Panel Survey for Revealing Travel Behavior Changes Caused by the Stay-at-home Request as the Measures for COVID-19 in Japan

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This study investigates activity-travel behavioral changes during/after issuing the Stay-at-home Request during the State of Emergency for the action to COVID-19 by the Japanese government. Three wave Web-based panel survey was conducted for 300 samples living in Tokyo and surrounding cities. The question-naire is designed to obtain changes of activity and travel behavior before, during, and after stay-at-home requests to reveal necessarily activities and effects for travel demand of travel modes. In this paper, we will report the suvey design and prompt results of on-going survey.

Key Words : COVID-19, Travel behavior, Panel survey, Web survey

1. INTRODUCTION

The COVID-19 pandemic has changed the world we take for granted in only a few months. Facing the crisis, the Japanese government declared the State of Emergency including the Stay-at-home Request on April 6 for the first time ever. It was expanded to the whole country on April 16 and was finally lifted on May 25. In a time when people are fear of contracting and spreading the virus and asked to avoid making unnecessary outgoings, risk per-ceptions of daily lives have changed. It has in turn altered how most people go about their daily lives Employees are working from home instead of commuting to work. Schools close, and students are taking classes online. Stores reduce opening hours.

Changes that occurred at the individual-behavior level lead to shifts in passenger transport demand rad-ically. While Big Data such as GPS and cellular data can capture the overall trends in demand fluctua-tions(e.g. COVID-19 Community Mobility Re-ports[1]), little is known about the latent information that which and to what extent various factors (indi-vidual socio-economic, etc.) affect people's travel behavior. Such information is crucial to a compre-hensive and correct understanding of transportation demand for urban policymakers and planners.

Ordinally, the Person Trip (PT) Survey provides the information. However, it is usually held once sev-eral years. In Japan, the interval is 10 years while the latest one was conducted in 2018. Obviously, the cur-rent PT Data is unable to offer the relevant in-for-mation under the COVID-19 outbreak.

The need is now. The impacts of COVID-19 are vast and will be long-lasting. understanding what fac-tors affect behavioral change at the individual level under the non-enforceable self-restriction requests, is of importance. Such information may provide helpful insights to local governments and may be used as a

foundation for new policies to mitigate the economic and social impacts caused. The literature on this subject is limited since the COVID-19 pandemic is still ongoing. Parady et al. (2020)[2] conducted a two-wave panel survey in the Kanto Region to evaluate the relationship between social anxiety and behavioral responses to COVID 19. Shamshripour et al. (2020)[3] implemented an SP-RP survey in the Chicago metropolitan area to analyze individuals' behavior changes. The purposes of this research will be covering the following:

(a) to design a survey able to capture the links between changes in travel behavior and social factors

(b) to present the results of the survey by aggregate analysis

2. DATA COLLECTION

(1) Survey Design

A three-wave online panel survey is designed (see Table 1) and implemented in the main cities of Tokyo Metropolitan Area, including Tokyo 23 Districts and four ordinance-designated cities around (Yokohama City, Kawasaki City, Saitama City, and Chiba City).

The first wave of the survey was conducted from May 1 to May 6, focusing on the activities performed from April 22 to April 28 (one week after the nationwide State of Emergency was announced). The second wave was conducted two months after the first one. It collected data during the period one month after the State of Emergency was lifted (Jun. 24–Jun. 30). The third wave, which is ongoing, is to collect data of Sep. 24–Sep. 30.

(2) Sampling

The survey is performed using the Web-based questionnaire system provided by Cross Marketing Inc. The sampling process is conducted with the monitors of this marketing company. A total of 4681 people is asked to answer a screening questionnaire firstly. Table 2 lists the items of the questionnaire.

After excluding some respondents (younger than 20, never use public transportation before Feb. 2020, or whose working conditions are affected drastically by reasons other than novel coronavirus), there are 3012 people left. They are then divided into two groups to apply different sampling methods, depending on whether they have physical difficulty.

(a) Respondents without physical difficulty (2850 people): the stratified sampling is applied. The stratification criteria are as follows:

• The average number of days of public trans-portation (such as railway and bus) per week: 1–4 days, 5–7 days

Table 1 Three-wave online panel survey

`	1st	2nd	3rd
Implementation Period	May, 1–6	Jul, 3–13	Oct, 1–
Target Activities	Before Feb. +Apr. 22–28	Jun. 24–30	Sep. 24–30
Sample Size	300	243	-
Area	Tokyo 23 Districts, Yokohama City, Kawasaki City, Saitama City, and Chiba City		

Table 2 Screening survey

No.	Survey Content		Options
1	Gender & Age		Gender & age brackets of below 20, 20–30, 30–40, 40–50, 50–60, 60–65, 65–75 and above 75 divided by male and female
2	Residence		Prefectures, districts & cities
3	The average number of days using public transportation per week before Feb. 2020		0–7 days
4	The most suitable description of the working conditions since April under the influence of novel coronavirus	i	Working hours/days at your workplace have increased (excluding student's part-time job).
		ii	Working hours/days at your workplace have decreased (excluding student's part-time job).
		iii	Number of working hours/days at your workplace has not changed (excluding student's part-time job).
		iv	Number of working days has changed and mostly teleworking.
		v	Number of working days has not changed but mostly teleworking.
		vi	Temporary absence from work
		vii	Not working (student)
		viii	Not working (housewife/househusband, unemployed)
		ix	Changes in life/work due to reasons other than novel coronavirus
		x	Other
5	Physical difficulty when going out	i	Have no difficulty
		ii	Able to go out by one's self with auxiliary tools (stick, etc.)
		iii	Need partial assistance sometimes
		iv	Need full-time assistance
		v	Unable to go out due to illness

• Gender & age: gender & age brackets of 20–30, 30–40, 40–50, 50–60 and above 60 divided by male and female

• Residence: Tokyo 23 districts, other four cities

5 respondents are selected from each stratum. After some adjustments, according to the number of responses and combining two strata of residence, it results in 20 groups of 10 respondents each.

(b) Respondents with physical difficulty (162 people): no special sampling method is applied since the number of people is small enough. 100 samples are selected randomly.

A sample size of 300 people are acquired finally. The participation rate for the second wave is 81% (243 respondents).

Table 3 Panel survey items

No.	No. (sub)	Question	Options
1		**Basic socio-demographic information**	
		Occupation/Employment status/Transportation mode for daily commute before the spread of novel coronavirus/The nearest station from your home/The nearest station from your workplace or school	
2		**Activities involving travel from home**	
		Activity	Commute/Pick-up and drop-off/Hospital visit/Shopping for food and necessities/Get take-out food at restaurants/Shopping for others (excluding food, necessities, and take-out food)/Eat and drink for socializing/Eat and drink for others/Indoor amusement (movie, etc.)/Individual outdoor activity/Group outdoor activity/Use essential services (city hall, bank, etc.)/None of the above
		for each activity conducted:	
2.1		conducting the activity	1–7 days
2.2		using the railway	
2.3	The number of days of	taking the bus	
2.4		taking the taxi	0–7 days
2.5		riding the motorbike or bicycle	
2.6		driving the private car	
2.7		The relationship with the companion (at least once every three times)	
2.8		The time spent to get to the most visited place from your home	
3		**Activities at home**	
		Activity	Telework/Use online medical care service/Use food delivery service (including online order)/Online shopping for food and necessities/Online shopping for others (excluding delivery, food and necessities)/Play a game at home/Video meeting or chat for non-work purposes (Skype, Zoom, etc.)/None of the above
		for each activity conducted:	
3.1		The number of days of conducting the activity	1–7 days
3.2		hours spent per day	
4		**Personal ranking regarding the safety of transportation modes**	
	Rank the safety/security of all the given modes	Railway/Bus/Taxi/Private Car/Motorbike/Bicycle/Walking	1st–7th
5		**Others**	
		Changes in home base/Shopping behavior for food and necessities/Route and time slot of using rail or bus/Time slot of morning travel	
		Personal and others' attitude towards refrain from going out /Expectation of refrain from going out from others	
		Inconvenience in the bus, train or station/Newly started habit/Stopped habit/Any other changes noticed in behavior	

(3) Survey items

This research focuses on investigating the activities performed actually. In order to collect the data of less-frequent activities, questions are asked on a one-week basis. Reasons for not using diary studies are due to the high cost and the intent to reduce the respondents' response time and other burdens. Survey items are summarized in **Table 3**.

All the items are asked repeatedly in three waves of the panel survey, except for item 1 (only requested in the first wave). Regarding activities, they are set up with reference to the 2018 PT Survey[4] (**Table 4**), divided into three categories: commute, shopping, and other personal affairs. Shopping is divided into two types according to the purpose: for food and necessities, for others. **Table 4** also organizes the correspondence of activities involving travel from home and activities at home. It is assumpted that the activity at home will take the place of the one involving travel from home during the State of Emergency. It will be further described in section 3.

3. ANALYSIS RESULTS

Section 3 is devoted to present the analysis results of item 2 and 3 in **Table 3** but only uses the data of respondents without physical difficulty.

(1) Activities involving travel frome home

(a) The number of people

Fig. 1 illustrates the number of people in each activity involving travel from home across three periods. The red, yellow, green bar represents the situation of three target periods, respectively.
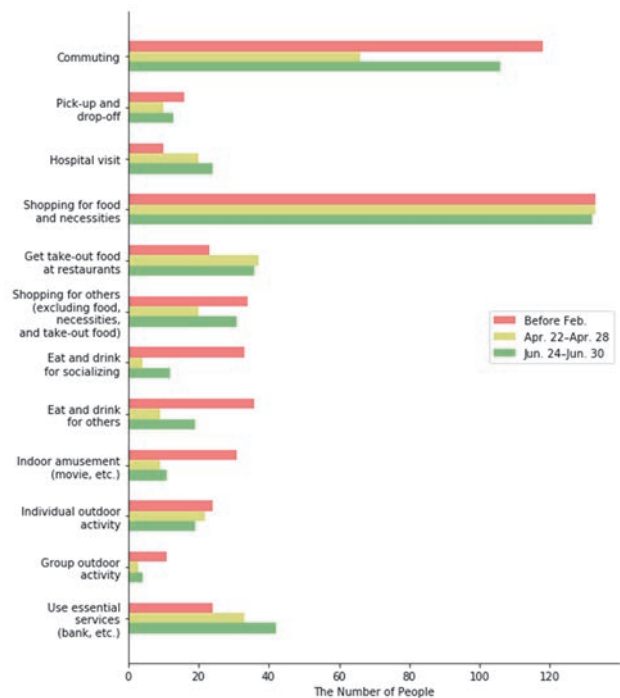
From Apr. 22–Apr. 28 (during the State of Emergency), there is a significant drop in commuting, shopping for others (excluding food, necessities and take-out food), eat and drink for both socializing and others, indoor amusement, and group outdoor activity. A recovery trend is shown in all these activities after the declaration is lifted, but a level lower than pre-corona times is still kept.

By contrast, the number of people visiting the hospital, getting take-out food at restaurants, and using essential services increases. The situation differs one month after the State of Emergency was lifted: the number of people visiting the hospital and using essential serives continues increasing, while getting take-out food at restaurants stay almost the same compared to the State of Emergency duration.

For pick-up and drop-off and individual outdoor activity, the fluctuations are slight. The former goes down then up while the latter keeps going down. As for shopping for food and necessities, the number of people keeps constant across three periods.

Table 4 Activity setting

Category in 2018 PT Survey	Activities involving travel from home	Activities at home
Commute	Commute	Telework
Shopping	Shopping for food and necessities/Get take-out food at restaurants	Use food delivery service (including online order)/Online shopping for food and necessities
	Shopping for others (excluding food, necessities, and take-out food)	Online shopping for others (excluding delivery, food and necessities)
Other personal affairs	Hospital visit	Use online medical care service
	Indoor amusement (movie, etc.)/Individual outdoor activity	Play a game at home
	Group outdoor activity	Video meeting or chat for non-work purposes (Skype, Zoom, etc.)
	Pick-up and drop off/Eat and drink for socializing/Eat and drink for others/Use essential service (bank, etc.)	N/A

Fig. 1 The Number of People

(b) Days per person per week (PPPW)

Fig. 2 depicts the weekly number of days of activities involving travel from home per person.

During the State of Emergency (Apr. 22–Apr. 28), a significant deduction in commuting can be observed. There are also slight drop happening in pick-up and drop-off, eat and drink for both socializing and other purposes, indoor amusement, and group outdoor activity. All these activities except for indoor amusement and group outdoor activity show a recovery trend one month after the declaration was lifted but maintain a lower level than before. Indoor amusement (see a movie, etc.) and outdoor group activity continue going down.

The frequency of visiting the hospital, getting take-out food at restaurants, conducting an individual outdoor activity, and using essential services maintain a sustained upward trend. For individual outdoor activity, it increases during the State of Emergency then goes down after its lift. As for shopping for food and necessities, the days per person per week of this activity maintain a stable level across three periods.
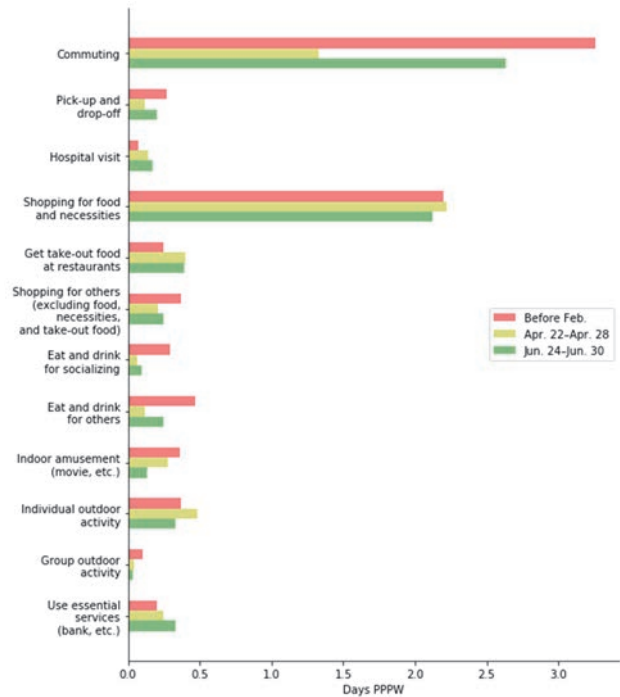
(2) Activities at home
(a) The number of people

Fig. 3 shows the number of people conducting activities involving travel from home. The overall trend for each activity is similar. In addition to online medical care services, the number of people of all the activities increases during the State of Emergency and maintains an above or almost consistent level compared to the situation before February 2020. It is noted that the number of people performing telework is far beyond the previous level even after the declaration was lifted.

(b) Days per person per week (PPPW)

The number of days per person per week of the activities at home is shown in **Fig. 4**. All the activities except for online medical care services show a similar trend. They increase first and then go down but keeps an above level compared to the situation before the spread of novel coronavirus.
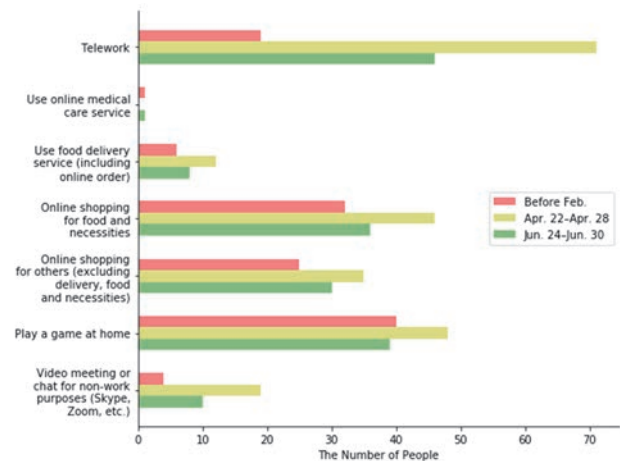
(3) Activities involving travel frome home vs activities at home

This part analyzes the correlations between two types of activities (involving travel from home and at home, see **Table 4**), in terms of increase or decrease in the number of days.

(a) Before Feb. vs Apr. 22–Apr. 28

Fig. 5 depicts the correlation of the increase or decrease in the number of days in before Feb. compared to Apr. 22–Apr. 28. The horizontal axis represents activities at home. The vertical axis represents activities involving travel from home. The values in the
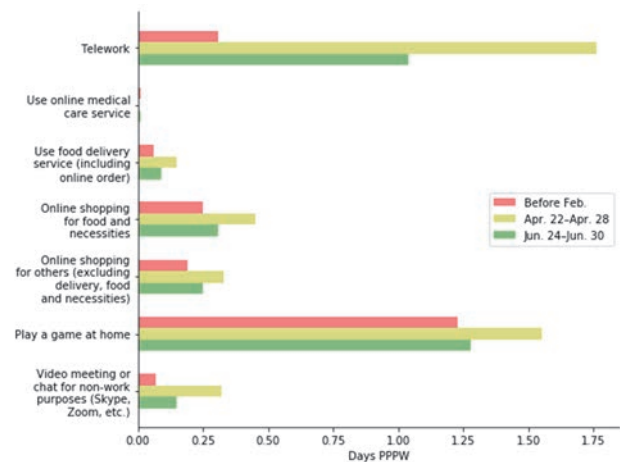

Fig. 2 Days PPPW

Fig. 3 The Number of People

Fig. 4 Days PPPW

grid represent the correlation coefficients calculated. Blue for positive correlation, red for negative. The stronger the correlation, the darker the color. Referring to **Table 4**, activities predetermined as correspondences are investigated firstly.

• Commute: for commuting and telework, the correlation coefficient is -0.35, indicating a negative relationship between the two activities. It is not difficult to understand the phenomenon when during the State of Emergency, the weekly number of commuting days decreases, and at the same time, the weekly number of days of telework increases since the ratio of telecommuting companies in the capital surged to 63 percent in April as the coronavirus spread according to the survey by the Tokyo Metropolitan Government.

• Shopping: no correlation relationship is shown between activities for acquirng food and necessities. (In-store shopping, the use of food delivery service, and online shopping). It can be explained by the fact that shopping for food and necessities barely changed while delivery and online shopping increased during the State of Emergency. A positive correlation relationship appears between take-out and delivery/online shopping for food and necessities since all three activities increased in the State of Emergency duration. However, with regard to shopping for non-food or necessities, there is no correlation shown in in-store and online behavior although a decrease in in-store shopping and an increase in online one can be observed from **Fig 2** and **Fig 4**. Further analysis and discussion are needed.

• Other personal affairs: there is almost no correlation between visiting the hospital and the use of online medical care services, as well as indoor amusement/individual outdoor activity and games at home. The reason for the former shall be the low-frequency use, online medical care services in particular. For the latter, similar to the relationship between in-store and online shopping for others, it requires further analysis. Group door activity and video meeting/chat for non-work purposes are positive-correlated. Under the situation unable to meet face to face, people still try to keep in touch with each other by different means.

A correlation relationship is also shown in some activities not predetermined as correspondences (eat and drink for socializing and use of food delivery, Group outdoor activity and online shopping for food and necessities).

(b) Apr. 22–Apr. 28 vs Jun. 24–Jun. 30

Looking into the correlations between the increase or decrease in the number of days in Apr. 22–Apr. 28 compared to Jun. 24–Jun. 30 (**Fig. 5**), the results do not differ significantly compared to the ones shown

in **Fig. 4**. The only difference is in the weak correlation between commuting and telework. From the weekly number of days per person, commuting is recovered 80.67% of the pre-corona level one month after the declaration. However, telework remains 59% percent of the State of Emergency level, increasing 235% compared to pre-corona times. Telework does not reduce that much.
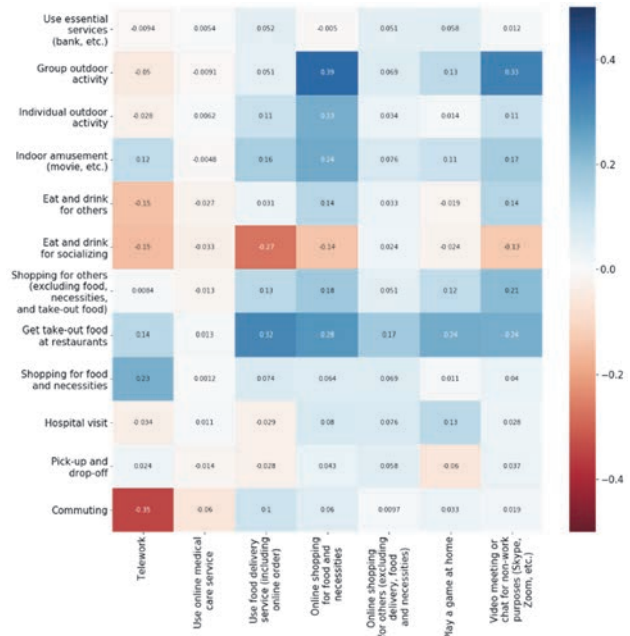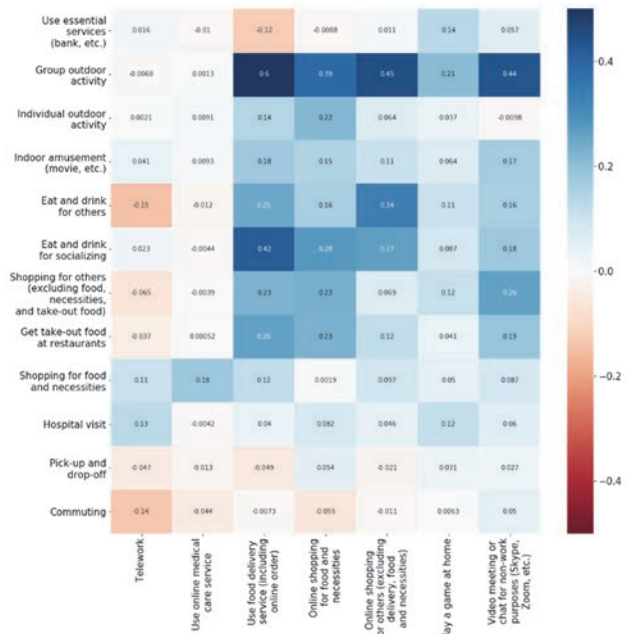

Fig. 5 Before Feb. vs Apr. 22–Apr.28

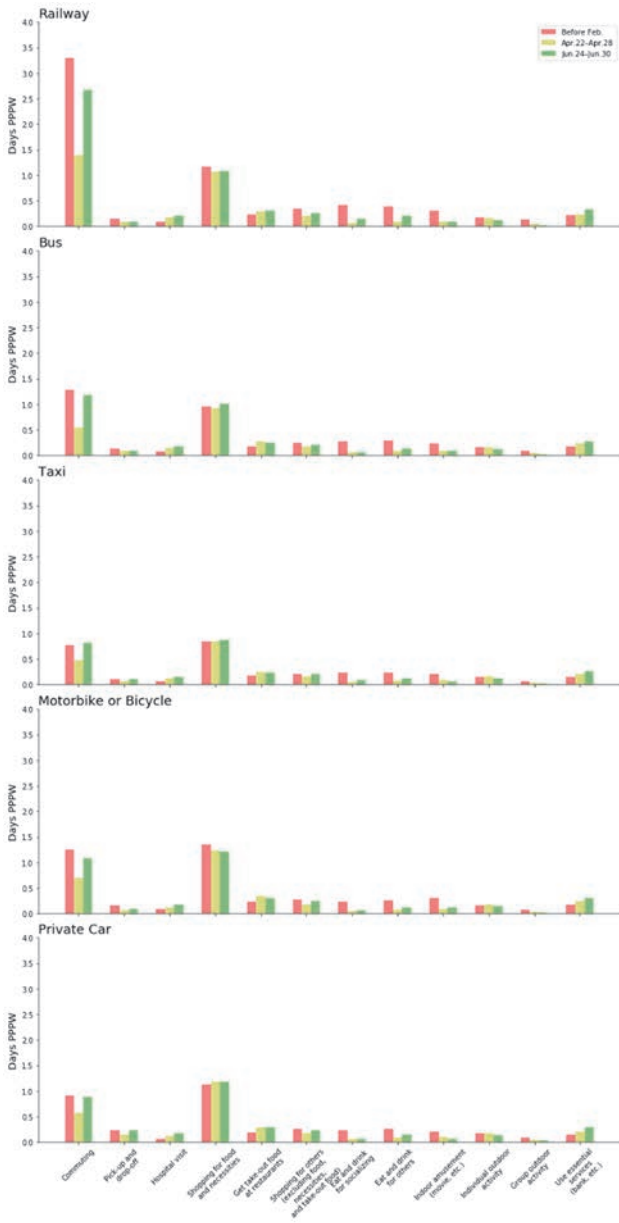**Fig. 6** Apr. 22–Apr. 28 vs Jun. 24–Jun. 30

Fig. 7 Transportation mode

Activities not predetermined as correspondences but show a correlation relationship include: Group outdoor activity and use of food delivery/online shopping for all (food and necessities and others), in-store shopping for others and video meeting or chat for non-work purposes, in-store shopping for others and use of food delivery/online shopping for food and necessities, eat and drink for socializing and use of food delivery/online shopping for all, eat and drink for other purposes and use of food delivery/online shopping for non-food items.

(4) Transportation mode

As a part of the survey, the transportation mode used to conduct each activity involving travel from home is also collected. There gives five choices: railway, bus, taxi, motorbike or bicycle, and private car.

The results are shown in . It can be seen that the railway is always the most used transportation modes across three periods, even there is a significant decline during the State of Emergency.

The overall trends are similar. A significant drop in the use of all the transportation modes for commuting during the State of Emergency and a revive after the declaration's lift can be observed. For shopping for food and necessities, there are few changes. As for other activities, only slight fluctuations exist.

4. DISCUSSION

This research using data from an online panel survey conducted in the Tokyo Metropolitan Area. The present article reports results of the first (conducted from May. 1, 2020 to May. 6, 2020) and second wave (conducted from Jul. 3, 2020 to Jul. 13, 2020). The third wave of the panel survey is still ongoing. The details of the survey are presented in section 2.
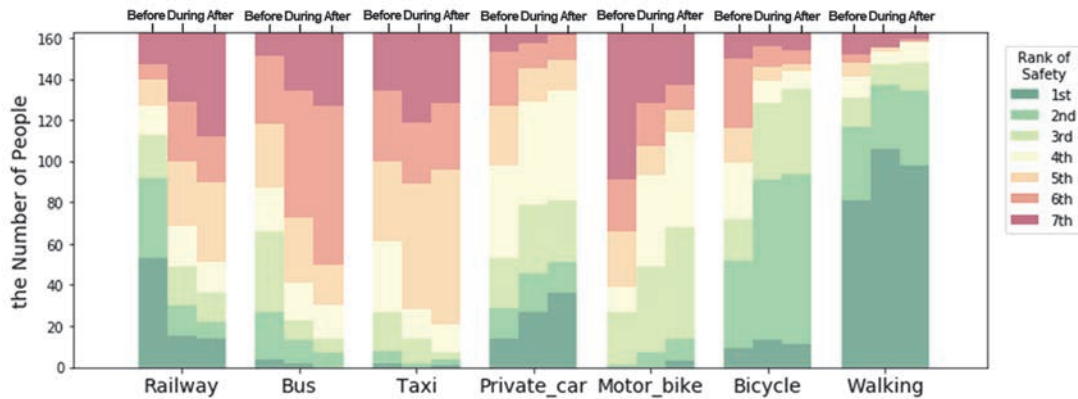

Fig 8. Ranks of transportation mode

The analysis results provided in section 3 include (i) the number of people and (ii) days per person per week of each activity, (iii) the correlation analysis of two types of activities (involving travel from home and at home) in terms of increase or decrease in the number of days, and (iv) the days per person per week using transportation mode for each activity. As stated in section 3, some results of the correlation analysis need further analysis. For the analysis of transportation modes, one limitation is that we do not know the changes is due to the changes in the frequency of the activity or the attitude towards the mode of transportation itself. **Fig. 8** plots the changes of personal rank regarding the safety of seven transportation modes, which may address the limitation.

The analyses this time are mostly geared towards identifying the overall behavioral trends. The future research should pay especial attention on identification of the underlying social factors.

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