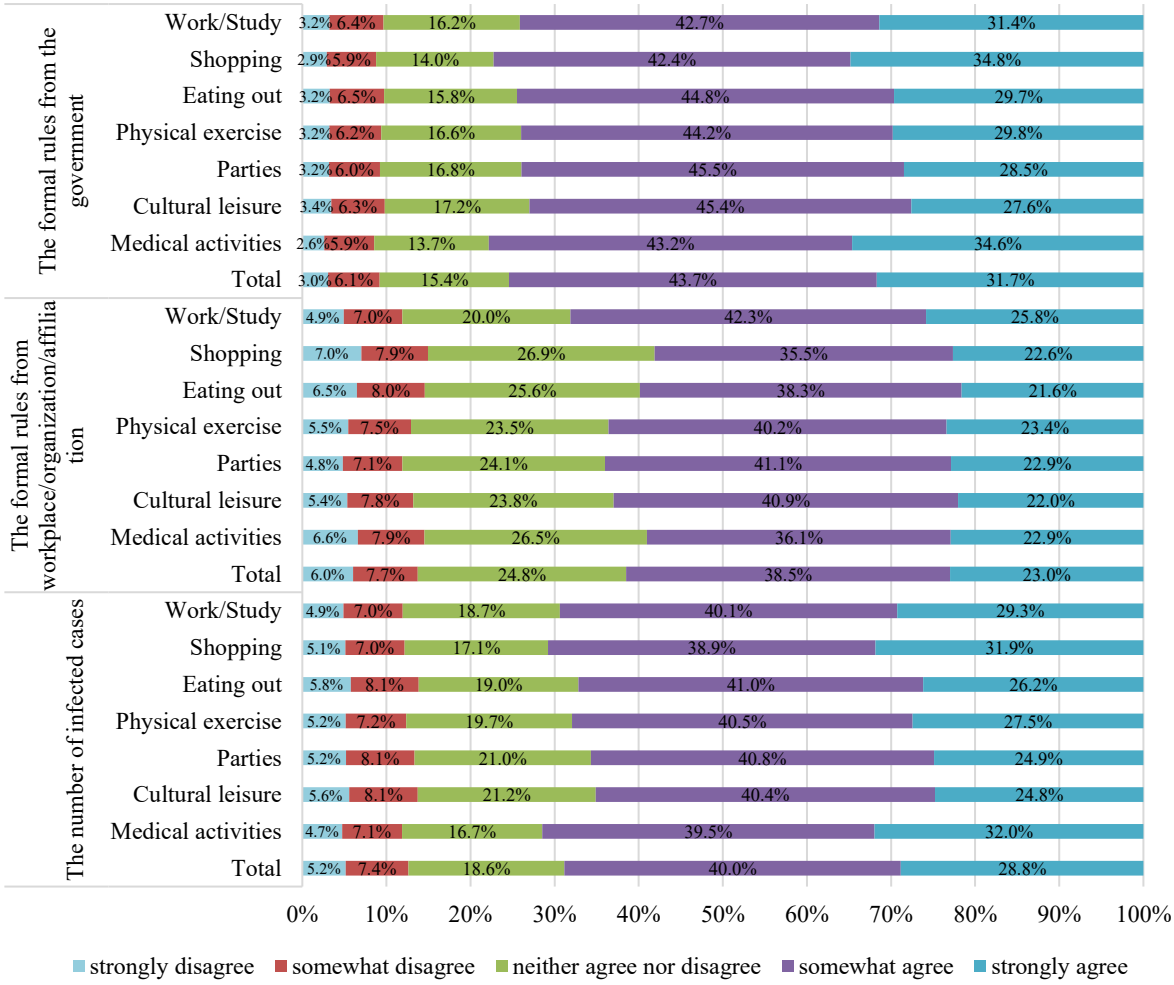

Figure 7. 13. Triggers for behavioral changes

3) Acceptance to change the duration/timing for activity participation

More than 70% of people were willing to change the duration/timing of performing activities (i.e., the shares of "somewhat agree" and "agree"). The "disagree" shares were just about 10%. Among the seven contact settings, the willingness was especially higher for medical activities and shopping, while the willingness for other settings was almost similar. Details refer to the Figure 7.14 of Supplementary Information.

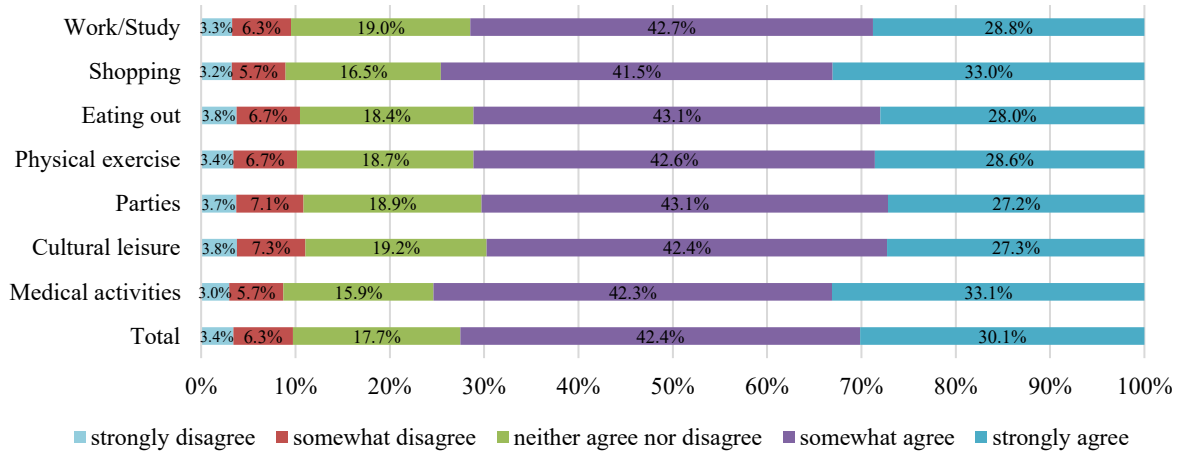

Figure 7. 14. Acceptance to change the duration/timing for activity participation

7.4 Integrated copula-based social contact decision modeling

As revealed from the above aggregate analyses, choices of social contact modes and the number of contacted persons seem not to be independent of each other. Therefore, it is worth exploring how to model these two decision variables together for a better understanding of people's decisions on social contact. Considering the features of the two variables, choices of social contact modes are presented by a multinomial logit model and the number of contacted persons based on an ordered logit model. The joint modeling is done based on a copula approach.

7.4.1 Modeling of social contact mode choices

Let n (n=1, 2, …, N) be the index for individuals, v (v=1, 2, …, V) be the index for explanatory variables and i (i=1, 2, …, I) be the index for social contact modes. To incorporate the heterogeneity of social contact decisions across activity settings for the same person, α_g is a parameter introduced to capture explanatory variables' influencing magnitudes that may be sensitive to or heterogeneous across activity settings (g=1,2, …, G). Thus, α_g can be called a sensitivity parameter. Let h_{nig} indicate the utility obtained by individual n who chooses contact mode i for activity setting g.

$$h_{nig} = \sum_v \alpha_g \beta_{iv} x_{niv} + \varepsilon_{nig} \tag{7-1}$$

Here, x_{niv} is the explanatory variable for mode i, β_{iv} is the corresponding parameter to be estimated, and ε_{nig} is the random error term following an independent and identical Gumbel distribution. Based on the random utility maximization principle, individual n chooses alternative i only when the utility of

alternative *i* is larger than that of other alternatives:

$$h_{nig} > max_{i \neq j} h_{njg} \tag{7-2}$$

Then, equations (7-1) and (7-2) can be rewritten as:

$$\sum_v \alpha_g \beta_{iv} x_{niv} > max_{i \neq j} h_{njg} - \varepsilon_{nig} \tag{7-3}$$

Let r_{nig} be a dummy variable indicating whether individual *n* chooses contact mode *i* (r_{nig}=1) or not (r_{nig}=0) for activity setting *g*. It is equal to 1 only if the equation (7-3) is true, otherwise it is zero.

If we define:

$$\varphi_{ig} = \{max_{i \neq j} h_{njg}\} - \varepsilon_{nig} \tag{7-4}$$

Then the implied marginal distribution of $F(\sum_v \alpha_g \beta_{iv} x_{niv})$ (i.e., choice probability) can be formed as follows:

$$F\left(\sum_v \alpha_g \beta_{iv} x_{niv}\right) = P\left(\varphi_{ig} < \sum_v \alpha_g \beta_{iv} x_{niv}\right) = \frac{\exp(\sum_v \alpha_g \beta_{iv} x_{niv})}{\sum_j \exp(\sum_v \alpha_g \beta_{jv} x_{njv})}, j = 1,2, \dots, J, g = 1,2, \dots, G \tag{7-5}$$

7.4.2 Number of contacted persons

In this study, the number of contacted persons was measured using an ordinal scale. Thus, an ordered logit model is selected to explain the number of contacted persons during performing an activity. Let *k* (*k*=1, 2, …, K) be the index for the number of contacted persons and s_{nig} be the number of contacted persons corresponding to contact mode *i* for activity setting *g*. s_{nig} is observed only if r_{nig} is equal to 1. The underlying propensity of the number of contacted persons with respect to contact mode *i* is shown as follows:

$$s^*_{nig} = \sum_v \alpha_g \gamma_v z_{niv} + \eta_{nig}, s_{nig} = k \quad if \ \ \tau_{k-1} < s^*_{nig} < \tau_k \tag{7-6}$$

Here, z_{niv} is the explanatory variable for the number of contacted persons, and γ_g is the unknown parameter. η_{qig} represents the error term following the Gumbel distribution. τ_k terms ($\tau_0 = -\infty, \tau_K = +\infty$) indicate the thresholds of s^*_{nig}. Let $G(x)$ be the cumulative distribution function of a standard logistic distribution. Then the marginal distribution of $G\left(\tau_k - \sum_v \alpha_g \gamma_v z_{niv}\right)$ is formed as follows.

$$G\left(\tau_k - \sum_v \alpha_g \gamma_v z_{niv}\right) = \frac{\exp\left(\tau_k - \sum_v \alpha_g \gamma_v z_{niv}\right)}{1 + \exp\left(\tau_k - \sum_v \alpha_g \gamma_v z_{niv}\right)} \tag{7-7}$$

The probability that the number of contacted persons being k is observed is written as follows.

$$P(s_{nig} = k) = P(\eta_{kg} < \tau_k - \sum_v \alpha_g \gamma_v z_{niv}) - P(\eta_{kg} < \tau_{k-1} - \sum_v \alpha_g \gamma_v z_{niv}) = G(\tau_k - \sum_v \alpha_g \gamma_v z_{niv}) - G(\tau_{k-1} - \sum_v \alpha_g \gamma_v z_{niv}) \quad (7\text{-}8)$$

In equation (7-8), because τ_k follows the ordering condition ($-\infty < \tau_1 < \tau_2 < \cdots < \tau_{K-1} < +\infty$), $P(\eta_{kg} < \tau_0 - \sum_v \alpha_g \gamma_v z_{niv})$ is equal to 0 and $P(\eta_{kg} < \tau_K - \sum_v \alpha_g \gamma_v z_{niv})$ is equal to 1.

7.4.3 Joint copula model of social contact

Here, the notion that contact mode choices and the number of contacted persons means that the above two error terms (ε_{nig} and η_{nig}) are not independent. In other words, they should follow a joint distribution (or a bivariate distribution). It is not easy to estimate models with such a joint distribution. To overcome this difficulty, the copula approach has been widely applied, which can use marginal distributions and dependence parameters to represent the joint distribution (Sklar, 1973; Nelsen, 2007; Schmidt, 2007; Trivedi et al., 2007; Meloni et al., 2011; Irannezhad et al., 2017). In other words, with the copula approach, it is not necessary to directly estimate the joint distribution, making the estimation tasks much easier. Moreover, compared with other multivariate correlation methods (e.g., Pearson, Kendall's tau, Spearman's rho), copulas can obtain nonlinear central dependence and tail dependence in both symmetric and asymmetric forms (Frey et al., 2001; Trivedi et al., 2007). Because of the flexibility of choosing marginal distributions, the copula-based approach allows complex dependency structures between discrete variables (Huang et al., 2022; Seyedabrishami et al., 2019; Rashidi and Mohammadian, 2016), continuous variables (Sener et al, 2010; Wali et al., 2022; Zilko et al., 2016; Kuwano et al., 2011), and ordered variables (Eluru et al., 2010; Laman et al., 2018; Wang et al., 2015). Only the copula approach allows such combinations with different types of marginal distributions (Bhat et al., 2009; Zhang et al., 2012; Habib et al., 2009; Spissu et al., 2009; Irannezhad et al., 2017; Nguyen et al., 2017; Rith et al., 2019; Shabanpour et al., 2017).

To the best knowledge of the authors, it is the first time in the social contact research to apply the copula approach. By referring to previous studies (Meloni et al., 2011; Jafari Shahdani et al., 2021; Keya et al., 2019), the joint representation of social contact mode choices and the number of contacted persons is described below.

According to Sklar's theorem (Sklar, 1973), any joint distribution of multiple variables can be represented in terms of a unique copula function, in which the continuous marginal probability distribution of each variable is uniform over the interval [0, 1]. For the bivariate case in this study:

$$C_\theta(u_{1g}, u_{2g}) = P(U_{1g} < u_{1g}, U_{2g} < u_{2g}) \tag{7-9}$$

Here, $C(.,.)$is a copula function, θ is dependence parameter vector of copula. U_{1g}, U_{2g} are uniformly distributed random variables with support contained in [0,1]. In this study, copula approach is applied to generate the joint multivariate distribution function with given marginals of contact modes and the number of contacted persons, where $u_{1g} = F(\sum_v \alpha_g \beta_{iv} x_{niv})$ and $u_{2g} = G(\tau_k - \sum_v \alpha_g \gamma_v z_{niv})$. The joint distribution of random variables φ_{ig} and η_{kg} can be expressed as:

$$\begin{aligned} &C_\theta\left(F\left(\sum\nolimits_v \alpha_g \beta_{iv} x_{niv}\right), G\left(\tau_k - \sum\nolimits_v \alpha_g \gamma_v z_{niv}\right)\right) \\ &\quad = P\left(U_{1g} < F\left(\sum\nolimits_v \alpha_g \beta_{iv} x_{niv}\right), U_{2g} < G\left(\tau_k - \sum\nolimits_v \alpha_g \gamma_v z_{niv}\right)\right) \\ &\quad = P\left(F^{-1}(U_{1g}) < \textstyle\sum_v \alpha_g \beta_{iv} x_{niv}, F^{-1}(U_{2g}) < \tau_k - \sum_v \alpha_g \gamma_v z_{niv}\right) \\ &\quad = P(\varphi_{ig} < \textstyle\sum_v \alpha_g \beta_{iv} x_{niv}, \eta_{kg} < \tau_k - \sum_v \alpha_g \gamma_v z_{niv}) \end{aligned} \tag{7-10}$$

where $F^{-1}(.)$ is the inverse univariate cumulative distribution function.

Let "CM_g = i" be the indication of "r_{nig}=1" for each contact mode (i=1,2,3,4 represent the choice of "no contact", "ONPC", "OPC", "PCNPC", respectively). If individual n has no contact with others, the number of contacted persons by him/her is zero. Because there are three ordered alternatives of the number of contacted persons, two thresholds are included in the model (k=1, 2, 3). Then the bivariate joint probability of social contact decisions is expressed as follows.

$$P(CM_g = i,\ s_{nig} = k) = \begin{cases} F\left(\sum_v \alpha_g \beta_{iv} x_{niv}\right) & if\ CM_g = 1 \\ P\left(\varphi_{ig} < \sum_v \alpha_g \beta_{iv} x_{niv}, \eta_{kg} < \tau_1 - \sum_v \alpha_g \gamma_v z_{niv}\right) & if CM_g = i, i = 2,3,4;\ s_{nig} = 1 \\ P\left(\varphi_{ig} < \sum_v \alpha_g \beta_{iv} x_{niv}, \tau_1 - \sum_v \alpha_g \gamma_v z_{niv} < \eta_{kg} < \tau_2 - \sum_v \alpha_g \gamma_v z_{niv}\right) & if CM_g = i, i = 2,3,4;\ s_{nig} = 2 \\ P\left(\varphi_{ig} < \sum_v \alpha_g \beta_{iv} x_{niv}, \eta_{kg} > \tau_2 - \sum_v \alpha_g \gamma_v z_{niv}\right) & if CM_g = i, i = 2,3,4;\ s_{nig} = 3 \end{cases}$$

$$= \begin{cases} F\left(\sum_v \alpha_g \beta_{iv} x_{niv}\right) & if\ CM_g = 1 \\ C_\theta\left(F\left(\sum_v \alpha_g \beta_{iv} x_{niv}\right), G\left(\tau_1 - \sum_v \alpha_g \gamma_v z_{niv}\right)\right) & if CM_g = i, i = 2,3,4;\ s_{nig} = 1 \\ P\left(\varphi_{ig} < \sum_v \alpha_g \beta_{iv} x_{niv}, \eta_{kg} < \tau_2 - \sum_v \alpha_g \gamma_v z_{niv}\right) - P(\varphi_{ig} < \sum_v \alpha_g \beta_{iv} x_{niv}, \eta_{kg} < \tau_1 - \sum_v \alpha_g \gamma_v z_{niv}) & if CM_g = i, i = 2,3,4;\ s_{nig} = 2 \\ P\left(\varphi_{ig} < \sum_v \alpha_g \beta_{iv} x_{niv}\right) - P(\varphi_{ig} < \sum_v \alpha_g \beta_{iv} x_{niv}, \eta_{kg} < \tau_2 - \sum_v \alpha_g \gamma_v z_{niv}) & if CM_g = i, i = 2,3,4;\ s_{nig} = 3 \end{cases}$$

$$= \begin{cases} F\left(\sum_v \alpha_g \beta_{iv} x_{niv}\right) & if\ CM_g = 1 \\ C_\theta\left(F\left(\sum_v \alpha_g \beta_{iv} x_{niv}\right), G\left(\tau_1 - \sum_v \alpha_g \gamma_v z_{niv}\right)\right) & if CM_g = i, i = 2,3,4;\ s_{nig} = 1 \\ C_\theta\left(F\left(\sum_v \alpha_g \beta_{iv} x_{niv}\right), G\left(\tau_2 - \sum_v \alpha_g \gamma_v z_{niv}\right)\right) - C_\theta\left(F\left(\sum_v \alpha_g \beta_{iv} x_{niv}\right), G\left(\tau_1 - \sum_v \alpha_g \gamma_v z_{niv}\right)\right) & if CM_g = i, i = 2,3,4;\ s_{nig} = 2 \\ F\left(\sum_v \alpha_g \beta_{iv} x_{niv}\right) - C_\theta\left(F\left(\sum_v \alpha_g \beta_{iv} x_{niv}\right), G\left(\tau_2 - \sum_v \alpha_g \gamma_v z_{niv}\right)\right) & if CM_g = i, i = 2,3,4;\ s_{nig} = 3 \end{cases}$$

(7-11)

There is no general agreement about which copula approach among the copula families should be used for a specific research target (Nelsen, 2007; Trivedi et al., 2007; Schmidt, 2007). Generally speaking, if people are more likely to have contact in normal times, no matter what kinds of contact modes are involved, it is reasonable to speculate that they would contact more persons. Thus, these types of contact decisions would be positively dependent. For such situations, adopting Gumbel, Clayton, or Joe copulas is obviously suitable. However, such positive associations may not always be observed in the context of COVID-19, because people may want to reduce the number of contacted persons for avoiding the infection in the case of, for example, having physical contact with others. For accommodating such possibilities, copulas allowing for negative dependence between these two types of contact decisions should also be an option. Therefore, in this study, five major copulas functions (FGM, Frank, Gumbel, Clayton, and Joe) are estimated and compared with a model assuming independence between the two social contact decision variables to find out the most suitable model. These copulas are introduced below.

FGM copula

The FGM (Farlie–Gumbel–Morgenstern) copula was proposed by Morgenstern (1956) and further discussed by Gumbel (1960) and Farlie (1960). In the FGM copula function, the dependence parameter θ must range between [-1, 1], and the correlation between variables is independent when $\theta = 0$. The FGM copula allows either negative or positive dependence for the correlation between the uniform marginals of u_{1g} and u_{2g} with the assumptions of asymptotic independence and radial symmetry in dependence structure. In this bivariate case, the FGM copula is formed as:

$$C_\theta(u_{1\mathrm{g}}, u_{2\mathrm{g}}) = u_{1\mathrm{g}}u_{2\mathrm{g}}(1 + \theta(1 - u_{1\mathrm{g}})(1 - u_{2\mathrm{g}})) \tag{7-12}$$

Frank copula

The Frank copula is the only comprehensive Archimedean copula approach allowing for both positive and negative dependence, which is proposed by Frank (1979). It imposes the assumption of asymptotic independence and is suited for strong central dependency with weak tail dependency. The θ of Frank copula has the threshold value of $(-\infty, +\infty)$, but the Frank copula is equal to independent structure when $\theta \to 0$. The Frank copula function for the bivariate case is defined as:

$$C_\theta(u_{1\mathrm{g}}, u_{2\mathrm{g}}) = -\frac{1}{\theta}\ln\left(1 + \frac{(e^{-\theta u_{1\mathrm{g}}} - 1)(e^{-\theta u_{2\mathrm{g}}} - 1)}{e^{-\theta} - 1}\right) \tag{7-13}$$

Gumbel copula

The Gumbel copula (also called as the Gumbel–Hougaard copula) is proposed by Gumbel (1960). The Gumbel copula is an Archimedean copula suited for cases with strong right-tail dependence (strong

correlation at high values) and weak left-tail dependence (weak correlation at low values). The dependence parameter θ of Gumbel copula must be [1,+∞), and the structure is independent when $\theta = 1$. The function of Gumbel copula for the bivariate case is provided as:

$$C_\theta(u_{1g}, u_{2g}) = \exp\left(-\left(\left(-lnu_{1g}\right)^\theta + \left(-lnu_{2g}\right)^\theta\right)^{1/\theta}\right) \quad (7\text{-}14)$$

Clayton copula

The Clayton copula is an Archimedean copula proposed by Clayton (1978) which only indicates asymmetric positive dependence ($\theta\epsilon(0,+\infty)$). It can achieve the Fréchet upper bound when $\theta \to +\infty$. The dependence parameter θ of Clayton copula should be larger than 0 and show independence when $\theta \to 0$. The Clayton copula is suited for strong left-tail dependence and weak right-tail dependence. The form of Clayton copula for the bivariate case is expressed as

$$C_\theta(u_{1g}, u_{2g}) = \left(u_{1g}{}^{-\theta} + u_{2g}{}^{-\theta} - 1\right)^{-1/\theta} \quad (7\text{-}15)$$

Joe copula

The Joe copula (Joe, 1993; Joe, 1997) is another copula function that only accounts for positive dependence. Just like for Gumbel copula, the dependence parameter θ of the Joe copula should satisfy the restricted condition of $\theta\epsilon[1,+\infty)$, and indicates the dependence when $\theta = 1$. The Joe copula cannot achieve the Fréchet lower bound but achieves the Fréchet upper bound when $\theta \to +\infty$ as well. Some scholars think the Joe copula is more like to be the reverse of the Clayton copula instead of that of the Gumbel copula (Bhat et al., 2009). The Joe copula function for the bivariate case is formed as:

$$C_\theta(u_{1g}, u_{2g}) = 1 - \left(\left(1-u_{1g}\right)^\theta + \left(1-u_{2g}\right)^\theta - \left(1-u_{1g}\right)^\theta\left(1-u_{2g}\right)^\theta\right)^{1/\theta} \quad (7\text{-}16)$$

7.4.4 Estimation and goodness of fit

In this study, the derived copula-based integrated model of social contact decisions is estimated by the maximum likelihood method, where the log-likelihood function is expressed as follows:

$$LL = \sum_N \sum_I \sum_K \sum_G M_{nikg} ln(P(CM_g = i,\ s_{nig} = k)) \quad (7\text{-}17)$$

$$M_{nikg} = 1[r_{nig} = 1] \times 1[s_{nig} = k] \quad (7\text{-}18)$$

where, M_{nikg} is an indicator of choice result (1 or 0), which is decided by the function 1[.], M_{nikg} is equal to 1 only when individual *n* chooses *i* and *k* simultaneously for contact setting *g*; otherwise, it is

0.

R programming language and the *R* package "maklik" (Henningsen et al., 2011) were used to evaluate the maximal value of the log-likelihood function. In this study, Newton-Raphson maximization was applied for the unconstrained optimization problems of Frank copula and independent copula. The Nelder-Mead maximization was applied for the optimization problems of FGM copula, Clayton copula, Joe copula and Gumbel copula, because there are some constraints for their dependence parameters of θ.

To compare the goodness-of-fit for different copula models, the Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC) are used. The BIC can control the complexity of the model and avoid overfitting (Aho et al., 2014). The lower the BIC value, the higher goodness-of-fit.

7.5 Results and discussion

As shown in Table 7.4, six models were estimated, including the model assuming independence between social contact mode choices and the number of contacted persons, where the "no contact" mode is chosen as the reference for MNL-based contact mode choice model.

7.5.1 Choosing the best copula

As evidenced by AIC and BIC, the Frank copula-based model generates the smallest values, suggesting it is the best model. In other words, the Frank copula-based integrated social contact decision model also outperforms the independence model. Other copula models unfortunately even perform worse than the independence model. This indicates that the other non-Frank copula-based models do not work well to represent the current social contact decisions. Looking at the range of dependence parameters, which are compared in Table 7.4, the Frank copula accommodates the largest range of dependence parameters, which can be understood to be the theoretical foundation that supports the Frank copula to be used for capturing people's joint decisions on social contact modes and the number of contacted persons. Hereafter, the Frank-based model (estimation results are shown in Table 7.5) will be explained and discussed.

Table 7. 4. The model fit for six copula-based models

Copula function	Range of dependence parameter	Number of parameters	Log-likelihood	AIC	BIC
Independence	–	*123*	*-60814.91*	*121875.8*	*122182.3*
FGM	[-1, 1]	126	-61376.02	123004.0	123318.0
Gumbel	$[1,+\infty)$	126	-61550.8	123353.6	123667.6
Joe	$[1,+\infty)$	126	-61821.76	123895.5	124209.5
Clayton	$(0,+\infty)$	126	-62092.45	124436.9	124750.9
Frank	$(-\infty,+\infty)$	*126*	*-60667.03*	*121586.1*	*121900.1*

The Frank-based modeling estimation results show that the dependency parameter is statistically significant for the ONPC mode and the number of contacted persons (estimated value: 1.06, t-test against 0: 3.80). The positive dependency parameter implies that the higher the probability of having only non-physical contacts with others, the more the number of contacted persons during activity participation. In other words, because an individual chooses to keep away from others with physical contact, contacting more people becomes less risky and consequently he/she contacts more people. The insignificance of the dependency parameters for OPC and PCNPC may suggest that once an individual decides to have physical contacts with others, he/she is less likely to care about the number of contacted persons during activity participation. Allowing different dependency parameters with respect to different contact modes makes the representation of the above heterogeneous responses possible.

Table 7. 5. Estimation results of copula-based social contact behavior model

Variables	**Multinomial Logit (MNL) Model**							**Ordered Logit (OL) Model**	
	No contact	**Non-physical contact (ONPC)**		**Physical contact (OPC)**		**Both physical and non-physical contact (PCNPC)**		**Number of contacted persons**	
		Est.	t-val(0)	Est.	t-val(0)	Est.	t-val(0)	Est.	t-val(0)
Threshold 1	-	-	-	-	-	-	-	1.12	7.91
Threshold 2	-	-	-	-	-	-	-	2.23	15.22
Constant term	-	-1.04	-4.31	-3.11	-9.40	-4.50	-11.44	-	-
Individual attributes									
Gender	-	0.10	2.88	0.18	4.00	0.02	0.40	0.20	5.73
Age	-	-0.05	-4.91	-0.12	-9.15	-0.12	-8.79	0.01	0.08
Household size	-	-0.01	-0.47	0.02	1.18	-0.01	-0.30	0.09	5.44

Marital status	-	0.12	3.02	0.29	6.05	0.12	2.55	-0.14	-2.68
Education qualification	-	0.05	3.69	0.09	4.78	0.11	5.71	0.03	2.08
Income	-	0.02	2.67	0.02	2.25	0.06	5.70	0.06	8.33
Factors related to activity participation									
Activity frequency	-	0.02	1.35	0.12	5.20	0.26	9.80	0.26	14.00
Travel distance	-	0.18	12.34	0.28	14.65	0.38	18.95	0.18	12.93
Companion of acquaintances	-	0.76	8.50	1.20	11.95	0.93	9.99	0.71	12.51
Wearing a mask	-	-0.51	-11.70	-0.91	-17.28	-0.59	-11.42	-0.57	-12.76
Disinfecting hands	-	0.40	10.02	0.07	1.48	0.18	3.92	-0.21	-5.82
Closed spaces with poor ventilation	-	0.12	2.57	-0.01	-0.23	0.36	6.69	-0.10	-2.44
Crowded places	-	0.37	8.66	0.53	9.96	0.42	7.63	0.45	12.84
Close-contact settings	-	0.32	8.59	0.65	14.88	0.68	14.87	0.46	13.20
Self-efficiency	-	-0.11	-5.83	-0.12	-5.35	-0.02	-1.03	0.07	3.71
Other's efficiency	-	0.01	0.69	0.04	1.76	0.09	3.44	-0.05	-2.86
Self-safety	-	0.04	1.90	0.06	2.12	0.13	4.63	0.03	1.85
Household member' safety	-	0.10	4.79	0.17	6.14	0.09	3.45	-0.05	-2.88
Necessity of activity	-	0.08	5.60	0.22	11.38	0.23	12.32	0.05	4.06
Punishment to activity	-	-0.08	-6.03	-0.04	-2.34	-0.10	-5.91	-0.04	-2.16
Risk-related psychological factors									
Reliability of the information from local government	-	0.12	5.79	0.17	6.67	0.19	7.20	-0.01	-0.60
Risk perception in residence country	-	-0.06	-3.02	0.03	1.20	-0.11	-4.73	-0.07	-3.61
Risk perception in residence region	-	0.06	2.84	0.18	7.20	0.10	4.09	0.10	6.69
Risk perception in public transport	-	-0.03	-1.59	-0.09	-3.79	-0.11	-4.54	-0.03	-2.10
Trigger of government	-	-0.05	-2.18	-0.19	-6.97	-0.10	-3.53	-0.07	-3.51
Trigger of workplace/organization/affiliation	-	0.01	0.41	0.03	1.17	0.06	2.40	0.12	6.99
Trigger of the number of infected cases	-	-0.04	-1.76	0.00	0.10	-0.04	-1.34	-0.07	-3.93
Acceptance of changing the duration/timing of activity participation	-	-0.01	-0.60	-0.12	-4.47	-0.10	-3.75	0.01	-0.23
Dependency	-	1.06	3.80	-0.31	-1.54	-0.33	-1.35	-	-

Sensitivity parameters of social contact settings	Est.	t-val(0)	t-val(1)
Work/study	1.02	26.71	0.46
Shopping	-	-	-
Eating out	0.69	24.44	-11.18
Physical exercise	0.90	22.02	-2.45
Parties	0.85	21.32	-3.71
Cultural leisure	0.82	23.03	-5.01
Medical activities	0.42	17.83	-24.79

7.5.2 Factors related to contact settings

Activity frequency

People are prone to have physical contact (fully or partially (i.e., mixed with non-physical contact)) when performing activities with high frequency, and the number of contacted persons increases with the increase in frequency. This observation may be due to psychological fatigue (Shearston et al., 2021) from following social distancing measures accumulated during the long COVID-19 pandemic. For those highly frequent activities (e.g., shopping, work/study), people may become less concerned about the exposure to the virus via social contacts and as a result, they are more likely to have OPC/PCNPC contacts, potentially leading to more and more infections.

Travel distance

The travel distance between home and destination shows positive influences on both social contact mode choices and the number of contacted persons, indicating that if people go to a distant place, they are more likely to have contacts with others in all possible contact forms (modes of OPC, ONPC, and PCNPC) and contact more people. This is probably because during the pandemic, many activity venues nearby people's homes were closed and as a result, these people had to visit activity venues that are far from their homes, making such venues gathering points that result in social contacts with more people.

Companion of acquaintances

If an individual performs an activity together with his/her acquaintances, he/she is more likely to have all kinds of social contacts with others and contact more people. In line with common sense, if people are going to perform daily activities excluding work/study with acquaintances, that daily activity itself has a social nature of communication with people, so it is easier to have more social contacts around them.

Protective measures

Wearing a mask does not prompt people to have contact with strangers except their household members or acquaintances. If people wear a mask, they are prone to contact fewer strangers, indicating that they already reduced their social contact consciously when realizing the necessity of wearing masks to keep themselves safe during the pandemic.

Oppositely, if people already disinfected their hands before/during/after performing an activity (e.g., shopping, eating out, parties), they do not mind contacting others in a physical or non-physical way. However, although people do not mind participating in activities with the physical presence of others after disinfecting their hands, they are still prone to contact fewer persons during the pandemic. This finding is in line with Chen et al. (2021) who showed that disinfection measure does not lead to a higher probability to use public transport.

Protective capability and perceived safety

Here, the following protective capability and perceived safety are analyzed: i.e., self-efficiency (an individual's belief in his/her capability to protect him/herself from the infection), others' efficiency (an individual's belief in other persons' capability to protect themselves from the infection), self-safety (whether an individual thinks he/she is safe from the infection when performing an activity), household members' safety (whether an individual thinks his/her household members are safe from the infection when performing an activity).

It is estimated that if people think they are highly capable of protecting themselves from the infection of the COVID-19 virus, they tend to contact more people. People would reduce their social contact with others in the cases of only non-physical contacts and only physical contacts: i.e., people with higher self-efficiency do not prefer to contact with others under these two contact modes. If people cannot avoid social contact with both physical and non-physical contacts (e.g., in the case of work/study and parties), they do not mind contacting more people, under the condition of high self-efficiency (e.g., being able to take sufficient protective measures). On the contrary, if people believe in others' capability of taking protective measures, they do not mind making social contact even when neither physical nor non-physical contact could not be avoided, but they would consciously reduce the number of contacts.

For the risk perception about whether people think themselves and their household members are safe from the infection, expectedly, when people think they or their household members are safer during performing daily activities, they are more likely to have social contact with others in different modes. However, if people think that their household members are safer, the number of contacted persons would decrease. This indicates that individuals would not try to contact more people during performing daily activities for the safety of household members.

Perception of 3Cs in activity locations

As for the 3Cs (i.e., closed spaces with poor ventilation, crowded places, close contacts), if activity venues have closed spaces with poor ventilation, people are more likely to contact fewer persons

(parameter: -0.10, t value: -2.44) for reducing the probability of being infected from others. Unexpectedly, people would not avoid contacting others and would not reduce the number of social contacts even when indoor activity venues are crowded places with close contact. This phenomenon reveals that although people can choose to go to locations without a crowd or close contact, it is difficult for individuals to avoid social contact when they have to do daily activities in crowded places or places with close contact (e.g., work/study, shopping, medical activities). Thus, there is still a lot of possibilities to improve crowded places with close contact.

Necessity and punishment

The perception of activity necessity (whether doing an activity is necessary or not) and punishment (whether doing a certain activity should be punished or not) have significant effects on people's social contact behaviors. People are more likely to have social contact with others in all contact modes and contact more people when they think that performing daily activities (e.g., work/study, shopping, medical activities) is necessary even with a high risk of infection. Conversely, if people think that performing daily activities during the pandemic should be punished (e.g., gathering in a concert), the number of persons they contact decreases, and they are prone to make no contact with others. It seems that most people have a clear understanding of the balance between necessity and punishment (or responsibility) when performing activities, which indirectly indicates the effectiveness of governments' policy measures and public opinion guidance related to COVID-19.

7.5.3 Risk-related psychological factors

Reliability of information

The more reliable the information announced by the local government, the higher the probability of having contact with others, while such a phenomenon is not confirmed with respect to the number of contacted persons. This may be due to the fact that people in these target countries have been willing to live with the virus. Hence, people are prone to have social contact with others if they trust the infection information (e.g., the Omicron variant only presents a low fatality rate) announced by the local government. However, although people trust such information, they tend to not take the risk of infection by contacting more people.

Risk perception at different spatial scales

The impacts of risk perception on people's social contact behaviors show spatial differences. To be specific, when people perceive a higher risk of infection in their residence country, they are prone to reduce the number of contacted persons and the social contacts through the modes of ONPC and PCNPC. If people's risk perception about public transport increases, they would reduce social contacts through the modes of OPC and PCNPC and the number of contacted persons for daily activities as well. Conversely, social contact behaviors are positively associated with the risk perception observed in

people's residence regions (province/prefecture/state), and people would have more contact with others although they perceive that the risk is increasing in their residence regions. This is probably because a high-risk perception at the national level makes people realize how serious the risks are, and the high-risk perception at specific locations (e.g., in public transport vehicles) reveals that the risk of infection has been increasing nearby their daily action spaces. Thus, people feel they need to reduce social contact instantly for safety, while the risks in residential regions are not treated as an obvious threat to people's daily lives.

Triggers of behavior changes

If people think they are more likely to change their behaviors because of formal governmental rules, they tend to make no contact with others and decrease the number of contacted persons. Meanwhile, people are prone to reduce the number of contacted persons if they attach more importance to the number of infection cases. However, for those people who are easier to be affected by the formal rules from their workplaces/organizations/affiliations, they tend to have social contact, through the mode of both non-physical and physical contact, and contact more people. This may be because the share of the contact mode "PCNPC" is highest for work/study, and the rules of workplaces/organizations/affiliations only have a strong binding force on people's contact behaviors for work/study. The rules of workplace/organization/affiliation may tend to request people to take protective measures rather than reducing work/study contacts.

Acceptance of changing the duration/timing of activity participation

The modeling results show that if people accept to change the duration/timing (or activity schedule) for performing activities, even leading to various inconveniencies, they will reduce the probability of contact through the modes of OPC and PCNPC simultaneously. That makes sense because if people can reschedule their activities, they could avoid the peak hours of daily activities and avoid social contact if there are fewer other people around.

7.5.4 Individual attributes

Males are more likely to have social contact with others through the forms of ONPC and OPC, and they are further prone to contact more people, than females. For the contact mode "PCNPC", gender does not matter. This observation may be because males usually have more social opportunities (e.g., working contacts or eating out after work) than females. But for activity settings with more participants (e.g., parties, and cultural leisure), both males and females are easier to have ONPC and OPC simultaneously, leading to a slight gender difference for the contact mode "PCNPC". Older people are less likely to contact with others through all contact modes, in comparison with no contact. However, age is not influential to the number of contacted persons. This may be because older people well recognize the higher infection risk (infection rate and severity of illness) of their age group. As a result, on one hand, they consciously try to avoid any contact with others for daily activities as far as possible.

On the other hand, if social contact with others cannot be avoided, they would have no way or no ability to reduce the number of persons they contact. People with higher education qualifications and income are more likely to contact others and contact more other people. This may be because such people have more opportunities or better access to perform various daily activities and consequently make more social contacts with others.

Married people are more likely to have social contact with others, probably because they have to perform more maintenance/mandatory (e.g., shopping, work) activities to support their family lives. On the other hand, married people try to contact fewer people. This may be because they are more worried about household members' infections through out-of-home social contact. Household size does not matter to people's contact mode choices, but it surely does to the number of contacted persons. This indicates that if people live with more household members, they are prone to contact more people during daily activities. This observation is intuitively understandable because larger households have more opportunities to perform maintenance/leisure activities (e.g., shopping, gathering) together with their members, resulting in contacting more people during activity participation.

7.5.5 Heterogeneous influences across activity settings

Larger (smaller) sensitivity parameter means that the people's choice probabilities of the social contact behaviors for corresponding contact setting are more (less) sensitive to external variables and easier (harder) to change under the impact of these variables when they are compared with the choice probabilities of contact behaviors for shopping setting. All the above observations are further heterogeneous across activity settings because all the activity-specific sensitivity parameters (except the work/study setting) are statistically significant against both 0 and 1. The t-test against 0 is for testing whether the obtained sensitivity is meaningful or not, and the t-test against 1 is for testing whether the obtained sensitivity is the same as that of the reference activity (i.e., shopping) or not. All the sensitivity parameters are positive, while the sensitivity for work/study is statistically indifferent from that for shopping. The sensitivity parameters for other activity settings are all smaller than 1, indicating that individuals' social contact behaviors for these activities are less sensitive (in terms of influencing magnitudes) to those significant factors identified from the modeling analysis, relative to shopping. This phenomenon is especially obvious for eating out (0.69) and medical activities (0.42).

7.6 Conclusion

In this study, a unique social contact survey concerning seven main daily contact settings (work/study, shopping, eating out, physical exercise, parties, cultural leisure, and medical activities) was conducted in six developed countries from March to May 2021 and more than 7000 respondents provided valid

answers. A copula approach was used to capture the dependence between social contact mode choices and the number of contacted persons which were represented by a multinomial logit model and an ordered logit model, respectively. Various factors affecting the social contact behaviors were investigated.

Findings

First, five types of copula functions, including FGM, Gumbel, Joe, Clayton, and Frank, were estimated and compared with a model without dependence on the two social contact behaviors. Results empirically confirmed that the Frank copula outperforms other copulas, where the theoretical features of the Frank copula also support this empirical observation. As for the dependence related to social contacts, indirect contacts were estimated to be dependent on the number of contacted persons. Considering that existing studies have neglected the role of indirect contact in COVID-19 transmission, the above finding is especially important to implementing more effective pandemic policies.

Second, frequency of activity participation is positively associated with more physical contacts and having contacts with more people during performing an activity. Various social contacts were observed at places far from home, while the presence of acquaintances will increase the number of social contacts in all modes and the number of contacted persons.

Third, people tried to perform activities in spaces with poor ventilation, but unexpectedly, crowded places with close contact would not encourage people to perform safer social contact. Wearing a mask and disinfecting hands discouraged people to contact more people. Disinfecting hands does not necessarily encourage people to avoid unsafe contact, but wearing a mask does.

Fourth, various influences of psychological factors on social contact are found. People feel struggling between performing necessary activities and worrying to be punished. Trust in the governmental risk information leads to more contact in all modes but does not affect the number of contacted persons. People's risk perceptions at different spatial scales (the highest risk was perceived within public transport vehicles) present inconsistent influences on the choices of social contact modes and the number of contacted persons: this observation seems to be in line with the fact of many infections even under strict restrictions, which obviously brings difficulties and complexities into pandemic policymaking.

Fifth, government rules are more effective in to encourage safer social contacts than the rules from workplaces/organizations/affiliations. Higher acceptance of changing the duration/timing for activity participation is positively associated with safer social contacts.

Sixth, all the above observations show their sensitivity to the specific social contact settings, in terms of the magnitudes of the effects, in the sense that the parameters supporting the above observations vary significantly across different settings.

The revealed influences of various factors on social contact behaviors in different contact settings suggest that pandemic control policies should be carefully designed and timely adjusted in response to various changes. In this regard, technology-supported scientific monitoring of people's behaviors and

the risk-protection conditions of activity-travel environments and the resulting context-sensitive warnings should be implemented in a seamless manner.

Academic contributions

Both survey and modeling approaches have unique and attractive features. The social contact survey implemented in this study differs from existing social contact surveys in several ways: (1) leisure activities are detailed; (2) psychological factors are investigated with respect to different social contact settings; (3) altruism is reflected by asking respondents' perceptions of their household members' capacity of managing social contacts under risky environments. The copula modeling approach is flexible and logical to represent the dependence between social contact mode choices and the number of contacted persons and especially, it has the potentials to represent more complicated social contact decisions even with larger dimensions.

Limitations and future challenges

The social contact survey of this study only targets average situations during the COVID-19 pandemic, which ignores changes and variations in social contact decisions themselves and their influential factors. It is therefore worth investigating a panel survey in the future, which is especially useful to capture the effects of social-distancing fatigue, even though the panel survey is costly and time-consuming. The way of investigating social contacts could also be improved, for example, by conducting an activity-travel diary survey, even though this will increase respondents' answering burdens. For deriving general findings, this study pooled all data collected from six developed countries. In the future, it may be worth exploring how the findings from this study may vary across countries.

CHAPTER 8 Conclusions

8.1 Introduction

This dissertation gives a seamless exploration of individuals' behaviors mechanisms of the activity-travel behaviors with social contacts and provides important policy implications for pandemic policymaking. In the beginning of this study, the necessity of pandemic policymaking based on analysis of behavioral mechanism is stated and the key research questions of pandemic behaviors is introduced (Chapter 1). Then, an overview of the research status about individual's pandemic behaviors is reviewed for the behavioral and psychological adaptations to COVID-19, travel mode choice and social contact (Chapter 2). The methodology applied in this study is introduced from the perspectives of survey data and modeling approaches (Chapter 3). Individuals' behaviors mechanisms are explored in the multiple behaviors case of dynamic activity-travel behaviors with social contacts (Chapter 4) and the single behavior cases of travel mode choice behaviors (Chapter 5) and social contact behaviors (Chapter 6 and 7) respectively. To answer the research questions in this study, this Chapter 8 would first give a summary of the research conclusion. Then it is followed by a discussion of policy implications. Finally, the limitations and future research challenges of this study are described.

8.2 Conclusion

The COVID-19 pandemic has made a tremendous impact on people' behaviors for whether multiple activity-travel behaviors with social contact or a certain single behavior in it during the process of travelling and doing activity. Exploring the individuals' behaviors mechanisms of the activity-travel behaviors with social contacts and obtaining a sufficient knowledge about it are the basic of conducting a sensible pandemic policymaking. A reasonable modelling approach and survey design contributes to exploring individuals' behavioral mechanisms. And individuals' demographic attributes, psychological factors and activity participation attributes play an important role in affecting people' behavior changes.

To realize the research purposes for exploring pandemic-related behavioral mechanism, this dissertation first attempts to develop a dynamic structural equation model for clarifying the dynamic associations between psychological factors of policymaking and temporal behavior changes with the data of Japan. After that, this study makes two single behavior analyses for travel mode choice behaviors

and social contact behaviors respectively with the case study in six developed countries (Australia, United States, New Zealand, Canada, United Kingdom, Japan). The impact of psychological/cultural risk factors and pre-pandemic preparedness on individuals' travel mode choices across travel purposes during the COVID-19 pandemic is revealed by estimating a mixed hybrid choice model with correlated latent variables. The changes of the number of social contacts between influenza period in 2019 and pandemic period since 2020 and its heterogeneity across variables and contact settings are revealed by the calculation of total number and mean number. Meanwhile, the joint social contact behavioral mechanism of the contact modes and the number of contacted persons are revealed by a copula-based approach. The analysis results of the dynamic activity-travel and social contact behavior changes, travel mode choice and social contact behavior in this study have shown an evident consistency with each other.

Some findings are summarized to show individuals' behaviors mechanisms of the activity-travel behaviors with social contacts under the background of the COVID-19 pandemic as follows.

First (answer Q-1), it is significantly confirmed that people's accumulated behavior changes in the past can affect all psychological factors of the reliability of information sources, the risk perceptions, the attitudes toward COVID-19 policymaking capability, the attitudes toward PASS-LASTING based policies. And these psychological factors will further influence the most recent behavior changes. That influence is especially obvious for the relationship between risk perception and recent/accumulated behavior changes. People have an obvious different share of the high-risk perceptions in different spatial scale. Meanwhile, the recent behavior changes are most affected by accumulated behavior changes in the past in an indirect way. People's behavior changes are mostly characterized by avoidance behaviors for the direct contacts or talking with others (avoid social contacts). The attitudes toward policymaking capacity (e.g., government) may be more important than the attitudes toward specific policy on influencing people's behavior changes. The positive attitudes (e.g., specialized, enthusiastic, competent, can be trusted) toward policymaking capacity can prompt people to follow PASS-LASTING based policy measures. People's perception of information reliability is most decided by the information from authorities (i.e., central/local governments, experts, medical institutes)

Second (answer Q-2, Q-3, Q-4, Q-8), people's travel mode choice behavior shows a diversity across the travel purposes. Although the use of public transport decreased significantly during the COVID-19 pandemic, people still rely on public transport for shopping and medical activities. People are less likely to change travel mode choices for commuting than other travel purposes. The impact of latent psychological/cultural factors on travel mode choice show an obvious diversity across different travel purposes. The trust is positively influential to risk perception, and the significant associations between latent factors indicate a direct and indirect effect of them on the travel mode choice behaviors. Risk perception is found to be more remarkable at larger spatial scales than inside crowded public transport vehicles. The effect of the cultural orientations on travel mode choices can be divide into two dimensions: hierarchism-egalitarianism and individualism-fatalism because of the higher similarities in each pair. Hierarchists and egalitarians are mainly reflected in travel mode choices for shopping and

physical exercise, while individualists and fatalists are dominating in travel mode choices for other travel purposes. Individualists and fatalists show a completely opposite preference to Hierarchists and egalitarians for all trip purposes except work/study. The preparedness focusing on risk-concerned travel habits formed before the COVID-19 pandemic shows a significant impact on travel mode choices, but the influences are not consistent across travel purposes.

Third (answer Q-5, Q-6, Q-8), there is an obvious heterogeneity of the number of social contacts and its changes across the targeted attributes and contact settings, the pandemic policymaking could focus on the protection of specific group with higher danger level of social contacts. For instance, people especially contact more people in work/study setting and public transport setting. Older people are more dangerous to the virus, but it is difficult for the elderly (over 70 years) to decrease the social contacts during the medical activities. If a country (e.g., US, AU) has eased the lockdown interventions for a long time, people in that country would contact more people for leisure activities averagely than other countries. However, the number of social contacts in that country were high as well for medical activities which could be led by the infection of the coronavirus. There is an obvious inequity of the access to safety from infection by decreasing social contacts for the people with low educated level and low income. People's number of social contacts is positively associated with the frequency and duration for performing the activities, but the social contacts occurred with high-frequency (e.g., shopping) and long-duration had decreased significantly after the pandemic. People's contact modes and the taken protecting measures are associated with the number of social contacts during the pandemic and show different features across the contact settings. On one hand, most PCNPC contacts occurred in work/study setting and party setting, while the most ONPC contact occurred in shopping setting and public transport setting. On the other hand, protecting measures are well implemented for work/study setting and shopping settings during the pandemic.

Fourth (answer Q-6, Q-7, Q-8), the joint estimation of people's different indexes of social contact behaviors is possible via the copula approach. Thus, a significant joint correlation between the ONPC mode and the number of social contacts is found indicating that people trend to simultaneously increase the number of contacted persons and the probability of having ONPC contacts with others under the influence of common unobserved factors during the COVID-19 pandemic, but that significant dependency is not found for OPC/ PCNPC contacts. Not only individuals' demographic attributes but also the psychological factors and activity participation attributes have a diversified influence on people's joint choice of social contact behaviors. Some factors may have a significant influence on the probability of a certain contact mode, while they may not be significant for other modes. Moreover, having contacts with others doesn't means people would contact more people, for instance, the perception of higher self-efficiency and lower other's efficiency would prompt people not to contact with others, but when they can't avoid the social contacts, they don't mind contacting more people. People's safe feelings (safe from infection) of their household members can decrease the probability of having no contacts with others, but it will decrease the number of contacted persons at the same time. Some attributes show the same impact on social contact choices that consistent with the findings in

descriptive analysis of the number of social contacts in chapter 6, which proves the consistency of model analysis and description analysis of social contacts. The behavior changes of social contact during the COVID-19 pandemic are found in the forms of dramatic decrease of the number of social contacts and avoid contacts with others. The additional subjective psychological variables in copula analysis highlight that people' risk-related psychological factors (e.g., reliability of information source, risk perception in different spatial scale) surely have the significant impact on a certain behavior change too. And it is reasonable to include risk perception with different spatial scales in the behavior analysis because of the obvious difference among them. The joint analysis of social contact also indicates that the difference of behavioral mechanisms for different contact settings can be reflected not only in the difference of positive-negative effects but also in different sensitivity to influencing factors.

8.3 Policy implication

Based on the result obtained in the case study of target countries, this dissertation has found five key prerequisites for the pandemic policymaking:

1) The pandemic policymaking for multiple activity-travel behaviors in daily life and the policymaking for a certain single behavior aren't separated process from each other. On one hand, the policymaking of multiple behaviors can comprehensively regulate people's daily behaviors and provide the guidelines for the policymaking of single behavior. Some influences of variables in the process of multiple behaviors policymaking are also applicable to that of single behavior policymaking, which can be used as a reference. On the other hand, the single behavior policymaking adds more operational details of conducting measures for multiple behaviors policymaking by including the influences of more external variables. And if the details in single behavior policymaking are contrary to the multiple behaviors policymaking, the feedback and error correction from single behavior policymaking can be made to the multiple behaviors policymaking reversely. The policymaking for multiple behaviors and single behavior is complementary to each other.

2) The dynamic associations between policymaking and behavior changes over time are especially important for behavior policymaking. Previously conducted policies (e.g., strict lockdown in initial phase of pandemic) may not be effective and practical anymore as the COVID-19 pandemic continues. And avoiding people's policy fatigue and prompting preparedness for the pandemic should be considered for pandemic policymaking as well.

3) Individuals' psychological factors are crucial for the pandemic policymaking. Especially the risk perception in different spatial scales can provide an overall view on the behavioral mechanisms when people facing the risk of a pandemic like the COVID-19, hence, it shouldn't be ignored in the policymaking process of activity-travel behavior and social contact.

4) There exists a significant logical relation between different psychological factors, policymaker

should pay attention to that, because it is very likely that changing one policy related to one aspect of individuals' psychological factors will have a knock-on effect on the implementation of other policies.

5) The pandemic policymaking should be tailored to specific situations of activity-travel behavior with social contact because people's behaviors have obvious differences not only across the groups of attributes but also across the contact/travel settings.

From the perspective of the five mentioned prerequisites, the specific recommended policies of activity-travel behavior with social contact are summarized as follows.

Policy implications of behavioral and psychological adaptations to COVID-19

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; Zhang, 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 et al. (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).

Policy implications of travel mode choice during the COVID-19 pandemic

1) The traffic restriction of public transport can control the infection, but it is worth discussing because people rely on the use of public transport for essential activities, such as shopping and medical activities travels. Guaranteeing a safer environment for the use of public transport during the COVID-19 pandemic and rebuilding confidence in using public transport after the pandemic would be crucial questions, even when people are inside public transport vehicles for a long time. Pandemic-resilient transport policies (e.g., social distancing) should be sensitive to locations. These previous measures could ensure the objective and subjective safety of people.

2) Trip makers' cultural risk factors should be properly reflected in making pandemic-resilient transport policies that can well distinguish between the four types of cultural orientations: i.e., hierarchism, egalitarianism, individualism, and fatalism, depending on different travel purposes. For instance, individualists and fatalists prefer to choose risky public transport for unessential activities, they are not interested in following social rules, thus some virtual personal benefits (e.g., free parking) for choosing a car or active transport would be more effective to attract individualists and fatalists. If policymakers want the use of public transport to restore to the level of pre-pandemic, building a social consensus that the use of public transport is recommended and safe for high-frequency daily travels (e.g., for shopping travel) would be more useful.

3) Governments and health/medical agencies should make efforts to encourage people to form a well-prepared distance-sensitive lifestyle that is useful to survive from pandemics. For instance, it is

difficult and uncomfortable for people to change their habit of travel mode for commuting suddenly, hence, consciously changing the travel habit of mode choice for commuting (e.g., from high-risk mode to low-risk mode) in the early pandemic would be helpful for people to prepare for or adapt to the life in a post-pandemic era. More types of preparedness should be made with respect to various stakeholders, as suggested by the PASS approach, from which various "prepare-protect-provide", "avoid-adjust", "shift-share", and "substitute-stop" policy measures have been summarized/proposed (Zhang, 2020).

4) As the during-pandemic tentative measures, reasonably sufficient parking places should be prepared at areas of shopping and physical exercise as well as medical activities, for the use by car, bus, shared mobility and taxi. At areas with medical facilities, bus stops should be further installed, which could contribute to the use of bus. Higher dependence on car caused by COVID-19 should be restricted by both effective transport and non-transport policy measures after the pandemic, where non-transport policies should be given a higher priority considering that travel demand is derived from activity participation.

5) Even though up to the survey period in this study, the governments of the targeted six countries had taken various protective measures (e.g., requirements of wearing masks, disinfection, and keeping social distance) for all types of travel modes, our analysis results revealed trip makers' diverse, heterogeneous and complicated responses to the pandemic, where some responses are even seemingly contradictory from each other. Both logical and illogical perceptions about the infection risk, which is significantly associated with trust in governments and medical agencies, are detected. The above observations re-confirm the importance of differentiated risk communication with respect to different activities, where different stakeholders should play different roles in the communication, as evidenced by Zhang (2021).

Policy implications of non-household social contact during the COVID-19 pandemic

1) The pandemic policymaking on social contacts should focus on the target population with high risk of infection through the daily social contacts. For instance, the people aging over 60 years have higher risk of the COVID-19 virus, however, they have contacted more people during the work. It is sensible to increase the percentage of telework and vaccination for old working people during the pandemic. The older people are harder to avoid social contact with others. And the elderly over 70 years is most dangerous under the exposure of the COVID-19 virus, however, they have to perform medical activities usually during the pandemic due to their health status. It is difficult for them to decrease the social contacts. But the remote medical services can resolve these problems easily. The government can provide some financial supports for the private or communal remote medical services. There are more social contacts for the staffs in government and educational institution, such as the contacts with the people coming to government for formalities or students in school. To ensure the normal operation of the government and the safety in reopened school during the pandemic, the staffs in these organization should take more protecting measures and regular nucleic acid amplification test could be conducted in

government and school if someone want to have a test. If people have a larger household size, they are less likely to decrease the work contacts, this phenomenon is also applicable to other contact settings as well. That is caused by many complicated reasons, such as the responsibility of earning money and support the family. But the government could provide more subsidy to these people who have higher economic pressures with a larger household size. The low educated people and people with low income have less ability to decrease their daily social contacts especially for public transport, work, and shopping during the pandemic. They are suffering from the higher risk of getting infection. The government could provide some free medical supplies for pandemic prevention (such as mask or disinfectant) to the people with low education background or low income.

2) The pandemic policymaking should especially focus on the protection in the locations of people's high-frequency activity (e.g., workplace, school, shopping venue), because it is easy for people to form a policy fatigue when performing high-frequency activities and relax their vigilance of the infection via social contacts. Closing the venues of daily activity (such as restaurants) near people's residences can reduce people's social contact, but it also encourages people to travel farther and meet more people, which in turn increases the risk of infection. Taking protecting measures could prompt people to decrease the social contact behaviors consciously. But the measures of disinfecting hands in public transport is very limited. It is necessary to provide more hand disinfection facilities in public transport and disinfect the public transport vehicle regularly. The social contacts without any protecting measures decreased significantly during the pandemic, however, the contacts without any protecting measures still increased slightly for shopping, cultural leisure, and medical activities settings, which means there are some people who never taking protecting measures and contacted more people during the pandemic. The policymaker should pay attention to these parts of people in the next wave of the pandemic. People are sensitive to the 3Cs features in activity locations, hence, the policy avoiding 3Cs should continue.

3) Pandemic policymaking should be made from the perspective of ensuring personal safety and from the perspective of ensuring the safety of people' household members. Because people are more willing to reduce social contact for the safety of their families even than the safety of themselves. Clarifying the necessity and possible punishments for performing activities during the pandemic can further improve the effectiveness of policies. In addition, the importance of the differentiated risk communication pathways (e.g., reliability of information source, trigger of formal rules introduced by the government) with respect to different activities for policymaking is confirmed again.

4) In fact, most people have a clear understanding of the high risk of infection for the close contacts, that is why previous studies and policymaking were focusing on close contacts. However, the the significant dependency between the number of social contact and the choice probability of having only indirect non-physical contacts has revealed that the policymaking for indirect non-physical contacts is also indispensable. When the policy affects the number of contacts, it will also affect the probability of having non-physical contacts. That increases the complexity of the policymaking for non-physical contacts. But this does not mean that ignoring policymaking for non-physical contacts is reasonable.

On the contrary, considering non-physical contacts is crucial for a comprehensive pandemic policymaking.

5) Non-mandatory policies have different effectiveness under different contact settings. A certain policy that is effective for work/study and shopping setting may not be so effective for other contact settings. For instance, people especially show less intention to change their contact mode and the number of contacted persons for medical activities setting. So, the pandemic policymaking needs to be flexible and depend on the specific circumstances.

8.4 Future research challenges

This dissertation has focus on the pandemic policymaking based on the exploration of people's behavioral mechanism of activity-travel behaviors with social contacts. However, there are some research challenges need to be discussed in future research.

First, for the research data, this study only applied the RP survey data for the behavior policymaking analysis, the Big Data and Open Data of people's mobility behaviors and social contact behavior could well expand the scope of macroscopic behavior analysis. And because the data is collected in a few target countries, the findings may not be generalizable, it is necessary to conduct further studies in other countries in order to make international comparisons. It is difficult to obtain the dynamic psychological data precisely in our conducted surveys, only individuals' psychological status during the conducted periods of surveys are collected. A longitudinal panel survey with dynamic psychological data at different points in time would be helpful for further dynamic analysis for behaviors.

Second, for the research framework, a comprehensive framework is built for the analysis of activity-travel and social contact. However, there are some elements illustrated by dotted arrows need to be resolved in future studies. Pre-pandemic preparedness is an important factor indicating the dynamic effect of people's behaviors before and during the pandemic, but the detailed behavior analysis of pre-pandemic preparedness hasn't been conducted with the correlations between different factor clusters in this study. And it is only be adopted to the analysis of travel mode choice behavior. For the behavioral analysis of activity-travel and social contact in this dissertation, only the analysis of social contact has considered about the joint relationship between different behaviors (contact mode and number of contacted persons), that kind of correlations across other behaviors could be further studied. In the multi-behavior dynamic analysis of activity-travel and social contact, I only analyzed the influence of accumulated experience during the pandemic on current behavior and ignored the dynamic effect between the behaviors at different time points within accumulated behavior.

Third, for the research contents, this dissertation explores the behavioral mechanism and conducts the pandemic policymaking with the help of psychological factors reflecting personal feelings about

policymaking processes. However, some unique policy measures made for all individuals in different countries haven't been examined directly. Only the travel mode choice behaviors and social contact behaviors outside home are further investigated in the scale of single behavior. Further research may focus on the single behavior research in other aspects of people's activity-travel behaviors during the pandemic. And the impact of individuals' influencing factors (e.g., psychological factors) on their behaviors is explored, however, the daily behaviors could also significantly affect people's psychological factors in reverse, that kinds of explorations haven't been investigated in the single behavior analysis of this study. Including the bidirectional relationship between behaviors and influencing factors in research is an important challenge for a comprehensive policymaking. The dynamic effect of behaviors is only investigated in the analysis in chapter 4 and 5, further dynamic analysis for people's social contact behaviors is needed.

Fourth, for the modeling analysis, the social contact behaviors in public transport vehicles setting are only explained by descriptive analysis due to the limitation of data. The modeling analysis for social contact behaviors in public transport vehicles is need for solid evidence of pandemic policymaking. The contact time for different contact setting is another important index of people's social contact behaviors, while it is only explored by the descriptive analysis in this study. Further study may investigate the social contact behaviors in the three dimensions of contact mode, number of contacts and contact time simultaneously via the Copula approach or other joint modeling approaches. The applied copula-based approach couldn't resolve the sample selection bias caused by individuals' random responses during the process of survey, a mixed copula-based model with randomness could be developed for further research.

REFERENCES

Abu-Rayash, A., Dincer, I. (2020). Analysis of mobility trends during the COVID-19 coronavirus pandemic: Exploring the impacts` on global aviation and travel in selected cities. Energy Research & Social Science, 68, 101693. https://doi.org/10.1016/j.erss.2020.101693

Akkermans, J., Richardson, J. and Kraimer, M.L. (2020). The COVID-19 crisis as a career shock: implications for careers and vocational behavior, Journal of Vocational Behavior, 119, 103434. https://doi.org/10.1016/j.jvb.2020.103434

Acuña-Zegarra, M.A., Santana-Cibrian, M. and Velasco-Hernandez, J.X. (2020). Modeling behavioral change and COVID-19 containment in Mexico: A trade-off between lockdown and compliance, Mathematical Biosciences, 325, 108370. https://doi.org/10.1016/j.mbs.2020.108370.

Akakzia, O., Friedrichs, V., Edmunds, W. J., Mossong, J. (2007). Comparison of paper diary vs computer assisted telephone interview for collecting social contact data relevant to the spread of airborne infectious diseases. European Journal of Public Health, 189(17).

Abouk, R., & Heydari, B. (2021). The immediate effect of COVID-19 policies on social-distancing behavior in the United States. Public health reports, 136(2), 245-252.

Aho, K., Derryberry, D., & Peterson, T. (2014). Model selection for ecologists: the worldviews of AIC and BIC. Ecology, 95(3), 631-636.

Aaditya, B., Rahul, T. M. (2021). Psychological impacts of COVID-19 pandemic on the mode choice behaviour: A hybrid choice modelling approach. Transport Policy, 108, 47–58. https://doi.org/10.1016/j.tranpol.2021.05.003

Atchley, P., Shi, J., Yamamoto, T. (2014). Cultural foundations of safety culture: A comparison of traffic safety culture in China, Japan and the United States. Transportation Research Part F: Traffic Psychology and Behaviour, 26, 317-325. https://doi.org/10.1016/j.trf.2014.01.004

Alaszewski, A. (2003). Risk, trust and health. 235-239. https://doi.org/10.1080/13698570310001606941

Abdullah, M., Ali, N., Hussain, S. A., Aslam, A. B., Javid, M. A. (2021a). Measuring changes in travel behavior pattern due to COVID-19 in a developing country: A case study of Pakistan. Transport Policy, 108, 21-33. https://doi.org/10.1016/j.tranpol.2021.04.023

Abdullah, M., Ali, N., Javid, M. A., Dias, C., Campisi, T. (2021b). Public transport versus solo travel mode choices during the COVID-19 pandemic: Self-reported evidence from a developing country. Transportation Engineering, 5, 100078. https://doi.org/10.1016/j.treng.2021.100078

Bagozzi, R. P., & Yi, Y. (1988). On the evaluation of structural equation models. Journal of the academy of marketing science, 16(1), 74-94.

Bielby, W. T., & Hauser, R. M. (1977). Structural equation models. Annual review of sociology, 137-161.

Brooks, S. K., Webster, R. K., Smith, L. E., Woodland, L., Wessely, S., Greenberg, N., Rubin, G. J. (2020). The psychological impact of quarantine and how to reduce it: rapid review of the evidence. Lancet

395(10227): 912–920.

Bangerter, A., Krings, F., Mouton, A., Gilles, I., Green, E.G.T. and Clémence, A. (2012). Longitudinal investigation of public trust in institutions relative to the 2009 H1N1 pandemic in Switzerland, PLOS ONE, 7, 49806. http://dx.doi.org/10.1371/journal.pone.0049806

Blendon, R. J., Koonin, L. M., Benson, J. M., Cetron, M. S., Pollard, W. E., Mitchell, E. W., Weldon, K. J. and Herrmann, M. J. (2008). Public response to community mitigation measures for pandemic influenza, Emerging Infectious Diseases, 14(5), 778-786.

Bhat, C. R. (2015). A new generalized heterogeneous data model (GHDM) to jointly model mixed types of dependent variables. Transportation Research Part B: Methodological, 79, 50-77. https://doi.org/10.1016/j.trb.2015.05.017

Bhat, C. R., Pinjari, A. R., Dubey, S. K., & Hamdi, A. S. (2016). On accommodating spatial interactions in a generalized heterogeneous data model (GHDM) of mixed types of dependent variables. Transportation Research Part B: Methodological, 94, 240-263. https://doi.org/10.1016/j.trb.2016.09.002.

Bhat, C. R., & Eluru, N. (2009). A copula-based approach to accommodate residential self-selection effects in travel behavior modeling. Transportation Research Part B: Methodological, 43(7), 749-765.

Böcker, L., Dijst, M., Faber, J. (2016). Weather, transport mode choices and emotional travel experiences. Transportation Research Part A: Policy and Practice, 94, 360-373. https://doi.org/10.1016/j.tra.2016.09.021

Ben-Akiva, M., McFadden, D., Train, K., Walker, J., Bhat, C., Bierlaire, M., Bolduc, D., Boersch-supan, A., Brownstone, D., Bunch, D. S., Daly, A., Palma, A. D., Gopinath, D., Karlstrom, A., Munizaga, M. A. (2002). Hybrid choice models: Progress and challenges. Marketing Letters, 13(3), 163-175. https://doi.org/10.1023/A:1020254301302

Borriello, A., Scagnolari, S., Rose, J. M. (2019). Reducing the randomness of latent variables using the evaluative space grid: Implementation in a hybrid choice model. Transportation Research Part F: Traffic Psychology and Behaviour, 62, 192-211.

Bhaduri, E., Manoj, B. S., Wadud, Z., Goswami, A. K., Choudhury, C. F. (2020). Modelling the effects of COVID-19 on travel mode choice behaviour in India. Transportation Research Interdisciplinary Perspectives, 8, 100273. https://doi.org/10.1016/j.trip.2020.100273.

Brooks-Pollock, E., Read, J. M., McLean, A., Keeling, M. J., & Danon, L. (2020). Using social contact data to predict and compare the impact of social distancing policies with implications for school re-opening. medRxiv, 2020-07.

Cusack, M. (2021). Individual, social, and environmental factors associated with active transportation commuting during the COVID-19 pandemic. Journal of Transport & Health, 22, 101089. https://doi.org/10.1016/j.jth.2021.101089

Crowley, F., Daly, H., Doran, J., Ryan, G., Caulfield, B. (2021). The impact of labour market disruptions and transport choice on the environment during COVID-19. Transport Policy, 106, 185-195. https://doi.org/10.1016/j.tranpol.2021.04.008

Chan, H. F., Brumpton, M., Macintyre, A., Arapoc, J., Savage, D. A., Skali, A., Stadelmann, D., & Torgler, B. (2020a). How confidence in health care systems affects mobility and compliance during the COVID-19 pandemic. PloS one, 15(10), e0240644. https://doi.org/10.1371/journal.pone.0240644

Chan, H. F., Skali, A., Savage, D. A., Stadelmann, D., Torgler, B. (2020b). Risk attitudes and human mobility during the COVID-19 pandemic. Nature - Scientific Reports, 10(1), 1–13. https://doi.org/10.1038/s41598-020-76763-2.

Cherchi, E., Manca, F. (2011). Accounting for inertia in modal choices: Some new evidence using a RP/SP dataset. Transportation, 38(4), 679–695. https://doi.org/10.1007/s11116-011-9338-9

Chen, C., Feng, T., Gu, X. (2022). Role of latent factors and public policies in travel decisions under COVID-19 pandemic: Findings of a hybrid choice model. Sustainable Cities and Society, 78, 103601. https://doi.org/10.1016/j.scs.2021.103601

Ciuffini, F., Tengattini, S., Bigazzi, A. Y. (2021). Mitigating Increased Driving after the COVID-19 Pandemic: An Analysis on Mode Share, Travel Demand, and Public Transport Capacity. Transportation Research Record, https://doi.org/10.1177/03611981211037884.

Cai, J., Sun, W., Huang, J., Gamber, M., Wu, J., & He, G. (2020). Indirect virus transmission in cluster of COVID-19 cases, Wenzhou, China, 2020. Emerging infectious diseases, 26(6), 1343.

Clayton, D.G., (1978). A model for association in bivariate life tables and its application in epidemiological studies of family tendency in chronic disease incidence. Biometrika, 65 (1), 141–151.

Cho, H., Reimer, T. and McComas, K. A. (2015). The SAGE Handbook of Risk Communication, SAGE Publications, Inc. USA.

Chakraborty, I., & Maity, P. (2020). COVID-19 outbreak: Migration, effects on society, global environment and prevention. Science of The Total Environment, 728, 138882.

Colomer, M. A., Margalida, A., Alòs, F., Oliva-Vidal, P., Vilella, A., & Fraile, L. (2021). Modelling the SARS-CoV-2 outbreak: Assessing the usefulness of protective measures to reduce the pandemic at population level. Science of The Total Environment, 789, 147816.

Duncan, O. D. (2014). Introduction to structural equation models. Elsevier.

Dussaillant, F. and Guzmán, E. (2014). Trust via disasters: The case of Chile's 2010 earthquake, Disasters, 38, 808-832.

Doll, W. J., Xia, W. and Torkzadeh, G. (1994). A confirmatory factor analysis of the end-user computing satisfaction instrument, MIS Quarterly, 12(2), 259-274.

De Vos, J., Schwanen, T., Van Acker, V. and Witlox, F. (2013). Travel and subjective well-being: A focus on findings, methods and future research needs, Transport Reviews, 33(4), 421-442.

De Vos, J., (2020). The effect of COVID-19 and subsequent social distancing on travel behavior. Transportation Research Interdisciplinary Perspectives, 5, 100121. https://doi.org/10.1016/j.trip.2020.100121.

Dorélien, A. M., Venkateswaran, N., Deng, J., Searle, K., Enns, E., & Kulasingam, S. (2021). Quantifying social contact patterns in Minnesota during Stay-at-Home social distancing order. medRxiv.

Daraei, H., Toolabian, K., Kazempour, M., & Javanbakht, M. (2020). The role of the environment and its

pollution in the prevalence of COVID-19. Journal of Infection, 81(2), e168-e169.

Das, S., Boruah, A., Banerjee, A., Raoniar, R., Nama, S., Maurya, A. K. (2021). Impact of COVID-19: A radical modal shift from public to private transport mode. Transport Policy, 109, 1-11. https://doi.org/10.1016/j.tranpol.2021.05.005

Das, T. K., Teng, B. S. (2004). The risk-based view of trust: A conceptual framework. Journal of Business and Psychology, 19(1), 85-116. https://doi.org/10.1023/B:JOBU.0000040274.23551.1b

Ding, H., & Zhang, J. (2021). Dynamic associations between temporal behavior changes caused by the COVID-19 pandemic and subjective assessments of policymaking: A case study in Japan. Transport Policy, 110, 58-70. https://doi.org/10.1016/j.tranpol.2021.05.014

Douglas, M. (1970). Natural Symbols. Barrie & Rockliff.

Douglas, M. (1982). Cultural bias in the active voice. Routledge.

Douglas, M. (1992). Risk and Blame: Essays in Cultural Theory. Routledge.

Dedeoğlu, B. B., Boğan, E. (2021) The motivations of visiting upscale restaurants during the COVID-19 pandemic: The role of risk perception and trust in government. International Journal of Hospitality Management, 95, 102905. https://doi.org/10.1016/j.ijhm.2021.102905

Efthymiou, D., Antoniou, C. (2016). Modeling the propensity to join carsharing using hybrid choice models and mixed survey data. Transport Policy, 51, 143-149. https://doi.org/10.1016/j.tranpol.2016.07.001

Eisenmann, C., Nobis, C., Kolarova, V., Lenz, B., Winkler, C. (2021). Transport mode use during the COVID-19 lockdown period in Germany: The car became more important, public transport lost ground. Transport Policy, 103, 60–67. https://doi.org/10.1016/j.tranpol.2021.01.012

Eluru, N., Paleti, R., Pendyala, R. M., & Bhat, C. R. (2010). Modeling injury severity of multiple occupants of vehicles: Copula-based multivariate approach. Transportation Research Record, 2165(1), 1-11.

Fadilah, M., & Arsinta, D. (2020). The effect of social contacts on the spreads of covid-19 in Indonesia. Advances in Social Sciences Research Journal, 7(6), 233-242.

Feehan, D. M., & Mahmud, A. S. (2021). Quantifying population contact patterns in the United States during the COVID-19 pandemic. Nature communications, 12(1), 1-9.

Frey, R., McNeil, A. J., & Nyfeler, M. (2001). Copulas and credit models. Risk, 10 (111114.10).

Farlie, D. J. G. (1960). The performance of some correlation coefficients for a general bivariate distribution. Biometrika, 47 (3-4), 307–323.

Frank, M. J. (1979). On the simultaneous associativity of F(x,y) and x + y - F(x,y). Aequationes Mathematicae 19 (1), 194–226.

Fischer, A. R. H. (2017). Perception, attitudes, intentions, decisions and actual behavior, In: Emilien, G., Weitkunat, R., Lüdicke, F. (eds.), Consumer Perception of Product Risks and Benefits. Springer: Cham, Switzerland.

Greenaway, K. H. and Cruwys, T. (2019). The source model of group threat: Responding to internal and external threats. American Psychologist, 74, 218-231.

Gilles, I., Bangerter, A., Clémence, A., Green, E. G. T., Krings, F., Staerklé, C. and Wagner-Egger, P. (2011). Trust in medical organizations predicts pandemic (H1N1) 2009 vaccination behavior and perceived

efficacy of protection measures in the Swiss public. European Journal of Epidemiology, 26, 203-210.

Gärling, T., Axhausen, K. W. (2003). Introduction: Habitual travel choice. Transportation, 30(1), 1–11. https://doi.org/10.1023/A:1021230223001

Gaygısız, E. (2010). Cultural values and governance quality as correlates of road traffic fatalities: A nation level analysis. Accident Analysis & Prevention, 42(6), 1894-1901. https://doi.org/10.1016/j.aap.2010.05.010

Gao, K., Yang, Y., Sun, L., Qu, X. (2020). Revealing psychological inertia in mode shift behavior and its quantitative influences on commuting trips. Transportation Research Part F: Traffic Psychology and Behaviour. 71, 272-287. https://doi.org/10.1016/j.trf.2020.04.006

González, R. M., Marrero, Á. S., Cherchi, E. (2017). Testing for inertia effect when a new tram is implemented. Transportation Research Part A: Policy and Practice, 98, 150-159. https://doi.org/10.1016/j.tra.2017.02.007

Guo, J., Feng, T., Timmermans, H. J. (2020). Co-dependent workplace, residence and commuting mode choice: Results of a multi-dimensional mixed logit model with panel effects. Cities, 96, 102448. https://doi.org/10.1016/j.cities.2019.102448.

Guan, D., Wang, D., Hallegatte, S., Davis, S. J., Huo, J., Li, S., Bai, Y., Lei, T., Xue, Q., Coffman, D., Cheng, D., Chen, P., Liang, X., Xu, B., Lu, X., Wang, S., Hubacek, K. & Gong, P. (2020). Global supply-chain effects of COVID-19 control measures. Nature human behaviour, 1-11.

Ge, Z. Y., Yang, L. M., Xia, J. J., Fu, X. H., & Zhang, Y. Z. (2020). Possible aerosol transmission of COVID-19 and special precautions in dentistry. Journal of Zhejiang University-SCIENCE B, 21(5), 361-368.

Gumbel, E. J. (1960). Bivariate exponential distributions. Journal of the American Statistical Association 55 (292), 698–707.

Haug, N., Geyrhofer, L., Londei, A., Dervic, E., Desvars-Larrive, A., Loreto, V., Pinior, B., Thurner, S. & Klimek, P. (2020). Ranking the effectiveness of worldwide COVID-19 government interventions. Nature human behaviour, 4(12), 1303-1312.

Huang, B., Wang, J., Cai, J., Yao, S., Chan, P. K. S., Tam, T. H. W., Hong, Y., Ruktanonchai, C., Carioli, A., Floyd, J., Ruktanonchai, N., Yang, W., Li, Z., Tatem, A. & Lai, S. (2021). Integrated vaccination and physical distancing interventions to prevent future COVID-19 waves in Chinese cities. Nature Human Behaviour, 1-11.

Huang, H., Fang, Z., Wang, Y., Tang, J., & Fu, X. (2022). Analysing taxi customer-search behaviour using Copula-based joint model. Transportation Safety and Environment, 4(1), tdab033.

Henningsen, A., & Toomet, O. (2011). maxLik: A package for maximum likelihood estimation in R. Computational Statistics, 26(3), 443-458.

Hoang, T., Coletti, P., Melegaro, A., Wallinga, J., Grijalva, C. G., Edmunds, J. W., Beutels, P., Hens, N. (2019). A systematic review of social contact surveys to inform transmission models of close-contact infections. Epidemiology (Cambridge, Mass.), 30(5), 723.

Habib, K. M. N., Day, N., & Miller, E. J. (2009). An investigation of commuting trip timing and mode choice in the Greater Toronto Area: Application of a joint discrete-continuous model. Transportation Research

Part A: Policy and Practice, 43(7), 639-653.

Ho, C., Mulley, C. (2015). Intra-household Interactions in tour-based mode choice: The role of social, temporal, spatial and resource constraints. Transport Policy, 38, 52-63. https://doi.org/10.1016/j.tranpol.2014.12.001

Huan, N., Hess, S., Yao, E. (2021). Understanding the effects of travel demand management on metro commuters' behavioural loyalty: a hybrid choice modelling approach. Transportation, 49(2), 343-372. https://doi.org/10.1007/s11116-021-10179-3

Hess, S., Spitz, G., Bradley, M., Coogan, M. (2018). Analysis of mode choice for intercity travel: Application of a hybrid choice model to two distinct US corridors. Transportation Research Part A: Policy and Practice, 116, 547-567. https://doi.org/10.1016/j.tra.2018.05.019

Hess, S., Palma, D. (2019). Apollo: a flexible, powerful and customisable freeware package for choice model estimation and application. Journal of Choice Modelling, 32, 100170. https://doi.org/10.1016/j.jocm.2019.100170

Haggar, P., Whitmarsh, L., Skippon, S. M. (2019). Habit discontinuity and student travel mode choice. Transportation research part F: traffic psychology and behaviour, 64, 1-13. https://doi.org/10.1016/j.trf.2019.04.022

Hendrickson, C., Rilett, L. R. (2020). The COVID-19 pandemic and transportation engineering. Journal of Transportation Engineering, Part A: Systems, 146(7), 01820001. https://doi.org/10.1061/JTEPBS.0000418

Hotle, S., Murray-Tuite, P. and Singh, K. (2020). Influenza risk perception and travel-related health protection behavior in the US: Insights for the aftermath of the COVID-19 outbreak, Transportation Research Interdisciplinary Perspectives, 5, 100127. https://doi.org/10.1016/j.trip.2020.100127

Hyland-Wood, B., Gardner, J., Leask, J. and Ecker, U. K. (2021). Toward effective government communication strategies in the era of COVID-19. Humanities and Social Sciences Communications, 8(1), 1-11.

Ibuka, Y., Chapman, G. B., Meyers, L. A., Li, M. and Galvani, A. P. (2010). The dynamics of risk perceptions and precautionary behavior in response to 2009 (H1N1) pandemic influenza, BMC Infectious Diseases, 10, 296. http://dx.doi.org/10.1186/1471-2334-10-296.

Ingvardson, J. B., Thorhauge, M., Kaplan, S., Nielsen, O. A., Raveau, S. (2021). Incorporating psychological needs in commute mode choice modelling: a hybrid choice framework. Transportation, 1-29. https://doi.org/10.1007/s11116-021-10230-3.

Islam, N., Sharp, S. J., Chowell, G., Shabnam, S., Kawachi, I., Lacey, B., Massaro, J. M., D'Agostino Sr, R. & White, M. (2020). Physical distancing interventions and incidence of coronavirus disease 2019: natural experiment in 149 countries. bmj, 370.

Irannezhad, E., Prato, C. G., Hickman, M., & Mohaymany, A. S. (2017). Copula-based joint discrete–continuous model of road vehicle type and shipment size. Transportation Research Record, 2610(1), 87-96.

Jarvis, C. I., Van Zandvoort, K., Gimma, A., Prem, K., Klepac, P., Rubin, G. J., & Edmunds, W. J. (2020).

Quantifying the impact of physical distance measures on the transmission of COVID-19 in the UK. BMC medicine, 18(1), 1-10.

Jafari Shahdani, F., Rasaizadi, A., & Seyedabrishami, S. (2021). The interaction between activity choice and duration: Application of copula-based and nested-logit models. Scientia Iranica, 28(4), 2037-2052.

Joe, H. (1993). Parametric families of multivariate distributions with given marginals. Journal of Multivariate Analysis, 46 (2), 262–282.

Joe, H. (1997). Multivariate Models and Dependence Concepts. Chapman & Hall, London.

Jenkins-Smith, H. C., Herron, K. G. (2009). Rock and a hard place: Public willingness to trade civil rights and liberties for greater security. Politics & Policy. 37, 1095–1129. https://doi.org/10.1111/j.1747-1346.2009.00215.x

Jenkins-Smith, H. C., Smith, W. K. (2019). Ideology, culture, and risk perception. In: Coyle, D. J., Ellis, R.J. (eds.), Politics, policy, and culture. 17-32. Routledge.

Kang, S., Mondal, A., Bhat, A. C., & Bhat, C. R. (2021). Pooled versus private ride-hailing: A joint revealed and stated preference analysis recognizing psycho-social factors. Transportation Research Part C: Emerging Technologies, 124, 102906. https://doi.org/10.1016/j.trc.2020.102906

Kamargianni, M., Dubey, S., Polydoropoulou, A., Bhat, C. (2015). Investigating the subjective and objective factors influencing teenagers' school travel mode choice–An integrated choice and latent variable model. Transportation Research Part A: Policy and Practice, 78, 473-488. https://doi.org/10.1016/j.tra.2015.06.011

Kahan, D. M. (2006). Cultural cognition and public policy. Yale Law and Policy Review, 24, 147–170.

Kim, J., Rasouli, S., Timmermans, H. J. (2017). The effects of activity-travel context and individual attitudes on car-sharing decisions under travel time uncertainty: A hybrid choice modeling approach. Transportation Research Part D: Transport and Environment, 56, 189-202. https://doi.org/10.1016/j.trd.2017.07.022

Kim, D. K. D. and Kreps, G. L. (2020). An analysis of government communication in the United States during the COVID-19 pandemic: recommendations for effective government health risk communication, World Medical & Health Policy, 12(4), 398-412.

Kitamura, R., Van Der Hoorn, T. (1987). Regularity and irreversibility of weekly travel behavior. Transportation, 14(3), 227-251. https://doi.org/10.1007/BF00837531

Kiti, M. C., Aguolu, O. G., Liu, C. Y., Mesa, A. R., Regina, R., Woody, M., Willebrand, K., Couzens, C., Bartelsmeyer, T., Nelson, K. N., Jenness, S., Riley, S., Melegaro, A., Ahmed, F., Malik, F., Lopman, B. & Omer, S. B. (2021). Social contact patterns among employees in 3 US companies during early phases of the COVID-19 pandemic, April to June 2020. Epidemics, 36, 100481.

Kuwano, M., Fujiwara, A., Zhang, J., & Tsukai, M. (2011). Joint modeling of vehicle holding duration and traveling distance with a copula-based multivariate survival model. Asian Transport Studies, 1(3), 303-317.

Keya, N., Anowar, S., & Eluru, N. (2019). Joint model of freight mode choice and shipment size: a copula-based random regret minimization framework. Transportation Research Part E: Logistics and

Transportation Review, 125, 97-115.

Katrakazas, C., Michelaraki, E., Sekadakis, M. and Yannis, G. (2020). A descriptive analysis of the effect of the COVID-19 pandemic on driving behavior and road safety, Transportation Research Interdisciplinary Perspectives, 7, 100186. https://doi.org/10.1016/j.trip.2020.100186

Laato, S., Islam, A.K. M.N. , Farooq, A. and Dhir, A. (2020a). Unusual purchasing behavior during the early stages of the COVID-19 pandemic: The stimulus-organism-response approach, Journal of Retailing and Consumer Services, 57, 102224. https://doi.org/10.1016/j.jretconser.2020.102224

Laato, S., Islam, A. K. M. N., Laine, T. H. (2020b). Did location-based games motivate players to socialize during COVID-19?. Telematics and Informatics, 54, 101458. https://doi.org/10.1016/j.tele.2020.101458

Li, Q., and Brewer, M.B. (2004). What does it mean to be an American? Patriotism, nationalism, and American identity after 9/11, Political Psychology, 25, 727-739.

Li, Y., Zeng, Y., Liu, G., Lu, D., Yang, H., Ying, Z., Hu, Y., Qiu, J., Zhang, C., Fall, K., Fang, F., Valdimarsdóttir, U., Zhang, W. and Song, H. (2020). Public awareness, emotional reactions and human mobility in response to the COVID-19 outbreak in China - A population-based ecological study, Psychological Medicine, 1-8. https://doi.org/10.1017/S003329172000375X.

Lu, L., Liu, J., Yuan, Y. C., Burns, K. S., Lu, E. and Li, D. (2020). Source trust and covid-19 information sharing: The mediating roles of emotions and beliefs about sharing, Health Education & Behavior, 1-8. https://doi.org/10.1177/1090198120984760.

Lodge, M., Wegrich, K., McElroy, G. (2010). Dodgy kebabs everywhere? Variety of worldviews and regulatory change. Public Administration, 88(1), 247-266. https://doi.org/10.1111/j.1467-9299.2010.01811.x

LaMondia, J., Snell, T., Bhat, C. R. (2010). Traveler behavior and values analysis in the context of vacation destination and travel mode choices: European Union case study. Transportation Research Record, 2156(1), 140-149. https://doi.org/10.3141/2156-16

Liu, B. F., Mehta, A. M. (2020). From the periphery and toward a centralized model for trust in government risk and disaster communication. Journal of Risk Research, 24, 853-869. https://doi.org/10.1080/13669877.2020.1773516

Liu, C. Y., Berlin, J., Kiti, M. C., Del Fava, E., Grow, A., Zagheni, E., Melegaro, A., Jenness, S., Omer, S., Lopman, S., Lopman, B. & Nelson, K. (2021). Rapid review of social contact patterns during the COVID-19 pandemic. Epidemiology (Cambridge, Mass.), 32(6), 781.

Lanzini, P., Khan, S. A. (2017). Shedding light on the psychological and behavioral determinants of travel mode choice: A meta-analysis. Transportation Research Part F: Traffic Psychology and Behaviour, 48, 13-27. https://doi.org/10.1016/j.trf.2017.04.020.

Laman, H., Yasmin, S., & Eluru, N. (2018). Joint modeling of traffic incident duration components (reporting, response, and clearance time): a copula-based approach. Transportation research record, 2672(30), 76-89.

López, L., & Rodó, X. (2020). The end of social confinement and COVID-19 re-emergence risk. Nature

Human Behaviour, 4(7), 746-755.

Latsuzbaia, A., Herold, M., Bertemes, J. P., & Mossong, J. (2020). Evolving social contact patterns during the COVID-19 crisis in Luxembourg. PloS one, 15(8), e0237128.

Leung, K., Jit, M., Lau, E. H., & Wu, J. T. (2017). Social contact patterns relevant to the spread of respiratory infectious diseases in Hong Kong. Scientific reports, 7(1), 1-12.

Leppin, A. and Aro, A. R. (2009). Risk perceptions related to SARS and Avian Influenza: Theoretical foundations of current empirical research. International Journal of Behavioral Medicine, 16, 7-29.

Li, Y., Zhang, R., Zhao, J., Molina, M.J. (2020). Understanding transmission and intervention for the COVID-19 pandemic in the United States. Science of The Total Environment, 748, 141560.

Li, X., Hui, E. C. M., & Shen, J. (2022). Institutional development and the government response to COVID-19 in China. Habitat International, 127, 102629.

Lv, Y., Tian, H. Luo, L., Liu, S., Bai, X., Zhao, H., Zhang, K., Lin, S., Zhao, S., Guo, Z., Xiao, Y., Yang, J. (2022). Understanding and revealing the intrinsic impacts of the COVID-19 lockdown on air quality and public health in North China using machine learning. Science of The Total Environment, 857 (1), 15933.

McCarthy, Z., Xiao, Y., Scarabel, F., Tang, B., Bragazzi, N. L., Nah, K., Heffernan, J. M., Asgary, A., Murty, V. K., Ogden, N. H. & Wu, J. (2020). Quantifying the shift in social contact patterns in response to non-pharmaceutical interventions. Journal of Mathematics in Industry, 10(1), 1-25.

Mossong, J., Hens, N., Jit, M., Beutels, P., Auranen, K., Mikolajczyk, R., Massari, M., Salmaso, S., Tomba, G. S., Wallinga, J., Heijne, J., Todys., S., Rosinska, M., Edmunds, W. J. (2008). Social Contacts and Mixing Patterns Relevant to the Spread of Infectious Diseases. PLoS Medicine, 5(3).

McCreesh, N., Mohlamonyane, M., Edwards, A., Olivier, S., Dikgale, K., Dayi, N., Gareta, D., Wood, R., Grant, A. D., White, R., & Middelkoop, K. (2022). Improving estimates of social contact patterns for the airborne transmission of respiratory pathogens. medRxiv.

Morgenstern, D., (1956). Einfache beispiele zweidimensionaler verteilungen. Mitteilingsblatt fur Mathematische Statistik, 8 (3), 234–235.

Meloni, I., Eluru, N., Spissu, E., Portoghese, A., & Bhat, C. R. (2011). A copula-based joint model of commute mode choice and number of non-work stops during the commute. International journal of transport economics: Rivista internazionale di economia dei trasporti: XXXVIII, 3, 337-364.

Mehdizadeh, M., Zavareh, M. F., Nordfjaern, T. (2019). Mono-and multimodal green transport use on university trips during winter and summer: Hybrid choice models on the norm-activation theory. Transportation Research Part A: Policy and Practice, 130, 317-332. https://doi.org/10.1016/j.tra.2019.09.046

Molin, E. J., Timmermans, H. J. (2010). Context dependent stated choice experiments: The case of train egress mode choice. Journal of choice modelling, 3(3), 39-56. https://doi.org/10.1016/S1755-5345(13)70013-7

McEvoy, J., Gilbertz, S. J., Anderson, M. B., Ormerod, K. J., Bergmann, N. T. (2017). Cultural theory of risk as a heuristic for understanding perceptions of oil and gas development in Eastern Montana, USA. The

Extractive Industries and Society, 4(4), 852-859. https://doi.org/10.1016/j.exis.2017.10.004

Marroquín, B., Vine, V. and Morgan, R. (2020). Mental health during the COVID-19 pandemic: Effects of stay-at-home policies, social distancing behavior, and social resources, Psychiatry Research, 293, 113419. https://doi.org/10.1016/j.psychres.2020.113419

Meltzer, M. I., Cox, N. J. and Fukuda, K. (1999). The economic impact of pandemic influenza in the United States: Priorities for intervention, Emerging Infectious Diseases, 5, 659-671.

Min, C., Shen, F., Yu, W. and Chu, Y. (2020). The relationship between government trust and preventive behaviors during the COVID-19 pandemic in China: Exploring the roles of knowledge and negative emotion, Preventive Medicine, 141. 106288. https://doi.org/10.1016/j.ypmed.2020.106288

Miri, S. M., Roozbeh, F., Omranirad, A. and Alavian, S. M. (2020). Panic of buying toilet papers: a historical memory or a horrible truth? Systematic review of gastrointestinal manifestations of COVID-19. Hepatitis Monthly, 20(3), 102729. https://doi.org/10.5812/hepatmon.102729.

Mei, C. (2020). Policy style, consistency and the effectiveness of the policy mix in China's fight against COVID-19. Policy and Society, 39(3), 309-325.

Melnyk, B.M., Hsieh, A.P., Mu, J., Jopp, D.A., & Miller, S. (2022). Associations among infection prevention professionals' mental/physical health, lifestyle behaviors, shift length, race, and workplace wellness support during COVID-19. American Journal of Infection Control, 51 (1), 62-69.

Mikszewski, A., Stabile, L., Buonanno, G., & Morawska, L. (2022). Increased close proximity airborne transmission of the SARS-CoV-2 Delta variant. Science of The Total Environment, 816, 151499.

Nelson, K.N., Siegler, A.J., Sullivan, O-P.S., Bradley, H., Hall, E., Luisi, N., Hipp-Ramsey, P., Sanchez, T., Shioda, K., Lopman, B. A. (2022). Nationally representative social contact patterns among U.S. adults, August 2020-April 2021. Epidemics, 40, 100605.

Nelsen, R. B. (2007). An introduction to copulas. Springer Science & Business Media.

Neuwirth, D. K. (1999). Proposed model of the relationship of risk information seeking and processing to the development of preventive behaviors. Environmental Research, 80(2), 230-245.

Nan, X., Madden, K. (2014). The role of cultural worldviews and message framing in shaping public opinions toward the human papillomavirus vaccination mandate. Human Communication Research, 40(1), 30-53. https://doi.org/10.1111/hcre.12016

Nelsen, R. B. (2007). An introduction to copulas. Springer Science & Business Media.

Nguyen, N. T., Miwa, T., & Morikawa, T. (2017). Vehicle type choice, usage, and CO2 emissions in Ho Chi Minh city: analysis and simulation using a discrete-continuous model. Asian Transport Studies, 4(3), 499-517.

Oña, J. D., Oña, R. D., Eboli, L. and Mazzulla, G. (2013). Perceived service quality in bus transit service: A structural equation approach. Transport Policy, 29, 219-226.

Oraby, T., Tyshenko, M. G., Maldonado, J. C., Vatcheva, K., Elsaadany, S., Alali, W. Q., Longenecker, J. C. & Al-Zoughool, M. (2021). Modeling the effect of lockdown timing as a COVID-19 control measure in countries with differing social contacts. Scientific reports, 11(1), 1-13.

Przybylowski, A., Stelmak, S., Suchanek, M. (2021). Mobility behaviour in view of the impact of the COVID-19 pandemic-public transport users in Gdansk case study. Sustainability, 13(1), 364.

Prati, G., Pietrantoni, L., Zani, B. (2011). Compliance with recommendations for pandemic influenza H1N1 2009: The role of trust and personal beliefs, Health Education Research, 26(5), 761-769. https://doi.org/10.1093/her/cyr035

Pennington-Gray, L., Schroeder, A. and Kaplanidou, K. K. (2011). Examining the influence of past travel experience, general web searching behaviour and risk perception on future travel intentions. International Journal of Safety and Security in Tourism, 1(1), 64-92.

Postmes, T., Haslam, S. A. and Jans, L. (2013). A single-item measure of social identification: Reliability, validity, and utility. British Journal of Social Psychology, 52, 597-617.

Parady, G., Taniguchi, A. and Takami, K. (2020). Travel behavior changes during the COVID-19 pandemic in Japan: Analyzing the effects of risk perception and social influence on going-out self-restriction. Transportation Research Interdisciplinary Perspectives, 7, 100181.

Petherick, A., Goldszmidt, R. G., Andrade, E. B., Furst, R., Pott, A. and Wood, A. (2021). A worldwide assessment of COVID-19 pandemic-policy fatigue, SSRN: https://ssrn.com/abstract=3774252.

Pouso, S., Borja, A., & Uyarra, M. C. (2020). Contact with blue-green spaces during the COVID-19 pandemic lockdown beneficial for mental health. Science of The Total Environment, 756, 143984.

Quinn, S. C., Parmer, J., Freimuth, V. S., Hilyard, K. M., Musa, D. and Kim, K. H. (2013), Exploring communication, trust in government, and vaccination intention later in the 2009 H1N1 pandemic: Results of a national survey. Biosecurity and Bioterrorism, 11, 96-106.

Ren, X. (2020). Pandemic and lockdown: A territorial approach to COVID-19 in China, Italy and the United States. Eurasian Geography and Economics, 61(4-5), 423-434.

Rahmandad, H., Lim, T. Y. and Sterman, J. (2021). Behavioral dynamics of COVID-19: Estimating under-reporting, multiple waves, and adherence fatigue across 92 nations. medRxiv. https://doi.org/10.1101/2020.06.24.20139451.

Ripberger, J. T., Song, G., Nowlin, M. C., Jones, M. D., Jenkins-Smith, H. C. (2012). Reconsidering the relationship between cultural theory, political ideology, and political knowledge. Social Science Quarterly, 93(3), 713-731. https://doi.org/10.1111/j.1540-6237.2012.00884.x

Rothengatter, W., Zhang, J., Hayashi, Y., Nosach, A., Wang, K., Oum, T. H. (2021). Pandemic waves and the time after Covid-19 – Consequences for the transport sector. Transport Policy, 110, 225-237. https://doi.org/10.1016/j.tranpol.2021.06.003.

Rith, M., Fillone, A. M., Doi, K., Inoi, H., & Ritbinoa, J. B. M. (2019). A Comparative Assessment between the Simultaneous and Sequential Maximum Likelihood Estimation Approaches for the Frank Copula-Based Joint Model of Vehicle Type Ownership and Usage in Metro Manila. Journal of the Eastern Asia Society for Transportation Studies, 13, 861-876.

Scagnolari, S., Walker, J., Maggi, R. (2015). Young drivers' night-time mobility preferences and attitude toward alcohol consumption: A hybrid choice model. Accident Analysis & Prevention, 83, 74-89. https://doi.org/10.1016/j.aap.2015.07.002

Sibley, C. G., Greaves, L. M., Satherley, N., Wilson, M. S., Overall, N. C., Lee, C. H. J., Milojev, P., Bulbulia, J., Osborne, D., Milfont, T. L., Houkamau, C. A., Duck, I. M., Vickers-Jones, R., Barlow, F. K. (2020). Effects of the COVID-19 pandemic and nationwide lockdown on trust, attitudes toward government, and well-being. American Psychologist, 75(5), 618-630. https://doi.org/10.1037/amp0000662

Silva, C. L., Jenkins-Smith, H. C. (2007). The precautionary principle in context: US and EU scientists' prescriptions for policy in the face of uncertainty. Social Science Quarterly, 88(3), 640-664. https://doi.org/10.1111/j.1540-6237.2007.00476.x

Slovic, P. (1993). Perceived risk, trust, and democracy. Risk Analysis, 13(6), 675-682. https://doi.org/10.1111/j.1539-6924.1993.tb01329.x

Slovic, P., Flynn, J. H., Layman, M. (1991). Perceived risk, trust, and the politics of nuclear waste. Science, 254(5038), 1603-1607. https://DOI: 10.1126/science.254.5038.1603

Shakibaei, S., De Jong, G. C., Alpkökin, P., Rashidi, T. H. (2021). Impact of the COVID19 pandemic on travel behavior in Istanbul: A panel data analysis. Sustainable Cities and Society, 65, 102619. https://doi.org/10.1016/j.scs.2020.102619

Song, G., Silva, C. L., Jenkins-Smith, H. C. (2014a). Cultural worldview and preference for childhood vaccination policy. Policy Studies Journal, 42(4), 528-554. https://doi.org/10.1111/psj.12076

Song, G. (2014b). Understanding public perceptions of benefits and risks of childhood vaccinations in the United States. Risk Analysis, 34(3), 541-555. https://doi.org/10.1111/risa.12114

Solmazer, G., Üzümcüoğlu, Y., Özkan, T. (2016). The role of traffic law enforcements in the relationship between cultural variables and traffic fatality rates across some countries of the world. Transportation Research Part F: Traffic Psychology and Behaviour, 38, 137-150. https://doi.org/10.1016/j.trf.2016.01.001

Sommer, L. (2011). The theory of planned behaviour and the impact of past behaviour. The International Business & Economics Research Journal, 10(1), 91. https://doi.org/10.19030/iber.v10i1.930

Siegrist, M., Earle, T. C., Gutscher, H. (2003). Test of a trust and confidence model in the applied context of Electromagnetic Field Risks (EMF). Risk Analysis, 23, 705-716. https://doi.org/10.1111/1539-6924.00349

Shaer, A., Haghshenas, H. (2021). Evaluating the effects of the COVID-19 outbreak on the older adults' travel mode choices. Transport Policy, 112, 162-172. https://doi.org/10.1016/j.tranpol.2021.08.016.

Shabanpour, R., Golshani, N., Derrible, S., Mohammadian, A., & Miralinaghi, M. (2017). Joint discrete-continuous model of travel mode and departure time choices. Transportation Research Record, 2669(1), 41-51.

Sypsa, V., Roussos, S., Paraskevis, D., Lytras, T., Tsiodras, S. S., & Hatzakis, A. (2020). Modelling the SARS-CoV-2 first epidemic wave in Greece: social contact patterns for impact assessment and an exit strategy from social distancing measures. medRxiv.

Spissu, E., Pinjari, A. R., Pendyala, R. M., & Bhat, C. R. (2009). A copula-based joint multinomial discrete–continuous model of vehicle type choice and miles of travel. Transportation, 36(4), 403-422.

Seyedabrishami, S., & Izadi, A. R. (2019). A copula-based joint model to capture the interaction between

mode and departure time choices in urban trips. Transportation Research Procedia, 41, 722-730.

Sparkman, G., & Walton, G. M. (2017). Dynamic norms promote sustainable behavior, even if it is counternormative. Psychological science, 28(11), 1663-1674.

Schmidt, T. (2007). Coping with copulas. Copulas-From theory to application in finance, 3, 34.

Sklar, A. (1973). Random variables, joint distribution functions, and copulas. Kybernetika, 9(6), 449-460

Sener, I. N., Eluru, N., & Bhat, C. R. (2010). On jointly analyzing the physical activity participation levels of individuals in a family unit using a multivariate copula framework. Journal of Choice Modelling, 3(3), 1-38.

Shaw, R., Kim, Y. and Hua, J. (2020). Governance, technology and citizen behavior in pandemic: Lessons from COVID-19 in East Asia, Progress in Disaster Science, 6, 100090. https://doi.org/10.1016/j.pdisas.2020.100090

Seyal, A. H., Rahman, M. N. A. and Rahim, M. M. (2002). Determinants of academic use of the Internet: A structural equation model, Behaviour & Information Technology, 21(1), 71-86.

Shamshiripour, A., Rahimi, E., Shabanpour, R. and Mohammadian, A. (2020). How is COVID-19 reshaping activity-travel behavior? Evidence from a comprehensive survey in Chicago, Transportation Research Interdisciplinary Perspectives, 7, 100216. https://doi.org/10.1016/j.trip.2020.100216

Stavrinos, D., McManus, B., Mrug, S., He, H., Gresham, B., Albright, M. G., Svancara, A. M., Whittington, C., Underhill, A. and White, D. M. (2020). Adolescent driving behavior before and during restrictions related to COVID-19, Accident Analysis & Prevention, 144, 105686. https://doi.org/10.1016/j.aap.2020.105686.

Smith, R. D. (2006). Responding to global infectious disease pandemics: lessons from SARS on the role of risk perception, communication and management, Social Science & Medicine, 63, 3113-3123.

Sadique, M. Z., Edmunds, W. J., Smith, R. D., Meerding, W. J., de Zwart, O., Brug, J. and Beutels, P. (2007). Precautionary behavior in response to perceived threat of pandemic influenza, Emerging Infectious Diseases, 13(9), 1307-1313.

Shimizu, K. and Negita, M. (2020). Lessons learned from Japan's response to the first wave of COVID-19: A content analysis, Healthcare, 8(4), 426. https://doi.org/10.3390/healthcare8040426

Statistics Bureau of Japan (2021) Japan Statistical Yearbook 2021: Chapter 2 'Population and Households'. https://www.stat.go.jp/english/data/nenkan/70nenkan/1431-02.html (Accessed on March 28, 2021).

Shearston, J.A., Martinez, M.A., Nunez, Y., & Hilpert, M. (2021). Social-distancing fatigue: Evidence from real-time crowd-sourced traffic data. Science of The Total Environment, 792, 148336.

Thu, T. P. B., Ngoc, P. N. H., Hai, N. M., Tuan, L. A. (2020). Effect of the social distancing measures on the spread of COVID-19 in 10 highly infected countries. Science of The Total Environment, 742, 140430.

Toya, H. and Skidmore, M. (2014). Do natural disasters enhance societal trust?, Kyklos, 67, 255-279.

Taylor, M., Raphael, B., Barr, M., Agho, K., Stevens, G. and Jorm, L. (2009). Public health measures during an anticipated influenza pandemic: Factors influencing willingness to comply. Risk Management and Health Care Policy, 2, 9-20.

Trivedi, P. K., & Zimmer, D. M. (2007). Copula modeling: an introduction for practitioners. Foundations and Trends® in Econometrics, 1(1), 1-111.

Tizzani, M., De Gaetano, A., Jarvis, C. I., Gimma, A., Wong, K., Edmunds, W. J., Beutels, P., Hens, N., Coletti, P., & Paolotti, D. (2022). Impact of tiered measures on social contact and mixing patterns in Italy during the second wave of COVID-19. Research square.

Trentini, F., Manna, A., Balbo, N., Marziano, V., Guzzetta, G., O'Dell, S., Kummer, A. G., Litvinova, M., Merler, S., Ajelli, M., Poletti, P. & Melegaro, A. (2022). Investigating the relationship between interventions, contact patterns, and SARS-CoV-2 transmissibility. Epidemics, 40, 100601.

Trentini, F., Guzzetta, G., Galli, M., Zardini, A., Manenti, F., Putoto, G., Marziano, V., Gamshie, W. N., Tsegaye, A., Greblo, A., Melegaro, A., Ajelli, M., Merler, S. & Poletti, P. (2021). Modeling the interplay between demography, social contact patterns, and SARS-CoV-2 transmission in the South West Shewa Zone of Oromia Region, Ethiopia. BMC medicine, 19(1), 1-13

Tomori, D. V., Rübsamen, N., Berger, T., Scholz, S., Walde, J., Wittenberg, I., Lange, B., Kuhlmann, A., Horn, J., Mikolajczyk, R., Jaeger, V. & Karch, A. (2021). Individual social contact data and population mobility data as early markers of SARS-CoV-2 transmission dynamics during the first wave in Germany—an analysis based on the COVIMOD study. BMC medicine, 19(1), 1-13.

Thorhauge, M., Cherchi, E., Walker, J. L., Rich, J. (2019). The role of intention as mediator between latent effects and behavior: application of a hybrid choice model to study departure time choices. Transportation, 46(4), 1421-1445. https://doi.org/10.1007/s11116-017-9839-2

Thompson, M., Ellis, R., Wildavsky, A. (2018). Cultural theory. Routledge.

Train, K. E. (2009). Discrete choice methods with simulation. Cambridge university press.

Thrane, C. (2015). Examining tourists' long-distance transportation mode choices using a Multinomial Logit regression model. Tourism Management Perspectives, 15, 115-121. https://doi.org/10.1016/j.tmp.2014.10.004

Thombre, A., Agarwal, A. (2021). A paradigm shift in urban mobility: policy insights from travel before and after COVID-19 to seize the opportunity. Transport Policy, 110, 335-353. https://doi.org/10.1016/j.tranpol.2021.06.010

Tarasi, D., Daras, T., Tournaki, S., Tsoutsos, T. (2021). Transportation in the Mediterranean during the COVID-19 pandemic era. Global Transitions, 3, 55-71. https://doi.org/10.1016/j.glt.2020.12.003.

Üzümcüoglu, Y., Ozkan, T., Lajunen, T. (2018). The relationships between cultural variables, law enforcements and driver behaviours across 37 nations. Transportation Research Part F: Traffic Psychology and Behaviour, 58(OCT.), 743-753.

Vij, A., Walker, J. L. (2016). How, when and why integrated choice and latent variable models are latently useful. Transportation Research Part B: Methodological, 90, 192-217. https://doi.org/10.1016/j.trb.2016.04.021

Vij, A., Walker, J. L. (2014). Hybrid choice models: The identification problem. In Handbook of Choice Modelling, 519-564, Edward Elgar Publishing.

Verelst, F., Hermans, L., Vercruysse, S., Gimma, A., Coletti, P., Backer, J. A., Wong, K. L. M., Wambua, J.,

van Zandvoort, K., Willem, L., Bogaardt, L., Faes, C., Jarvis, C. I., Wallinga, J., Edmunds, W. J., Beutels, P., Hens, N. (2021). SOCRATES-CoMix: a platform for timely and open-source contact mixing data during and in between COVID-19 surges and interventions in over 20 European countries. BMC medicine, 19(1), 1-7.

Van Bavel, J. J., Baicker, K. and Boggio, P. S., Capraro, V., Cichocka, A., Cikara, M., Crockett, M., Crum, A., Douglas, K., Druckman, J., Drury, J., Dube, O., Ellemers, N., Finkel, E., Fowler, J., Gelfand, M., Han, S., Haslam, A., Jetten, J., Kitayama, S., Mobbs, D., Napper, L., Packer, D., Pennycook, G., Peters, E., Petty, R., Rand, D., Reicher, S., Schnall, S., Shariff, A., Skitka, L., Smith, S., Sunstein, C., Tabri, N., Tucker, J., van der Linden, S., van Lange, P., Weeden, K., Wohl, M., Zaki, J., Zion, S., Willer, R. (2020). Using social and behavioural science to support COVID-19 pandemic response, Nature Human Behaviour, 4, 460-471.

Van Prooijen, J.W. and van Dijk, E. (2014). When consequence size predicts belief in conspiracy theories: The moderating role of perspective taking. Journal of Experimental Social Psychology, 55, 63-73.

Vinck, P., Pham, P. N., Bindu, K. K., Bedford, J. and Nilles, E. J. (2019). Institutional trust and misinformation in the response to the 2018–19 Ebola outbreak in north Kivu, DR Congo: A population-based survey. The Lancet Infectious Diseases, 19(5), 529-536.

Verweij, M. (2005). Trust (and social capital) in cultural theory.

Williams, D. E. (1998). Expanding the crisis planning function: Introducing elements of risk communication to crisis communication practice. Public Relations Review, 24(3), 387-400.

Wong, L., Wu, Q., Chen, X., Chen, Z., Alias, H., Shen, M., Hu, J., Duan, S., Zhang, J., & Han, L. (2020). The role of institutional trust in preventive and treatment-seeking behaviors during the 2019 novel coronavirus (2019-nCoV) outbreak among residents in Hubei, China. medRxiv. https://doi.org/10.1101/2020.02.15.20023333.

Wong, K. L., Gimma, A., Coletti, P., Faes, C., Beutels, P., Hens, N., Jaeger, V., Karch,, A., Johnson, H., Edmunds, W., Jarvis, C. & CoMix Europe Working Group. (2022). Social contact patterns during the COVID-19 pandemic in 21 European countries: evidence from a two-year study. medRxiv.

Walker, J., Ben-Akiva, M., Bolduc, D. (2004). Identification of the logit kernel (or mixed logit) model. In 10th International Conference on Travel Behavior Research, Lucerne, Switzerland, August.

Walker, J., Ben-Akiva, M. (2002). Generalized random utility model. Mathematical Social Sciences, 43(3), 303-343. https://doi.org/10.1016/S0165-4896(02)00023-9

Weiss, A., Habib, K. N. (2020). Understanding joint travel and vehicle allocation at the household level through inference of revealed preference data. Travel Behaviour and Society, 19, 207-218. https://doi.org/10.1016/j.tbs.2020.01.006

Wildavsky, A. (1987). Choosing Preferences by Constructing Institutions: A Cultural Theory of Preference Formation. The American Political Science Review, 81(1), 4-21. https://doi.org/10.2307/1960776

Wildavsky, A., Dake, K. (1990). Theories of risk perception: Who fears what and why?. Daedalus, 41-60.

Wu, L., Zhang, J., Fujiwara, A. (2011). Representing tourists' heterogeneous choices of destination and travel party with an integrated latent class and nested logit model. Tourism Management, 32(6), 1407-1413.

https://doi.org/10.1016/j.tourman.2011.01.017

Wang, K., Yasmin, S., Konduri, K. C., Eluru, N., & Ivan, J. N. (2015). Copula-based joint model of injury severity and vehicle damage in two-vehicle crashes. Transportation research record, 2514(1), 158-166.

Witte, K., & Allen, M. (2000). A meta-analysis of fear appeals: Implications for effective public health campaigns. Health education & behavior, 27(5), 591-615.

Wali, B., Santi, P., & Ratti, C. (2022). A joint demand modeling framework for ride-sourcing and dynamic ridesharing services: a geo-additive Markov random field based heterogeneous copula framework. Transportation, 1-37.

Zafri, N. M., Khan, A., Alam, B. M. (2022). Risk perceptions of COVID-19 transmission in different travel modes. Transportation Research Interdisciplinary Perspectives. 13, 100548. https://doi.org/10.1016/j.trip.2022.100548

Zhu, R., Anselin, L., Batty, M., Kwan, M., Chen, M., Luo, W., Cheng, T., Lim, C. K., Santi, P., Cheng, C., Gu, Q., Wong, M. S., Zhang, K., Lü, G., Ratti, C. (2021). The effects of different travel modes and travel destinations on COVID-19 transmission in global cities. Science Bulletin, 67(6), 588–592. https://doi.org/10.1016/j.scib.2021.11.023

Zilko, A. A., Kurowicka, D., & Goverde, R. M. (2016). Modeling railway disruption lengths with Copula Bayesian Networks. Transportation Research Part C: Emerging Technologies, 68, 350-368.

Zannat, K. E., Bhaduri, E., Goswami, A. K., Choudhury, C. F. (2021). The tale of two countries: modeling the effects of COVID-19 on shopping behavior in Bangladesh and India. Transportation Letters, 13(5-6), 421-433. https://doi.org/10.1080/19427867.2021.1892939

Zhao, E., Wu, Q., Crimmins, E.M. and Ailshire, J.A. (2020), Media trust and infection mitigating behaviours during the COVID-19 pandemic in the USA, British Medical Journal Global Health, 5(10). http://dx.doi.org/10.1136/bmjgh-2020-003323

Zhang, C., Liu, Y., Lu, W. and Xiao, G. (2019), Evaluating passenger satisfaction index based on PLS-SEM model: Evidence from Chinese public transport service, Transportation Research Part A: Policy and Practice, 120, 149-164.

Zhang, J. and Van Acker, V. (2017), Life-oriented travel behavior research: An overview, Transportation Research Part A: Policy and Practice, 104, 167-178.

Zhang, J. (2014), Revisiting the residential self-selection issues: A life-oriented approach, Journal of Transport and Land Use, 7(3), 29-45.

Zhang, J. (2017), Life-Oriented Behavioral Research for Urban Policy. Springer.

Zhang J. and Jiang Y. (2020), An introduction to the special issue of young people's life choices and travel behavior, Transportation Research Part D: Transport and Environment, 85, 102477. https://doi.org/10.1016/j.trd.2020.102477

Zhang, J. (2020). Transport policymaking that accounts for COVID-19 and future public health threats: A PASS approach. Transport Policy, 99, 405-418. https://doi.org/10.1016/j.tranpol.2020.09.009.

Zhang, J., Hayashi, Y., Rothengatter, W., Seetha Ram, K.E. (2021a). The COVID-19 Pandemic and Transport Policy: State of the Art and State of the Practice. In: Hayashi, Y, Rothengatter, W. and Seetha Ram, K.E.

(eds.), Frontiers in High-Speed Rail Development. 17-72, ADB Institute Press, Tokyo, Japan.

Zhang, J., Hayashi, Y., Frank, L. D. (2021b). COVID-19 and transport: Findings from a world-wide expert survey. Transport Policy, 103, 68-85. https://doi.org/10.1016/j.tranpol.2021.01.011

Zhang, J. (2021). People's responses to the COVID-19 pandemic during its early stages and factors affecting those responses. Nature – Humanities and Social Sciences Communications, 8(1), 1-13. https://doi.org/10.1057/s41599-021-00720-1.

Zhang, J., Hayashi, Y. (2022a). Research Frontier of COVID-19 and passenger transport: A focus on policymaking. Transport Policy, 119, 78-88. https://doi.org/10.1016/j.tranpol.2022.02.014

Zhang, J., Hayashi, Y. (2022b). Transportation Amid Pandemics, Elsevier.

Zhang, J., Litvinova, M., Liang, Y., Zheng, W., Shi, H., Vespignani, A., Viboud, C., Ajelli, M. & Yu, H. (2021b). The impact of relaxing interventions on human contact patterns and SARS-CoV-2 transmission in China. Science Advances, 7(19), 2584.

Zhang, J., Litvinova, M., Liang, Y., Wang, Y., Wang, W., Zhao, S., Wu, Q., Merler, S., Viboud, C., Yu, H., Vespignani, A., Ajelli, M. & Yu, H. (2020a). Changes in contact patterns shape the dynamics of the COVID-19 outbreak in China. Science, 368(6498), 1481-1486.

Zhang, H., Zhang, J., & Kuwano, M. (2012). An integrated model of tourists' time use and expenditure behaviour with self-selection based on a fully nested Archimedean copula function. Tourism Management, 33(6), 1562-1573.

Zhang, Z., Zhang, L., & Wang, Y. (2020). COVID-19 indirect contact transmission through the oral mucosa must not be ignored. Journal of Oral Pathology & Medicine, 49(5), 450-451.

PUBLICATIONS

Journal articles and book chapters:

1) **Chapter 4. Ding, H.,** & Zhang, J. (2021). Dynamic associations between temporal behavior changes caused by the COVID-19 pandemic and subjective assessments of policymaking: A case study in Japan. Transport Policy, 110, 58-70. (Published) (IF=6.173)
2) **Chapter 5. Ding, H.,** Zhang, J. & Zhang, L. (2022). Psychological/cultural risk factors and influenza-induced preparedness associated the travel mode choices under the impacts of COVID-19: Analysis based on a mixed hybrid choice model. Transport Policy. (passed the first round of review: major revision - resubmitted) (IF=6.173)
3) **Chapter 6. Ding, H.,** Zhang, J. (2023). Book chapter for Research Handbook on Transport and COVID-19. Edward Elgar Publishing. (Accepted)
4) **Chapter 7. Ding, H.,** Zhang, J. (2023). Dependence analysis of social contact behaviors under the impacts of COVID-19 based on a copula approach. (Submitted)
5) Zhang, J., Zhang, R., **Ding, H.,** Li, S., Liu, R., Ma, S., ... & Hayashi, Y. (2021). Effects of transport-related COVID-19 policy measures: a case study of six developed countries. Transport Policy, 110, 37-57. (Published) (IF=6.173)

Conference presentations:

1) **Hongxiang Ding**, Junyi Zhang, Saori Kashima, Runsen Zhang. (2020). The role of risk communication in mitigating the spread of COVID-19 in Japan: An analysis by building a dynamic Scobit model. International e-Conference on Pandemics and Transport Policy (ICPT2020), WCTRS COVID-19 Task Force, December 7-11, 2020.

2) **Hongxiang Ding**, Junyi Zhang. (2020). Examining the effects of PASS-based and LAST-based COVID-19 policy measures on changes in intercity and intracity behavioral choices in Japan by building a dynamic structural equation model with panel data. International e-Conference on Pandemics and Transport Policy (ICPT2020), WCTRS COVID-19 Task Force, December 7-11, 2020.

APPENDICES

Appendix 1: Questionnaire of life-oriented panel survey of behavioral and psychological adaptations to COVID-19 in Japanese

パートⅠ 個人と世帯に関する質問
SC1
あなたの性別を教えて下さい。
1.男性 2.女性
SC2
あなたの年齢を教えて下さい。
1.１４歳以下 2.１５～１９歳 3.２０代 4.３０代 5.４０代 6.５０代 7.６０～６４歳 8.６５～６９歳 9.７０代以上
SC3
あなたのお住まいの都道府県をお答えください。

1.北海道　11.埼玉県 21.岐阜県 31.鳥取県 41.佐賀県 2.青森県　12.千葉県 22.静岡県 32.島根県 42.長崎県 3.岩手県　13.東京都 23.愛知県 33.岡山県 43.熊本県 4.宮城県　14.神奈川県 24.三重県 34.広島県 44.大分県 5.秋田県　15.新潟県 25.滋賀県 35.山口県 45.宮崎県 6.山形県　16.富山県 26.京都府 36.徳島県 46.鹿児島県 7.福島県　17.石川県 27.大阪府 37.香川県 47.沖縄県 8.茨城県　18.福井県 28.兵庫県 38.愛媛県 9.栃木県　19.山梨県 29.奈良県 39.高知県 10.群馬県 20.長野県 30.和歌山県 40.福岡県
SC4
あなたのお住まいをお答えください。
1.東京都 2.横浜市 3.川崎市 4.さいたま市 5.千葉市 6.相模原市 7.名古屋市 8.京都市 9.堺市 10.大阪市 11.神戸市 12.札幌市 13.仙台市 14.新潟市 15.静岡市 16.浜松市 17.岡山市 18.広島市 19.北九州市 20.福岡市 21.熊本市 22.その他の地域
SC5
あなたがお住まいの地域の郵便番号を７桁の数字（ハイフン無し）でお教えください。／※ハイフンなし
_____

SC6
あなたの職業をお答えください。
1.会社員／会社役員または自営業 **2.公務員・団体職員** **3.学校や大学などの教育機関の教職員** **4.専業主婦** **5.パート・アルバイト** **6.学生** **7.その他の無職（年金生活者を含む）** **8.その他**
SC7
あなたの業種をお答えください。
1.農林漁業 **2.鉱業、建設業** **3.製造業** **4.電気・ガス・熱供給・水道業** **5.情報通信業** **6.運輸業** **7.卸売・小売業** **8.金融・保険業** **9.不動産業** **10.飲食店・宿泊業** **11.医療・福祉** **12.教育・学習支援業** **13.その他のサービス業（法務、学術、宗教、複合サービスなど）** **14.その他**
SC8
あなたを含めて同居されているご家族の人数は何人ですか。
総人数___人
小学生以下の人数__人
中学生の人数__人
６５歳以上の高齢者の人数__人
SC9-SQ
あなたの婚姻状況をお知らせください。
1.未婚 **2.既婚** **3.離別・死別**

SC9
あなたと同居しているご家族の方を教えて下さい。
1.配偶者 **2.自身の子ども** **3.孫** **4.自身の親・配偶者の親** **5.その他** **6.同居していない（一人暮らし）**
SC10
あなたのお住まいについて当てはまるものをお選びください。
1.持ち家：一戸建て **2.持ち家：マンション等の集合住宅** **3.賃貸：一戸建て** **4.賃貸：マンション等の集合住宅** **5.その他**
SC11
あなたの最終学歴を教えて下さい。
1.中学（卒業済） **2.高校（卒業済）** **3.専修・専門学校（卒業済）** **4.短大・高専（卒業済）** **5.大学（卒業済）** **6.大学院（卒業済）** **7.中学（在学中）** **8.高校（在学中）** **9.専修・専門学校（在学中）** **10.短大・高専（在学中）** **11.大学（在学中）** **12.大学院（在学中）**
SC12
あなたの世帯の年収（税込み）は次のどれに当てはまりますか。もし収入がある方が２名以上いる場合は、すべての方の収入を合算してください。

1.３００万円未満 2.３００万円～４００万円未満 3.４００万円～５００万円未満 4.５００万円～６００万円未満 5.６００万円～７００万円未満 6.７００万円～８００万円未満 7.８００万円～９００万円未満 8.９００万円～１０００万円未満 9.１０００万円～１５００万円未満 10.１５００万円～２０００万円未満 11.２０００万円以上
パート II 新型コロナウイルス感染症に関する質問
Q1
あなたは、新型コロナウイルスの感染を予防するため、以下のことを行なわれていますか。
Q1_1.２０秒以上の手洗いを頻繁に行う
Q1_2.水がない場合、消毒液で手を清潔にする
Q1_3.目、鼻や口を、洗っていない手で触らない
Q1_4.咳エチケットをよく行う
Q1_5.マスクをよく着用する
Q1_6.体調が不良のときに、自宅にいるようにする
1.まったくあてはまらない 2.あまりあてはまらない 3.どちらとも言えない 4.まあまああてはまる 5.非常にあてはまる
Q2
あなたは、この１週間くらいの間に、新型コロナウイルスの感染情報や対策などについて、情報を入手されましたか。情報を入手されている場合、一日で最大どれくらいの時間（分）を情報入手に費やされたかをご記入ください。もし、その手段からは情報入手されていない場合は、「０」とご記入ください。
Q2_1.テレビ: __分
Q2_2.ＳＮＳ（ソーシャル・ネットワーキング・サービス）から入手：Ｆａｃｅｂｏｏｋ、ＬＩＮＥ、Ｔｗｉｔｔｅｒ、ＷｈａｔｓＡｐｐなど: __分
Q2_3.紙媒体の情報源（新聞、政府の広報誌など）: __分
Q2_4.ラジオ: __分
Q2_5.ご自身のソーシャルネットワーク（周囲の人：知人、知人や同僚など）との情報交流: __分
Q3
新型コロナウイルスに関する情報源の「信頼性」として、あなたご自身の評価をお答えください。

Q3_1.日本政府の発表情報（ホームページ情報、ニュース、広報誌など）
Q3_2.地方自治体政府の発表情報（ホームページ情報、ニュース、広報誌など）
Q3_3.専門家の見解（様々なチャンネルを通じて）
Q3_4.国内ニュース
Q3_5.海外ニュース
Q3_6.医療機関
Q3_7.職場・学校
Q3_8.ＳＮＳ（ソーシャル・ネットワーキング・サービス）：Ｆａｃｅｂｏｏｋ、ＬＩＮＥ、Ｔｗｉｔｔｅｒ、ＷｈａｔｓＡｐｐなど
Q3_9.検索エンジン：グーグル、ヤフーなど
Q3_10.ご自身のソーシャルネットワーク：周囲の人（知人、知人や同僚など）
1.最も低い 2.低い 3.どちらとも言えない 4.高い 5.最も高い
Q4
以下の新型コロナウイルス感染のことについて、どのように感じていますか。
Q4_1.日本全体の感染リスクが高まっている
Q4_2.ご自身が居住する都道府県での感染リスクが高まっている
Q4_3.ご自身が居住する市町村での感染リスクが高まっている
Q4_4.ご自身がよく行く場所（職場や学校、スーパー、レストラン、スポーツジムなど）での感染リスクが高まっている
Q4_5.混んでいる電車やバスのなかで感染する可能性が高い
Q4_6.新型コロナウイルスはとても怖い病気だ
Q4_7.ご自身が新型コロナウイルスにかかる可能性は非常に高い
Q4_8.ご自身は季節性インフルエンザにかかりやすいほうだ
1.まったく思っていない 2.あまり思っていない 3.どちらとも言えない 4.まあまあ思っている 5.非常に思っている
Q5
Q5_1. ４月は

Q5_1_1.国内観光旅行 Q5_1_2.国内出張 Q5_1_3.海外観光旅行 Q5_1_4.海外出張 Q5_1_5.フライト（国内） Q5_1_6.鉄道（国内） Q5_1_7.ほかの国内移動 Q5_1_8.コンサート Q5_1_9.スポーツ観戦
1.変更せずに実施した 2.延期した 3.キャンセルした 4.該当しない（この活動を行う予定はなかった）
Q5_2. 5 月は
Q5_2_1.国内観光旅行 Q5_2_2.国内出張 Q5_2_3.海外観光旅行 Q5_2_4.海外出張 Q5_2_5.フライト（国内） Q5_2_6.鉄道（国内） Q5_2_7.ほかの国内移動 Q5_2_8.コンサート Q5_2_9.スポーツ観戦
1.変更せずに実施した 2.延期した 3.キャンセルした 4.該当しない（この活動を行う予定はなかった）
Q5_3. 6 月は
Q5_3_1.国内観光旅行 Q5_3_2.国内出張 Q5_3_3.海外観光旅行 Q5_3_4.海外出張 Q5_3_5.フライト（国内） Q5_3_6.鉄道（国内） Q5_3_7.ほかの国内移動 Q5_3_8.コンサート Q5_3_9.スポーツ観戦
1.変更せずに実施した 2.延期した 3.キャンセルした 4.該当しない（この活動を行う予定はなかった）

Q5_4. 7 月は
Q5_4_1.国内観光旅行 **Q5_4_2.国内出張** **Q5_4_3.海外観光旅行** **Q5_4_4.海外出張** **Q5_4_5.フライト（国内）** **Q5_4_6.鉄道（国内）** **Q5_4_7.ほかの国内移動** **Q5_4_8.コンサート** **Q5_4_9.スポーツ観戦**
1.変更せずに実施した **2.延期した** **3.キャンセルした** **4.該当しない（この活動を行う予定はなかった）**
Q5_5. 8 月は
Q5_5_1.国内観光旅行 **Q5_5_2.国内出張** **Q5_5_3.海外観光旅行** **Q5_5_4.海外出張** **Q5_5_5.フライト（国内）** **Q5_5_6.鉄道（国内）** **Q5_5_7.ほかの国内移動** **Q5_5_8.コンサート** **Q5_5_9.スポーツ観戦**
1.変更せずに実施した **2.延期した** **3.キャンセルした** **4.該当しない（この活動を行う予定はなかった）**
Q5_6. 9 月は
Q5_6_1.国内観光旅行 **Q5_6_2.国内出張** **Q5_6_3.海外観光旅行** **Q5_6_4.海外出張** **Q5_6_5.フライト（国内）** **Q5_6_6.鉄道（国内）** **Q5_6_7.ほかの国内移動** **Q5_6_8.コンサート** **Q5_6_9.スポーツ観戦**

1.変更せずに実施した 2.延期した 3.キャンセルした 4.該当しない（この活動を行う予定はなかった）
Q6
Q6_1. 一年前の「４月」　と　今年の「４月」　を比較すると・・・・・
Q6_1_1.出勤・退社時刻（通学・帰宅時刻）はもっと柔軟になった
Q6_1_2.混雑時時以外の出勤・退社（通学・帰宅）をするようにした
Q6_1_3.勤務先や学校を出た後の寄り道行動が減った
Q6_1_4.自宅でのテレワークや勉強が増えた
Q6_1_5.仕事の量が減った
Q6_1_6.全体の外出回数が減った
Q6_1_7.オンラインショッピングやテレショッピングは増えた
Q6_1_8.食事のオンライン注文や電話注文が増えた
Q6_1_9.店に行く買物が減った
Q6_1_10.外食は減った
Q6_1_11.人混みの多い場所への外出を避けるようにした
Q6_1_12.人との接触のある密閉空間での活動を避けるようにした
Q6_1_13.近い距離で人と話すことを避けるようにした
Q6_1_14.感染症状がなくてもご家族への訪問を避けるようにした
Q6_1_15.ご家族に、ご自身への訪問をしないように依頼した
Q6_1_16.感染状況が悪い場所からの来訪客に会わないようにした
Q6_1_17.公共交通での移動が減 Q6
Q6_1_18.車での移動が増えた
Q6_1_19.徒歩や自転車での移動が増えた
Q6_1_20.国内旅行が減った
Q6_1_21.海外旅行が減った
Q6_1_22.予定なしの国内旅行をした：日帰り
Q6_1_23.予定なしの国内旅行をした：宿泊
Q6_1_24.運動頻度・時間が増えた
Q6_1_25.自分の家事の時間が増えた
Q6_1_26.家族の家事の時間が増えた
Q6_1_27.家族との会話が増えた
Q6_1_28.自宅でのＳＮＳが増えた
Q6_1_29.友人・知人との付き合いが減った
Q6_1_30.睡眠時間が増えた

Q6_1_31.自分の趣味に費やす時間が増えた
Q6_1_32.世帯エネルギー消費（ガソリン、光熱、電力など）が増えた
Q6_1_33.飲酒の回数・量が増えた
Q6_1_34.体重が増えた
Q6_1_35.医療費の出費が増えた
Q6_1_36.消費全体を控えるようになった
Q6_1_37.家にこもる時間が長くなり、心身的に疲れてきている
Q6_1_38.ご自身が周りの人の行動変容を勧めるようにした
1.はい 2.いいえ 3.該当しない
Q6_2. 一年前の「5 月」　と　今年の「5 月」　を比較すると・・・・・
Q6_2_1.出勤・退社時刻（通学・帰宅時刻）はもっと柔軟になった
Q6_2_2.混雑時時以外の出勤・退社（通学・帰宅）をするようにした
Q6_2_3.勤務先や学校を出た後の寄り道行動が減った
Q6_2_4.自宅でのテレワークや勉強が増えた
Q6_2_5.仕事の量が減った
Q6_2_6.全体の外出回数が減った
Q6_2_7.オンラインショッピングやテレショッピングは増えた
Q6_2_8.食事のオンライン注文や電話注文が増えた
Q6_2_9.店に行く買物が減った
Q6_2_10.外食は減った
Q6_2_11.人混みの多い場所への外出を避けるようにした
Q6_2_12.人との接触のある密閉空間での活動を避けるようにした
Q6_2_13.近い距離で人と話すことを避けるようにした
Q6_2_14.感染症状がなくてもご家族への訪問を避けるようにした
Q6_2_15.ご家族に、ご自身への訪問をしないように依頼した
Q6_2_16.感染状況が悪い場所からの来訪客に会わないようにした
Q6_2_17.公共交通での移動が減 Q6
Q6_2_18.車での移動が増えた
Q6_2_19.徒歩や自転車での移動が増えた
Q6_2_20.国内旅行が減った
Q6_2_21.海外旅行が減った
Q6_2_22.予定なしの国内旅行をした：日帰り
Q6_2_23.予定なしの国内旅行をした：宿泊

Q6_2_24.運動頻度・時間が増えた
Q6_2_25.自分の家事の時間が増えた
Q6_2_26.家族の家事の時間が増えた
Q6_2_27.家族との会話が増えた
Q6_2_28.自宅でのＳＮＳが増えた
Q6_2_29.友人・知人との付き合いが減った
Q6_2_30.睡眠時間が増えた
Q6_2_31.自分の趣味に費やす時間が増えた
Q6_2_32.世帯エネルギー消費（ガソリン、光熱、電力など）が増えた
Q6_2_33.飲酒の回数・量が増えた
Q6_2_34.体重が増えた
Q6_2_35.医療費の出費が増えた
Q6_2_36.消費全体を控えるようになった
Q6_2_37.家にこもる時間が長くなり、心身的に疲れてきている
Q6_2_38.ご自身が周りの人の行動変容を勧めるようにした
1.はい 2.いいえ 3.該当しない
Q6_3. 一年前の「6 月」　と　今年の「6 月」　を比較すると・・・・・
Q6_3_1.出勤・退社時刻（通学・帰宅時刻）はもっと柔軟になった
Q6_3_2.混雑時時以外の出勤・退社（通学・帰宅）をするようにした
Q6_3_3.勤務先や学校を出た後の寄り道行動が減った
Q6_3_4.自宅でのテレワークや勉強が増えた
Q6_3_5.仕事の量が減った
Q6_3_6.全体の外出回数が減った
Q6_3_7.オンラインショッピングやテレショッピングは増えた
Q6_3_8.食事のオンライン注文や電話注文が増えた
Q6_3_9.店に行く買物が減った
Q6_3_10.外食は減った
Q6_3_11.人混みの多い場所への外出を避けるようにした
Q6_3_12.人との接触のある密閉空間での活動を避けるようにした
Q6_3_13.近い距離で人と話すことを避けるようにした
Q6_3_14.感染症状がなくてもご家族への訪問を避けるようにした
Q6_3_15.ご家族に、ご自身への訪問をしないように依頼した
Q6_3_16.感染状況が悪い場所からの来訪客に会わないようにした

Q6_3_17.公共交通での移動が減 Q6
Q6_3_18.車での移動が増えた
Q6_3_19.徒歩や自転車での移動が増えた
Q6_3_20.国内旅行が減った
Q6_3_21.海外旅行が減った
Q6_3_22.予定なしの国内旅行をした：日帰り
Q6_3_23.予定なしの国内旅行をした：宿泊
Q6_3_24.運動頻度・時間が増えた
Q6_3_25.自分の家事の時間が増えた
Q6_3_26.家族の家事の時間が増えた
Q6_3_27.家族との会話が増えた
Q6_3_28.自宅でのＳＮＳが増えた
Q6_3_29.友人・知人との付き合いが減った
Q6_3_30.睡眠時間が増えた
Q6_3_31.自分の趣味に費やす時間が増えた
Q6_3_32.世帯エネルギー消費（ガソリン、光熱、電力など）が増えた
Q6_3_33.飲酒の回数・量が増えた
Q6_3_34.体重が増えた
Q6_3_35.医療費の出費が増えた
Q6_3_36.消費全体を控えるようになった
Q6_3_37.家にこもる時間が長くなり、心身的に疲れてきている
Q6_3_38.ご自身が周りの人の行動変容を勧めるようにした
1.はい 2.いいえ 3.該当しない
Q6_4. 一年前の「7 月」　と　今年の「7 月」　を比較すると・・・・・
Q6_4_1.出勤・退社時刻（通学・帰宅時刻）はもっと柔軟になった
Q6_4_2.混雑時時以外の出勤・退社（通学・帰宅）をするようにした
Q6_4_3.勤務先や学校を出た後の寄り道行動が減った
Q6_4_4.自宅でのテレワークや勉強が増えた
Q6_4_5.仕事の量が減った
Q6_4_6.全体の外出回数が減った
Q6_4_7.オンラインショッピングやテレショッピングは増えた
Q6_4_8.食事のオンライン注文や電話注文が増えた
Q6_4_9.店に行く買物が減った

Q6_4_10.外食は減った
Q6_4_11.人混みの多い場所への外出を避けるようにした
Q6_4_12.人との接触のある密閉空間での活動を避けるようにした
Q6_4_13.近い距離で人と話すことを避けるようにした
Q6_4_14.感染症状がなくてもご家族への訪問を避けるようにした
Q6_4_15.ご家族に、ご自身への訪問をしないように依頼した
Q6_4_16.感染状況が悪い場所からの来訪客に会わないようにした
Q6_4_17.公共交通での移動が減 Q6
Q6_4_18.車での移動が増えた
Q6_4_19.徒歩や自転車での移動が増えた
Q6_4_20.国内旅行が減った
Q6_4_21.海外旅行が減った
Q6_4_22.予定なしの国内旅行をした：日帰り
Q6_4_23.予定なしの国内旅行をした：宿泊
Q6_4_24.運動頻度・時間が増えた
Q6_4_25.自分の家事の時間が増えた
Q6_4_26.家族の家事の時間が増えた
Q6_4_27.家族との会話が増えた
Q6_4_28.自宅でのＳＮＳが増えた
Q6_4_29.友人・知人との付き合いが減った
Q6_4_30.睡眠時間が増えた
Q6_4_31.自分の趣味に費やす時間が増えた
Q6_4_32.世帯エネルギー消費（ガソリン、光熱、電力など）が増えた
Q6_4_33.飲酒の回数・量が増えた
Q6_4_34.体重が増えた
Q6_4_35.医療費の出費が増えた
Q6_4_36.消費全体を控えるようになった
Q6_4_37.家にこもる時間が長くなり、心身的に疲れてきている
Q6_4_38.ご自身が周りの人の行動変容を勧めるようにした
1.はい 2.いいえ 3.該当しない
Q6_5. 一年前の「8 月」　と　今年の「8 月」　を比較すると・・・・・
Q6_5_1.出勤・退社時刻（通学・帰宅時刻）はもっと柔軟になった
Q6_5_2.混雑時時以外の出勤・退社（通学・帰宅）をするようにした

Q6_5_3.勤務先や学校を出た後の寄り道行動が減った
Q6_5_4.自宅でのテレワークや勉強が増えた
Q6_5_5.仕事の量が減った
Q6_5_6.全体の外出回数が減った
Q6_5_7.オンラインショッピングやテレショッピングは増えた
Q6_5_8.食事のオンライン注文や電話注文が増えた
Q6_5_9.店に行く買物が減った
Q6_5_10.外食は減った
Q6_5_11.人混みの多い場所への外出を避けるようにした
Q6_5_12.人との接触のある密閉空間での活動を避けるようにした
Q6_5_13.近い距離で人と話すことを避けるようにした
Q6_5_14.感染症状がなくてもご家族への訪問を避けるようにした
Q6_5_15.ご家族に、ご自身への訪問をしないように依頼した
Q6_5_16.感染状況が悪い場所からの来訪客に会わないようにした
Q6_5_17.公共交通での移動が減 Q6
Q6_5_18.車での移動が増えた
Q6_5_19.徒歩や自転車での移動が増えた
Q6_5_20.国内旅行が減った
Q6_5_21.海外旅行が減った
Q6_5_22.予定なしの国内旅行をした：日帰り
Q6_5_23.予定なしの国内旅行をした：宿泊
Q6_5_24.運動頻度・時間が増えた
Q6_5_25.自分の家事の時間が増えた
Q6_5_26.家族の家事の時間が増えた
Q6_5_27.家族との会話が増えた
Q6_5_28.自宅でのＳＮＳが増えた
Q6_5_29.友人・知人との付き合いが減った
Q6_5_30.睡眠時間が増えた
Q6_5_31.自分の趣味に費やす時間が増えた
Q6_5_32.世帯エネルギー消費（ガソリン、光熱、電力など）が増えた
Q6_5_33.飲酒の回数・量が増えた
Q6_5_34.体重が増えた
Q6_5_35.医療費の出費が増えた
Q6_5_36.消費全体を控えるようになった
Q6_5_37.家にこもる時間が長くなり、心身的に疲れてきている
Q6_5_38.ご自身が周りの人の行動変容を勧めるようにした

1.はい 2.いいえ 3.該当しない
Q6_6. 一年前の「9 月」　と　今年の「9 月」　を比較すると・・・・・
Q6_6_1.出勤・退社時刻（通学・帰宅時刻）はもっと柔軟になった
Q6_6_2.混雑時時以外の出勤・退社（通学・帰宅）をするようにした
Q6_6_3.勤務先や学校を出た後の寄り道行動が減った
Q6_6_4.自宅でのテレワークや勉強が増えた
Q6_6_5.仕事の量が減った
Q6_6_6.全体の外出回数が減った
Q6_6_7.オンラインショッピングやテレショッピングは増えた
Q6_6_8.食事のオンライン注文や電話注文が増えた
Q6_6_9.店に行く買物が減った
Q6_6_10.外食は減った
Q6_6_11.人混みの多い場所への外出を避けるようにした
Q6_6_12.人との接触のある密閉空間での活動を避けるようにした
Q6_6_13.近い距離で人と話すことを避けるようにした
Q6_6_14.感染症状がなくてもご家族への訪問を避けるようにした
Q6_6_15.ご家族に、ご自身への訪問をしないように依頼した
Q6_6_16.感染状況が悪い場所からの来訪客に会わないようにした
Q6_6_17.公共交通での移動が減 Q6
Q6_6_18.車での移動が増えた
Q6_6_19.徒歩や自転車での移動が増えた
Q6_6_20.国内旅行が減った
Q6_6_21.海外旅行が減った
Q6_6_22.予定なしの国内旅行をした：日帰り
Q6_6_23.予定なしの国内旅行をした：宿泊
Q6_6_24.運動頻度・時間が増えた
Q6_6_25.自分の家事の時間が増えた
Q6_6_26.家族の家事の時間が増えた
Q6_6_27.家族との会話が増えた
Q6_6_28.自宅でのＳＮＳが増えた
Q6_6_29.友人・知人との付き合いが減った
Q6_6_30.睡眠時間が増えた
Q6_6_31.自分の趣味に費やす時間が増えた

Q6_6_32.世帯エネルギー消費（ガソリン、光熱、電力など）が増えた
Q6_6_33.飲酒の回数・量が増えた
Q6_6_34.体重が増えた
Q6_6_35.医療費の出費が増えた
Q6_6_36.消費全体を控えるようになった
Q6_6_37.家にこもる時間が長くなり、心身的に疲れてきている
Q6_6_38.ご自身が周りの人の行動変容を勧めるようにした
1.はい 2.いいえ 3.該当しない
Q7
先ほどお答えいただいたような日常生活における様々な変化は、色々なキッカケによって引き起こされたと考えられますが、以下のような事柄は、どの程度きっかけになったと思われますか。
Q7_1.自分の感染状況に対する理解によって、上記の各種変化が生じた
Q7_2.政府の要請によって、上記の各種変化が生じた
Q7_3.家族からの勧めによって、上記の各種変化が生じた
Q7_4.同僚、知人や友人などからの勧めによって、上記の各種変化が生じた
Q7_5.所属団体からの要請によって、上記の各種変化が生じた
Q7_6.感染者数の状況を見て、上記の各種変化が生じた
Q7_7.周りの目や批判を気にして、上記の各種変化が生じた
1.まったく思っていない 2.あまり思っていない 3.どちらとも言えない 4.まあまあ思っている 5.非常に思っている
Q8
新型コロナウイルスの感染拡大を防ぐ各種取り組みについて、あなたはどう思いますか。
Q8_1.新型コロナウイルスについて、日本の保健・医療機関は十分な専門的知識を持っている
Q8_2.新型コロナウイルスについて、日本政府は十分な専門的知識を持っている
Q8_3.新型コロナウイルスについて、ご自身が居住している地方自治体は十分な専門的知識を持っている
Q8_4.新型コロナウイルス感染拡大を防ぐにあたり、日本政府の熱意が感じられる
Q8_5.新型コロナウイルス感染拡大を防ぐにあたり、ご自身が居住している地方自治体の熱意が感じられる
Q8_6.新型コロナウイルス感染拡大を防ぐにあたり、日本政府の管理体制や対策ができている
Q8_7.新型コロナウイルス感染拡大を防ぐにあたり、ご自身が居住している地方自治体の管理体制や対策ができている
Q8_8.感染拡大を防ぐにあたり、日本の保健・医療機関を信頼できる

Q8_9.新型コロナウイルスの感染拡大を防ぐにあたり、日本政府を信頼できる
Q8_10.新型コロナウイルスの感染拡大を防ぐにあたり、ご自身が居住している地方自治体を信頼できる
Q8_11.日本政府は、説明責任をもっと果たすべき
Q8_12.ご自身が居住している地方自治体は、説明責任をもっと果たすべき
Q8_13.日本政府として、全国規模の対策をもっと関連徹底的に講じるべき
Q8_14.ご自身が居住している地方自治体は関連対策をもっと徹底的に講じるべき
Q8_15.感染者の行動履歴を通信会社などから入手し、個人情報を保護の上、ホームページの地図上に公開すべき
Q8_16.感染者の行動履歴（個人情報を保護の上）を通信会社などから入手し、それをもとに、感染可能性の高い場所を特定し、場所限定の対策を講じるべき
Q8_17.政府が講じている現在の対策・対応をみると、万が一、新型コロナウイルスが日本全体に流行する場合（パンデミックの状態）、大変心配だ
Q8_18.新型コロナウイルスの感染拡大を防ぐ政府の現在の対策は、日本全体の感染リスクを下げるのに大きな効果がある
Q8_19.新型コロナウイルスの感染拡大を防ぐ政府の現在の対策は、ご自身が居住する都道府県での感染リスクを下げるのに大きな効果がある
Q8_20.新型コロナウイルスの感染拡大を防ぐ政府の現在の対策は、日本経済の短期的な景気停滞をもたらす恐れが高い
Q8_21.感染しない、または他人に感染させないようにするために、ご自身は非常に不便だと感じても、自分の生活ニーズ、ライフタイルを見直すことにまったく抵抗がないほうだ
Q8_22.感染しない、または他人に感染させないようにするために、ご自身は非常に不便だと感じても、毎日の活動内容、活動場所、活動時間を見直すことにまったく抵抗がないほうだ
Q8_23.ご自身がこのようなパンデミックのような非常事態によく備えるほうだ
Q8_24.感染しない、または他人に感染させないようにするために、非常に不便だと感じても、ご自身はフィジカルディスタンシングをよく実践しているほうだ
Q8_25.感染しない、または他人に感染させないようにするために、ご自身の行動履歴の詳細を医療機関・政府機関に提供することにまったく抵抗がないほうだ
Q8_26.感染しない、または他人に感染させないようにするために、ご自身は非常に不便だと感じても、３密（密集、密接、密閉）のある活動・行動を常に避けるようにするほうだ
Q8_27.感染しない、または他人に感染させないようにするために、非常に不便だと感じても、ご自身の活動・行動スケジュールや計画を常に調整するほうだ
Q8_28.感染しない、または他人に感染させないようにするために、ご自身は非常に不便だと感じても、仕事の勤務形態をテレワークにシフトしたり、公共交通以外の交通手段の利用にシフトしたりするほうだ
Q8_29.感染しない、または他人に感染させないようにするために、ご自身の行動履歴、健康状況の情報を他人に共用することにまったく抵抗がないほうだ
Q8_30.感染しない、または他人に感染させないようにするために、ご自身は非常に不便だと感じても、オンラインでの活動に切り換えたり、旅行などを延期したり、移動回数や距離を減らしたり、不要不急の活動を止めたりするほうだ
Q8_31.感染しない、または他人に感染させないようにするために、ご自身は非常に不便だと感じても、移動を伴う活動を中止し、家でパーティーしないようにするほうだ
Q8_32.日本では新型コロナウイルスワクチンの予防接種が無料化となれば、予防接種を受けたい
Q8_33.新型コロナウイルスのワクチンを接種すれば、感染しないと思う
Q8_34.コロナ禍であるが、自分の生活の質が非常にいい

Q8_35.今後の生活に非常に不安を感じている
Q8_36.一般論として、ご自身は今日のために生きていて、明日のことを考えないほうだ
Q8_37.今回の新型コロナウイルス感染の状況をみると、ご自身の人生観が大きく変わった
Q8_38.重要な意思決定を専門家や政府に任せて、そのような社会的な秩序を支持するほうだ
Q8_39.だれもが平等で、多数の人々の利益がどの個人の利益よりも優先されるべき、そして、重大なリスクに関する意思決定は少数のエリートや権威ではなく、すべての人々で行うべきだと思う
Q8_40.個人の自由が絶対に重要であり、個人の選択が社会や他の人々によって制約されるべきではないと思う
Q8_41.自分自身が周りの環境を左右することができないので、運命に身を任せ、その運命を知ろうとしない、心配しないように努めるほうだ
1.まったく思っていない 2.あまり思っていない 3.どちらとも言えない 4.まあまあ思っている 5.非常に思っている
Q9
あなたは、Ｇｏ　Ｔｏ　トラベル　キャンペーンを利用しましたか。
1.既に利用した 2.まだ利用していないが、利用する予定 3.利用する予定はない
Q10
あなたは、今年のゴールデンウイーク期間中に、帰省や旅行をしましたか。
1.はい 2.いいえ
Q11
あなたは、今年のシルバーウィーク期間中（９／１８～９／２２）に、どこかを旅行しましたか。
1.はい 2.いいえ
Q12
あなたは今年、インフルエンザの予防接種をしましたか。
1.既に接種した 2.まだ接種していないが、接種する予定 3.接種する予定はない
Q13

あなたは、ＣＯＶＩＤ－１９の重症化リスクが高くなる可能性がある基礎疾患をお持ちですか。当てはまるものがあればいくつでもお選びください。
1.糖尿病 2.心不全 3.呼吸器疾患（喘息、ＣＯＰＤ等） 4.肥満（ＢＭＩ　３０　以上） 5.慢性腎疾患 6.免疫抑制剤や抗がん剤などを用いている 7.この中にあてはまるものはない
Q14
あなたの世帯で保有している自動車の総台数を教えてください。
__台
Q15
あなたの世帯で保有している自動車のうち、ご自身が自由に使える車の有無について教えてください。
1.ほぼ自分専用の自動車はある 2.家族共用の自動車はある 3.自分が使える自動車はない

Appendix 2: Questionnaire of comparative survey of activity-travel and social contact before-during COVID-19 in English

Intro	**The current COVID-19 pandemic has imposed various impacts on people's lives. This questionnaire survey aims to investigate changes in your daily life, social contacts, and protective measures against infection from viruses, etc., during the current pandemic (2020 and 2021) and before the pandemic (i.e., during influenza seasons in and before 2019). Your perceptions and attitudes related to the control of the current pandemic are also asked. All data collected will be treated statistically and used only for scientific research on how to control the current pandemic and prevent future pandemics. Any privacy information that can identify a specific person will not be included in the data. We would like to express our sincere thanks to your kind cooperation.**	
Part 1 Individual Household Attributes		
A1	Please tell us your gender.	
	1	Male
	2	Female
A2	Please tell us your age.	
	1	14 and below
	2	15~19
	3	20~29
	4	30~39
	5	40~49
	6	50~59

	7	60~64
	8	65~69
	9	70 and above
A3	Please tell us region/state, city/town and Postal code of your residence.	
	Province/State/Region	
	City/town	
	Zip code/postal code	
A4	Please tell us your occupation.	
	1	Company employee / company officer or self-employed
	2	Governmental officier/staff / organization employee
	3	Faculty or staff of an educational institution: e.g., school or university
	4	Housewife or househusband
	5	Part-time job
	6	Student
	7	Other unemployed (including pensioners)
	8	Other
A5	Which industry does your occupation belong to?	
	1	Agriculture, forestry, or fishery
	2	Mining, or construction

	3	Manufacturing industry
	4	Electricity, gas, heat supply, or water supply
	5	Information and communication industry
	6	Transportation industry
	7	Wholesale / retail
	8	Finance / insurance business
	9	Real estate business
	10	Restaurant / accommodation business
	11	Medical / welfare
	12	Education / learning support business
	13	Other service industries (legal, academic, religion, complex services, etc.)
	14	Others
A6	How many household members (including yourself) live together?	
	1	Total number of household members living together (including yourself)
	2	Number of children under 11
	3	Number of children 11-18
	4	Number of people aged 65 and over
A7	Please tell us your marital status.	
	1	Unmarried
	2	Married
	3	Divorce / bereavement

	4	Civil Partnership (not marriage but a legal status for couples)
A8	Please tell us the family members with whom you live?	
	1	Spouse/Couple
	2	Your child/children
	3	Grandchild / Grandchildren
	4	Parents/grandparents of you / Parents/grandparents of your spouse
	5	Other
	6	None
A9	**What is the type of your house?**	
	1	Rental: Detached
	2	Your own: Detached
	3	Rental: Semi-Detached
	4	Your own: Semi-Detached
	5	Rental: Terraced
	6	Your own: Terraced
	7	Rental: Flat/Apartment
	8	Your own: Flat/Apartment
	9	Other
A10	**What is the highest level of educational qualification you have achieved?**	

	(Allows one selection)	
	1	No formal qualification
	2	Primary school/Elementary school
	3	Secondary school/Middle school/ Junior high school
	4	High school/Senior high school
	5	Vocational school/College
	6	Undergraduate/ Bachelor
	7	Master degree
	8	Doctoral degree
A11	**Which of the following represents the total ANNUAL income of your household BEFORE covid-19 PANDEMIC from all sources, before tax?**	

(Allows one selection)	AUD	**USD**	**NZD**	**CAD**	GBP
1	under 15,000AUD	under 15,000USD	under 15,000NZD	under 15,000CAD	under 10,000GBP
2	15,000AUD to 24,999AUD	15,000USD to 24,999USD	15,000NZD to 24,999NZD	15,000CAD to 24,999CAD	10,000GBP to 19,999GBP
3	25,000AUD to 34,999AUD	25,000USD to 34,999USD	25,000NZD to 34,999NZD	25,000CAD to 34,999CAD	20,000GBP to 29,999GBP
4	35,000AUD to 49,999AUD	35,000USD to 49,999USD	35,000NZD to 49,999NZD	35,000CAD to 49,999CAD	30,000GBP to 39,999GBP
5	50,000AUD to 74,999AUD	50,000USD to 74,999USD	50,000NZD to 74,999NZD	50,000CAD to 74,999CAD	40,000GBP to 49,999GBP
6	75,000AUD to 99,999AUD	75,000USD to 99,999USD	75,000NZD to 99,999NZD	75,000CAD to 99,999CAD	50,000GBP to 74,999GBP
7	100,000AUD to 124,999AUD	100,000USD to 124,999USD	100,000NZD to 124,999NZD	100,000CAD to 124,999CAD	75,000GBP to 99,999GBP
8	125,000AUD to 149,999AUD	125,000USD to 149,999USD	125,000NZD to 149,999NZD	125,000CAD to 149,999CAD	100,000GBP to 124,999GBP
9	150,000AUD to 174,999AUD	150,000USD to 174,999USD	150,000NZD to 174,999NZD	150,000CAD to 174,999CAD	125,000GBP to 149,999GBP
10	175,000AUD to 199,999AUD	175,000USD to 199,999USD	175,000NZD to 199,999NZD	175,000CAD to 199,999CAD	150,000GBP and over
11	200,000AUD and over	200,000USD and over	200,000NZD and over	200,000CAD and over	

Part 2 Social Contacts During Activity

activity category of social contact		activity location of social contact	**Q1. How often do you perform the following activity at the following location?** [1] Never [2] The first time [3] Less than once a month [4] Once or twice a month [5] Once or twice a week [6] Daily or almost daily	
		Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**	**During the pandemic: from 2020 to present**
work/study		company/ school	[1] [2] [3] [4] [5] [6]	[1] [2] [3] [4] [5] [6]
shopping		supermarket/shopping mall	[1] [2] [3] [4] [5] [6]	[1] [2] [3] [4] [5] [6]
leisure/recreation	eating out	restaurant	[1] [2] [3] [4] [5] [6]	[1] [2] [3] [4] [5] [6]
	exercise/sports	indoor places (e.g., gym)	[1] [2] [3] [4] [5] [6]	[1] [2] [3] [4] [5] [6]
	party	indoor public places(e.g., bar)	[1] [2] [3] [4] [5] [6]	[1] [2] [3] [4] [5] [6]
	culture leisure	cinema, concert hall, etc.	[1] [2] [3] [4] [5] [6]	[1] [2] [3] [4] [5] [6]
medical activities	see a doctor/purchase medicine	hospital, clinic, etc.	[1] [2] [3] [4] [5] [6]	[1] [2] [3] [4] [5] [6]

category	location [Multiple choice]	**Q2. How long is the distance between the following activity location and your home?** [1] Less than 1 km [2] 1 km or longer, but less than 2 km [3] 2 km or longer, but less than 5 km [4] 5 km or longer, but less than 10 km [5] Longer than 10 km	
	Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**	**During the pandemic: from 2020 to present**

work/study		company/ school	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
shopping		supermarket/shopping mall	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
leisure/recreation	eating out	restaurant	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	exercise/sports	indoor places (e.g., gym)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	party	indoor public places(e.g., bar)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	culture leisure	cinema, concert hall, etc.	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
medical activities	see a doctor/purchase medicine	hospital, clinic, etc.	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

activity category of social contact		activity location of social contact	**Q3. How much is your average time to perform the following activity at the following location each time?** [1] less than 5 mins [2] 5 mins or longer, but less than 15 mins [3] 15 mins or longer, but less than 30 mins [4] 30 mins or longer, but less than 1 hour [5] 1 hour or longer, but less than 4 hours [6] 4 hours or longer	
		Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**	**During the pandemic: from 2020 to present**
work/study		company/ school	[1] [2] [3] [4] [5] [6]	[1] [2] [3] [4] [5] [6]
shopping		supermarket/shopping mall	[1] [2] [3] [4] [5] [6]	[1] [2] [3] [4] [5] [6]
leisure/recreation	eating out	restaurant	[1] [2] [3] [4] [5] [6]	[1] [2] [3] [4] [5] [6]
	exercise/sports	indoor places (e.g., gym)	[1] [2] [3] [4] [5] [6]	[1] [2] [3] [4] [5] [6]
	party	indoor public places(e.g., bar)	[1] [2] [3] [4] [5] [6]	[1] [2] [3] [4] [5] [6]
	culture leisure	cinema, concert hall, etc.	[1] [2] [3] [4] [5] [6]	[1] [2] [3] [4] [5] [6]
medical activities	see a doctor/purchase medicine	hospital, clinic, etc.	[1] [2] [3] [4] [5] [6]	[1] [2] [3] [4] [5] [6]

activity category of social contact		activity location of social contact	**Q4. What is your major transportation to reach the location of the following activity?** [1] Shared mobility: Uber/DiDi/Grab, etc. [2] Taxi [3] Bus [4] Rail: Train, metro, street car, etc. [5] Private car [6] Active transportation (walk, bicycle) [7] Others	
		Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**	**During the pandemic: from 2020 to present**
work/study		company/ school	[1] [2] [3] [4] [5] [6] [7]	[1] [2] [3] [4] [5] [6] [7]
shopping		supermarket/shopping mall	[1] [2] [3] [4] [5] [6] [7]	[1] [2] [3] [4] [5] [6] [7]
leisure/recreation	eating out	restaurant	[1] [2] [3] [4] [5] [6] [7]	[1] [2] [3] [4] [5] [6] [7]
	exercise/sports	indoor places (e.g., gym)	[1] [2] [3] [4] [5] [6] [7]	[1] [2] [3] [4] [5] [6] [7]
	party	indoor public places(e.g., bar)	[1] [2] [3] [4] [5] [6] [7]	[1] [2] [3] [4] [5] [6] [7]
	culture leisure	cinema, concert hall, etc.	[1] [2] [3] [4] [5] [6] [7]	[1] [2] [3] [4] [5] [6] [7]
medical activities	see a doctor/purchase medicine	hospital, clinic, etc.	[1] [2] [3] [4] [5] [6] [7]	[1] [2] [3] [4] [5] [6] [7]

activity category of social contact		activity location of social contact	**Q5. How much is your average travel time (one-way) to reach the following location of performing the following activity?** [1] Less than 10 mins [2] 10 mins or longer, but less than 30 mins [3] 30 mins or longer, but less than 1 hour [4] 1 hour or longer	
		Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**	**During the pandemic: from 2020 to present**
work/study		company/ school	[1] [2] [3] [4]	[1] [2] [3] [4]
shopping		supermarket/shopping mall	[1] [2] [3] [4]	[1] [2] [3] [4]
	eating out	restaurant	[1] [2] [3] [4]	[1] [2] [3] [4]

leisure/recreation	exercise/sports	indoor places (e.g., gym)	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]		
	party	indoor public places(e.g., bar)	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]		
	culture leisure	cinema, concert hall, etc.	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]		
medical activities	see a doctor/purchase medicine	hospital, clinic, etc.	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]		

activity category of social contact		activity location of social contact	**Q6. Please tell us your main companion when performing this activity at this location.** [1] Spouse/Couple [2] Children/Grandchildren [3] Parents/Grandparents [4] Friends [5] Other acquaintances [6] Alone										
		Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**						**During the pandemic: from 2020 to present**					
shopping		supermarket/shopping mall	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
leisure/recreation		restaurant	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
	exercise/sports	indoor places (e.g., gym)	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
	party	indoor public places(e.g., bar)	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
	culture leisure	cinema, concert hall, etc.	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
	see a doctor/purchase medicine	hospital, clinic, etc.	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]

activity category of social contact	activity location of social contact	**Q7. Except for your main companion, do you have contact with other persons during performing this activity at this location?** [1] No contact [2] Yes: only non-physical contacts (e.g., in the physical presence of another person without face to face conversation, skin-to-skin touching or other indirect physical contacts) [3] Yes: only physical contacts (e.g., having a face to face conversation or,

		skin-to-skin touching or other indirect physical contacts) [4] Yes: both non-physical and physical contacts	
Target periods		**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**	**During the pandemic: from 2020 to present**
work/study		company/ school (Your colleagues and classmates are also included as contacts with other persons for this location of company/school)	[1] [2] [3] [4] / [1] [2] [3] [4]
shopping		supermarket/shopping mall	[1] [2] [3] [4] / [1] [2] [3] [4]
leisure/recreation	eating out	restaurant	[1] [2] [3] [4] / [1] [2] [3] [4]
	exercise/sports	indoor places (e.g., gym)	[1] [2] [3] [4] / [1] [2] [3] [4]
	party	indoor public places(e.g., bar)	[1] [2] [3] [4] / [1] [2] [3] [4]
	culture leisure	cinema, concert hall, etc.	[1] [2] [3] [4] / [1] [2] [3] [4]
medical activities	see a doctor/purchase medicine	hospital, clinic, etc.	[1] [2] [3] [4] / [1] [2] [3] [4]

activity category of social contact		activity location of social contact	**Q8. Except for your main companion, how many persons do you contact when performing the following activity?** [1] 2 persons or fewer [2] 3~4 persons [3] 5~6 persons [4] 7~9 persons [5] 10 persons or more	
Target periods			**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**	**During the pandemic: from 2020 to present**
work/study		company/ school (Your colleagues and classmates are also included as contacts with other persons for this location of company/school)	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
shopping		supermarket/shopping mall	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
leisure/recreation	eating out	restaurant	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
	exercise/sports	indoor places (e.g., gym)	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
	party	indoor public places(e.g., bar)	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
	culture leisure	cinema, concert hall, etc.	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]

medical activities	see a doctor/purchase medicine	hospital, clinic, etc.	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

activity category of social contact		activity location of social contact	**Q9. Do you take the following protective measures when performing this activity at this location?** [1] Wear a mask [2] Disinfect your hands before/during/after activity [3] Keep a proper distance with others [4] Other measures [5] No measures are taken									
		Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**					**During the pandemic: from 2020 to present**				
work/study		company/ school	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
shopping		supermarket/shopping mall	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
leisure/recreation	eating out	restaurant	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	exercise/sports	indoor places (e.g., gym)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	party	indoor public places(e.g., bar)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	culture leisure	cinema, concert hall, etc.	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
medical activities	see a doctor/purchase medicine	hospital, clinic, etc.	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

activity category of social contact		activity location of social contact	**Q10. How do you think about your self-efficiency for protecting yourself when performing the following activity at the following location? (here, self-efficiency means your belief for your power of protecting yourself from infection)** [1] Very low [2] Low [3] Neither [4] High [5] Very high
		Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)** / **During the pandemic: from 2020 to present**

work/study		company/ school	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
shopping		supermarket/shopping mall	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
leisure/recreation	eating out	restaurant	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	exercise/sports	indoor places (e.g., gym)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	party	indoor public places(e.g., bar)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	culture leisure	cinema, concert hall, etc.	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
medical activities	see a doctor/purchase medicine	hospital, clinic, etc.	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

activity category of social contact		activity location of social contact	**Q11. Do you agree that people (e.g., staffs, other consumers) in the following activity location take proper measures to protect other persons (including you)?** [1] Strongly disagree [2] Somewhat disagree [3] Neither [4] Somewhat agree [5] Strongly agree									
		Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**					**During the pandemic: from 2020 to present**				
work/study		company/ school	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
shopping		supermarket/shopping mall	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
leisure/recreation	eating out	restaurant	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	exercise/sports	indoor places (e.g., gym)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	party	indoor public places(e.g., bar)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	culture leisure	cinema, concert hall, etc.	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
medical activities	see a doctor/purchase medicine	hospital, clinic, etc.	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

activity category of social contact		activity location of social contact	**Q12. Do you think that the following activity is performed at the following location with either of the following three Cs (Closed spaces with poor ventilation, Crowded places, Close-contact settings)?** [1] Closed spaces with poor ventilation [2] Crowded places [3] Close-contact settings [4] None of the above							
		Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**				**During the pandemic: from 2020 to present**			
work/study		company/ school	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]
shopping		supermarket/shopping mall	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]
leisure/recreation	eating out	restaurant	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]
	exercise/sports	indoor places (e.g., gym)	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]
	party	indoor public places(e.g., bar)	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]
	culture leisure	cinema, concert hall, etc.	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]
medical activities	see a doctor/purchase medicine	hospital, clinic, etc.	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]

activity category of social contact		activity location of social contact	**Q13. Do you feel you are safe (from infection) when performing the following activity at the following location?** [1] Strongly disagree [2] Somewhat disagree [3] Neither [4] Somewhat agree [5] Strongly agree									
		Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**					**During the pandemic: from 2020 to present**				
work/study		company/ school	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
shopping		supermarket/shopping mall	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	eating out	restaurant	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

leisure/recreation	exercise/sports	indoor places (e.g., gym)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	party	indoor public places(e.g., bar)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	culture leisure	cinema, concert hall, etc.	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
medical activities	see a doctor/purchase medicine	hospital, clinic, etc.	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

activity category of social contact		activity location of social contact	**Q14. Do you feel your household members is are safe (from infection) if they are performing the following activity at the following location?** [1] Strongly disagree [2] Somewhat disagree [3] Neither [4] Somewhat agree [5] Strongly agree									
		Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**					**During the pandemic: from 2020 to present**				
work/study		company/ school	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
shopping		supermarket/shopping mall	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
leisure/recreation	eating out	restaurant	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	exercise/sports	indoor places (e.g., gym)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	party	indoor public places(e.g., bar)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	culture leisure	cinema, concert hall, etc.	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
medical activities	see a doctor/purchase medicine	hospital, clinic, etc.	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

activity category of social contact	activity location of social contact	**Q15. What is your psychological state when performing the following activity at the following location?** [1] Exhausted [2] Depressed, discouraged [3] Nervous [4] Energetic, vigorous

			[5] Tensed, under pressure [6] Happy, satisfied [7] Helpless [8] Refresh, rested [9] Impetuous, inpatient [10] Anxious [11] Other	
		Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**	**During the pandemic: from 2020 to present**
work/study		company/ school	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]
shopping		supermarket/shopping mall	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]
leisure/recreation	eating out	restaurant	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]
	exercise/sports	indoor places (e.g., gym)	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]
	party	indoor public places(e.g., bar)	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]
	culture leisure	cinema, concert hall, etc.	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]
medical activities	see a doctor/purchase medicine	hospital, clinic, etc.	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]

activity category of social contact	activity location of social contact	**Q16. What are your benefits/purposes for doing the following activities?** [1] Warm relationships with others [2] Convenience of life [3] Supply of food and daily life [4] Relieve the pressure [5] Preserving my public image/ Social recognition /Being well-respected [6] Self-Security [7] Saving money [8] Make money [9] Wisdom [10] Physical Health [11] Sense of accomplishment [12] Feeling of freedom [13] Self-fulfillment/ Self-respect [14] Sense of belonging [15] Fun-enjoyment-excitement

		[16] Relaxation [17] Other	
		Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**	**During the pandemic: from 2020 to present**
work/study		company/ school	[1] [2] [3] [4] [5] [……] [15] [16] [17]	[1] [2] [3] [4] [5] [……] [15] [16] [17]
shopping		supermarket/shopping mall	[1] [2] [3] [4] [5] [……] [15] [16] [17]	[1] [2] [3] [4] [5] [……] [15] [16] [17]
leisure/recreation	eating out	restaurant	[1] [2] [3] [4] [5] [……] [15] [16] [17]	[1] [2] [3] [4] [5] [……] [15] [16] [17]
	exercise/sports	indoor places (e.g., gym)	[1] [2] [3] [4] [5] [……] [15] [16] [17]	[1] [2] [3] [4] [5] [……] [15] [16] [17]
	party	indoor public places(e.g., bar)	[1] [2] [3] [4] [5] [……] [15] [16] [17]	[1] [2] [3] [4] [5] [……] [15] [16] [17]
	culture leisure	cinema, concert hall, etc.	[1] [2] [3] [4] [5] [……] [15] [16] [17]	[1] [2] [3] [4] [5] [……] [15] [16] [17]
medical activites	see a doctor/purchase medicine	hospital, clinic, etc.	[1] [2] [3] [4] [5] [……] [15] [16] [17]	[1] [2] [3] [4] [5] [……] [15] [16] [17]

activity category of social contact		activity location of social contact	**Q17. Do you agree with that in order to avoid the spread of virus, without governments' permission, the people performing the following activity at such a location should be punished?** [1]Totally disagree [2]Somewhat disagree [3]Neither [4]Somewhat agree [5]Totally agree	
		Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**	**During the pandemic: from 2020 to present**
work/study		company/ school	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
shopping		supermarket/shopping mall	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
leisure/recreation	eating out	restaurant	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
	exercise/sports	indoor places (e.g., gym)	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
	party	indoor public places(e.g., bar)	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]

	culture leisure	cinema, concert hall, etc.	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
medical activities	see a doctor/purchase medicine	hospital, clinic, etc.	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

activity category of social contact		activity location of social contact	**Q18. Do you agree with that you will perform the following activity at the following location, even if a high infection risk is known?** [1] Strongly disagree [2] Somewhat disagree [3] Neither [4] Somewhat agree [5] Strongly agree									
Target periods			**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**					**During the pandemic: from 2020 to present**				
work/study		company/ school	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
shopping		supermarket/shopping mall	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
leisure/recreation	eating out	restaurant	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	exercise/sports	indoor places (e.g., gym)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	party	indoor public places(e.g., bar)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	culture leisure	cinema, concert hall, etc.	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
medical activities	see a doctor/purchase medicine	hospital, clinic, etc.	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

Part 3 Social Contacts in Transport

Transport modes	**Q19. How often to use each of the following transport modes in your daily life?** [1] Never [2] The first time [3] Less than once a month [4] Once or twice a month [5] Once or twice a week [6] Daily or almost daily

Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**						**During the pandemic: from 2020 to present**					
Taxi; Shared mobility (Uber/DiDi/Grab, etc.)	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
Public transport (train, metro, street car, bus, etc.)	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
Flight	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
Ship / cruise	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]

Transport modes	**Q20. How much is your average time to use the following transport modes each time?** [1] less than 5 mins [2] 5 mins or longer, but less than 15 mins [3] 15 mins or longer, but less than 30 mins [4] 30 mins or longer, but less than 1 hour [5] 1 hour or longer, but less than 4 hours [6] 4 hours or longer

Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**						**During the pandemic: from 2020 to present**					
Taxi, Shared mobility (Uber/DiDi/Grab, etc.)	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
Public transport (train, metro, street car, bus, etc.)	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
Flight	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
Ship / cruise	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]

Transport modes	**Q21. Who are your main companion when using each of the following transport modes?** [1] spouse/couple [2] children/grandchildren [3] parents/grandparents [4] friends [5] other acquaintances [6] alone

Target periods	**Before the COVID-19 pandemic: in 2019**	**During the pandemic: from 2020 to present**

Taxi, Shared mobility (Uber/DiDi/Grab, etc.)	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
Public transport (train, metro, street car, bus, etc.)	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
Flight	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
Ship / cruise	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]

Transport modes	**Q22. Except for your companion, do you have contacts with other persons when using each of the following transport modes in your daily life?** [1] No contact [2] Yes: only non-physical contacts (e.g., in the physical presence of another person without face to face conversation, skin-to-skin touching or other indirect physical contacts) [3]Yes: only physical contacts (e.g., having a face to face conversation, skin-to-skin touching or other indirect physical contacts or other indirect physical contacts) [4] Yes: both non-physical and physical contacts								
Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**				**During the pandemic: from 2020 to present**				
Taxi, Shared mobility (Uber/DiDi/Grab, etc.)	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]	
Public transport (train, metro, street car, bus, etc.)	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]	
Flight	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]	
Ship / cruise	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]	

Transport modes	**Q23. Except your companion, how many persons do you contact when using each of the following transport modes in your daily life?** [1] 2 persons or fewer [2] 3~4 persons [3] 5~6 persons [4] 7~9 persons [5] 10 persons or more									
Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**					**During the pandemic: from 2020 to present**				
Taxi, Shared mobility (Uber/DiDi/Grab, etc.)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

Public transport (train, metro, street car, bus, etc.)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
Flight	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
Ship / cruise	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

Transport modes	**Q24. Do you take the following protective measures when using each of the following transport modes in your daily life?** [1] wear a mask [2] disinfect your hands before/during/after using it [3] distancing with others [4] other measures [5] no measures are taken									
Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**					**During the pandemic: from 2020 to present**				
Taxi, Shared mobility (Uber/DiDi/Grab, etc.)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
Public transport (train, metro, street car, bus, etc.)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
Flight	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
Ship / cruise	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

Transport modes	**Q25. How do you think about your self-efficiency for protecting yourself when using each of the following transport modes in your daily life? (here, self-efficiency means your belief for your power of protecting yourself from infection)** [1] very low [2] low [3] neither low or high [4] high [5] very high									
Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**					**During the pandemic: from 2020 to present**				
Taxi, Shared mobility (Uber/DiDi/Grab, etc.)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
Public transport (train, metro, street car, bus, etc.)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

Flight	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
Ship / cruise	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

Transport modes	**Q26. Do you think each of the following transport modes involves either of the following three Cs (Closed spaces with poor ventilation, Crowded places, Close-contact settings)?** [1] Closed spaces with poor ventilation [2] Crowded places [3] Close-contact settings [4] None of the above							
Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**				**During the pandemic: from 2020 to present**			
Taxi, Shared mobility (Uber/DiDi/Grab, etc.)	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]
Public transport (train, metro, street car, bus, etc.)	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]
Flight	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]
Ship / cruise	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]

Transport modes	**Q27. Do you agree that people using each of the following transport modes take sufficient measures for protecting other persons (including you) in your daily life?** [1] strongly disagree [2] somewhat disagree [3] neither agree nor disagree [4] somewhat agree [5] strongly agree									
Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**					**During the pandemic: from 2020 to present**				
Taxi, Shared mobility (Uber/DiDi/Grab, etc.)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
Public transport (train, metro, street car, bus, etc.)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
Flight	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
Ship / cruise	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

Transport modes	**Q28. Do you think you are safe (from infection) when using each of the following transport modes in your daily life?** [1] strongly disagree [2] somewhat disagree [3] neither agree nor disagree [4] somewhat agree [5] strongly agree									
Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**					**During the pandemic: from 2020 to present**				
Taxi, Shared mobility (Uber/DiDi/Grab, etc.)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
Public transport (train, metro, street car, bus, etc.)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
Flight	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
Ship / cruise	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

Transport modes	**Q29. Do you think your household members are safe (from infection) when using each of the following transport modes in your their daily life?** [1] strongly disagree [2] somewhat disagree [3] neither agree nor disagree [4] somewhat agree [5] strongly agree									
Target periods	**Before the COVID-19 pandemic: in 2019 (during the Influenza season)**					**During the pandemic: from 2020 to present**				
Taxi, Shared mobility (Uber/DiDi/Grab, etc.)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
Public transport (train, metro, street car, bus, etc.)	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
Flight	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
Ship / cruise	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

Part 4 Psychological Factors

Q30. What is your evaluation of reliability for the following information sources?	strongly disagree	somewhat disagree	Neither agree nor disagree	somewhat agree	strongly agree
Information (homepage information, news, public relations magazines, etc.) announced by the central government of your residence country	1	2	3	4	5
Information (homepage information, news, public relations magazines, etc.) announced by the local government of your residence city/town	1	2	3	4	5
Domestic news	1	2	3	4	5
Overseas news	1	2	3	4	5
Medical institution	1	2	3	4	5
Workplace / school	1	2	3	4	5
SNS (Social Networking Service): Facebook, LINE, Twitter, WhatsApp, etc.	1	2	3	4	5

Q31. To what extend do you agree or disagree to each of the following statements related to COVID-19?	strongly disagree	somewhat disagree	Neither agree nor disagree	somewhat agree	strongly agree
The COVID-19 outbreak in your residence country is severe than many other countries.	1	2	3	4	5
The infection risk of COVID-19 in your residence country is high	1	2	3	4	5
The infection risk of COVID-19 in your residence region (prefecture, province, state) is high	1	2	3	4	5
The infection risk of COVID-19 in your residence city/town is high	1	2	3	4	5

The infection risk of COVID-19 in the place where you often go (workplaces, schools, supermarkets, restaurants, gyms, etc.) in your daily life is high	1	2	3	4	5
The infection risk of COVID-19 in crowded train or bus is high	1	2	3	4	5

Q32. There were various triggers causing the changes in your life during the current COVID-19 pandemic. To what extent do you think the following things triggered you to make the correspoding change?	strongly disagree	somewhat disagree	Neither agree nor disagree	somewhat agree	strongly agree
You have changed your behavior because of your own understanding of the virus.	1	2	3	4	5
You have changed your behavior because of the formal rules which the government of your residence country has introduced.	1	2	3	4	5
You have changed your behavior because of the advice by your household.	1	2	3	4	5
You have changed your behavior because of the advice by your colleagues, acquaintances and friends.	1	2	3	4	5
You have changed your behavior because of the formal rules which your workplace/organization/affiliation has introduced.	1	2	3	4	5
You have changed your behavior because of the number of infected cases.	1	2	3	4	5
You have changed your behavior because of worrying about other people's eyes or blames.	1	2	3	4	5

Q33. To what extend do you agree or disagree to each of the following statements related to COVID-19?	strongly disagree	somewhat disagree	Neither agree nor disagree	somewhat agree	strongly agree
You can trust your residence country's health and medical institutions in preventing the spread of COVID-19.	1	2	3	4	5
You can trust your residence country's central government in preventing the spread of COVID-19.	1	2	3	4	5
You can trust your residence city's/town's local government in your residence place in preventing the spread of COVID-19.	1	2	3	4	5
Behavior trajectories of infected persons should be obtained from telecommunication companies and published on maps on the Internet, by following proper privacy protection.	1	2	3	4	5
In order to keep yourself or others from infection, even if you find it is very inconvenient, you are totally accepting to change the needs in your life, and your lifestyles.	1	2	3	4	5
In order to keep yourself or others from infection, even if you find it is very inconvenient, you are totally accepting to change your daily activities.	1	2	3	4	5
In order to keep yourself or others from infection, even if you find it is very inconvenient, you are totally accepting to change places that you perform activities.	1	2	3	4	5
In order to keep yourself or others from infection, even if you find it is very inconvenient, you are totally accepting to change time/timing that you perform activities.	1	2	3	4	5
You are a person who well prepare for emergencies like this COVID-19 pandemic.	1	2	3	4	5

In order to keep yourself or others from infection, you are the person who can keep physical distance well, even if you find it is very inconvenient.	1	2	3	4	5
In order to keep yourself or others from infection, you are totally accepting to provide your details of behavior trajectories to medical and government agencies.	1	2	3	4	5
In order to keep yourself or others from infection, you are the person who can avoid performing activities and making trips with three Cs (closed spaces, crowded places, and close contacts), even if you find it is very inconvenient.	1	2	3	4	5
In order to keep yourself or others from infection, you are the person who can adjust your activity-travel schedules or plans, even if you find it is very inconvenient.	1	2	3	4	5
In order to keep yourself or others from infection, you are the person who can shift to the telework working style and to use of travel modes other than public transport, even if you find it is very inconvenient.	1	2	3	4	5
In order to keep yourself or others from infection, you are totally accepting to share your behavior trajectories and health status information with other persons.	1	2	3	4	5
In order to keep yourself or others from infection, you are the person who can perform more online activities, postpone travel and tourism, reduce the frequency and distance of trips, and stop unnecessary and non-urgent activities, even if you find it is very inconvenient.	1	2	3	4	5
In order to keep yourself or others from infection, you are the person who can stop activities involving trips and avoid parties at home, even if you find it is very inconvenient.	1	2	3	4	5
Even if vaccination against COVID-19 is very expensive to you, you are still willing to get vaccinated.	1	2	3	4	5

You are a person who leaves important decisions to experts or government and support the social order.	1	2	3	4	5
You agree with that everyone is equal and the good of the many people comes before the good of any individual, the risk decision should be made by all people instead of a small elite or authority.	1	2	3	4	5
You agree with that individual freedom is absolutely important, and individual choices should not be constrained by society and other people?	1	2	3	4	5
You agree with that there is little you can do to control the environment so that you will receive whatever fate throws at you and try not to know or worry about it..	1	2	3	4	5

Appendix 3: Questionnaire of comparative survey of activity-travel and social contact before-during COVID-19 in Japanese

Intro		**現在の新型コロナウイルス感染拡大（COVID-19 パンデミック）が人々の生活に様々な影響を与えてきています。このアンケート調査は、COVID-19 パンデミック期間中（2020 年と 2021 年）とパンデミック前（2019 年とそれ以前のインフルエンザ季節）における、あなたの日常生活、ソーシャルコンタクト（社会的接触：人と人との触れあい）、ウイルスに感染されないための保護措置などをお尋ねいたします。また、現在のパンデミックのコントロールに関するあなたの知覚や態度なども教えていただければ幸いです。収集されたデータはすべて統計的に処理し、現在のパンデミックのコントロールと将来のパンデミックの防止に役立つ科学的な研究のみに使います。特定の個人を識別することのできるプライバシー情報をデータに取り入れません。本調査の趣旨にご理解していただき、ぜひ、調査に参加していただければ幸いでございます。**
パート I　あなた個人と世帯のことについて教えてください。		
A1	あなたの性別をお選びください。	
	1	男性
	2	女性
A2	あなたの年齢をお選びください。	
	1	15 歳未満
	2	15~19 歳

	3	20~29 歳
	4	30~39 歳
	5	40~49 歳
	6	50~59 歳
	7	60~64 歳
	8	65~69 歳
	9	70 歳以上
A3	**現在の居住地をご入力ください。**	
	都道府県	
	市区町村	
	郵便番号	
A4	**ご自身の職業をお選びください。**	
	1	会社員／会社役員または自営業
	2	公務員・団体職員
	3	学校や大学などの教育機関の教職員
	4	専業主婦
	5	パート・アルバイト
	6	学生
	7	その他の無職（年金生活者を含む）
	8	その他
A5	**あなたの具体的な職業を教えてください。**	

	1	農林漁業
	2	鉱業、建設業
	3	製造業
	4	電気・ガス・熱供給・水道業
	5	情報通信業
	6	運輸業
	7	卸売・小売業
	8	金融・保険業
	9	不動産業
	10	飲食店・宿泊業
	11	医療・福祉
	12	教育・学習支援業
	13	その他のサービス業（法務、学術、宗教、複合サービスなど）
	14	その他
A6	**ご自身を含む世帯人数をご入力ください。**	
	1	ご自身を含む世帯総人数
	2	11 歳未満の子供の数
	3	11-18 歳未満の子供の数
	4	65 歳以上の高齢者の数
A7	**現在の婚姻状況をお選びください。**	
	1	未婚
	2	既婚

	3	離別･死別
A8	**同居家族について教えてください。**	
	1	配偶者・カップル
	2	自身の子ども
	3	孫
	4	自身の親・祖父母、配偶者の親・祖父母
	5	その他
	6	同居していない（一人暮らし）
A9	**住居のタイプについて教えてください。**	
	1	持ち家:一戸建て
	2	持ち家:マンション等の集合住宅
	3	賃貸:一戸建て
	4	賃貸:マンション等の集合住宅
	5	その他
A10	**ご自身の最終学歴をお選びください。**	
	1	学校に行ったことはない
	2	**小学**
	3	**中学**
	4	**高校**
	5	**専修・専門学校・短大・高専**

	6	大学
	7	大学院博士前期（修士）課程
	8	大学院博士後期（博士）課程
A11	あなたの世帯の年収（税込み）は次のどれに当てはまりますか。もし収入がある方が２名以上いる場合は、すべての方の収入を合算してください。	
	1	３００万円未満
	2	３００万円～４００万円未満
	3	４００万円～５００万円未満
	4	５００万円～６００万円未満
	5	６００万円～７００万円未満
	6	７００万円～８００万円未満
	7	８００万円～９００万円未満
	8	９００万円～１０００万円未満
	9	１０００万円～１５００万円未満
	10	１５００万円～２０００万円未満
	11	２０００万円以上

パート II　新型コロナウイルス感染拡大中（COVID-19 パンデミック期間中：2020 年から現在に至るまで）とその以前（2019 年）の活動種類・場所ごとのソーシャルコンタクト（社会的接触）の状況について教えてください。

活動種類	活動場所	**Q1. 当該活動を当該場所で行う頻度を教えてください。** [1] まったくない

			[2] 初めて [3] １ヶ月 1 回未満 [4] １ヶ月 1 回か 2 回 [5] 毎週 1 回か 2 回 [6] 毎日かほぼ毎日									
		対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**						**COVID-19 パンデミック期間中：2020 年から現在に至るまで**					
仕事・勉強		職場・学校	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
買物		スーパー、ショッピングモール	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
余暇・娯楽	外食	レストラン	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
	運動・スポーツ	室内施設（体育館やジムなど）	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
	パーティー	室内施設（レストランやバーなど）	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
	文化的余暇	映画館やコンサートホール	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
医療活動	受診、薬の購入	病院・診療所など	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]

活動種類	活動場所	**Q2. 当該活動場所とご自宅との距離はどれぐらいですか。** [1] 1 キロ未満 [2] 1 キロ以上、2 キロ未満 [3] 2 キロ以上、5 キロ未満 [4] 5 キロ以上、10 キロ未満 [5] 10 キロ以上		
	対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**	**COVID-19 パンデミック期間中：2020 年から現在に至るまで**	

仕事・勉強		職場・学校	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
買物		スーパー、ショッピングモール	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
余暇・娯楽	外食	レストラン	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	運動・スポーツ	室内施設（体育館やジムなど）	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	パーティー	室内施設（レストランやバーなど）	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	文化的余暇	映画館やコンサートホール	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
医療活動	受診、薬の購入	病院・診療所など	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

活動種類		活動場所	**Q3. 毎回、当該活動を当該場所で行う時間の長さを教えてください。** [1] 5 分未満 [2] 5 分以上、15 分未満 [3] 15 分以上、1 時間未満 [4] 1 時間以上、4 時間未満 [5] 4 時間以上									
		対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**					**COVID-19 パンデミック期間中：2020 年から現在に至るまで**				
仕事・勉強		職場・学校	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
買物		スーパー、ショッピングモール	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
余暇・娯楽	外食	レストラン	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	運動・スポーツ	室内施設（体育館やジムなど）	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	パーティー	室内施設（レストランやバーなど）	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	文化的余暇	映画館やコンサートホール	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

医療活動	受診、薬の購入	病院・診療所など	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]

活動種類		活動場所	**Q4. 当該活動を当該場所で行うための主な移動手段を教えてください。** [1] Uber や DiDi のサービスを有するタクシー [2] 通常のタクシー [3] バス [4] 軌道系交通：鉄道、メトロ、路面電車、新交通システムなど [5] 自家用車 [6] 徒歩・自転車 [7] その他	
		対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**	**COVID-19 パンデミック期間中：2020 年から現在に至るまで**
仕事・勉強		職場・学校	[1] [2] [3] [4] [5] [6] [7]	[1] [2] [3] [4] [5] [6] [7]
買物		スーパー、ショッピングモール	[1] [2] [3] [4] [5] [6] [7]	[1] [2] [3] [4] [5] [6] [7]
余暇・娯楽	外食	レストラン	[1] [2] [3] [4] [5] [6] [7]	[1] [2] [3] [4] [5] [6] [7]
	運動・スポーツ	室内施設（体育館やジムなど）	[1] [2] [3] [4] [5] [6] [7]	[1] [2] [3] [4] [5] [6] [7]
	パーティー	室内施設（レストランやバーなど）	[1] [2] [3] [4] [5] [6] [7]	[1] [2] [3] [4] [5] [6] [7]
	文化的余暇	映画館やコンサートホール	[1] [2] [3] [4] [5] [6] [7]	[1] [2] [3] [4] [5] [6] [7]
医療活動	受診、薬の購入	病院・診療所など	[1] [2] [3] [4] [5] [6] [7]	[1] [2] [3] [4] [5] [6] [7]

活動種類	活動場所	**Q5. 当該活動を当該場所で行うための移動時間（片道）はどれぐらいですか。** [1] 10 分未満 [2] 10 分以上、30 分未満

		[3] 30 分以上、1 時間未満 [4] 1 時間以上	
		対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**	**COVID-19 パンデミック期間中：2020 年から現在に至るまで**
仕事・勉強		職場・学校	[1] [2] [3] [4]	[1] [2] [3] [4]
買物		スーパー、ショッピングモール	[1] [2] [3] [4]	[1] [2] [3] [4]
余暇・娯楽	外食	レストラン	[1] [2] [3] [4]	[1] [2] [3] [4]
	運動・スポーツ	室内施設（体育館やジムなど）	[1] [2] [3] [4]	[1] [2] [3] [4]
	パーティー	室内施設（レストランやバーなど）	[1] [2] [3] [4]	[1] [2] [3] [4]
	文化的余暇	映画館やコンサートホール	[1] [2] [3] [4]	[1] [2] [3] [4]
医療活動	受診、薬の購入	病院・診療所など	[1] [2] [3] [4]	[1] [2] [3] [4]

活動種類 （職場・学校関係を除外）		活動場所	**Q6. 当該活動を当該場所で行うための主な同伴者を教えてください。** [1] 配偶者・カップル [2] 子供、孫 [3] 両親、祖父母 [4] 友人 [5] ほかの知人 [6] ひとり	
		対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**	**COVID-19 パンデミック期間中：2020 年から現在に至るまで**
買物		スーパー、ショッピングモール	[1] [2] [3] [4] [5] [6]	[1] [2] [3] [4] [5] [6]
余暇・娯楽	外食	レストラン	[1] [2] [3] [4] [5] [6]	[1] [2] [3] [4] [5] [6]

	運動・スポーツ	室内施設（体育館やジムなど）	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
	パーティー	室内施設（レストランやバーなど）	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
	文化的余暇	映画館やコンサートホール	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
医療活動	受診、薬の購入	病院・診療所など	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]

活動種類		活動場所	**Q7. 主な同伴者以外に、当該活動を当該場所で行う際に何らかのソーシャルコンタクトはありますか。** [1] いいえ、まったくない [2] はい：非物理的な接触のみ（例：他の人が物理的に存在する場合、対面会話や身体に触れるような物理的接触がない） [3] はい：物理的な接触のみ（例：対面会話や身体に触れるような物理的接触とその他の間接的な物理接触がある） [4] はい：非物理的な接触と物理的な接触の両方	
		対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**	**COVID-19 パンデミック期間中：2020 年から現在に至るまで**
仕事・勉強		職場・学校（あなたの同僚・クラスメートもこの場所でのソーシャルコンタクトに含まれる）	[1] [2] [3] [4]	[1] [2] [3] [4]
買物		スーパー、ショッピングモール	[1] [2] [3] [4]	[1] [2] [3] [4]
余暇・娯楽	外食	レストラン	[1] [2] [3] [4]	[1] [2] [3] [4]
	運動・スポーツ	室内施設（体育館やジムなど）	[1] [2] [3] [4]	[1] [2] [3] [4]
	パーティー	室内施設（レストランやバーなど）	[1] [2] [3] [4]	[1] [2] [3] [4]

	文化的余暇	映画館やコンサートホール	[1] [2] [3] [4]	[1] [2] [3] [4]
医療活動	受診、薬の購入	病院・診療所など	[1] [2] [3] [4]	[1] [2] [3] [4]

活動種類		活動場所	**Q8. 主な同伴者以外で、当該活動を当該場所で行う際に接触する人数を教えてください。** [1] 2 人以下 [2] 3〜4 人 [3] 5〜6 人 [4] 7〜9 人 [5] 10 人以上	
		対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**	**COVID-19 パンデミック期間中：2020 年から現在に至るまで**
仕事・勉強		職場・学校（あなたの同僚・クラスメートもこの場所でのソーシャルコンタクトに含まれる）	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
買物		スーパー、ショッピングモール	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
余暇・娯楽	外食	レストラン	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
	運動・スポーツ	室内施設（体育館やジムなど）	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
	パーティー	室内施設（レストランやバーなど）	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
	文化的余暇	映画館やコンサートホール	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
医療活動	受診、薬の購入	病院・診療所など	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]

活動種類	活動場所	**Q9. 当該活動を当該場所で行う際の保護措置を教えてください。** [1] マスク着用

			[2] 活動前後または活動中に手の消毒を行う [3] 人と適切な距離を取る [4] ほかの保護措置 [5] 保護措置をまったく取らない								
		対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**					**COVID-19 パンデミック期間中：2020 年から現在に至るまで**			
仕事・勉強		職場・学校	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
買物		スーパー、ショッピングモール	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
余暇・娯楽	外食	レストラン	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	運動・スポーツ	室内施設（体育館やジムなど）	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	パーティー	室内施設（レストランやバーなど）	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	文化的余暇	映画館やコンサートホール	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
医療活動	受診、薬の購入	病院・診療所など	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

活動種類	活動場所	**Q10. 当該活動を当該場所で行う際の感染保護の自己効力感（自己保護能力の意識・認識）について教えてください。** [1] 非常に低い [2] 低い [3] どちらとも言えない [4] 高い [5] 非常に高い	
	対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**	**COVID-19 パンデミック期間中：2020 年から現在に至るまで**

仕事・勉強		職場・学校	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
買物		スーパー、ショッピングモール	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
余暇・娯楽	外食	レストラン	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	運動・スポーツ	室内施設（体育館やジムなど）	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	パーティー	室内施設（レストランやバーなど）	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	文化的余暇	映画館やコンサートホール	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
医療活動	受診、薬の購入	病院・診療所など	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

活動種類		活動場所	**Q11. 当該活動場所においてほかの人々（例：スタッフ、他の消費者）が他人（ご自身を含む）を保護するために適切な措置を取ったと思いますか。** [1] 強くそう思わない [2] あまりそう思わない [3] どちらとも言えない [4] まあまあそう思う [5] 強くそう思う									
		対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**					**COVID-19 パンデミック期間中：2020 年から現在に至るまで**				
仕事・勉強		職場・学校	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
買物		スーパー、ショッピングモール	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
余暇・娯楽	外食	レストラン	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	運動・スポーツ	室内施設（体育館やジムなど）	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	パーティー	室内施設（レストランやバーなど）	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

	文化的余暇	映画館やコンサートホール	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
医療活動	受診、薬の購入	病院・診療所など	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

活動種類		活動場所	**Q12. 当該活動を当該場所で行う際にその状況は以下の 3 密のいずれかに当たると思いますか。** [1] 密閉（空間が密閉し、換気が悪い） [2] 密集（多くの人で混んでいる） [3] 密接（接触距離が近すぎる） [4] 左記の 3 密のいずれかにも当たらない								
		対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**					**COVID-19 パンデミック期間中：2020 年から現在に至るまで**			
仕事・勉強		職場・学校	[1]	[2]	[3]	[4]		[1]	[2]	[3]	[4]
買物		スーパー、ショッピングモール	[1]	[2]	[3]	[4]		[1]	[2]	[3]	[4]
余暇・娯楽	外食	レストラン	[1]	[2]	[3]	[4]		[1]	[2]	[3]	[4]
	運動・スポーツ	室内施設（体育館やジムなど）	[1]	[2]	[3]	[4]		[1]	[2]	[3]	[4]
	パーティー	室内施設（レストランやバーなど）	[1]	[2]	[3]	[4]		[1]	[2]	[3]	[4]
	文化的余暇	映画館やコンサートホール	[1]	[2]	[3]	[4]		[1]	[2]	[3]	[4]
医療活動	受診、薬の購入	病院・診療所など	[1]	[2]	[3]	[4]		[1]	[2]	[3]	[4]

活動種類	活動場所	**Q13. 感染リスクを考えた際に、当該活動を当該場所で行うことは安全だと思いますか。** [1] 強くそう思わない [2] あまりそう思わない [3] どちらとも言えない

			[4] まあまあそう思う [5] 強くそう思う							
		対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**					**COVID-19 パンデミック期間中：2020 年から現在に至るまで**				
仕事・勉強		職場・学校	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
買物		スーパー、ショッピングモール	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
余暇・娯楽	外食	レストラン	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	運動・スポーツ	室内施設（体育館やジムなど）	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	パーティー	室内施設（レストランやバーなど）	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	文化的余暇	映画館やコンサートホール	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
医療活動	受診、薬の購入	病院・診療所など	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

活動種類	活動場所	**Q14. もしあなたの家族が当該活動を当該場所で行う場合、感染リスクを考えた際に安全だと思いますか。** [1] 強くそう思わない [2] あまりそう思わない [3] どちらとも言えない [4] まあまあそう思う [5] 強くそう思う									
	対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**					**COVID-19 パンデミック期間中：2020 年から現在に至るまで**				
仕事・勉強	職場・学校	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
買物	スーパー、ショッピングモール	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

余暇・娯楽	外食	レストラン	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	運動・スポーツ	室内施設（体育館やジムなど）	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	パーティー	室内施設（レストランやバーなど）	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	文化的余暇	映画館やコンサートホール	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
医療活動	受診、薬の購入	病院・診療所など	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

活動種類		活動場所	**Q15. 当該活動を当該場所で行う際のあなたの心理的状態について教えてください。** [1] 疲れ果てた [2] うつ状態、落胆した [3] 神経的 [4] エネルギッシュで元気 [5] プレッシャーを感じた [6] 幸せ、満足的 [7] 無力 [8] 気分がさわやか、くつろぎを感じた [9] 耐えらない [10] 不安 [11] その他	
		対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**	**COVID-19 パンデミック期間中：2020 年から現在に至るまで**
仕事・勉強		職場・学校	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]
買物		スーパー、ショッピングモール	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]
余暇・娯楽	外食	レストラン	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]

	運動・スポーツ	室内施設（体育館やジムなど）	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]
	パーティー	室内施設（レストランやバーなど）	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]
	文化的余暇	映画館やコンサートホール	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]
医療活動	受診、薬の購入	病院・診療所など	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11]

活動種類	活動場所	**Q16. 当該活動を当該場所で行う良さ（メリット）・目的を教えてください。**
		[1] 他者との温かい関係 [2] 生活の利便性 [3] 食料の供給と日常生活 [4] プレッシャーを和らげる [5] 私の公的イメージ、社会的認知、他人からの尊敬を保つ [6] 自己安心感 [7] お金を節約する [8] お金を稼ぐ [9] 知恵 [10] 身体的健康 [11] 達成感 [12] 自由の感覚 [13] 自己実現/自尊心 [14] 帰属意識 [15] 楽しさーうれしさー刺激 [16] くつろぎ [17] その他

		対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**	**COVID-19 パンデミック期間中：2020 年から現在に至るまで**
仕事・勉強		職場・学校	[1] [2] [3] [4] [5] [……] [15] [16] [17]	[1] [2] [3] [4] [5] [……] [15] [16] [17]
買物		スーパー、ショッピングモール	[1] [2] [3] [4] [5] [……] [15] [16] [17]	[1] [2] [3] [4] [5] [……] [15] [16] [17]
余暇・娯楽	外食	レストラン	[1] [2] [3] [4] [5] [……] [15] [16] [17]	[1] [2] [3] [4] [5] [……] [15] [16] [17]
	運動・スポーツ	室内施設（体育館やジムなど）	[1] [2] [3] [4] [5] [……] [15] [16] [17]	[1] [2] [3] [4] [5] [……] [15] [16] [17]
	パーティー	室内施設（レストランやバーなど）	[1] [2] [3] [4] [5] [……] [15] [16] [17]	[1] [2] [3] [4] [5] [……] [15] [16] [17]
	文化的余暇	映画館やコンサートホール	[1] [2] [3] [4] [5] [……] [15] [16] [17]	[1] [2] [3] [4] [5] [……] [15] [16] [17]
医療活動	受診、薬の購入	病院・診療所など	[1] [2] [3] [4] [5] [……] [15] [16] [17]	[1] [2] [3] [4] [5] [……] [15] [16] [17]

活動種類		活動場所	**Q17. 政府の許可なしでこの活動をこのような場所で行う人々を罰するべきだと思いますか** [1] 強くそう思わない [2] あまりそう思わない [3] どちらとも言えない [4] まあまあそう思う [5] 強くそう思う	
		対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**	**COVID-19 パンデミック期間中：2020 年から現在に至るまで**
仕事・勉強		職場・学校	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
買物		スーパー、ショッピングモール	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
余暇・娯楽	外食	レストラン	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
	運動・スポーツ	室内施設（体育館やジムなど）	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]

	パーティー	室内施設（レストランやバーなど）	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	文化的余暇	映画館やコンサートホール	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
医療活動	受診、薬の購入	病院・診療所など	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

活動種類		活動場所	**Q18. たとえ感染リスクが高くても、あなたは当該活動を当該場所で行うと思いますか。** [1] 強くそう思わない [2] あまりそう思わない [3] どちらとも言えない [4] まあまあそう思う [5] 強くそう思う									
		対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**					**COVID-19 パンデミック期間中：2020 年から現在に至るまで**				
仕事・勉強		職場・学校	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
買物		スーパー、ショッピングモール	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
余暇・娯楽	外食	レストラン	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	運動・スポーツ	室内施設（体育館やジムなど）	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	パーティー	室内施設（レストランやバーなど）	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
	文化的余暇	映画館やコンサートホール	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
医療活動	受診、薬の購入	病院・診療所など	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]

パート III　新型コロナウイルス感染拡大中（COVID-19 パンデミック期間中：2020 年から現在に至る）とその以前（2019 年）の移動手段を使う際のソーシャルコンタクト（社会的接触）の状況について教えてください。

移動手段	**Q19. 普段の当該移動手段の利用頻度はどれぐらいですか。** [1] まったくない [2] 初めて [3] １ヶ月 1 回未満 [4] １ヶ月 1 回か 2 回 [5] 毎週 1 回か 2 回 [6] 毎日かほぼ毎日	
対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**	**COVID-19 パンデミック期間中：2020 年から現在に至るまで**
タクシー	[1] [2] [3] [4] [5] [6]	[1] [2] [3] [4] [5] [6]
公共交通手段：鉄道、メトロ、路面電車、新交通システム、バスなど	[1] [2] [3] [4] [5] [6]	[1] [2] [3] [4] [5] [6]
飛行機	[1] [2] [3] [4] [5] [6]	[1] [2] [3] [4] [5] [6]
船・クルーズ船	[1] [2] [3] [4] [5] [6]	[1] [2] [3] [4] [5] [6]

移動手段	**Q20. 毎回、当該移動手段を使うときの平均移動時間（片道）はどれぐらいですか。** [1] 5 分未満 [2] 5 分以上、15 分未満 [3] 15 分以上、30 分未満 [4] 30 分以上、1 時間未満

	[5] 1 時間以上、4 時間未満 [6] 4 時間以上											
対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**						**COVID-19 パンデミック期間中：2020 年から現在に至るまで**					
タクシー	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
公共交通手段：鉄道、メトロ、路面電車、新交通システム、バスなど	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
飛行機	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
船・クルーズ船	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]

移動手段	**Q21. 当該移動手段を使うときの主な同伴者を教えてください。** [1] 配偶者・カップル [2] 子供、孫 [3] 両親、祖父母 [4] 友人 [5] ほかの知人 [6] ご自身のみ											
対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**						**COVID-19 パンデミック期間中：2020 年から現在に至るまで**					
タクシー	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
公共交通手段：鉄道、メトロ、路面電車、新交通システム、バスなど	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
飛行機	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
船・クルーズ船	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]

移動手段	**Q22. 主な同伴者以外に、当該移動手段を使う際に何らかのソーシャルコンタクトはありますか。** [1] いいえ、まったくない [2] はい：非物理的な接触のみ（例：他の人が物理的に存在する場合、対面会話や身体に触れるような物理的接触がない） [3] はい：物理的な接触のみ（例：対面会話や身体に触れるような物理的接触とその他の間接的な物理接触がある） [4] はい：非物理的な接触と物理的な接触の両方	
対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**	**COVID-19 パンデミック期間中：2020 年から現在に至るまで**
タクシー	[1] [2] [3] [4]	[1] [2] [3] [4]
公共交通手段：鉄道、メトロ、路面電車、新交通システム、バスなど	[1] [2] [3] [4]	[1] [2] [3] [4]
飛行機	[1] [2] [3] [4]	[1] [2] [3] [4]
船・クルーズ船	[1] [2] [3] [4]	[1] [2] [3] [4]

移動手段	**Q23. 主な同伴者以外、当該移動手段を使う際に接触する人数を教えてください。** [1] 2 人以下 [2] 3〜4 人 [3] 5〜6 人 [4] 7〜9 人 [5] 10 人以上	
対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**	**COVID-19 パンデミック期間中：2020 年から現在に至るまで**
タクシー	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]

公共交通手段：鉄道、メトロ、路面電車、新交通システム、バスなど	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
飛行機	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
船・クルーズ船	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]

移動手段	**Q24. 当該移動手段を使う際の保護措置を教えてください。** [1] マスク着用 [2] 移動前後または移動中に手の消毒を行う [3] 人と適切な距離を取る [4] ほかの保護措置 [5] 保護措置をまったく取らない	
対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**	**COVID-19 パンデミック期間中：2020 年から現在に至るまで**
タクシー	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
公共交通手段：鉄道、メトロ、路面電車、新交通システム、バスなど	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
飛行機	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
船・クルーズ船	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]

移動手段	**Q25. 当該移動手段を使う際の感染保護の自己効力感（自己保護能力の意識・認識）について教えてください。** [1] 非常に低い [2] 低い [3] どちらとも言えない

	[4] 高い [5] 非常に高い	
対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**	**COVID-19 パンデミック期間中：2020 年から現在に至るまで**
タクシー	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
公共交通手段：鉄道、メトロ、路面電車、新交通システム、バスなど	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
飛行機	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
船・クルーズ船	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]

移動手段	**Q26. 当該移動手段を使う際にその状況は以下の 3 密のいずれかに当たると思いますか 。** [1] 密閉（空間が密閉し、換気が悪い） [2] 密集（多くの人で混んでいる） [3] 密接（接触距離が近すぎる） [4] 左記の３密のいずれかにも当たらない	
対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**	**COVID-19 パンデミック期間中：2020 年から現在に至るまで**
タクシー	[1] [2] [3] [4]	[1] [2] [3] [4]
公共交通手段：鉄道、メトロ、路面電車、新交通システム、バスなど	[1] [2] [3] [4]	[1] [2] [3] [4]
飛行機	[1] [2] [3] [4]	[1] [2] [3] [4]
船・クルーズ船	[1] [2] [3] [4]	[1] [2] [3] [4]

移動手段	**Q27. 当該移動手段を使うほかの人々が他人（ご自身を含む）を保護するために適切な措置を取ったと思いますか。** [1] 強くそう思わない [2] あまりそう思わない [3] どちらとも言えない [4] まあまあそう思う [5] 強くそう思う	
対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**	**COVID-19 パンデミック期間中：2020 年から現在に至るまで**
タクシー	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
公共交通手段：鉄道、メトロ、路面電車、新交通システム、バスなど	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
飛行機	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
船・クルーズ船	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]

移動手段	**Q28. 感染リスクを考えた際に、当該移動手段を使うことは安全だと思いますか。** [1] 強くそう思わない [2] あまりそう思わない [3] どちらとも言えない [4] まあまあそう思う [5] 強くそう思う	
対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**	**COVID-19 パンデミック期間中：2020 年から現在に至るまで**
タクシー	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]

公共交通手段：鉄道、メトロ、路面電車、新交通システム、バスなど	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
飛行機	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
船・クルーズ船	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]

移動手段	**Q29. もしあなたの家族が当該移動手段を使う場合、感染リスクを考えた際に安全だと思いますか。** [1] 強くそう思わない [2] あまりそう思わない [3] どちらとも言えない [4] まあまあそう思う [5] 強くそう思う	
対象期間	**COVID-19 パンデミック前：2019 年のインフルエンザ流行時期**	**COVID-19 パンデミック期間中：2020 年から現在に至るまで**
タクシー	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
公共交通手段：鉄道、メトロ、路面電車、新交通システム、バスなど	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
飛行機	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]
船・クルーズ船	[1] [2] [3] [4] [5]	[1] [2] [3] [4] [5]

パートIV 心理的ファクター

Q30. 新型コロナウイルスに関する情報源の「信頼性」について、あなたご自身の評価をお答えください。	**強くそう思わない**	**あまりそう思わない**	**どちらとも言えない**	**まあまあそう思う**	**強くそう思う**

日本政府の発表情報（ホームページ情報、ニュース、広報誌など）	1	2	3	4	5
お住まいの地方自治体の発表情報（ホームページ情報、ニュース、広報誌など）	1	2	3	4	5
国内ニュース	1	2	3	4	5
海外ニュース	1	2	3	4	5
医療機関	1	2	3	4	5
職場・学校	1	2	3	4	5
SNS (ソーシャルネットワーキングサービス): Facebook, LINE, Twitter, WhatsApp など	1	2	3	4	5

Q31. 新型コロナウイルスの感染リスクについて、あなたはどのように感じていますか。	**強くそう思わない**	**あまりそう思わない**	**どちらとも言えない**	**まあまあそう思う**	**強くそう思う**
日本全体の感染リスクがほかの国より高いと思っていますか	1	2	3	4	5
日本全体の感染リスクが高まっていると思っていますか	1	2	3	4	5
お住まいの都道府県での感染リスクが高まっていると思っていますか	1	2	3	4	5
お住まいの市町村での感染リスクが高まっていると思っていますか	1	2	3	4	5
あなたがよく行く場所（職場や学校、スーパー、レストラン、スポーツジムなど）での感染リスクが高まっていると思っていますか	1	2	3	4	5
混んでいる電車やバスの感染リスクが高いと思いますか	1	2	3	4	5

Q32. 新型コロナウイルス感染拡大によって、あなたご自身の生活行動に様々な変化が生じています。その変化は色々なキッカケによって引き起こされたと考えられますが、以下のような事柄は、どの程度そのきっかけになったと思いますか。	**強くそう思わない**	**あまりそう思わない**	**どちらとも言えない**	**まあまあそう思う**	**強くそう思う**
自分の感染状況に対する理解によって、自分の行動を変えた。	1	2	3	4	5
日本政府の要請によって、自分の行動を変えた。	1	2	3	4	5
家族からの勧めによって、自分の行動を変えた。	1	2	3	4	5
同僚、知人や友人などからの勧めによって、自分の行動を変えた。	1	2	3	4	5
所属団体からの要請によって、自分の行動を変えた。	1	2	3	4	5
感染者数をみて、自分の行動を変えた。	1	2	3	4	5
周りの目や批判を気にして、自分の行動を変えた。	1	2	3	4	5

Q33. 以下の新型コロナウイルス感染拡大に関するそれぞれの事柄について、どう思うか~~について~~お答えください。	**強くそう思わない**	**あまりそう思わない**	**どちらとも言えない**	**まあまあそう思う**	**強くそう思う**
感染拡大を防ぐにあたり、日本の保健・医療機関を信頼できる。	1	2	3	4	5
新型コロナウイルスの感染拡大を防ぐにあたり、日本政府を信頼できる。	1	2	3	4	5
新型コロナウイルスの感染拡大を防ぐにあたり、ご自身が居住している地方自治体を信頼できる。	1	2	3	4	5

感染者の行動履歴を通信会社などから入手し、個人情報を保護の上、ホームページの地図上に公開すべき。	1	2	3	4	5
感染しない、または他人に感染させないようにするために、非常に不便だと感じても、自分の生活ニーズ、ライフタイルを見直すことにまったく抵抗がないほうだ。	1	2	3	4	5
感染しない、または他人に感染させないようにするために、非常に不便だと感じても、毎日の活動内容を見直すことにまったく抵抗がないほうだ。	1	2	3	4	5
感染しない、または他人に感染させないようにするために、非常に不便だと感じても、毎日の活動場所を見直すことにまったく抵抗がないほうだ。	1	2	3	4	5
感染しない、または他人に感染させないようにするために、非常に不便だと感じても、毎日の活動時間（長さ、タイミング）を見直すことにまったく抵抗がないほうだ。	1	2	3	4	5
私はパンデミックのような非常事態によく備えるほうだ。	1	2	3	4	5
感染しない、または他人に感染させないようにするために、非常に不便だと感じても、フィジカルディスタンシングをよく実践しているほうだ。	1	2	3	4	5
感染しない、または他人に感染させないようにするために、ご自身の行動履歴の詳細を医療機関・政府機関に提供することにまったく抵抗がないほうだ。	1	2	3	4	5
感染しない、または他人に感染させないようにするために、非常に不便だと感じても、３密（密集、密接、密閉）のある活動・移動を常に避けるようにするほうだ。	1	2	3	4	5
感染しない、または他人に感染させないようにするために、非常に不便だと感じても、ご自身の活動・行動スケジュールや計画を常に調整するほうだ。	1	2	3	4	5
感染しない、または他人に感染させないようにするために、非常に不便だと感じても、仕事の勤務形態をテレワークにシフトしたり、公共交通以外の交通手段の利用にシフトしたりするほうだ。	1	2	3	4	5

感染しない、または他人に感染させないようにするために、ご自身の行動履歴、健康状況の情報を他人に共用することにまったく抵抗がないほうだ。	1	2	3	4	5
感染しない、または他人に感染させないようにするために、非常に不便だと感じても、オンライン活動への切り換え、旅行などの延期、移動回数や距離を減らしたり、不要不急の活動を止めたりするほうだ。	1	2	3	4	5
感染しない、または他人に感染させないようにするために、非常に不便だと感じても、移動を伴う活動を中止し、家でパーティーしないようにするほうだ。	1	2	3	4	5
たとえ新型コロナウイルスのワクチンの接種費用が高くても、私は接種したい。	1	2	3	4	5
重要な意思決定を専門家や政府に任せて、そのような社会的な秩序を支持するほうだ。	1	2	3	4	5
だれもが平等で、多数の人々の利益がどの個人の利益よりも優先されるべき、そして、重大なリスクに関する意思決定は少数のエリートや権威ではなく、すべての人々で行うべきだと思う。	1	2	3	4	5
個人の自由が絶対に重要であり、個人の選択が社会や他の人々によって制約されるべきではないと思う。	1	2	3	4	5
自分自身が周りの環境を左右することができないので、運命に身を任せ、その運命を知ろうとしない、心配しないように努めるほうだ。	1	2	3	4	5

Appendix 4: Statistics of social contacts for Work/Study, Shopping, Eating out, Physical exercise setting before and during the COVID-19 pandemic

	Work/Study				Shopping				Eating out				Physical exercise			
	Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic	
Variable	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)
Total	3606 (1)	8.85 (8.67-9.03)	2838 (1)	7.42 (7.22-7.62)	5236 (1)	4.98 (4.85-5.11)	4512 (1)	4.5 (4.36-4.64)	5318 (1)	4.85 (4.74-4.96)	3355 (1)	4.26 (4.13-4.39)	3427 (1)	5.8 (5.63-5.97)	2254 (1)	4.83 (4.66-5)
Age																
Less than 19	111 (0.031)	9.04 (8-10.08)	77 (0.027)	7.73 (6.44-9.02)	118 (0.023)	5.36 (4.48-6.24)	88 (0.02)	4.93 (4.02-5.84)	117 (0.022)	5.65 (4.83-6.47)	75 (0.022)	5.29 (4.33-6.25)	100 (0.029)	6.01 (5.02-7)	55 (0.024)	5.69 (4.39-6.99)
20~29	943 (0.262)	7.91 (7.57-8.25)	765 (0.27)	6.41 (6.06-6.76)	1056 (0.202)	5.18 (4.9-5.46)	944 (0.209)	4.64 (4.36-4.92)	1071 (0.201)	5.16 (4.91-5.41)	797 (0.238)	4.43 (4.17-4.69)	875 (0.255)	5.42 (5.13-5.71)	664 (0.295)	4.53 (4.26-4.8)
30~39	787 (0.218)	8.66 (8.27-9.05)	651 (0.229)	7.13 (6.72-7.54)	938 (0.179)	5.14 (4.83-5.45)	830 (0.184)	4.61 (4.3-4.92)	954 (0.179)	5 (4.73-5.27)	668 (0.199)	4.43 (4.14-4.72)	739 (0.216)	5.52 (5.19-5.85)	528 (0.234)	4.74 (4.41-5.07)
40~49	758 (0.21)	8.99 (8.58-9.4)	579 (0.204)	7.53 (7.08-7.98)	912 (0.174)	5.3 (4.97-5.63)	790 (0.175)	4.57 (4.25-4.89)	908 (0.171)	4.94 (4.65-5.23)	583 (0.174)	4.34 (4.02-4.66)	619 (0.181)	5.81 (5.41-6.21)	398 (0.177)	4.66 (4.27-5.05)
50~59	599 (0.166)	10.24 (9.8-10.68)	454 (0.16)	8.87 (8.34-9.4)	853 (0.163)	5.4 (5.03-5.77)	709 (0.157)	4.92 (4.53-5.31)	855 (0.161)	5.12 (4.81-5.43)	501 (0.149)	4.32 (3.94-4.7)	473 (0.138)	6.24 (5.74-6.74)	264 (0.117)	5.14 (4.55-5.73)
60~64	174 (0.048)	9.83 (8.96-10.7)	136 (0.048)	9.32 (8.29-10.35)	343 (0.066)	4.77 (4.23-5.31)	276 (0.061)	4.59 (3.98-5.2)	349 (0.066)	4.46 (4.03-4.89)	162 (0.048)	3.82 (3.23-4.41)	149 (0.043)	5.97 (5.08-6.86)	71 (0.031)	5.11 (3.88-6.34)
65~69	126 (0.035)	9.6 (8.59-10.61)	88 (0.031)	8.27 (7-9.54)	379 (0.072)	4.34 (3.86-4.82)	328 (0.073)	3.93 (3.45-4.41)	389 (0.073)	4.43 (4.03-4.83)	197 (0.059)	3.87 (3.33-4.41)	180 (0.053)	6.31 (5.5-7.12)	102 (0.045)	4.95 (4-5.9)
70 and above	108 (0.03)	7.12 (6.01-8.23)	88 (0.031)	6.21 (5.06-7.36)	637 (0.122)	3.83 (3.5-4.16)	547 (0.121)	3.66 (3.3-4.02)	675 (0.127)	4.03 (3.75-4.31)	372 (0.111)	3.59 (3.22-3.96)	292 (0.085)	6.45 (5.83-7.07)	172 (0.076)	5.78 (4.96-6.6)
Gender																
Male	1889 (0.524)	8.46 (8.21-8.71)	1542 (0.543)	7.13 (6.86-7.4)	2593 (0.495)	4.9 (4.72-5.08)	2287 (0.507)	4.58 (4.39-4.77)	2629 (0.494)	4.81 (4.65-4.97)	1745 (0.52)	4.37 (4.19-4.55)	1808 (0.528)	5.6 (5.38-5.82)	1280 (0.568)	4.75 (4.53-4.97)
Female	1717 (0.476)	9.28 (9.01-9.55)	1296 (0.457)	7.77 (7.46-8.08)	2643 (0.505)	5.06 (4.87-5.25)	2225 (0.493)	4.41 (4.21-4.61)	2689 (0.506)	4.9 (4.73-5.07)	1610 (0.48)	4.14 (3.95-4.33)	1619 (0.472)	6.02 (5.77-6.27)	974 (0.432)	4.95 (4.67-5.23)
Country																
AU	535 (0.148)	8.29 (7.82-8.76)	446 (0.157)	7.21 (6.71-7.71)	795 (0.152)	5.02 (4.68-5.36)	717 (0.159)	4.73 (4.39-5.07)	835 (0.157)	4.87 (4.59-5.15)	631 (0.188)	4.46 (4.17-4.75)	571 (0.167)	5.51 (5.13-5.89)	479 (0.213)	4.82 (4.46-5.18)
US	651 (0.181)	7.92 (7.5-8.34)	489 (0.172)	6.23 (5.78-6.68)	1009 (0.193)	4.85 (4.57-5.13)	851 (0.189)	4.35 (4.06-4.64)	1028 (0.193)	4.91 (4.65-5.17)	673 (0.201)	4.46 (4.15-4.77)	675 (0.197)	5.64 (5.28-6)	455 (0.202)	4.64 (4.28-5)
NZ	619 (0.172)	9.44 (9-9.88)	553 (0.195)	8.63 (8.16-9.1)	908 (0.173)	5.28 (4.95-5.61)	823 (0.182)	5 (4.66-5.34)	956 (0.18)	5.1 (4.82-5.38)	762 (0.227)	4.68 (4.39-4.97)	608 (0.177)	6.29 (5.88-6.7)	489 (0.217)	5.9 (5.46-6.34)
CA	563 (0.156)	8.74 (8.26-9.22)	360 (0.127)	6.86 (6.3-7.42)	840 (0.16)	5.11 (4.77-5.45)	633 (0.14)	4.28 (3.92-4.64)	854 (0.161)	4.76 (4.47-5.05)	394 (0.117)	3.3 (3-3.6)	538 (0.157)	6.12 (5.67-6.57)	228 (0.101)	4.01 (3.55-4.47)
UK	647 (0.179)	9.05 (8.62-9.48)	445 (0.157)	6.52 (6.03-7.01)	880 (0.168)	4.59 (4.28-4.9)	680 (0.151)	3.82 (3.51-4.13)	895 (0.168)	4.62 (4.36-4.88)	303 (0.09)	3.84 (3.48-4.2)	590 (0.172)	5.23 (4.85-5.61)	266 (0.118)	3.8 (3.44-4.16)
JP	591 (0.164)	9.65 (9.19-10.11)	545 (0.192)	8.55 (8.07-9.03)	804 (0.154)	5.07 (4.71-5.43)	808 (0.179)	4.68 (4.33-5.03)	750 (0.141)	4.82 (4.49-5.15)	592 (0.176)	4.16 (3.82-4.5)	445 (0.13)	6.12 (5.63-6.61)	337 (0.15)	4.95 (4.45-5.45)
Occupation																
Company employee / self-employed	2054 (0.57)	8.85 (8.61-9.09)	1663 (0.586)	7.42 (7.16-7.68)	2236 (0.427)	5.42 (5.21-5.63)	1951 (0.432)	4.84 (4.63-5.05)	2273 (0.427)	5.21 (5.03-5.39)	1524 (0.454)	4.46 (4.26-4.66)	1673 (0.488)	5.75 (5.52-5.98)	1140 (0.506)	4.6 (4.37-4.83)

	Work/Study				Shopping				Eating out				Physical exercise			
	Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic	
Variable	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)
Governmental officer	273 (0.076)	9.97 (9.31-10.63)	228 (0.08)	8.49 (7.76-9.22)	281 (0.054)	5.67 (5.07-6.27)	248 (0.055)	5.15 (4.55-5.75)	305 (0.057)	5.01 (4.54-5.48)	208 (0.062)	4.6 (4.05-5.15)	229 (0.067)	6.03 (5.39-6.67)	170 (0.075)	5.22 (4.61-5.83)
Faculty or staff of an educational institution	178 (0.049)	10.42 (9.61-11.23)	150 (0.053)	8.82 (7.91-9.73)	171 (0.033)	6.35 (5.52-7.18)	152 (0.034)	5.94 (5.1-6.78)	185 (0.035)	5.81 (5.14-6.48)	125 (0.037)	5.6 (4.89-6.31)	143 (0.042)	6.34 (5.49-7.19)	96 (0.043)	5.92 (5.06-6.78)
Housewife or househusband	88 (0.024)	8.18 (6.95-9.41)	47 (0.017)	5.32 (3.86-6.78)	394 (0.075)	4.11 (3.67-4.55)	329 (0.073)	3.75 (3.28-4.22)	382 (0.072)	4.01 (3.63-4.39)	238 (0.071)	3.44 (3.03-3.85)	211 (0.062)	5.51 (4.85-6.17)	124 (0.055)	4.48 (3.75-5.21)
Part-time job	424 (0.118)	8.1 (7.56-8.64)	371 (0.131)	7.34 (6.78-7.9)	490 (0.094)	5.17 (4.72-5.62)	444 (0.098)	4.71 (4.27-5.15)	499 (0.094)	4.83 (4.45-5.21)	338 (0.101)	4.3 (3.88-4.72)	321 (0.094)	5.42 (4.89-5.95)	223 (0.099)	4.81 (4.26-5.36)
Student	242 (0.067)	8.94 (8.22-9.66)	171 (0.06)	7.02 (6.19-7.85)	250 (0.048)	5.5 (4.88-6.12)	202 (0.045)	4.54 (3.93-5.15)	251 (0.047)	5.72 (5.14-6.3)	161 (0.048)	4.51 (3.94-5.08)	210 (0.061)	6.1 (5.41-6.79)	124 (0.055)	5.23 (4.44-6.02)
Other unemployed (including retired)	200 (0.055)	8.63 (7.81-9.45)	82 (0.029)	6.31 (5.12-7.5)	1128 (0.215)	3.85 (3.6-4.1)	945 (0.209)	3.54 (3.28-3.8)	1142 (0.215)	4.09 (3.87-4.31)	585 (0.174)	3.55 (3.26-3.84)	467 (0.136)	5.97 (5.48-6.46)	250 (0.111)	5.36 (4.71-6.01)
Other	147 (0.041)	7.55 (6.63-8.47)	126 (0.044)	6.17 (5.26-7.08)	286 (0.055)	4.91 (4.34-5.48)	241 (0.053)	4.48 (3.9-5.06)	281 (0.053)	4.73 (4.22-5.24)	176 (0.052)	4.38 (3.76-5)	173 (0.05)	5.79 (5.04-6.54)	127 (0.056)	4.54 (3.85-5.23)
Household size																
1	552 (0.153)	8.83 (8.35-9.31)	424 (0.149)	7.35 (6.81-7.89)	926 (0.177)	4.45 (4.14-4.76)	798 (0.177)	4.11 (3.79-4.43)	936 (0.176)	4.48 (4.22-4.74)	531 (0.158)	3.71 (3.41-4.01)	503 (0.147)	5.72 (5.26-6.18)	337 (0.15)	4.53 (4.06-5)
2	1056 (0.293)	8.95 (8.61-9.29)	793 (0.279)	7.66 (7.27-8.05)	1827 (0.349)	4.81 (4.58-5.04)	1565 (0.347)	4.45 (4.21-4.69)	1890 (0.355)	4.66 (4.47-4.85)	1098 (0.327)	4.15 (3.91-4.39)	1061 (0.31)	5.87 (5.56-6.18)	623 (0.276)	4.87 (4.51-5.23)
3	818 (0.227)	8.88 (8.5-9.26)	654 (0.23)	7.26 (6.85-7.67)	1092 (0.209)	5.15 (4.86-5.44)	947 (0.21)	4.58 (4.29-4.87)	1079 (0.203)	4.88 (4.63-5.13)	723 (0.215)	4.28 (4.01-4.55)	767 (0.224)	5.66 (5.32-6)	515 (0.228)	4.67 (4.33-5.01)
4	787 (0.218)	8.75 (8.36-9.14)	648 (0.228)	7.34 (6.92-7.76)	916 (0.175)	5.43 (5.11-5.75)	791 (0.175)	4.58 (4.28-4.88)	929 (0.175)	5.27 (4.99-5.55)	666 (0.199)	4.57 (4.28-4.86)	716 (0.209)	5.86 (5.52-6.2)	509 (0.226)	5 (4.65-5.35)
5	260 (0.072)	8.63 (7.95-9.31)	213 (0.075)	7.45 (6.7-8.2)	309 (0.059)	5.64 (5.08-6.2)	267 (0.059)	5.24 (4.65-5.83)	309 (0.058)	5.53 (5.07-5.99)	209 (0.062)	4.72 (4.22-5.22)	241 (0.07)	5.89 (5.32-6.46)	162 (0.072)	4.71 (4.16-5.26)
6+	133 (0.037)	9.02 (8.08-9.96)	106 (0.037)	7.38 (6.31-8.45)	166 (0.032)	5.02 (4.3-5.74)	144 (0.032)	4.74 (4-5.48)	175 (0.033)	5.48 (4.81-6.15)	128 (0.038)	5.08 (4.31-5.85)	139 (0.041)	5.82 (5.03-6.61)	108 (0.048)	5.76 (4.87-6.65)
Education																
No formal qualification	17 (0.005)	10.26 (7.41-13.11)	16 (0.006)	6.53 (3.65-9.41)	37 (0.007)	4.36 (2.93-5.79)	26 (0.006)	4.15 (2.55-5.75)	40 (0.008)	4.23 (3.11-5.35)	24 (0.007)	3.4 (2.42-4.38)	21 (0.006)	5.33 (2.99-7.67)	15 (0.007)	4.8 (2.63-6.97)
Elementary school	24 (0.007)	6.88 (4.96-8.8)	32 (0.011)	5.78 (4.17-7.39)	38 (0.007)	4.47 (3.12-5.82)	46 (0.01)	4.32 (3.41-5.23)	57 (0.011)	4.41 (3.36-5.46)	47 (0.014)	5.57 (4.42-6.72)	42 (0.012)	5.02 (4.13-5.91)	43 (0.019)	5.81 (4.83-6.79)
Middle school/ Junior high school	199 (0.055)	8.56 (7.76-9.36)	167 (0.059)	7.06 (6.24-7.88)	387 (0.074)	4.59 (4.1-5.08)	321 (0.071)	4.11 (3.62-4.6)	376 (0.071)	4.27 (3.89-4.65)	213 (0.063)	3.79 (3.37-4.21)	200 (0.058)	5.28 (4.6-5.96)	143 (0.063)	4.87 (4.16-5.58)
High school/ Senior high school	606 (0.168)	8.53 (8.08-8.98)	490 (0.173)	7.41 (6.92-7.9)	998 (0.191)	4.63 (4.34-4.92)	880 (0.195)	4.28 (3.99-4.57)	960 (0.181)	4.47 (4.21-4.73)	584 (0.174)	4.19 (3.87-4.51)	569 (0.166)	5.49 (5.09-5.89)	358 (0.159)	4.82 (4.38-5.26)
College/ Vocational school	725 (0.201)	8.86 (8.45-9.27)	565 (0.199)	7.39 (6.93-7.85)	1162 (0.222)	5.06 (4.77-5.35)	990 (0.219)	4.53 (4.23-4.83)	1199 (0.225)	4.97 (4.72-5.22)	737 (0.22)	4.19 (3.89-4.49)	720 (0.21)	5.83 (5.46-6.2)	434 (0.193)	4.86 (4.45-5.27)
Undergraduate/ Bachelor	1347 (0.374)	9.22 (8.92-9.52)	1025 (0.361)	7.94 (7.6-8.28)	1770 (0.338)	5.14 (4.9-5.38)	1527 (0.338)	4.54 (4.3-4.78)	1824 (0.343)	4.99 (4.79-5.19)	1175 (0.35)	4.24 (4.02-4.46)	1200 (0.35)	6 (5.71-6.29)	786 (0.349)	4.73 (4.43-5.03)
Master degree	588 (0.163)	8.5 (8.05-8.95)	461 (0.162)	6.68 (6.2-7.16)	711 (0.136)	5.22 (4.87-5.57)	606 (0.134)	4.83 (4.47-5.19)	730 (0.137)	5.18 (4.87-5.49)	486 (0.145)	4.53 (4.19-4.87)	575 (0.168)	5.91 (5.52-6.3)	408 (0.181)	4.91 (4.53-5.29)
Doctoral degree	100 (0.028)	8.58 (7.45-9.71)	82 (0.029)	6.99 (5.79-8.19)	133 (0.025)	4.99 (4.21-5.77)	116 (0.026)	4.87 (4.04-5.7)	132 (0.025)	5.03 (4.31-5.75)	89 (0.027)	4.83 (3.89-5.77)	100 (0.029)	5.78 (4.84-6.72)	67 (0.03)	4.81 (3.85-5.77)
Income																
Under 24,999USD	317 (0.088)	8.03 (7.4-8.66)	241 (0.085)	7.11 (6.4-7.82)	621 (0.119)	4.52 (4.15-4.89)	569 (0.126)	4.39 (4-4.78)	541 (0.102)	4.36 (4.01-4.71)	365 (0.109)	4.18 (3.77-4.59)	300 (0.088)	5.44 (4.89-5.99)	206 (0.091)	4.9 (4.28-5.52)
25,000 to 34,999USD	269 (0.075)	7.62 (6.95-8.29)	223 (0.079)	6.83 (6.12-7.54)	533 (0.102)	3.81 (3.45-4.17)	458 (0.102)	3.7 (3.32-4.08)	539 (0.101)	4.01 (3.69-4.33)	318 (0.095)	3.56 (3.2-3.92)	285 (0.083)	5.52 (4.95-6.09)	205 (0.091)	4.9 (4.3-5.5)

		Work/Study				Shopping				Eating out				Physical exercise			
		Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic	
Variable		Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)
35,000 to 49,999USD		388 (0.108)	8.21 (7.65-8.77)	310 (0.109)	6.99 (6.39-7.59)	681 (0.13)	4.61 (4.26-4.96)	579 (0.128)	4.08 (3.72-4.44)	677 (0.127)	4.58 (4.27-4.89)	371 (0.111)	3.95 (3.57-4.33)	360 (0.105)	5.75 (5.22-6.28)	222 (0.098)	4.73 (4.16-5.3)
50,000 to 74,999USD		606 (0.168)	8.86 (8.41-9.31)	463 (0.163)	7.14 (6.65-7.63)	885 (0.169)	4.84 (4.52-5.16)	744 (0.165)	3.96 (3.66-4.26)	923 (0.174)	4.69 (4.42-4.96)	543 (0.162)	3.83 (3.54-4.12)	611 (0.178)	5.4 (5.02-5.78)	371 (0.165)	4.51 (4.1-4.92)
75,000 to 99,999USD		583 (0.162)	9.05 (8.6-9.5)	446 (0.157)	7.58 (7.07-8.09)	804 (0.154)	5.53 (5.17-5.89)	686 (0.152)	4.88 (4.51-5.25)	847 (0.159)	5.23 (4.93-5.53)	538 (0.16)	4.59 (4.24-4.94)	553 (0.161)	5.99 (5.57-6.41)	374 (0.166)	4.62 (4.21-5.03)
100,000 to 124,999USD		487 (0.135)	9.2 (8.7-9.7)	390 (0.137)	7.39 (6.85-7.93)	605 (0.116)	5.24 (4.84-5.64)	518 (0.115)	4.68 (4.28-5.08)	648 (0.122)	4.94 (4.62-5.26)	410 (0.122)	4.26 (3.89-4.63)	463 (0.135)	5.67 (5.23-6.11)	289 (0.128)	4.62 (4.19-5.05)
125,000 to 149,999USD		374 (0.104)	9.2 (8.64-9.76)	293 (0.103)	7.71 (7.08-8.34)	443 (0.085)	5.4 (4.94-5.86)	379 (0.084)	5.11 (4.63-5.59)	451 (0.085)	5.06 (4.67-5.45)	317 (0.094)	4.61 (4.18-5.04)	331 (0.097)	5.93 (5.41-6.45)	224 (0.099)	5.09 (4.55-5.63)
150,000 to 174,999USD		266 (0.074)	9.37 (8.7-10.04)	229 (0.081)	8.09 (7.37-8.81)	294 (0.056)	5.63 (5.04-6.22)	266 (0.059)	5.17 (4.56-5.78)	307 (0.058)	5.58 (5.07-6.09)	230 (0.069)	4.96 (4.39-5.53)	235 (0.069)	6.56 (5.89-7.23)	167 (0.074)	5.56 (4.85-6.27)
175,000 to 199,999USD		134 (0.037)	9.37 (8.39-10.35)	103 (0.036)	8.07 (6.93-9.21)	159 (0.03)	5.73 (4.93-6.53)	129 (0.029)	5.41 (4.57-6.25)	165 (0.031)	5.55 (4.86-6.24)	110 (0.033)	4.67 (3.94-5.4)	130 (0.038)	6.42 (5.54-7.3)	87 (0.039)	4.7 (3.83-5.57)
200,000USD and over		182 (0.05)	9.99 (9.15-10.83)	140 (0.049)	8.26 (7.29-9.23)	211 (0.04)	5.9 (5.16-6.64)	184 (0.041)	5.48 (4.69-6.27)	220 (0.041)	6.02 (5.36-6.68)	153 (0.046)	5.06 (4.31-5.81)	159 (0.046)	6.48 (5.64-7.32)	109 (0.048)	5.67 (4.7-6.64)
Frequency																	
A few times a year		116 (0.032)	4.63 (3.97-5.29)	94 (0.033)	4.27 (3.57-4.97)	73 (0.014)	4.16 (3.46-4.86)	107 (0.024)	4.62 (3.92-5.32)	77 (0.014)	4.34 (3.61-5.07)	103 (0.031)	4.37 (3.69-5.05)	66 (0.019)	4.26 (3.36-5.16)	100 (0.044)	4.53 (3.78-5.28)
Less than once a month		212 (0.059)	5.5 (4.93-6.07)	268 (0.094)	4.92 (4.44-5.4)	262 (0.05)	4.37 (3.91-4.83)	503 (0.111)	3.93 (3.59-4.27)	1263 (0.237)	4.39 (4.17-4.61)	1483 (0.442)	3.97 (3.77-4.17)	692 (0.202)	5.08 (4.73-5.43)	648 (0.287)	4.29 (3.99-4.59)
Once or twice a month		191 (0.053)	5.52 (4.92-6.12)	260 (0.092)	5.25 (4.75-5.75)	739 (0.141)	4.66 (4.34-4.98)	969 (0.215)	4.25 (3.98-4.52)	1914 (0.36)	4.96 (4.76-5.16)	966 (0.288)	4.38 (4.13-4.63)	683 (0.199)	5.16 (4.85-5.47)	499 (0.221)	4.29 (3.99-4.59)
Once or twice a week		413 (0.115)	7.26 (6.74-7.78)	524 (0.185)	6.7 (6.26-7.14)	3558 (0.68)	5.05 (4.88-5.22)	2594 (0.575)	4.61 (4.42-4.8)	1819 (0.342)	4.97 (4.77-5.17)	654 (0.195)	4.49 (4.19-4.79)	1323 (0.386)	6.26 (5.98-6.54)	669 (0.297)	5.48 (5.14-5.82)
Daily or almost daily		2674 (0.742)	9.78 (9.57-9.99)	1692 (0.596)	8.55 (8.28-8.82)	604 (0.115)	5.34 (4.93-5.75)	339 (0.075)	5.18 (4.65-5.71)	245 (0.046)	5.71 (5.13-6.29)	149 (0.044)	5.3 (4.64-5.96)	663 (0.193)	6.44 (6.02-6.86)	338 (0.15)	5.49 (4.96-6.02)
Duration																	
Less than 5 mins		90 (0.025)	5.79 (4.69-6.89)	109 (0.038)	4 (3.17-4.83)	106 (0.02)	3.61 (2.92-4.3)	123 (0.027)	3.85 (3.1-4.6)	123 (0.023)	3.53 (2.98-4.08)	148 (0.044)	3.15 (2.58-3.72)	146 (0.043)	3.91 (3.23-4.59)	116 (0.051)	3.4 (2.75-4.05)
5 mins - 15 mins		245 (0.068)	5.39 (4.81-5.97)	190 (0.067)	4.75 (4.14-5.36)	562 (0.107)	4.19 (3.84-4.54)	578 (0.128)	3.95 (3.62-4.28)	387 (0.073)	3.85 (3.51-4.19)	292 (0.087)	3.64 (3.25-4.03)	267 (0.078)	4.5 (4.02-4.98)	237 (0.105)	3.97 (3.56-4.38)
15 mins - 1 hour		623 (0.173)	6.21 (5.85-6.57)	599 (0.211)	5.13 (4.82-5.44)	2953 (0.564)	4.81 (4.64-4.98)	2813 (0.623)	4.34 (4.17-4.51)	2045 (0.385)	4.51 (4.34-4.68)	1659 (0.494)	4.03 (3.86-4.2)	1476 (0.431)	5.08 (4.86-5.3)	1102 (0.489)	4.34 (4.13-4.55)
1 hour - 4 hours		377 (0.105)	6.98 (6.45-7.51)	365 (0.129)	6.25 (5.73-6.77)	1508 (0.288)	5.52 (5.26-5.78)	924 (0.205)	5.29 (4.96-5.62)	2656 (0.499)	5.24 (5.07-5.41)	1180 (0.352)	4.77 (4.52-5.02)	1417 (0.413)	6.87 (6.59-7.15)	712 (0.316)	5.81 (5.45-6.17)
4 hours or longer		2271 (0.63)	10.38 (10.15-10.61)	1575 (0.555)	9.13 (8.85-9.41)	107 (0.02)	7.68 (6.61-8.75)	74 (0.016)	6.05 (4.82-7.28)	107 (0.02)	7 (6.02-7.98)	76 (0.023)	6.08 (5.05-7.11)	121 (0.035)	7.19 (6.27-8.11)	87 (0.039)	7.3 (6.21-8.39)
Contact mode																	
Only non-physical contacts		1082 (0.3)	6.54 (6.23-6.85)	1188 (0.419)	5.88 (5.6-6.16)	2442 (0.466)	4.51 (4.32-4.7)	2703 (0.599)	4.03 (3.86-4.2)	2051 (0.386)	4.12 (3.95-4.29)	1694 (0.505)	3.7 (3.53-3.87)	1267 (0.37)	4.86 (4.61-5.11)	1039 (0.461)	4.12 (3.88-4.36)
Only physical contacts		838 (0.232)	8.69 (8.32-9.06)	633 (0.223)	7.24 (6.84-7.64)	1279 (0.244)	4.96 (4.71-5.21)	977 (0.217)	4.79 (4.51-5.07)	1514 (0.285)	5.03 (4.82-5.24)	883 (0.263)	4.6 (4.35-4.85)	1041 (0.304)	5.9 (5.62-6.18)	699 (0.31)	5.18 (4.89-5.47)
Both non-physical and physical contacts		1686 (0.468)	10.41 (10.15-10.67)	1017 (0.358)	9.34 (8.99-9.69)	1515 (0.289)	5.75 (5.48-6.02)	832 (0.184)	5.65 (5.28-6.02)	1753 (0.33)	5.57 (5.35-5.79)	778 (0.232)	5.1 (4.79-5.41)	1119 (0.327)	6.77 (6.45-7.09)	516 (0.229)	5.8 (5.38-6.22)
Protecting measures																	
Wear a mask	Yes	797 (0.221)	7 (6.61-7.39)	1775 (0.625)	7.51 (7.25-7.77)	1006 (0.192)	4.31 (4.03-4.59)	3093 (0.686)	4.2 (4.04-4.36)	769 (0.145)	4.34 (4.06-4.62)	1700 (0.507)	3.8 (3.62-3.98)	533 (0.156)	4.56 (4.23-4.89)	1010 (0.448)	4.14 (3.89-4.39)
	No	2809 (0.779)	9.38 (9.18-9.58)	1063 (0.375)	7.28 (6.97-7.59)	4230 (0.808)	5.14 (4.99-5.29)	1419 (0.314)	5.16 (4.92-5.4)	4549 (0.855)	4.94 (4.81-5.07)	1655 (0.493)	4.74 (4.55-4.93)	2894 (0.844)	6.03 (5.84-6.22)	1244 (0.552)	5.39 (5.15-5.63)

		Work/Study				Shopping				Eating out				Physical exercise			
		Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic	
Variable		Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)
Disinfect hands	Yes	936 (0.26)	8.19 (7.83-8.55)	1709 (0.602)	7.88 (7.61-8.15)	1351 (0.258)	4.87 (4.62-5.12)	3108 (0.689)	4.41 (4.24-4.58)	1345 (0.253)	4.61 (4.39-4.83)	2104 (0.627)	3.98 (3.82-4.14)	828 (0.242)	5.5 (5.19-5.81)	1199 (0.532)	4.75 (4.5-5)
	No	2670 (0.74)	9.08 (8.87-9.29)	1129 (0.398)	6.73 (6.43-7.03)	3885 (0.742)	5.02 (4.86-5.18)	1404 (0.311)	4.68 (4.44-4.92)	3973 (0.747)	4.94 (4.81-5.07)	1251 (0.373)	4.73 (4.51-4.95)	2599 (0.758)	5.9 (5.71-6.09)	1055 (0.468)	4.93 (4.69-5.17)
Distancing with others	Yes	617 (0.171)	7.34 (6.93-7.75)	1606 (0.566)	7.68 (7.41-7.95)	1068 (0.204)	4.52 (4.26-4.78)	3011 (0.667)	4.39 (4.22-4.56)	995 (0.187)	4.57 (4.33-4.81)	2136 (0.637)	4.1 (3.94-4.26)	692 (0.202)	4.97 (4.67-5.27)	1207 (0.535)	4.75 (4.51-4.99)
	No	2989 (0.829)	9.16 (8.96-9.36)	1232 (0.434)	7.09 (6.79-7.39)	4168 (0.796)	5.1 (4.95-5.25)	1501 (0.333)	4.72 (4.49-4.95)	4323 (0.813)	4.92 (4.79-5.05)	1219 (0.363)	4.55 (4.33-4.77)	2735 (0.798)	6.01 (5.82-6.2)	1047 (0.465)	4.93 (4.68-5.18)
No measures are taken	Yes	1900 (0.527)	10.05 (9.8-10.3)	220 (0.078)	7.78 (7-8.56)	2933 (0.56)	5.22 (5.03-5.41)	194 (0.043)	5.69 (4.91-6.47)	3041 (0.572)	5 (4.84-5.16)	216 (0.064)	5.39 (4.73-6.05)	1805 (0.527)	6.34 (6.08-6.6)	177 (0.079)	5.83 (5.04-6.62)
	No	1706 (0.473)	7.51 (7.25-7.77)	2618 (0.922)	7.39 (7.18-7.6)	2303 (0.44)	4.67 (4.49-4.85)	4318 (0.957)	4.44 (4.3-4.58)	2277 (0.428)	4.66 (4.5-4.82)	3139 (0.936)	4.19 (4.06-4.32)	1622 (0.473)	5.2 (5-5.4)	2077 (0.921)	4.75 (4.57-4.93)

Appendix 5: Statistics of social contacts for Party, Cultural leisure, Medical activities, Public transport setting before and during the COVID-19 pandemic

	Party				Cultural leisure				Medical activities				Public transport			
	Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic	
Variable	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)
Total	4278 (1)	7.21 (7.05-7.37)	2304 (1)	5.68 (5.5-5.86)	4476 (1)	6.32 (6.16-6.48)	2223 (1)	5.29 (5.1-5.48)	5365 (1)	3.66 (3.56-3.76)	4211 (1)	3.34 (3.24-3.44)	3186 (1)	6.96 (6.77-7.15)	1928 (1)	5.96 (5.74-6.18)
Age																
Less than 19	96 (0.022)	8.06 (7-9.12)	55 (0.024)	6.74 (5.39-8.09)	101 (0.023)	6.67 (5.7-7.64)	55 (0.025)	5.25 (4.11-6.39)	113 (0.021)	4.75 (3.95-5.55)	84 (0.02)	3.62 (2.87-4.37)	87 (0.027)	6.93 (5.81-8.05)	63 (0.033)	6.03 (4.81-7.25)
20~29	959 (0.224)	6.87 (6.56-7.18)	663 (0.288)	5.45 (5.13-5.77)	974 (0.218)	6.17 (5.86-6.48)	632 (0.284)	5.07 (4.75-5.39)	1041 (0.194)	4.47 (4.22-4.72)	834 (0.198)	4.06 (3.81-4.31)	787 (0.247)	6.35 (6-6.7)	574 (0.298)	5.47 (5.12-5.82)
30~39	857 (0.2)	7.06 (6.72-7.4)	539 (0.234)	5.55 (5.18-5.92)	899 (0.201)	6.24 (5.91-6.57)	539 (0.242)	4.99 (4.64-5.34)	940 (0.175)	4.4 (4.13-4.67)	741 (0.176)	3.93 (3.66-4.2)	673 (0.211)	7.15 (6.74-7.56)	454 (0.235)	6.01 (5.58-6.44)
40~49	769 (0.18)	7.39 (7.01-7.77)	422 (0.183)	5.67 (5.23-6.11)	798 (0.178)	6.46 (6.09-6.83)	404 (0.182)	5.18 (4.74-5.62)	900 (0.168)	3.78 (3.53-4.03)	663 (0.157)	3.47 (3.21-3.73)	563 (0.177)	6.85 (6.4-7.3)	356 (0.185)	5.74 (5.23-6.25)
50~59	672 (0.157)	7.67 (7.25-8.09)	293 (0.127)	6.33 (5.74-6.92)	700 (0.156)	6.91 (6.48-7.34)	284 (0.128)	6.06 (5.43-6.69)	861 (0.16)	3.19 (2.96-3.42)	659 (0.156)	2.91 (2.68-3.14)	447 (0.14)	8 (7.42-8.58)	222 (0.115)	7.21 (6.43-7.99)
60~64	250 (0.058)	7.67 (6.99-8.35)	73 (0.032)	6.41 (5.24-7.58)	275 (0.061)	6.48 (5.8-7.16)	74 (0.033)	5.16 (3.91-6.41)	358 (0.067)	3.04 (2.68-3.4)	265 (0.063)	2.93 (2.53-3.33)	178 (0.056)	7.42 (6.53-8.31)	67 (0.035)	6.6 (5.2-8)
65~69	262 (0.061)	7.22 (6.58-7.86)	97 (0.042)	5.57 (4.66-6.48)	272 (0.061)	5.96 (5.29-6.63)	86 (0.039)	6.17 (4.94-7.4)	418 (0.078)	2.75 (2.49-3.01)	339 (0.081)	2.62 (2.35-2.89)	174 (0.055)	7.02 (6.11-7.93)	71 (0.037)	6.36 (4.97-7.75)
70 and above	413 (0.097)	6.73 (6.25-7.21)	162 (0.07)	5.3 (4.61-5.99)	457 (0.102)	5.69 (5.19-6.19)	149 (0.067)	5.66 (4.79-6.53)	734 (0.137)	2.6 (2.42-2.78)	626 (0.149)	2.52 (2.33-2.71)	277 (0.087)	6.46 (5.75-7.17)	121 (0.063)	5.89 (4.85-6.93)
Gender																
Male	2189 (0.512)	6.87 (6.66-7.08)	1302 (0.565)	5.65 (5.41-5.89)	2204 (0.492)	6.04 (5.83-6.25)	1250 (0.562)	5.15 (4.91-5.39)	2615 (0.487)	3.83 (3.69-3.97)	2103 (0.499)	3.56 (3.41-3.71)	1664 (0.522)	6.68 (6.42-6.94)	1072 (0.556)	5.83 (5.55-6.11)
Female	2089 (0.488)	7.56 (7.33-7.79)	1002 (0.435)	5.72 (5.43-6.01)	2272 (0.508)	6.59 (6.36-6.82)	973 (0.438)	5.47 (5.16-5.78)	2750 (0.513)	3.5 (3.36-3.64)	2108 (0.501)	3.12 (2.98-3.26)	1522 (0.478)	7.26 (6.97-7.55)	856 (0.444)	6.14 (5.79-6.49)
Country																
AU	726 (0.17)	6.88 (6.52-7.24)	510 (0.221)	5.83 (5.44-6.22)	728 (0.163)	6.06 (5.7-6.42)	500 (0.225)	5.49 (5.09-5.89)	848 (0.158)	3.86 (3.59-4.13)	727 (0.173)	3.51 (3.26-3.76)	549 (0.172)	6.62 (6.18-7.06)	397 (0.206)	5.88 (5.42-6.34)
US	827 (0.193)	6.84 (6.5-7.18)	481 (0.209)	5.26 (4.89-5.63)	846 (0.189)	6.57 (6.22-6.92)	419 (0.188)	5 (4.6-5.4)	1065 (0.199)	3.81 (3.6-4.02)	868 (0.206)	3.33 (3.13-3.53)	483 (0.152)	6.63 (6.17-7.09)	290 (0.15)	5.01 (4.58-5.44)
NZ	795 (0.186)	7.97 (7.6-8.34)	614 (0.266)	6.95 (6.54-7.36)	800 (0.179)	6.67 (6.29-7.05)	598 (0.269)	6.06 (5.65-6.47)	969 (0.181)	3.41 (3.19-3.63)	860 (0.204)	3.11 (2.9-3.32)	519 (0.163)	6.5 (6.04-6.96)	373 (0.193)	6.22 (5.68-6.76)
CA	696 (0.163)	7.46 (7.06-7.86)	215 (0.093)	4.53 (4.02-5.04)	735 (0.164)	6.55 (6.16-6.94)	196 (0.088)	4.24 (3.77-4.71)	867 (0.162)	3.36 (3.13-3.59)	557 (0.132)	2.72 (2.5-2.94)	466 (0.146)	7.69 (7.15-8.23)	203 (0.105)	5.98 (5.34-6.62)
UK	798 (0.187)	6.78 (6.42-7.14)	247 (0.107)	4.25 (3.84-4.66)	815 (0.182)	5.46 (5.12-5.8)	214 (0.096)	3.82 (3.44-4.2)	865 (0.161)	2.9 (2.7-3.1)	511 (0.121)	2.81 (2.57-3.05)	654 (0.205)	6.69 (6.26-7.12)	302 (0.157)	4.78 (4.3-5.26)
JP	436 (0.102)	7.44 (6.94-7.94)	237 (0.103)	5.47 (4.86-6.08)	552 (0.123)	6.72 (6.23-7.21)	296 (0.133)	5.55 (4.94-6.16)	751 (0.14)	4.75 (4.42-5.08)	688 (0.163)	4.34 (4.02-4.66)	515 (0.162)	7.79 (7.26-8.32)	363 (0.188)	7.53 (6.91-8.15)

	Party				Cultural leisure				Medical activities				Public transport			
	Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic	
Variable	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)
Occupation																
Company employee / self-employed	1994 (0.466)	7.4 (7.17-7.63)	1149 (0.499)	5.64 (5.38-5.9)	2029 (0.453)	6.53 (6.3-6.76)	1131 (0.509)	5.29 (5.02-5.56)	2197 (0.41)	4 (3.84-4.16)	1674 (0.398)	3.64 (3.47-3.81)	1484 (0.466)	7.22 (6.94-7.5)	927 (0.481)	6.22 (5.9-6.54)
Governmental officier	267 (0.062)	7.62 (7-8.24)	170 (0.074)	6.42 (5.69-7.15)	272 (0.061)	6.85 (6.23-7.47)	158 (0.071)	5.93 (5.18-6.68)	296 (0.055)	4.56 (4.06-5.06)	236 (0.056)	4.25 (3.72-4.78)	207 (0.065)	6.93 (6.21-7.65)	134 (0.07)	5.75 (5-6.5)
Faculty or staff of an educational institution	177 (0.041)	7.52 (6.77-8.27)	104 (0.045)	6.56 (5.66-7.46)	177 (0.04)	7.5 (6.71-8.29)	97 (0.044)	6.62 (5.65-7.59)	189 (0.035)	4.94 (4.32-5.56)	158 (0.038)	4.15 (3.56-4.74)	119 (0.037)	7.39 (6.41-8.37)	86 (0.045)	5.78 (4.93-6.63)
Housewife or househusband	267 (0.062)	6.61 (6-7.22)	119 (0.052)	4.99 (4.2-5.78)	306 (0.068)	5.97 (5.36-6.58)	106 (0.048)	4.82 (3.94-5.7)	403 (0.075)	3.41 (3.06-3.76)	315 (0.075)	3.2 (2.82-3.58)	203 (0.064)	6.62 (5.82-7.42)	113 (0.059)	5.35 (4.39-6.31)
Part-time job	393 (0.092)	6.97 (6.47-7.47)	238 (0.103)	5.72 (5.13-6.31)	412 (0.092)	5.95 (5.44-6.46)	223 (0.1)	4.78 (4.25-5.31)	496 (0.092)	3.65 (3.32-3.98)	407 (0.097)	3.43 (3.11-3.75)	302 (0.095)	6.91 (6.27-7.55)	197 (0.102)	6.5 (5.77-7.23)
Student	221 (0.052)	7.7 (7-8.4)	126 (0.055)	6.17 (5.33-7.01)	228 (0.051)	6.7 (6.03-7.37)	121 (0.054)	5.61 (4.81-6.41)	240 (0.045)	4.67 (4.1-5.24)	180 (0.043)	3.52 (3.02-4.02)	194 (0.061)	7.21 (6.43-7.99)	130 (0.067)	6.13 (5.28-6.98)
Other unemployed (including retired)	752 (0.176)	6.78 (6.41-7.15)	278 (0.121)	5.37 (4.84-5.9)	828 (0.185)	5.66 (5.29-6.03)	261 (0.117)	4.98 (4.39-5.57)	1259 (0.235)	2.57 (2.44-2.7)	1008 (0.239)	2.51 (2.36-2.66)	525 (0.165)	6.49 (5.98-7)	237 (0.123)	5.48 (4.8-6.16)
Other	207 (0.048)	6.75 (6.03-7.47)	120 (0.052)	5.08 (4.29-5.87)	224 (0.05)	6.08 (5.4-6.76)	126 (0.057)	5.07 (4.27-5.87)	285 (0.053)	3.52 (3.09-3.95)	233 (0.055)	3.17 (2.78-3.56)	152 (0.048)	6.03 (5.18-6.88)	104 (0.054)	4.67 (3.82-5.52)
Household size																
1	698 (0.163)	7.06 (6.67-7.45)	311 (0.135)	5.25 (4.75-5.75)	764 (0.171)	5.83 (5.45-6.21)	330 (0.148)	4.81 (4.3-5.32)	968 (0.18)	2.91 (2.72-3.1)	752 (0.179)	2.78 (2.59-2.97)	601 (0.189)	6.71 (6.24-7.18)	337 (0.175)	5.95 (5.37-6.53)
2	1446 (0.338)	7.15 (6.88-7.42)	686 (0.298)	5.72 (5.37-6.07)	1483 (0.331)	6.45 (6.17-6.73)	610 (0.274)	5.53 (5.14-5.92)	1938 (0.361)	3.28 (3.13-3.43)	1494 (0.355)	3.03 (2.87-3.19)	979 (0.307)	7.3 (6.93-7.67)	532 (0.276)	6.17 (5.72-6.62)
3	902 (0.211)	7.06 (6.73-7.39)	525 (0.228)	5.71 (5.33-6.09)	952 (0.213)	6.15 (5.83-6.47)	523 (0.235)	5.3 (4.92-5.68)	1081 (0.201)	4.07 (3.83-4.31)	861 (0.204)	3.63 (3.39-3.87)	632 (0.198)	6.79 (6.37-7.21)	422 (0.219)	5.92 (5.47-6.37)
4	809 (0.189)	7.38 (7.02-7.74)	511 (0.222)	5.76 (5.38-6.14)	850 (0.19)	6.53 (6.19-6.87)	496 (0.223)	5.24 (4.85-5.63)	903 (0.168)	4.21 (3.95-4.47)	724 (0.172)	3.67 (3.43-3.91)	647 (0.203)	6.93 (6.52-7.34)	416 (0.216)	5.68 (5.25-6.11)
5	267 (0.062)	7.63 (7.01-8.25)	164 (0.071)	5.38 (4.75-6.01)	274 (0.061)	6.75 (6.14-7.36)	159 (0.072)	5.14 (4.52-5.76)	312 (0.058)	4.64 (4.17-5.11)	239 (0.057)	4.14 (3.65-4.63)	207 (0.065)	7.26 (6.53-7.99)	137 (0.071)	6.16 (5.36-6.96)
6+	156 (0.036)	7.61 (6.81-8.41)	107 (0.046)	6.68 (5.72-7.64)	153 (0.034)	6.65 (5.86-7.44)	105 (0.047)	5.81 (4.93-6.69)	163 (0.03)	4.97 (4.24-5.7)	141 (0.033)	4.71 (3.91-5.51)	120 (0.038)	6.07 (5.21-6.93)	84 (0.044)	5.98 (4.98-6.98)
Education																
No formal qualification	31 (0.007)	5.73 (3.86-7.6)	21 (0.009)	5.21 (3.09-7.33)	33 (0.007)	4.32 (2.76-5.88)	21 (0.009)	3.81 (2.26-5.36)	39 (0.007)	2.63 (1.79-3.47)	32 (0.008)	2.91 (1.69-4.13)	16 (0.005)	3.72 (2.26-5.18)	13 (0.007)	2.58 (1.52-3.64)
Elementary school	47 (0.011)	7.02 (5.8-8.24)	45 (0.02)	6.49 (5.36-7.62)	50 (0.011)	6.61 (5.58-7.64)	46 (0.021)	7.12 (5.89-8.35)	59 (0.011)	7.52 (6.18-8.86)	54 (0.013)	5.51 (4.3-6.72)	43 (0.013)	5.59 (4.46-6.72)	46 (0.024)	5.62 (4.64-6.6)
Middle school/ Junior high school	295 (0.069)	6.98 (6.38-7.58)	155 (0.067)	6.22 (5.47-6.97)	315 (0.07)	5.24 (4.71-5.77)	150 (0.067)	4.88 (4.2-5.56)	406 (0.076)	2.91 (2.61-3.21)	319 (0.076)	2.83 (2.51-3.15)	215 (0.067)	5.45 (4.75-6.15)	112 (0.058)	5.5 (4.59-6.41)
High school/ Senior high school	717 (0.168)	6.94 (6.56-7.32)	365 (0.158)	5.81 (5.33-6.29)	734 (0.164)	6.16 (5.78-6.54)	343 (0.154)	5.31 (4.82-5.8)	994 (0.185)	3.43 (3.21-3.65)	773 (0.184)	3.25 (3.02-3.48)	501 (0.157)	6.49 (6.01-6.97)	334 (0.173)	5.83 (5.3-6.36)
College/ Vocational school	916 (0.214)	7.42 (7.08-7.76)	458 (0.199)	5.76 (5.33-6.19)	968 (0.216)	6.51 (6.16-6.86)	428 (0.193)	5.06 (4.62-5.5)	1206 (0.225)	3.51 (3.31-3.71)	941 (0.223)	3.05 (2.86-3.24)	628 (0.197)	7 (6.56-7.44)	345 (0.179)	5.83 (5.31-6.35)
Undergraduate/ Bachelor	1497 (0.35)	7.38 (7.11-7.65)	794 (0.345)	5.47 (5.16-5.78)	1591 (0.355)	6.44 (6.17-6.71)	773 (0.348)	5.29 (4.96-5.62)	1784 (0.333)	3.74 (3.56-3.92)	1379 (0.327)	3.41 (3.23-3.59)	1098 (0.345)	7.51 (7.17-7.85)	644 (0.334)	6.35 (5.94-6.76)
Master degree	662 (0.155)	6.87 (6.49-7.25)	405 (0.176)	5.59 (5.17-6.01)	662 (0.148)	6.44 (6.05-6.83)	400 (0.18)	5.46 (5.03-5.89)	739 (0.138)	4.09 (3.82-4.36)	597 (0.142)	3.76 (3.5-4.02)	510 (0.16)	6.75 (6.3-7.2)	340 (0.176)	5.65 (5.17-6.13)
Doctoral degree	113 (0.026)	7.92 (6.92-8.92)	61 (0.026)	5.87 (4.68-7.06)	123 (0.027)	6.76 (5.83-7.69)	62 (0.028)	5.75 (4.58-6.92)	138 (0.026)	4.11 (3.46-4.76)	116 (0.028)	3.69 (3.02-4.36)	86 (0.027)	8.05 (6.78-9.32)	59 (0.031)	6.42 (5.13-7.71)
Income																
Under 24,999USD	368 (0.086)	6.44 (5.93-6.95)	204 (0.089)	5.52 (4.88-6.16)	405 (0.09)	5.81 (5.3-6.32)	211 (0.095)	5.05 (4.41-5.69)	626 (0.117)	3.45 (3.17-3.73)	525 (0.125)	3.2 (2.92-3.48)	358 (0.112)	6.92 (6.32-7.52)	241 (0.125)	5.75 (5.1-6.4)

		Party				Cultural leisure				Medical activities				Public transport			
		Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic	
Variable		Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)
25,000 to 34,999USD		370 (0.086)	6.46 (5.97-6.95)	190 (0.082)	5.1 (4.53-5.67)	419 (0.094)	5.58 (5.09-6.07)	199 (0.09)	4.81 (4.21-5.41)	562 (0.105)	3.28 (2.99-3.57)	446 (0.106)	3.15 (2.85-3.45)	323 (0.101)	6.28 (5.69-6.87)	188 (0.098)	5.85 (5.13-6.57)
35,000 to 49,999USD		493 (0.115)	6.9 (6.45-7.35)	214 (0.093)	5.45 (4.87-6.03)	534 (0.119)	5.89 (5.44-6.34)	219 (0.099)	4.72 (4.14-5.3)	698 (0.13)	3.23 (2.98-3.48)	524 (0.124)	2.84 (2.61-3.07)	355 (0.111)	6.27 (5.7-6.84)	201 (0.104)	5.4 (4.73-6.07)
50,000 to 74,999USD		767 (0.179)	6.99 (6.63-7.35)	387 (0.168)	5.26 (4.83-5.69)	794 (0.177)	6.11 (5.75-6.47)	356 (0.16)	4.82 (4.39-5.25)	920 (0.171)	3.36 (3.14-3.58)	687 (0.163)	3.07 (2.85-3.29)	534 (0.168)	6.45 (5.98-6.92)	306 (0.159)	5.73 (5.21-6.25)
75,000 to 99,999USD		701 (0.164)	7.62 (7.22-8.02)	393 (0.171)	5.82 (5.36-6.28)	731 (0.163)	6.65 (6.26-7.04)	375 (0.169)	5.73 (5.24-6.22)	826 (0.154)	3.95 (3.68-4.22)	631 (0.15)	3.37 (3.11-3.63)	455 (0.143)	7.07 (6.55-7.59)	266 (0.138)	5.7 (5.12-6.28)
100,000 to 124,999USD		569 (0.133)	7.31 (6.88-7.74)	310 (0.135)	5.65 (5.14-6.16)	572 (0.128)	6.53 (6.1-6.96)	285 (0.128)	5.25 (4.74-5.76)	634 (0.118)	3.69 (3.4-3.98)	495 (0.118)	3.54 (3.23-3.85)	429 (0.135)	7.45 (6.91-7.99)	262 (0.136)	6.16 (5.55-6.77)
125,000 to 149,999USD		393 (0.092)	7.64 (7.13-8.15)	229 (0.099)	6.27 (5.66-6.88)	395 (0.088)	6.67 (6.15-7.19)	219 (0.099)	5.45 (4.87-6.03)	443 (0.083)	4.04 (3.7-4.38)	361 (0.086)	3.64 (3.3-3.98)	296 (0.093)	7.78 (7.16-8.4)	185 (0.096)	6.47 (5.77-7.17)
150,000 to 174,999USD		258 (0.06)	7.56 (6.92-8.2)	157 (0.068)	6.06 (5.35-6.77)	269 (0.06)	6.8 (6.13-7.47)	154 (0.069)	5.82 (5.05-6.59)	287 (0.053)	4.61 (4.1-5.12)	235 (0.056)	4.57 (4-5.14)	189 (0.059)	7.59 (6.78-8.4)	134 (0.07)	6.88 (5.95-7.81)
175,000 to 199,999USD		151 (0.035)	7.52 (6.69-8.35)	91 (0.039)	5.87 (4.92-6.82)	149 (0.033)	7.02 (6.17-7.87)	85 (0.038)	5.87 (4.81-6.93)	155 (0.029)	4.18 (3.55-4.81)	131 (0.031)	3.45 (2.88-4.02)	109 (0.034)	7.52 (6.46-8.58)	67 (0.035)	6.64 (5.37-7.91)
200,000USD and over		208 (0.049)	8.25 (7.47-9.03)	129 (0.056)	6.46 (5.54-7.38)	208 (0.046)	7.13 (6.36-7.9)	120 (0.054)	6.26 (5.29-7.23)	214 (0.04)	4.27 (3.68-4.86)	176 (0.042)	3.68 (3.13-4.23)	138 (0.043)	7.48 (6.5-8.46)	78 (0.04)	6.15 (4.96-7.34)
Frequency																	
A few times a year		101 (0.024)	5.46 (4.6-6.32)	130 (0.056)	5.15 (4.44-5.86)	126 (0.028)	5.58 (4.79-6.37)	117 (0.053)	4.53 (3.77-5.29)	189 (0.035)	3.75 (3.28-4.22)	185 (0.044)	3.92 (3.39-4.45)	147 (0.046)	5.76 (5.01-6.51)	125 (0.065)	4.46 (3.86-5.06)
Less than once a month		1872 (0.438)	7.48 (7.23-7.73)	1138 (0.494)	5.69 (5.41-5.97)	2334 (0.521)	6.39 (6.16-6.62)	1190 (0.535)	5.32 (5.03-5.61)	3600 (0.671)	3.23 (3.12-3.34)	2688 (0.638)	2.84 (2.73-2.95)	1223 (0.384)	6.99 (6.67-7.31)	713 (0.37)	6.05 (5.66-6.44)
Once or twice a month		1319 (0.308)	7.08 (6.81-7.35)	494 (0.214)	5.69 (5.3-6.08)	1284 (0.287)	6.4 (6.11-6.69)	411 (0.185)	5.03 (4.64-5.42)	1065 (0.199)	3.96 (3.74-4.18)	846 (0.201)	3.67 (3.45-3.89)	616 (0.193)	6.37 (5.95-6.79)	386 (0.2)	5.36 (4.92-5.8)
Once or twice a week		809 (0.189)	7.16 (6.81-7.51)	400 (0.174)	5.75 (5.35-6.15)	541 (0.121)	6.01 (5.63-6.39)	340 (0.153)	5.31 (4.9-5.72)	363 (0.068)	5.82 (5.33-6.31)	344 (0.082)	5.11 (4.67-5.55)	551 (0.173)	6.6 (6.17-7.03)	393 (0.204)	6.05 (5.59-6.51)
Daily or almost daily		177 (0.041)	6.46 (5.74-7.18)	142 (0.062)	5.9 (5.18-6.62)	191 (0.043)	6.25 (5.69-6.81)	165 (0.074)	6.23 (5.62-6.84)	148 (0.028)	6.55 (5.76-7.34)	148 (0.035)	5.56 (4.86-6.26)	649 (0.204)	8.06 (7.6-8.52)	311 (0.161)	7.01 (6.4-7.62)
Duration																	
Less than 5 mins		190 (0.044)	5.7 (4.97-6.43)	149 (0.065)	4.65 (3.9-5.4)	151 (0.034)	4.84 (4.04-5.64)	130 (0.058)	4.66 (3.8-5.52)	134 (0.025)	3.38 (2.75-4.01)	138 (0.033)	3.61 (2.92-4.3)	111 (0.035)	5.39 (4.41-6.37)	72 (0.037)	4.61 (3.52-5.7)
5 mins - 15 mins		263 (0.061)	5.31 (4.8-5.82)	227 (0.099)	4.59 (4.09-5.09)	271 (0.061)	5.05 (4.56-5.54)	231 (0.104)	4.22 (3.81-4.63)	631 (0.118)	2.86 (2.64-3.08)	553 (0.131)	2.67 (2.45-2.89)	368 (0.116)	5.22 (4.73-5.71)	293 (0.152)	4.68 (4.2-5.16)
15 mins - 1 hour		1173 (0.274)	5.54 (5.3-5.78)	925 (0.401)	4.76 (4.53-4.99)	956 (0.214)	5.39 (5.12-5.66)	761 (0.342)	4.53 (4.27-4.79)	3369 (0.628)	3.3 (3.19-3.41)	2677 (0.636)	3.07 (2.96-3.18)	2028 (0.637)	7.11 (6.86-7.36)	1181 (0.613)	6.05 (5.77-6.33)
1 hour - 4 hours		2230 (0.521)	7.96 (7.74-8.18)	862 (0.374)	6.74 (6.4-7.08)	2839 (0.634)	6.73 (6.52-6.94)	1014 (0.456)	6.04 (5.72-6.36)	1079 (0.201)	4.53 (4.27-4.79)	732 (0.174)	4.25 (3.96-4.54)	578 (0.181)	7.74 (7.27-8.21)	319 (0.165)	6.88 (6.3-7.46)
4 hours or longer		422 (0.099)	9.74 (9.23-10.25)	141 (0.061)	8.08 (7.21-8.95)	259 (0.058)	7.44 (6.77-8.11)	87 (0.039)	6.94 (5.88-8)	152 (0.028)	8.98 (8.08-9.88)	111 (0.026)	6.79 (5.8-7.78)	101 (0.032)	7.64 (6.61-8.67)	63 (0.033)	7.21 (5.91-8.51)
Contact mode																	
Only non-physical contacts		1341 (0.313)	5.89 (5.63-6.15)	963 (0.418)	4.74 (4.48-5)	1801 (0.402)	5.5 (5.27-5.73)	1058 (0.476)	4.77 (4.5-5.04)	1622 (0.302)	3.56 (3.38-3.74)	1666 (0.396)	3.07 (2.92-3.22)	1553 (0.487)	6.49 (6.21-6.77)	1079 (0.56)	5.56 (5.27-5.85)
Only physical contacts		1286 (0.301)	7 (6.73-7.27)	692 (0.3)	5.81 (5.49-6.13)	1280 (0.286)	6.49 (6.21-6.77)	635 (0.286)	5.43 (5.11-5.75)	1699 (0.317)	3.67 (3.5-3.84)	1209 (0.287)	3.55 (3.37-3.73)	805 (0.253)	6.48 (6.14-6.82)	531 (0.275)	5.96 (5.58-6.34)
Both non-physical and physical contacts		1651 (0.386)	8.44 (8.18-8.7)	649 (0.282)	6.93 (6.54-7.32)	1395 (0.312)	7.21 (6.92-7.5)	530 (0.238)	6.16 (5.72-6.6)	2044 (0.381)	3.72 (3.55-3.89)	1336 (0.317)	3.48 (3.29-3.67)	828 (0.26)	8.32 (7.91-8.73)	318 (0.165)	7.35 (6.72-7.98)
Protecting measures																	
Wear a mask	Yes	582 (0.136)	5.18 (4.83-5.53)	924 (0.401)	4.67 (4.4-4.94)	606 (0.135)	5.12 (4.75-5.49)	976 (0.439)	4.62 (4.34-4.9)	1005 (0.187)	3.68 (3.46-3.9)	2837 (0.674)	2.97 (2.86-3.08)	533 (0.167)	6.16 (5.71-6.61)	1168 (0.606)	6.25 (5.93-6.57)
	No	3696 (0.864)	7.53 (7.36-7.7)	1380 (0.599)	6.36 (6.12-6.6)	3870 (0.865)	6.51 (6.34-6.68)	1247 (0.561)	5.81 (5.56-6.06)	4360 (0.813)	3.65 (3.54-3.76)	1374 (0.326)	4.11 (3.92-4.3)	2653 (0.833)	7.12 (6.91-7.33)	760 (0.394)	5.52 (5.24-5.8)

		Party				Cultural leisure				Medical activities				Public transport			
		Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic		Pre-pandemic		During-pandemic	
Variable		Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)	Sample (%)	Mean (95%CI)
Disinfect hands	Yes	865 (0.202)	6.21 (5.89-6.53)	1221 (0.53)	5.52 (5.26-5.78)	917 (0.205)	5.73 (5.41-6.05)	1178 (0.53)	5.15 (4.88-5.42)	1372 (0.256)	3.63 (3.44-3.82)	2821 (0.67)	2.97 (2.86-3.08)	816 (0.256)	6.19 (5.84-6.54)	1058 (0.549)	5.76 (5.46-6.06)
	No	3413 (0.798)	7.46 (7.28-7.64)	1083 (0.47)	5.86 (5.6-6.12)	3559 (0.795)	6.47 (6.29-6.65)	1045 (0.47)	5.44 (5.18-5.7)	3993 (0.744)	3.67 (3.55-3.79)	1390 (0.33)	4.07 (3.87-4.27)	2370 (0.744)	7.23 (7-7.46)	870 (0.451)	6.21 (5.88-6.54)
Distancing with others	Yes	746 (0.174)	5.67 (5.35-5.99)	1176 (0.51)	5.56 (5.29-5.83)	758 (0.169)	5.49 (5.16-5.82)	1160 (0.522)	5.25 (4.98-5.52)	1033 (0.193)	3.9 (3.68-4.12)	2609 (0.62)	3.15 (3.03-3.27)	570 (0.179)	6.01 (5.62-6.4)	986 (0.511)	6.05 (5.73-6.37)
	No	3532 (0.826)	7.53 (7.36-7.7)	1128 (0.49)	5.81 (5.55-6.07)	3718 (0.831)	6.49 (6.32-6.66)	1063 (0.478)	5.34 (5.08-5.6)	4332 (0.807)	3.6 (3.49-3.71)	1602 (0.38)	3.65 (3.48-3.82)	2616 (0.821)	7.17 (6.95-7.39)	942 (0.489)	5.87 (5.56-6.18)
No measures are taken	Yes	2576 (0.602)	8.09 (7.88-8.3)	235 (0.102)	7.61 (6.95-8.27)	2752 (0.615)	6.75 (6.54-6.96)	213 (0.096)	6.85 (6.15-7.55)	2926 (0.545)	3.32 (3.19-3.45)	202 (0.048)	4.07 (3.46-4.68)	1669 (0.524)	7.75 (7.46-8.04)	103 (0.053)	7.11 (5.97-8.25)
	No	1702 (0.398)	5.88 (5.67-6.09)	2069 (0.898)	5.46 (5.27-5.65)	1724 (0.385)	5.62 (5.4-5.84)	2010 (0.904)	5.12 (4.92-5.32)	2439 (0.455)	4.06 (3.91-4.21)	4009 (0.952)	3.3 (3.2-3.4)	1517 (0.476)	6.1 (5.85-6.35)	1825 (0.947)	5.9 (5.68-6.12)