



Exploring activity-travel behavior changes during the beginning of COVID-19 pandemic in Indonesia

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Abstract

This study examines the change in activities and associated travel during the beginning of COVID-19 pandemic in Indonesia. This study is particularly interested in analyzing the role of attitudes, descriptive norms, protective behaviors toward COVID-19, travel frequency before the pandemic, and spatial and individual characteristics on activity-travel behavior changes in relation to information and communication technology (ICT) use. Data were obtained from 1062 respondents using a web-based questionnaire survey. Structural equation modeling was used to examine the complex relationships among variables. This study found that descriptive norms positively affected the frequency of travel during the COVID-19 pandemic. Teleworking and e-learning and attitudes toward COVID-19 directly affected activity-travel behavior changes. On the contrary, teleshopping did not contribute to reducing out-of-home activities during the COVID-19 pandemic. Experience of ICT influenced a decline in travel frequency and ride-hailing use. Furthermore, although personal attributes insignificantly influenced activity-travel behavior change, these attributes directly affected ICT use. Meanwhile, people living outside of Java Island had a higher travel frequency during the beginning of COVID-19 pandemic than their counterparts. Based on our findings, this study recommends that the very initial step in an emergency caused by a disaster be to massively socialize or educate people about the risk of the pandemic and to continue with a policy to minimize travel by encouraging teleworking and e-learning. Empowering ICT to support activities from home will beneficially minimize the spread of the pandemic.

Keywords COVID-19 · Activities change · Travel behavior · Technology use · Attitudes

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Introduction

According to the World Health Organization (WHO), the Coronavirus Disease 2019 (COVID-19) is a global pandemic with the first case reported in Wuhan, Hubei Province, China, in late December 2019 (Zhu et al. 2020). By July 1, 2020, more than 10 million cases were reported worldwide resulting in more than 513,000 casualties.¹ Due to the rapid spread of this virus, on February 28, 2020, the Indonesian government declared it a pandemic disaster (Indonesia National Disaster Management Agency 2020). On March 2, 2020, approximately 11 days after the first 2 confirmed cases, the national government established a task force for rapid response to COVID-19 patients, as directly ordered by the President (Ministry of State Secretariat 2020). However, in the beginning of pandemic, the national government preferred mobility and activity restriction rather than a partial- or full-fledge lockdown (AHK Indonesien 2020). Since April 18, 2020, the national government approved enforcement of partial-fledge lockdown (or large-scale social restriction policy) in 18 regions in Indonesia. This policy is stated in the Minister of Health Regulation No. 9, the Year 2020 consisting of workplace and school closure, restriction of social, cultural, and religious activities, and the operation and occupation limitation of public transport and private vehicle. People also must have a permission letter before entering into or exiting from partial-fledge lockdown zones (Ministry of Health Republic of Indonesia 2020).

There have been benefited and disadvantaged sectors due to the COVID-19 outbreak. According to Dcode Economic and Financial Consulting (2020), e-commerce, information and communication technology (ICT), and the food processing and retail sectors potentially benefited from the outbreak. Many studies have considered the effects of e-commerce and ICT on behavioral changes in activity and associated travel (or activity-travel behavior changes), particularly the potential for replacing out-of-home activities with virtual-based tasks, such as e-learning, telework, and online shopping (Cao 2009; Chakrabarti 2018; Sener and Reeder 2012). The use of ICT in the transportation sector, such as ride-hailing, has successfully changed travel behaviors and sustainability (Irawan et al. 2020a; Tarabay and Abou-Zeid 2020; Tirachini 2020).

Although many studies related to the rapid response to COVID-19 have been carried out (de Bruin et al. 2020; Djalante et al. 2020; Ha 2020; Karnon 2020; Makurumidze 2020; Wilder-Smith et al. 2020; Xiao and Torok 2020), understanding how ICT has impacted out-of-home activities and associated travel during the pandemic has been little discussed. To fill this gap, this study aims to investigate the activity-travel behavior changes during the beginning of COVID-19 outbreak as an effect of attitudes, descriptive norms, protective behaviors toward COVID-19, travel frequency before the pandemic, and spatial and socio-demography in accordance with the use of ICT. Specifically, the objectives of this study are threefold. First, to analyze factors influencing activity-travel behavior change and to explore the interrelationship between the influence factors. Second, to investigate the ability for ICT to facilitate activity-travel behavior change and to understand how ICT facilitated activities correlate to each other. Third, to explore the impact of individual and spatial characteristics on activity-travel behavior change in accordance with ICT use. Some policies are then recommended to optimize the implementation of mobility and activity restriction policies in Indonesia. Note that even though we mentioned ride-hailing usage

¹ The real-time coronavirus disease update from every country can be seen at <https://www.worldometers.info/coronavirus/>

when discussing travel behavior change, the modes that were used before the pandemic and will be used during the pandemic are not necessarily ride-hailing. That means if a person before the pandemic uses a car or public transport, he/she might use the same mode or different mode during the pandemic.

To the best of our knowledge, this is the first study to investigate the utilization of many features of ICT as an instantaneous and massive tool to limit pandemic spread through activity-travel behavior restrictions. Understanding the COVID-19 spread in Indonesia is also crucial because Indonesia is the fourth most populous country in the world and potentially suffers greatly and over a long period of pandemic. Indonesia is predicted to become the world's next COVID-19 hotspot. Data were collected from an online survey from March 2020 to April 2020. Structural equation modeling (SEM) was employed to deal with the complexity of relationships among the variables. With this background, this study contributes to understanding the travel behavior in the era of pandemic and how to manage mobility without exposing travelers to greater risk. In other words, we are not focusing to investigate the detail of impacted activities/travels and its magnitude, but we are focusing on how individuals fulfill their daily needs for mobility and activity. It is hypothesized that individuals will utilize ICT and change their travel behavior to fulfill their mobility and activities needs.

The remaining section of the paper is organized as follows: a literature review, followed by a part ([Research design](#) section) that briefly introduces the conceptual model, and explains the questionnaire design and data collection method. The results are presented in [Results](#) section, while the final section summarizes the essential findings and discusses policy implications.

Literature review

The COVID-19 has significantly changed people's activity-travel behavior around the world. The mobility restriction aiming to minimize the COVID-19 spread has influenced the increase of ICT use. There are many types of ICT facilitated activities, with each form causing a variety of activity-travel behavioral changes. These include teleworking (Chakrabarti 2018; He and Hu 2015; Melo and Silva 2017; Pendyala et al. 1991), teleshopping (Farak et al. 2007; Loo and Wang 2018), and ride-hailing (Alemi et al. 2018; Irawan et al. 2020b; Jin et al. 2018; Tarabay and Abou-Zeid 2020). Studies during the pandemic showed that office working is being replaced by teleworking, while in-store shopping is being replaced by teleshopping. For example, Shamsheeripour et al. (2020) showed that there was a significant increase in teleworking and teleshopping during the pandemic in Chicago, where out of 71% of workers who had zero experience working from home-even before the pandemic, only about half of them continued to work at their workplaces. They also showed that 45% and 67% of them become new teleshoppers for fresh food and grocery shopping, respectively. Beck and Hensher (2020) also reported the impact of COVID-19 on activity-travel behavior change in Australia. They showed that 47% of respondents shifted to telework. The pandemic also disrupted the respondents' out-of-home activities such as social activity, dine-in, and shopping by 80%, 76%, and 76%, respectively. Another study also found that shares of employees working from home have increased from 6 to 39% in the Netherlands (de Haas et al. 2020).

Although not specific to pandemics, one of the aspects that might be relevant to ICT facilitated activities is the experience of ICT use. In terms of teleshopping, studies have

shown that the more months spent on the internet, the greater the frequency of online shopping and the more money spent (Joewono et al. 2019; Ren and Kwan 2009). The experience of ride-hailing app usage also indirectly affected the frequency of usage in the Jakarta Metropolitan Area (Irawan et al. 2020b). Meanwhile, Varghese and Jana (2019) found that access to ICT, include the use of laptop and mobile phones, as well as internet data usage per month, had a significant influence on activity-travel behavior. An increase in access to ICT led to a rise in in-home maintenance and leisure activity participation, as well as out-of-home mandatory activities. However, for informal housing residents such as renters and squatters, their in-home mandatory activities participation did not depend on access to ICT. Similarly, Kenyon (2010) determined a positive relationship between internet use and education, shopping, and social activities. Increased internet usage led to a rise in out-of-home education activities participation. Meanwhile, both online shopping and social network activities complemented in-store and out-of-home social activities participation.

The change of activity-travel behavior during the pandemic is also influenced by psychological construct. Parady et al. (2020) found that risk perception, trait anxiety, and social influence significantly affected a decrease in participation frequency of in-store shopping, eating outside, and leisure activities during the outbreak in Kanto Region, Japan. Risk perception also significantly influenced travel behavior change during the COVID-19 pandemic in the United States (Hotle et al. 2020). They found that people perceiving a medium or high risk of COVID-19 were more likely to stay at home, avoid public spaces, and avoid to use the transit system. However, they also found that an increase in risk perception is followed by a decrease in work at home. Meanwhile, Nguyen (2021) found that fear of COVID-19 was positively correlated to home-based telework in Hanoi, Vietnam, meaning that people with more fear of the dangers of COVID-19 were more likely to telework. The psychological construct is also correlated with ICT use during the pandemic. Koch et al. (2020) found that perceived usefulness, subjective norms, descriptive norms, and hedonic motivation significantly impacted the increased participation of teleshopping during the COVID-19 pandemic in Germany.

Studies exploring the change of activity and travel behavior during the pandemic also consider the socio-demography as a determinant variable. According to Parady et al. (2020), there was a significant correlation between factor of gender and going-out self-restriction behavior for shopping, eating out, and leisure activities during the COVID-19 pandemic in Japan. A similar finding was also found by Hotle et al. (2020) showing that females in the United States were more likely to avoid public space and stay at home during the pandemic than males. Females also perceived a higher risk from being contracted to COVID-19 at work or school. They also revealed that workers, people with high income, and who had at least a bachelor's degree were less likely to reduce their participation in out-of-home activities. However, they found that the factor of age had no significant correlation to stay at home during the COVID-19 outbreak. Meanwhile, a study about participation frequency in out-of-home activities during the pandemic in Istanbul, Turkey showed that no relationship existed between working trips during the pandemic and the factor of gender, age, and income level. There was also no correlation between the factor of gender and the frequency of leisure, social, recreational activity participation during the pandemic. However, for shopping activities, males and people living in a household with less than four family members were more active than their counterparts (Shakibaei et al. 2021). In addition, Beck et al. (2020) considered the effect of socioeconomic characteristics including age, gender, occupation, and household income on teleworking activities during the beginning of COVID-19 outbreak in Australia. They found that only income and occupation factors influencing people to telework. The results showed that high-income people

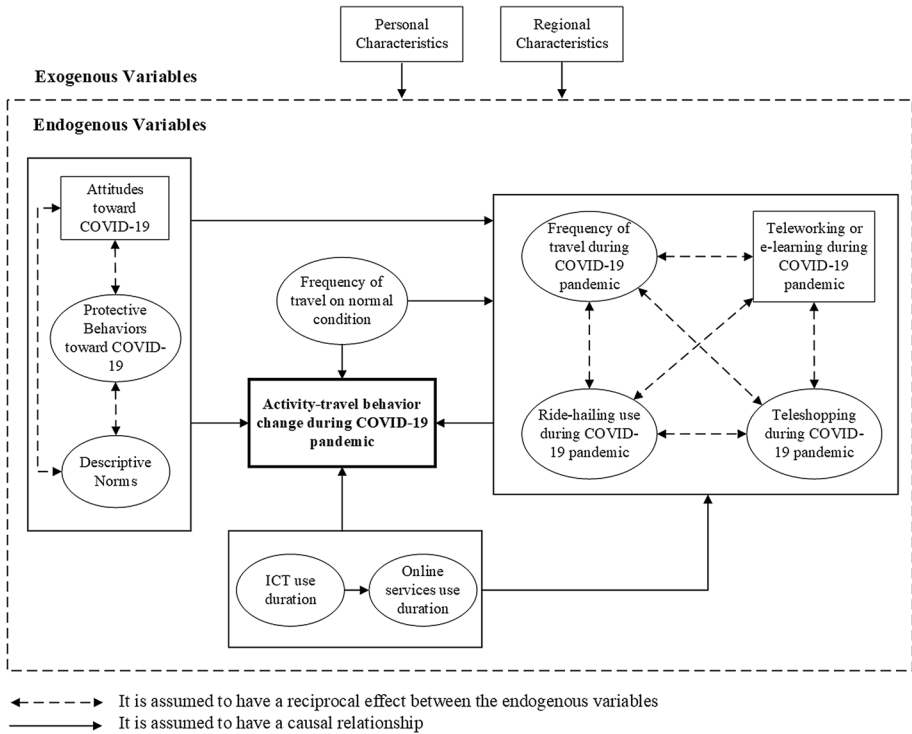


Fig. 1 Proposed hypothesized SEM model

tended to have a higher probability of teleworking, while technician and trade occupations tended to increase out-of-home activities participation of work. They also found that people living in metropolitan areas in Australia such as Sydney, Brisbane, and Melbourne were more likely to telework during the outbreak.

Research design

Conceptual model

Based on the literature reviewed above, a model framework was constructed to explain possible changes in activities-travel behavior triggered by the COVID-19 pandemic, as shown in Fig. 1. Ellipse and rectangular were used to denote latent and observed variables, respectively. Solid and dotted arrow lines were used to indicate the causal and reciprocal relationships between 2 variables, respectively. This study determined 8 latent and 3 observed endogenous variables, as well as ten exogenous variables.

In achieving the objectives of this study, the modeling procedure involved 6 steps. Firstly, the study assumed that the endogenous variables of attitudes toward COVID-19, descriptive norms, protective behaviors toward COVID-19, ICT and online service experience, and travel frequency under normal conditions directly influenced activity-travel behavior changes and use of ICT. In terms of protective behaviors toward COVID-19, this

research includes several COVID-19 prevention actions suggested by WHO (2020) to protect the body from this virus, such as physical distancing, use of face masks when participating in out-of-home activities, regular handwashing with soap/sanitizer, and keeping the body healthy through regular exercise, adequate sleep, and nutritious diet. Meanwhile, although WHO stated that sunbathing does not prevent the spread of this virus, this study considered that activity as a way to increase the body's immune system (González Maglio et al. 2016). Secondly, the study argues that reciprocal relationships exist between attitudes toward COVID-19, protective behaviors toward COVID-19, and descriptive norms. Although previous studies have discussed how attitudes influence behavior, some studies have criticized that notion by indicating a causality relationship. For example, Kroesen et al. (2017) investigated the possibility of a bidirectional relationship and found that attitudes and behavior have mutual influence over time. van Wee et al. (2019) stated that travel behavior and builds environment influences attitude over time. In addition, Kroesen and Chorus (2020) report that researchers need to be careful in interpreting the statistical results of attitude toward behavior for policy recommendations due to the existence of inadequate information on their causality relationships. Thirdly, this research assumes that ICT experience affects online services. The three steps above aim to reach the first objective of the study.

Fourthly, the study hypothesized that travel frequency during the COVID-19 pandemic and the use of ICT in teleworking or e-learning, teleshopping, and ride-hailing directly affects the activity-travel behavior changes of individuals during the COVID-19 outbreak. Fifthly, this study also argues for reciprocal relationships between travel frequency, teleworking or e-learning, teleshopping, and the use of ride-hailing. The fourth to fifth step above is used to answer the second objective.

In attaining the last objective, the research argues that exogenous variables of spatial demography and socio-demographics consisting of gender, age, education, income, and job type impact on all endogenous variables. In terms of spatial attributes, each region or province was determined as a dummy variable. We coded the response as one (1) if those people lived in that province, and zero (0) if otherwise. Furthermore, the dummy areas were divided into 6 zones, with 5 of them representing provinces in Java Island, otherwise known as Greater Jakarta, Special Region of Yogyakarta, Central Java, East Java, and West Java. The last zone was located outside the Java Island. We determined the Greater of Jakarta, which is known as the epicenter of COVID-19 in Indonesia, as the reference category.

This study employed the structural equation model (SEM) to analyze the complex correlation among the variables. SEM is a multivariate regression widely used in transportation research to explore travel behavior changes using latent variables. In SEM, the correlation between endogenous and exogenous variables and among the endogenous are accommodated as a structural equation. In contrast, the relationship between observed variables and latent variables are accommodated as a measurement equation (Hair et al. 2010).

Questionnaire design and data collection

The questionnaire form was specifically used to record respondents' activity-travel behavior changes during the beginning of COVID-19 in Indonesia. The questionnaire form consisted of 8 sections. From Section 1 to 4, the respondents answered the questions on a five-point Likert scale. The first comprised questions related to the activity-travel change of respondents during the COVID-19 pandemic. The respondents' answers ranged from

1 for “no change,” to 5 for “fully stay at home.” In Section 2, they were asked about their attitudes toward the pandemic with a specific question is “In your opinion, how dangerous is the COVID-19 virus.” Their responses ranged from 1 for “not dangerous at all” to 5 for “extremely dangerous.” Section 3 pertains to the descriptive norms with a specific question is “How did people around you react in anticipation of the COVID-19?” The respondents were asked to report their perceived responses in preventing COVID-19 among 5 reference groups, namely people in their families, neighborhoods, cities, and within and outside their province. The scales were from 1 for “no response,” to 5 for “very extreme response.” The five reference groups were adjusted from Belgiawan et al. (2017). Since these variables asked respondents whether they believe that it is important to them perform the behavior or not, we named these variables with descriptive norms (Fishbein and Ajzen 2011). In the fourth section, the respondents were asked to indicate their protective behaviors with regard to COVID-19 on a five-point scale from “never” to “always.” The routines consisted of sunbathing, using face masks outside the home, participating in sports, physical distancing, washing hands with soap/sanitizer, adequate sleep (± 8 h), and eating nutritious food.

The fifth section collected information on travel frequency before and during COVID-19 pandemic for each out-of-home activity within a week. The activity included work or study, shopping, dining-in, sightseeing, and social activities, such as visiting relatives or families. They also had to identify their travel mode before and during the pandemic for each activity above with eight travel mode options: motorcycle, car, bus, train, car-based ride-hailing, motorcycle-based ride-hailing, bicycle, and walk. For trips during the pandemic, other than those eight travel mode options, we added “not traveling” option. The sixth section asked for respondents’ reactions to the use of ICT during the COVID-19 pandemic, including teleworking, teleshopping, and use of ride-hailing. The respondents were asked whether they had been making changes in ICT usage during the COVID-19 pandemic. Their answers ranged from 0 for “have stopped doing,” to 3 for “do more than usual.” This was followed by questions in Section 7 pertaining to the duration of ICT usage and online services. They were asked about the length of time (1) using a laptop, (2) smartphone, (3) shopping online, (4) ride-hailing, and (5) ordering fresh food and drink through the same-day delivery. The length of time in using a laptop or smartphone was measured since the individual owns a laptop or smartphone for the first time. Meanwhile, the duration of e-shopping, ride-hailing use, and online food and drink order was measured since the first time the individual undertakes those related online activities. Finally, the last section collected the respondents’ characteristics such as gender, age, income, education, type of job, and city of residence.

The questionnaire survey was created by using google forms facility. As there is a limitation for face-to-face interaction during the pandemic, the data were collected through an online survey in between the months of March 2020 and April 2020. With the constraints, the respondents were recruited using convenience sampling through various online forum (i.e., WhatsApp, Facebook, Instagram, Twitter, and Line). The authors were also helped by students and colleagues in distributing the questionnaire link on social media sites. When the survey started, there were 1,528 infected patients with 129 daily new cases and 122 deaths in Indonesia (AHK Indonesien 2020). At the time of the survey, people can still travel and participate in out-of-home activities, such as working, shopping, recreation and social activities. No partial- or full-fledge lockdown was applied by the government. However, the government massively socialized the dangers of COVID-19, urged people to stay at home, and adhere to physical or social distancing. There was also a different pace of response among businesses and schools and universities. The majority assigned their workers and students to telework and e-learning during the early days of the outbreak. However,

some companies/universities mandated their employees/students to keep coming to work/study by implementing COVID-19 protocols (Adi and Rochman 2020; Santoso and Mufflih 2020; Wulandari 2020). At the end of the survey, 1062 data were collected which were used in the analysis.

Results

Descriptive analysis

Data were obtained from respondents spread across several provinces in Indonesia. Table 1 showed that 35.59% were living in Yogyakarta Special Province and 21.28% in Greater Jakarta. Most were people between the ages of 26–40 (44.54%) and 18–25 years old (32.49%). Out of a total of 1062 respondents, 87% were workers and students. Approximately 90.68% had at least a bachelor's degree. In terms of income, the survey results showed that most respondents were medium (2.6–5 million IDR) and low income (less than 1 million IDR or 64.5 USD) earners by 24.68% and 22.12%, respectively. For reference purposes, at the time of conducting this study, 1 USD was approximately 15,500 IDR. Their attitudes toward COVID-19 were very serious, with 46.05% and 43.88% of them stating that it was very dangerous and extremely dangerous, respectively.

The majority of respondent activity-travel behavior during the outbreak changed. Data showed that 71.28% and 15.82% of the respondents reported their travel reductions as “very significant” and “significant,” respectively. Moreover, approximately 8.10% chose to stay at home throughout the outbreak. They also reported that they had reduced their average number of work/school trips from 5 times per week to 2. Dine-in and sightseeing trips also likewise decreased from at least 3 times to once a week. In addition, the number of social and shopping trips decreased slightly, from 2 times to once and 3 times to twice a week on the average, respectively. Related to travel mode used before the pandemic, as shown in Fig. 2, more than 50% of our respondents used motorcycles for their trips to work/school, shopping, eating outside, and sightseeing. However, the majority of respondents used car mode for their social trips. Comparing with trips during the pandemic, it can be seen that except on shopping trips, more than 40% of our respondents chose to not traveling rather than participate in out-of-home activities of working/studying, eating outside, sightseeing, and social. It means that there was a substantial reduction in the number of cars, motorcycles, and other modes use during the pandemic compared to before the pandemic. The number of those who worked from home is reportedly higher in percentage compared to Shamsheeripour et al. (2020) findings in Chicago and de Haas et al. (2020) for the Netherlands.

Regarding the use of ICT tools, nearly 80% utilized teleworking more than usual, and the majority had stopped using ride-hailing, both motorcycle- and car-based. Surprisingly, there was a reduction in the use of teleshopping during the beginning of COVID-19 outbreak by 68% and 72% for online shopping and fresh food and drink delivery, respectively. The survey also reported that respondents have been using laptops and smartphones for almost 5 years with online services, such as shopping and ride-hailing, used in the past 3 years.

The respondents' descriptive norms in anticipating COVID-19 implied that they perceive that people in their households and neighborhoods have high-to-moderate responses to the pandemic. Personal behaviors showed that they carried out the following actions

Table 1 Descriptive statistics of the sample (n = 1062)

Variable	n	%	Mean	SD
<i>Personal characteristics</i>				
Gender				
0 = Female	470	44.26%		
1 = Male	592	55.74%		
Age				
1 = < 18 years old	12	1.13%		
2 = 18–25 years old	345	32.49%		
3 = 26–40 years old	473	44.54%		
4 = 41–60 years old	216	20.34%		
5 = > 60 years old	16	1.51%		
Income				
1 = < 1 million IDR	235	22.12%		
2 = 1–2.5 million IDR	163	15.35%		
3 = 2.6–5 million IDR	264	24.86%		
4 = 5.1–7.5 million IDR	145	13.65%		
5 = 7.5–10 million IDR	100	9.42%		
6 = > 10 million IDR	155	14.60%		
Education				
1 = High school or lower	99	9.32%		
2 = Bachelor or professional courses	544	51.22%		
3 = Master or PhD	419	39.45%		
Workers / Students				0.34
1 = yes, 0 = otherwise				0.87
<i>City living (dummy variable)</i>				
Greater Jakarta (Used as reference province group)	226	21.28%		
Special Region of Yogyakarta (1 for yes; 0 for otherwise)	378	35.59%		
West Java (1 for yes; 0 for otherwise)	92	8.66%		
East Java (1 for yes; 0 for otherwise)	59	5.56%		
Center Java (1 for yes; 0 for otherwise)	119	11.21%		
Other provinces (1 for yes; 0 for otherwise)	188	17.70%		
<i>Activity-travel behavior change</i>				
1 = No change	12	1.13%		

Table 1 (continued)

Variable	n	%	Mean	SD
2 = Less significant change	39	3.67%		
3 = Significant change	168	15.82%		
4 = Very significant change	757	71.28%		
5 = Fully stay at home	86	8.10%		
<i>Attitudes toward COVID-19</i>				
1 = Not dangerous at all	2	0.18%		
2 = Less dangerous	76	7.16%		
3 = Dangerous	29	2.73%		
4 = Very dangerous	489	46.05%		
5 = Extremely dangerous	466	43.88%		
<i>Protective Behaviors toward COVID-19</i>				
Sunbathing			3.32	1.16
Using a face mask when out of home	1 = Never		3.71	1.17
Doing sport	2 = Seldom		3.29	1.06
Physical distancing	3 = Sometimes		4.24	0.86
Washing hand with soap/sanitizer	4 = Often		4.57	0.68
Enough sleeping (8 h)	5 = Always		4.03	0.91
Eating nutritious food			4.27	0.81
<i>Descriptive norms</i>				
People outside of the province	1 = Nothing		2.85	0.80
People outside of the city	2 = Less moderate		3.12	0.71
People in the city	3 = Moderate		3.10	0.76
People in the neighborhood	4 = Extreme		3.20	0.84
People in the household	5 = Very extreme		3.48	0.68

Table 1 (continued)

Variable	n	%	Mean	SD
<i>Frequency of travel during COVID-19 pandemic</i>				
Work/school trips	0 = never		2.15	1.95
Shopping trips	1 = 1 trip/week		2.48	1.30
Eating outside	2 = 2 trips/week		1.57	1.30
Sightseeing trips	...		1.56	1.11
Social trips	7 = 7 trips/week or more		1.31	0.84
<i>Frequency of travel before COVID-19 pandemic</i>				
Work/school trips	0 = never		5.86	1.51
Shopping trips	1 = 1 trip		3.66	1.67
Eating outside	2 = 2 trips		3.76	1.96
Sightseeing trips	...		3.06	1.65
Social trips	7 = 7 trips/week or more		2.79	2.79
<i>Teleworking and e-learning</i>				
0 = Stop doing	0	0%		
1 = Do less than usual	58	5.46%		
2 = Do as usual	158	14.88%		
3 = Do more than usual	846	79.66%		
<i>Teleshopping</i>				
Online shopping				
0 = Stop doing	327	30.79%		
1 = Do less than usual	396	37.29%		
2 = Do as usual	229	21.56%		
3 = Do more than usual	110	10.36%		
Fresh food and drink with same-day delivery				
0 = Stop doing	317	29.85%		

Table 1 (continued)

Variable	n	%	Mean	SD
1 = Do less than usual	448	42.18%		
2 = Do as usual	180	16.95%		
3 = Do more than usual	117	11.02%		
<i>Ride-hailing use</i>				
Using motorcycle-based ride-hailing				
0 = Stop doing	740	69.68%		
1 = Do less than usual	252	23.73%		
2 = Do as usual	52	4.90%		
3 = Do more than usual	18	1.69%		
Using car-based ride-hailing				
0 = Stop doing	791	74.48%		
1 = Do less than usual	209	19.68%		
2 = Do as usual	42	3.95%		
3 = Do more than usual	20	1.88%		
<i>ICT use duration</i>				
Laptop use duration				
	1 = < 6 months		4.85	1.58
	2 = 6–12 months			
	3 = 1–2 years			
	4 = 2–4 years		4.99	1.38
	5 = 4–6 years			
	6 = > 6 years			
Smartphone use duration				
<i>Online services use duration</i>				
Online shopping use duration				
	1 = < 6 months		3.43	1.59
	2 = 6–12 months			
	3 = 1–2 years		3.23	1.31
	4 = 2–4 years			
Ride-hailing use duration				

Table 1 (continued)

Variable	n	%	Mean	SD
Experience of fresh food and drink with same-day delivery	5 = 4–6 years			
	6 = > 6 years			
			3.05	1.29

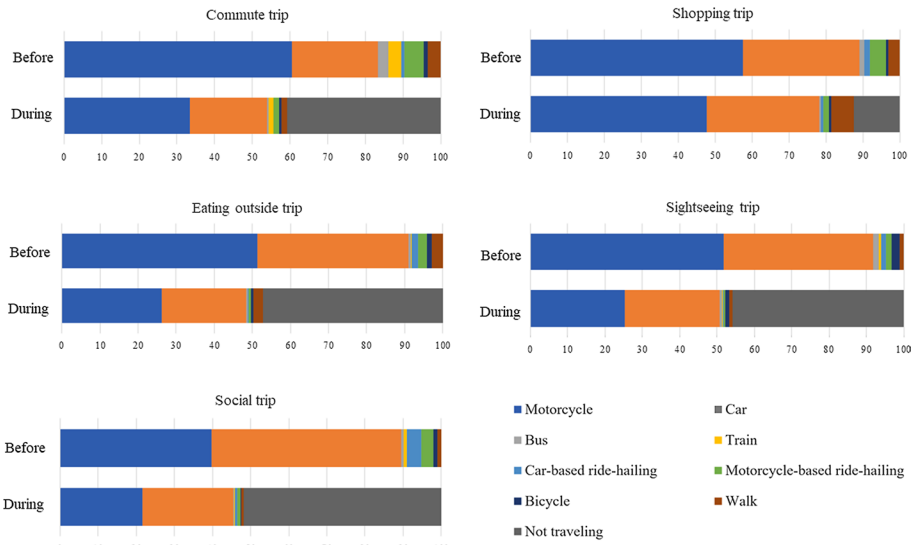


Fig. 2 Travel mode before and during the COVID-19 pandemic

to prevent the spread of the virus: washing hands with soap/sanitizer, eating nutritious food, physical distancing, and adequate sleep. Other measures have included wearing face masks, sunbathing, and physical exercises.

Model results

Since our SEM consists of eight latent variables that cannot be observed, their presence is explained by indicators that observable and represent the underlying construct. In order to ensure the reliability of the latent construct, before performing the SEM, we had to first check whether the observed variables constructing the latent variables satisfied the minimum value of Cronbach's alpha. As shown in Table 2, except for the latent variable of travel frequency during the COVID-19 pandemic (0.67), the Cronbach's alpha values for all latent variables ranged from 0.707 to 0.90, exceeding the critical value of 0.7, indicating that it has good internal consistency (Nunnally 1978).

This study adopted several models' fit criteria in the assessment of SEM output. The results show that the root mean square error of approximation value of 0.036 was less than 0.05, indicating a good fit. The goodness of fit index was 0.921, while the adjusted goodness of fit index was 0.901, and the comparative fit index was 0.926. The results of all parameters varied from 0 to 1, and values of 0.9 or higher were acceptable. The relative Chi-square corrected for degrees of freedom (Chi-square/df) was 2.372, where values of 3 or less indicate a good fit. Hair et al. (2010) suggested the need for all results to meet the requirements of fit criteria, which indicate a good-fitting model.

Table 2 shows the standardized parameter estimates of the indicators constructing the latent variables. In estimating the indicators' parameter, we determined that the first indicator of each latent variable is fixed as one as suggested by Hox and Bechger (1998). They explained that one of its observed indicators constructing a latent variable must be fixed

Table 2 Standardized parameter estimates of the observed indicators for the latent variables

Latent variables	Standardized parameter	Standard error	Cronbach's alpha
<i>Ride-hailing use during COVID-19 pandemic</i>			0.82
Using motorcycle-based ride-hailing	0.778 ^a		
Using car-based ride-hailing	0.9	0.065	
<i>Teleshopping during COVID-19 pandemic</i>			0.74
Online shopping	0.785 ^a		
Fresh food and drink with same-day delivery	0.757	0.059	
<i>Frequency of travel during COVID-19 pandemic</i>			0.672
Work/school trips	0.473 ^a		
Shopping trips	0.406	0.058	
Eat outside	0.667	0.075	
Sightseeing trips	0.682	0.067	
Social trips	0.682	0.051	
<i>Frequency of travel before COVID-19 pandemic</i>			0.707
Work/school trips	0.409 ^a		
Shopping trips	0.486	0.483	
Eating outside	0.621	0.708	
Sightseeing trips	0.775	0.761	
Social trips	0.69	0.608	
<i>Protective Behaviors toward COVID-19</i>			0.77
Sunbathing	0.478 ^a		
Using a face mask when out of home	0.552	0.117	
Doing sport	0.509	0.088	
Physical distancing	0.621	0.098	
Washing hand with soap/sanitizer	0.765	0.086	
Enough sleeping (8 h a day)	0.584	0.093	
Eating nutritious food	0.61	0.093	
<i>Descriptive norms</i>			0.721
People outside of the province	0.628 ^a		
People outside of the city but within the province	0.881	0.063	
People in the city	0.799	0.059	
People in the neighborhood	0.546	0.062	
People in the household	0.452	0.045	
<i>ICT use duration</i>			0.813
Laptop use duration	0.865 ^a		
Mobile phone use duration	0.795	0.040	
<i>Online services use duration</i>			0.90
Online shopping	0.699 ^a		
Fresh food and drink with same-day delivery	0.938	0.039	
Ride-hailing	0.914	0.041	

^aItem fixed on 1.00 for unstandardized

on one aiming to normalize the estimated parameters. Judging by the standard error, all observed indicators for the latent variables performed well.

Table 3 shows the standardized coefficients, which facilitate a comparison of the effect magnitudes. The effects were estimated by using the bootstrapping technique with 2000 replications. Answering the first objective of this study, a significant negative correlation exists between the frequency of travel during the pandemic and the activity-travel behavior changes, as expected. It means that the lower frequency of travel during the COVID-19 pandemic corresponds to an increase in nonparticipation in out-of-home activities. Also, there was a significant positive impact of attitudes and protective behaviors toward COVID-19 on activity-travel behavior change. It means that people who perceive that COVID-19 is a serious problem, and people with positive protective behaviors such as physical distancing, washing hands with soap or sanitizer, etc., have tended to increase their nonparticipation in out-of-home activities during the pandemic. This result is consistent with travel behavior change in the United States, where people who had a perception that COVID-19 is a medium or high-risk disease tend to stay at home (Hotle et al. 2020). The results also indicate that attitudes and protective behaviors toward COVID-19 indirectly affected activity-travel behavior change through the mediations of travel frequency during the pandemic. As direct and indirect effects were significant with a similar positive sign, it implies that travel frequency during the pandemic plays as a complementary partial mediation on the relationship from protective behavior and attitudes to activity-travel behavior change.

Furthermore, descriptive norms and online service use duration had no significant relationship to activity-travel behavior changes. The descriptive norms seem to do not able to determine people's activity-travel behavior changes since, at the time of this study, the pandemic has not spread evenly in Indonesia. There are many places (city or even provinces) reported very low cases. It contributes to the understanding of the risk. With a similar fact that during March 2020 and April 2020, people seem in the phase of understanding the situation and learning to find a suitable adaptation activity-travel behavior. This finding implies an application of the learning curve of people to adapt to the situation and create more stable activity-travel behavior. The model results also show that although travel frequency before the pandemic and ICT use duration had no significant direct effect on activity-travel behavior change, those two variables indirectly and significantly affected activity-travel behavior change through the mediation of travel frequency during the pandemic. It implies that travel frequency during the pandemic plays as a full mediator from ICT use duration and travel frequency before pandemic to activity-travel behavior change. A positive sign of the indirect effect of ICT use duration on activity-travel behavior change means that persons with a long experience in using laptop and handphone less often travel during the pandemic, thereby making them more likely to change their activity-travel behavior. A similar case also occurs on the indirect effect of travel frequency before the pandemic on the activity-travel behavior change. Shown by a negative sign, it reveals that people with a lower travel frequency before the pandemic are less likely to travel during the pandemic, and, therefore, result in a greater activity-travel behavior change.

Considering the effect of attitudes, descriptive norms, and protective behaviors on ICT use, people with positive protective behaviors toward COVID-19 have tended to increase their participation in teleworking or e-learning and reduce their ride-hailing use. People with negative attitudes toward COVID-19 and those with positive descriptive norms tend to use ride-hailing more frequently. Additionally, as expected, ICT use duration was found to bear a significant positive impact on online service use duration. It means that people with long experience in laptop and mobile phone use were also more likely to have long experience in online transportation service use as well. The

Table 3 Direct and indirect effects given in standardized coefficients

Dependent variables		Activity-travel behavior	Freq. of travel during pandemic	Teleworking/e-learning	Tele shopping	Ride-hailing use	Attitudes	Descriptive norms	Protective behaviors	ICT use duration	Online services use duration	Freq. of travel before pandemic
<i>Endogenous variables</i>												
Freq. of travel during pandemic	-0.121 ⁺											
Teleworking/e-learning	0.055*											
Teleshopping												
Ride-hailing use				-0.063*	0.531 ⁺							
Attitudes	0.154 ⁺ (0.037*)	-0.135 ⁺ (0.081 [#])				-0.068* (0.066 [#])		0.56*				
escriptive norms		0.092 ⁺ (0.053*)				0.1 ⁺ (0.018 ⁺)			-0.55 ⁺ (0.109 [#])			
Protective behaviors	0.103 ⁺ (0.059*)	-0.172 ⁺ (-0.015 ⁺)		0.083* (0.007 ⁺)		-0.129 ⁺ (-0.001 [#])			0.282 ⁺			
ICT use duration	0.015* (0.015*)	-0.117 ⁺				-0.162 ⁺ (0.045 [#])					0.445 ⁺	
Online services use duration					0.23 ⁺ (0.054*)	0.102*						
Freq. of travel before pandemic	(-0.031 ⁺)	0.26 ⁺										
<i>Exogenous variables</i>												
Gender (male)		0.159 ⁺ (0.056 ⁺)				0.078* (0.013 ⁺)			-0.18 ⁺		-0.098 ⁺	0.087*

Table 3 (continued)

	Dependent variables										
	Activity-travel behavior	Freq. of travel during pandemic	Teleworking/e-learning	Tele shopping	Ride-hailing use	Attitudes	Descriptive norms	Protective behaviors	ICT use duration	Online services use duration	Freq. of travel before pandemic
Age			-0.092* (0.001 ⁺)				0.157 ⁺	0.122 ⁺ (-0.017 ⁺)			-0.197 ⁺
Income		0.058 [#] (0.011 ⁺)	0.167 ⁺ (0.033 ⁺)					0.121 ⁺	0.123 ⁺	0.129 ⁺ (0.055 ⁺)	
Education					-0.071* (-0.057 ⁺)		-0.179 ⁺		0.307 ⁺		
Worker/Student											
Yogyakarta											
Central Java											
East Java											
West Java											
Other Provinces											0.077 [#]

(1) ⁺ means $p < 0.01$ (2) * means $0.01 \leq p < 0.05$ (3) [#] means $0.05 \leq p < 0.1$ (4) an empty cell means the coefficient is insignificant at the 0.1 level (5) The numbers in parentheses are indirect effects

model results also found the R-square value for online services use duration is 0.26, implying that ICT use duration, as well as gender and income, explained variance of online services use duration by 26%. Meanwhile, people with long experience in using laptops and mobile phones have tended to reduce their travel frequency during the COVID-19 pandemic, using either online transportation services or other transportation means. Conversely, online service use duration significantly affects higher ride-hailing and teleshopping use. It means that the longer people use online transportation services, the more frequently they shop online and order ride-hailing during the COVID-19 pandemic. This result also shows the dependency of online services for longtime users. The model results also demonstrate a contradictory causal relationship between attitudes and descriptive norms, as Table 3 shows the positive influence of attitudes on descriptive norms, which have a negative effect in return. Therefore, people with the perception of COVID-19 as a serious problem also perceived other individuals behaving positively toward the disease. In contrast, people who perceive that other people behaved positively toward COVID-19 tended to ignore the severity of COVID-19. The explanation of this counterintuitive result between attitude and descriptive norms could be because of other variables that are not in the model. Meanwhile, people with these positive descriptive norms also tended to protect themselves toward COVID-19 less positively and had a higher travel frequency during the COVID-19 pandemic.

For the second objective, the model results found the possibility for teleworking or e-learning to support the reduction in out-of-home activities. Workers and students are more likely to perform teleworking or e-learning compared with other counterparts. However, teleworking or e-learning had no effect on the decline in travel frequency during the outbreak, including engagements in shopping trips, eating out, sightseeing, social explorations, as well as movements to work and school. It means that a person who could work or study from home keeps travel with a lower trip frequency for those trip purposes. It also indicates that people have experience in trip chaining, where one trip is combined with other trips. When one activity is canceled, it does not mean people will reduce the trip. It is argued that this behavior is temporary or during the outbreak only since people are still in the phase of shaping their new behavior to establish more stable behavior.

Teleshopping could not substitute trips and out-of-home activities during the COVID-19 pandemic. This is evident by the absence of a significant correlation with the frequency of travel and activity-travel behavior change. The outcome was not expected because teleshopping was predicted to result in fewer trips and the minimization of out-of-home activities. This finding can be explained by the limited opportunities to participate in out-of-home activities during the pandemic, especially for leisure activities. Due to this, people seem to shop online for enjoyment purposes, and not for in-store shopping activity substitution. This reason is supported by Koch et al. (2020) who found that entertainment and enjoyment experienced from online shopping influenced teleshopping behavior during the COVID-19 outbreak. Similarly, the use of ride-hailing has no direct effect on activity-travel behavior change. However, a significant positive correlation was identified against teleshopping. This result was due to the application of ride-hailing to deliver goods bought online. We found that the R-square value for teleshopping is 0.36, meaning that ride-hailing use, as well as online service use duration, age, and income, explained 36% of teleshopping variance. A significant negative correlation was recognized between ride-hailing and teleworking or e-learning, indicating that the use of ride-hailing potentially replaces those latter 2 activities. It also means that ride-hailing services support people who still work or study outside the home during the COVID-19 pandemic.

For the last objective of this research, regarding the impact of individual characteristics on activity-travel behavior change, Table 3 shows that they were all insignificant, suggesting that personal characteristics did not affect the changes in activity-travel behavior. The reason might be due to a possibility that the effect of individual characteristics is already captured by other explanatory variables such as frequency of travel during the pandemic, teleworking or e-learning, attitudes, and protective behavior as can be seen in Table 3. Furthermore, personal attributes significantly affected endogenous variables. Males were more likely to travel, both before and during the COVID-19 pandemic, and more likely to use ride-hailing than females. A similar finding is also found by Parady et al. (2020) in exploring travel behavior change during the pandemic in Japan. They found that males tended to increase their out-of-home activities participation of shopping, eating out, and leisure during the pandemic than females. This study results also found that males were also less likely to engage in positive protective behaviors toward COVID-19 than females. Meanwhile, elderly individuals had a lesser tendency to shop online compared to the young. The older the individual, the more they displayed positive COVID-19 protective behaviors, and the more they perceived that people around them exhibited similar positive protective behaviors.

The income factor had a significant positive effect on teleshopping, teleworking or e-learning, ICT and online services use duration, and positive protective behaviors. It means that individuals with higher incomes more often shop online and telework during the COVID-19 pandemic. A study by Beck et al. (2020) also found that Australians' high-income had a higher probability of being able to telework. Higher-income people also had longer experience in using ICT and online services than do their counterparts in other classes. They were more likely to behave positively in facing the COVID-19 outbreak. Similarly, more highly educated people had more ICT experience than the less well educated. They were also less likely to use ride-hailing to participate in out-of-home activities during the COVID-19 pandemic. In terms of descriptive norms, the lower the person's education level, the more they perceived that people positively behave toward COVID-19 protection. Finally, the model results reveal that except on travel frequency during the pandemic, spatial characteristic did not correlate with all endogenous variables. It represents that people who are living outside the Greater Jakarta have similar attitudes, descriptive norms, protective behaviors toward COVID-19, activity-travel behavior changes, and ICT use duration and frequency during the beginning of COVID-19 pandemic with people who are living in the Greater Jakarta, the epicenter of COVID-19 in Indonesia. Meanwhile, a positive correlation existed between people who are living outside of Java Island and travel frequency during the pandemic. It means that people who are living outside of Java Island have a higher frequency of travel during the beginning of COVID-19 pandemic than inhabitants in Java Island.

Conclusions and recommendations

This study was the first attempt to explore activity-travel behavior changes during the beginning of COVID-19 pandemic in Indonesia. Although we faced severe time restrictions, we were able to collect a considerable amount of data and apply the structural equation model with a good-fitting model.

This study found a decrease in travel frequency during the beginning of COVID-19 pandemic that has resulted in activity-travel behavior changes, as also has been found by other

studies (de Haas et al. 2020; Molloy et al. 2020; Parady et al. 2020; Shamshiripour et al. 2020). As expected, work and study habits evolved from office and school to telework and e-learning, significantly cutting back out-of-home activities. Similar to Hotle et al.'s (2020) and Nguyen's (2021) findings, attitudes toward COVID-19 contributed to the activity-travel behavior change; the more people perceived the severe virus effects, the more they reduced out-of-home activities. Descriptive norms positively affected the frequency of travel and ride-hailing. Although there was a decline in ride-hailing use, changes in this action did not significantly contribute to out-of-home activity changes. The model results also revealed that the experience of ICT directly reduced travel frequency and ride-hailing use during the pandemic. By contrast, the experience of online service impacted an increase in teleshopping and ride-hailing. For the last finding, it meant a greater dependency on ride-hailing use for longtime users of online services. That cohort used this mode more often during COVID-19 pandemic than their counterparts. Our result also found that males tend to travel more often than females for both normal conditions and during the COVID-19 pandemic. Younger people were more likely to participate in teleshopping. Meanwhile, higher-income people were more likely to participate not only in teleshopping but in teleworking. Higher-income people also tend to have more ICT use and online services experience.

The research findings led to proposals to reduce out-of-home activities as a means of curbing the spread of COVID-19 in Indonesia. These recommendations are generally useful for initial steps in an emergency. First, the government must massively educate the public about the deadly seriousness of COVID-19 via television and social media because the model results showed that attitudes toward the pandemic significantly reduced travel frequency and out-of-home activities. Once the travel frequency and out-of-home activities participation can be minimized since the beginning of COVID-19 pandemic, it is expected that the virus spread in the future can be suppressed.

Second, considering how descriptive norms have positively affected travel frequency during the pandemic, the society must be educated in personal responsibility for suppressing the spread of COVID-19 by minimizing their frequency of travel during the pandemic. It is not expected that people travel more to fulfill their needs during the COVID-19 outbreak because they perceive safe since other people behave positively toward the disease. This action is especially for those with low education level and older people because the model results reveal that those persons had a positive correlation with descriptive norms.

Third, the government could regulate the utilization of online transportation to reduce out-of-home activities during the COVID-19 pandemic. Since there was a significant positive correlation between ride-hailing use and teleshopping, the government needs to encourage ride-hailing use to support teleshopping, especially for fresh food and drink with same-day delivery. The government and operators of online transportation and logistics should focus on preparing the protocol of goods preparation and delivery not only for drivers but also for supplier companies. Providing transparent communication and sophisticated online platforms could be carried out to increase the demand for teleshopping during the pandemic as suggested by Koch et al. (2020). Conversely, the ban for people-transport ride-hailing services is recommended, at least for the motorcycle-based-ride-hailing, especially for those who use ride-hailing to trip to work during COVID-19 pandemic. The recommendation is supported by our model result, where we found a negative correlation between ride-hailing use and teleworking. Using ride-hailing also potentially threatens more passengers from contacting COVID-19 since other people have used this travel mode.

This paper has several limitations. First, this study focuses more on travel behavior during the beginning of COVID-19 pandemic. Using other pandemic or emergency situational data might be fruitful to explore more travel behavior changes before and during pandemic

or emergency situations. It is important to support transport management during emergency situations. Second, to better understand the activity-travel behavior changes during pandemics or emergencies, either in-home or out-of-home activities, collecting individuals' activity diaries over longer durations could capture more of activity-travel behavior changes. The activities diaries could be used to investigate in more detail the type of highly impacted activities or travels as well as its amount. With the increasing issue of mental and physical health and well-being during the outbreak, the investigation from the activity-travel behavior perspective could be the next research agenda. Third, other variables must be considered in future research to more fully explore the determinant factors of activity-travel behavior change during the pandemic, such as the nature of job. It is also related to the change in employment status during the pandemic. Shamshiripour et al. (2020) reveal that around 14% of full-time workers in Chicago lost their jobs temporarily and 17% of part-time workers were laid off permanently. Furthermore, with the intense change of daily activities during this outbreak, there are questions on how activity and travel behavior changes during the outbreak affect the post-outbreak period. This is an important topic for mitigating emergency situations from the mobility side.

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Compliance with ethical standards

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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