Impact Analysis of COVID-19 on Travel Behavior and Mode Preferences of Hong Kong Residents

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ABSTRACT

The outbreak of COVID-19 and the unprecedented response policies issued by the government have compelled the citizen to reshape their daily travel behavior. To explore the impact of the pandemic on urban residents' travel behavior and mode preferences, questionnaires are designed to obtain three main related indicators of socio-economic and demographic characteristics, primary travel purposes and patterns, and factors influencing mode choice. By applying the online survey method with Snowball sampling techniques, a total of 591 valid questionnaire responses from Hong Kong residents are received in a designated time period. Then, the non-parametric test methods (e.g., McNemar-Bowker test and Mann-Whitney U test) are employed to implement the statistical analysis. Based on the survey findings, the traffic administrators can adjust current policies or delineate new policies to align with the passengers' travel behavior to ensure more fluent and safer transportation.

INTRODUCTION

With the eruption of the COVID-19, the governments around the globe implemented unprecedented policies to contain the virus. Many countries, like France, Italy, UK and Thailand implemented national lockdowns, limiting all non-essential traveling. Likewise, Hong Kong Special Administrative Region (HKSAR) initiated region-wide lockdown on February 8, 2020, and limitations on traveling is still in effect. Under this situation, travel behavior has been affected around the globe. It is beyond a health crisis because several industries including transportation industry have been severely impacted by the pandemic. As the virus is transmitted through close contact with infected people, number of outdoor trips have declined causing roads and public transport to be less crowded than before. Besides other socio-economic influence of this outbreak, this unique situation has compelled people to reshape their daily lives within a span of days and weeks (Musselwhite, et al., 2020). Work and travel, the basic facets of daily lives, have altered radically because of the COVID-19 outbreak.

In Hong Kong, public transport (buses, metros, trains and alike) carries millions of people, often transporting passengers reaching their designated

maximum capacity with little consideration for hygiene and personal space. In addition, social distance (approx. 2m) in public transportation seems an impossible practice, which may affect mode choice behavior. To develop transport-related policies for the post COVID-19 world, it is necessary to explore how the pandemic has influenced the travel behavior pattern. This study aims to explore how COVID-19 affected the travel behavior in Hong Kong. It focuses on the changes in primary traveling purpose, mode choice and factors influencing mode choice before as well as during the COVID-19 pandemic. It also charts out new guidelines and policies for public and private stakeholders to address the mobility needs for current as well as future pandemics. The findings of this study are believed to be useful in shaping up the policies for post-pandemic Hong Kong society.

The rest of the paper is organized as follows. Firstly, past corresponding studies will be reviewed. The methodology used in our study is subsequently illustrated. Then, main results and some discussions will be detailly analyzed to reveal the managerial insights. Finally, conclusion is refined at the end of this paper.

LITERATURE REVIEW

The spread of infectious diseases has been found to affect travel behavior and vice versa. Mandatory lockdowns and the fear of getting infected generally decreases outdoor trips (Aaditya and Rahul, 2021). For instance, during the MERS outbreak in South Korea, the percentage changes in visitors from areas with a previous SARS outbreak of ≥100 cases reduced more than the percentage changes in visitors from their counterparts in June (52.4% vs. 23.3%) and July (60.0% vs. 31.4%) during the 2015 MERS outbreak (Joo et al., 2021). On the one hand, infectious diseases alter the travel behavior, while on the other hand, travel behavior can help predict the spread of infectious diseases. For example, a mainland China study suggested that highways, and air transport propagate the spread of influenza and coronaviruses (Zhou et. Al., 2012). Hence, appropriate travel restrictions and social distancing measures can limit the spread of infectious diseases like COVID-19 and MERS (Vonnahme et al., 2017). As there is a two-way relationship between spread of infectious diseases and travel behavior, the current ongoing phenomenon of COVID-19 outbreak is also being researched through two different lines of investigations with respect to its relationship with travel behavior. One strand of studies seeks to investigate the effects of the COVID-19 pandemic on travel pattern while the other strand of studies explores the role of travel pattern in predicting the COVID-19 spread. Many recent studies of former type have found out significant changes in the travel behavior and mode preferences of the people across the globe due to the COVID-19 pandemic, while the latter strand of studies has also established an association between the mobility pattern and the COVID-19 spread.

The first direct influence of the COVID-19 pandemic on the travel pattern was the implementation of mobility restrictions, which has resulted in the disruption of livelihoods and social life of the people. Pinchoff et al. (2021) argued that the multifaceted dimensions of COVID-19 have being changing the travel pattern across the world and that the corresponding changes may be long lasting in the post-COVID-19 world. Professors from USA revealed that the mobility constraints posed by the COVID-19 might drive the public to lower the car usage frequency in favor of walking, cycling or cheaper public transport modes (Doubleday et al., 2021).

Nevertheless, it is argued that predicting the future changes in the travel pattern is not that straight forward because people might switch from public transport to private cars due to safety and health woes. Some scholars believed that places lacking cycling and walking infrastructure might not have a significant increase in walking or cycling travel pattern (Dunning and Nurse, 2021). The total travel trips, mainly the passenger transport trips have been reduced around the world (Hara and Yamaguchi, 2021), but some argued that this change will be temporary, and the pre-COVID-19 travel pattern will return as the direct effects of COVID-19 fade away.

Various travel modes have their merits and demerits over each other with respect to the risks associated with COVID-19 spread. Public transport and active traveling modes have been encouraged much in the recent years as a way of sustainable mobility. However, social distancing, one of the agreed upon precautionary measures against COVID-19, is in conflict with the principle of public transportation (Kamga et al., 2021). Public transportation modes offer a closed environment for passengers to sit or stand for a considerable time next to each other. Thus, the close contact between riders greatly increases the risks of infectious diseases spread. Nonetheless, public transportation can still be safely used during the COVID-19 pandemic by adhering to precautionary measures by its users although an entirely risk-free environment for traveling will not be possible. For example, the HKSAR has stipulated that all passengers shall wear mask when taking the public transports and in public places including MTR, buses and minibuses. Other proposed precautionary measures with respect to public transport use are physical distancing, avoiding congestion and crowding, disinfection of public transport vehicles and transit hubs, and availability of sanitizers in all public transport vehicles and hubs.

The COVID-19 pandemic is a global event which has impacted various aspects of daily lives. However, there is insufficient empirical evidence on how this pandemic has affected travel behavior in Hong Kong. This study fills the gap by exploring how COVID-19 pandemic is affecting travel behaviors and mode preferences in Hong Kong. This study could provide insights and practical implications for both public and private policy makers and stakeholders to navigate through these uncertain times and delineating new transport policies.

METHOD

Survey design and sample

The questionnaire is designed to measure the travel pattern both before and during the COVID-19 pandemic in Hong Kong. The timepoint of ‘During COVID-19’ and ‘Before COVID-19’ are provided to the respondents to obtain reliable responses and ensure the data will not be affect from the social movement in 2019. ‘Before COVID-19’ is taking the time in June of 2019, and ‘During COVID-19’ is June of 2021. Due to the safety concern and social distancing, online survey is used instead of face-to-face interview. The online questionnaire is designed using Google forms and distributed to the target population through personal contacts and social media channels such as Facebook and Instagram. The language of the questionnaire is prepared in both English and Chinese language to meet the official language in Hong Kong. The survey is run for a period of about one months from 28 June to 27 July 2021. Snowball sampling technique is used to collect responses. Five hundred

and ninety-one (591) responses were received during that period.

Survey instrument

The questionnaire has three distinct sections: (i) socio-economic and demographic characteristics (SEDs), also including the change during COVID-19; (ii) primary travel pattern before and during the COVID-19 pandemic; (iii) factors influencing mode choice before as well as during the COVID-19 pandemic. Socio-demographic characteristics consists of gender, age, education level, monthly household income (in HKD), household size. Some of SEDs are asked in the situation before and during the COVID-19. People may have changed in their employment status and job category during the lockdowns and economic environment change. Moreover, people may avoid infection when using public transport to buy their own car.

Due to COVID-19, some company and school are started to use online mode, and it will influence people traveling reason and frequency. It also contains questions about preferred mode before and during the pandemic. This section is using 5-point Likert type items to identify factors that influence travel mode preference, before and during COVID-19. COVID-19 virus is spreading with fluid from infected person or contact the same surface with infected person. Therefore, people will have less willing to stay in a crowed area and reduce contact with others. When choosing travel mode during COVID-19, people may focus more on the item which related to pandemics as infected concern and keep social distancing, such as cleanliness and less congested vehicle. Those factors are affecting people on choosing travel mode, and it is asked respondents to place priority on each factor.

Analysis methods

Non-parametric test, which requires fewer hypothesis and relatively easy to understand is used in this study. If the data are normal distribution and satisfy all other assumptions, the power loss will be relatively small (Kitchen, 2009). It is recommended to use non-parametric tests instead of parametric tests when there is no experimental show about the error distribution. This study deals with both independent and paired observations about travel behavior before and during COVID-19 which require special considerations during the statistical analysis.

Statistical analyses on repeated measurements: McNemar-Bowker test is applied on the repeated measurements of nominal data, such as the primary traveling purpose and mode choice before and during the pandemic. This is a nonparametric test for each nominal variable with more than 2 levels and summarized in a k×k contingency table. McNemar's nonparametric test is carried out as a post-hoc tests to investigate items of nominal variables differed significantly. The McNemar test is used to find out if there are differences on a binary dependent variable between two paired groups. To compare the ordinal repeated measurements under two different conditions, such as number of non-commuting trips made before and during the COVID-19 pandemic, a non-parametric alternative of the paired t-test, Wilcoxon signed rank test is used in our study.

Statistical analyses on independent measurements: The Mann-Whitney U test can be used to compare differences between two independent groups. It is a non-parametric alternative to the two-sample t-test and does not require the dependent

variable to be continuous and normally distributed. Hence, Mann-Whitney U test is carried out on the independent groups when the dependent variables are ordinal, e.g., effect of age group on the frequency of non-commuting purposes trips.

RESULTS AND DISCUSSION

Socio-economic demographics

591 responses to questionnaire survey are received, and their socio-economic demographic characteristic is shown in Table 1. The majority of the respondents are 18-22 years old (41.1%), and their education level is a bachelor's (53.3%). Young people with high education have a higher share in the collected sample. It may cause bias in the results and further findings on the impact of the pandemic on travel patterns and mode.

Table 1. Demographic Information of the Sample

Items	Category	Frequency	Percentage
Gender	Male	297	45.2%
	Female	316	53.5%
	Prefer not to say	8	1.4%
Age Group	<18	97	16.4%
	18-22	243	41.1%
	23-30	142	24.0%
	31-40	86	14.6%
	41-50	16	2.7%
	>50	7	1.2%
Education level	High School and below	137	23.2%
	College (Diploma/Associate degree)	118	20.0%
	Bachelors	315	53.3%
	Master or PhD	21	3.6%
Monthly household income (HKD)	Less than 10,000	25	4.2%
	10,000 to 30,000	284	48.1%
	31,000 to 50,000	226	38.2%
	51,000 to 100,000	53	9.0%
	100,000 above	3	0.5%
Household Size	1	86	14.6%
	2	134	22.7%
	3	174	29.4%
	4 or more	197	33.3%

Primary purpose of traveling

The primary purpose of traveling is the main reason of people leaving their home of every day. A primary trip is usually a necessity and people may only have very little or no control over it. Some people might travel due to their work, or school, while others may travel primarily for social activities. During the pandemic, people would like to reduce trips for other reasons, but still, need to compel to make trips for a primary reason which are of utmost importance and beyond their control. The characteristics of primary traveling, mode and distance, may change based on the circumstances, like during pandemic and social movement. Distribution of primary

travelling purpose before and during COVID-19 pandemic is shown in Figure 1 and the cross-tabulation and results of the McNamara test are shown in Figure 2.

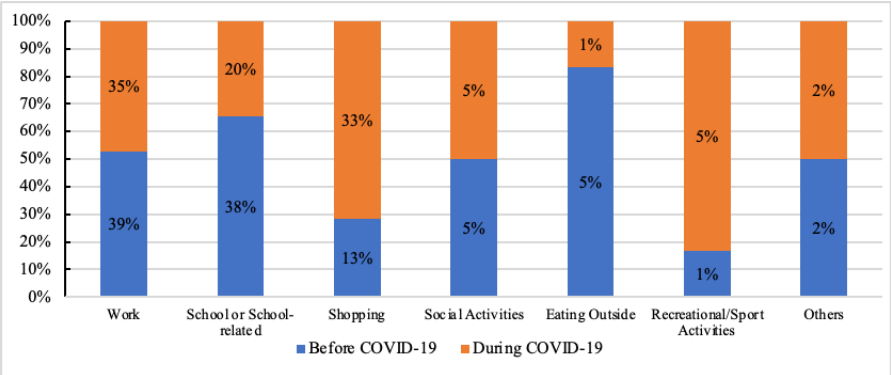
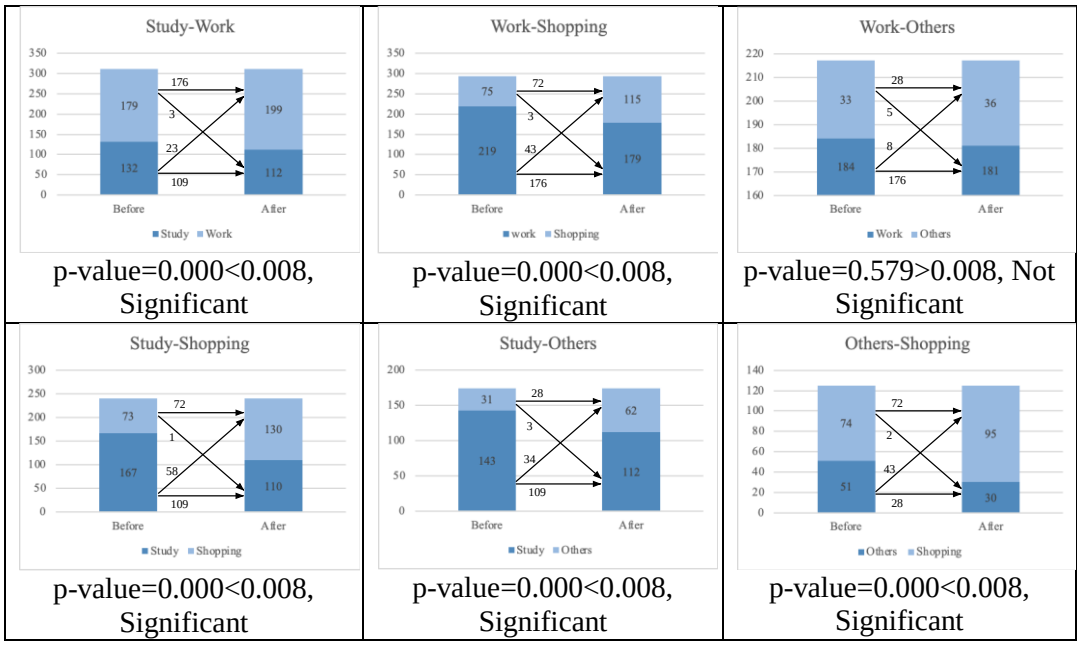


Figure 1. Distribution of primary travelling purpose before and during COVID-19 pandemic



p-value=0.000<0.008, Significant

p-value=0.000<0.008, Significant

p-value=0.579>0.008, Not Significant

p-value=0.000<0.008, Significant

p-value=0.000<0.008, Significant

p-value=0.000<0.008, Significant

Figure 2. Change in primary trip purpose and McNemar Test results

As shown in Figure 1, before the pandemic, the primary purpose of traveling for most of the respondents was working (39%), followed by school-related reasons (38%). There is a reducing change on both purposes that only 35% people declares their primary purpose traveling is work while only 20% people are going to school as their primary purpose of traveling. However, it can be explained by the fact that people are allowed to work or study from home through online software during the pandemic. There are about 72% of people declared that they could work from home or online learning during COVID-19, and only 8% of people could do it before the pandemic. Shopping becomes the most primary purpose of respondents during the pandemic. It is raising from only 13% before COVID-19 to 33%.

For “social activities”, “eating outside”, “recreational and sports”, those primary purposes are only portioning a small percentage, they are put together into

a single category named “others” for further analyses. In Figure 2, The results of the McNamara-Bowker test showed that there is significant variation between primary traveling purposes before and after the COVID-19 pandemic ($\chi 2$ (6) = 835.941, p < 0.001). Post-hoc tests are performed, and results shows whether the primary purpose change significantly. Alpha and n for Bonferroni correction are set as 0.05 and 6, respectively. The primary purpose of traveling significantly change from work, study and others to shopping during COVID-19. However, the shift from work to others is less than 10 cases, and it is not significant to have meaning on statistics.

Frequency of primary trips

The primary trip of a day is defined as a journey from home to a destination and back to home, and the destination is the main purpose that people go out. In this study, respondent is asked the frequency of their non-commuting trips in a week. The reason to have a non-commuting trip may be shopping, social activities, sport, and recreational. It is unlike commuting trips that do on daily basis. Figure 3 compares the number of primary traveling before and during COVID-19. The frequency of people travel is remarkably reduced during the pandemic. About 5 % of respondents do not travel for a week for their non-commuting trips. It is shown that people are trying to reduce unnecessary trips during the pandemic period. The results of the Wilcoxon signed ranks test explains that there is a statistically significant difference in the number of non-commuting trips carried out before and during COVID-19 (Z= - 13.084, p<0.001). A similar finding has been reported in the world (Abdullah et al., 2020).

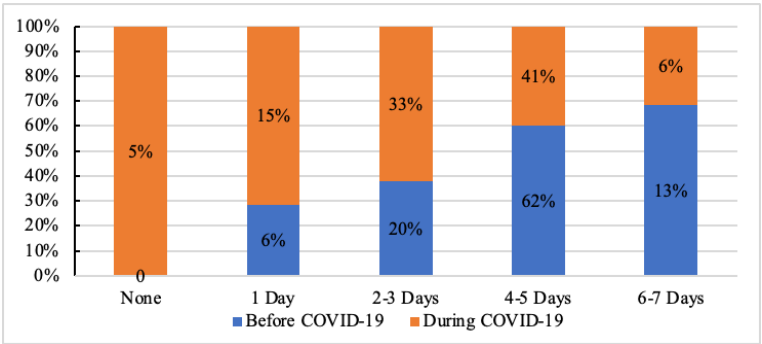


Figure 3. Frequency of non-commuting trips before and during COVID-19 pandemic

People with different socio-demographic may influence their attitudes on the frequency of trips before and during pandemics. Mann-Whitney U test is applied to examine the impact of SEDs, and the result is shown in Table 2.

In Table 2, a significant difference can be found between females and men on the frequency of non-commuting trips before and during COVID-19. In Hong Kong, the financial responsibility is mostly relied on to men, and female has more time on social activities or buying grocery for the household. Therefore, women undertake more non-commuting trips. Before COVID-19, their difference is non-significant between the younger and older age group. However, there is a sign that more non-commuting trips are taking by the above 22 years old age group compared to the younger age group. This finding indicates that those above 22 years of age

have more social responsibilities, such as travel out to cater to family needs, instead of having e-learning at home.

Table 2. Effects of SEDs on the Frequency of Non-Commuting Trips (Results of Mann Whitney U Test)

Item	Group	Before COVID-19			During COVID-19		
		Mean	U	P	Mean	U	P
Gender	Male	297.34	35170.5	0.000	292.87	32654.2	0.000
	Female	354.29			356.12		
Age	Below 22	364.85	42364.1	0.008	318.12	42357.5	0.005
	Above 22	348.29			351.35		
Education	College*	237.53	2874.5	0.135	201.64	2648.3	0.246
	Undergrad*	219.35			220.64		
Profession	Student	327.57	43365.5	0.037	305.68	42197.3	0.021
	Employed	364.26			372.64		
Car Ownership	Yes	367.12	42813.0	0.000	394.16	44160.0	0.000
	No	333.22			317.91		

College*: College and below; Undergrad*: Undergraduate and above

Car owners significantly undertake more trips for non-commuting trips before and during COVID-19 as compared to those who own no car. This indicates that the number of outdoor trips is associated with car ownership. The private car can provide a safe and lower infection chance of travel. Car owners are more willing to travel even during the pandemic.

Preferred mode for primary trips

The distribution of travel mode share for primary trips before and during COVID-19 is shown in Figure 4. Most of the respondents are using public transport, bus and MTR/Railway, for their primary travel. There is a significant decline in public transport. Combined with the group of "bus" and "MTR/Railway", there are only about 66% of respondents used during COVID-19 and it is 20% less than before COVID-19. In contrast, the percentage of respondents using taxi or ride-hailing, like Uber, is highly increased from 5% before COVID-19 to 20% during COVID-19. The reason for this change may be related to people are less willing to contact others to reduce the chance of infection. Moreover, the number of public transports is cut due to work from home policy and operating costs. People are needed to looking at private vehicles or taxis. Ride-hailing is providing a safer environment than public transport, it is not only about less contact with others, and also it can be the easy track of infection cases base on the license plate number. Very respondents choose walking/bicycle mode for primary traveling. However, there is a 3% increment from the situation before COVID-19. It means that some respondents reduce their distance of travel and use the non-motorized mode to reduce the chance of infection.

"Bus" and "MTR/Railway are combined into one category name "Public Transport" while walking and bicycle are named as "non-motorized" for analysis of the mode shift. The results of the McNamara-Bowker test show that there is significant variation between primary traveling purposes before and after the COVID-19 pandemic ($\chi 2$ (6) = 511.294, $p < 0.001$). The cross-tabulation and results of the McNamara test are shown in Figure5. Post-hoc tests are performed to

determine modal shifts between different modes.

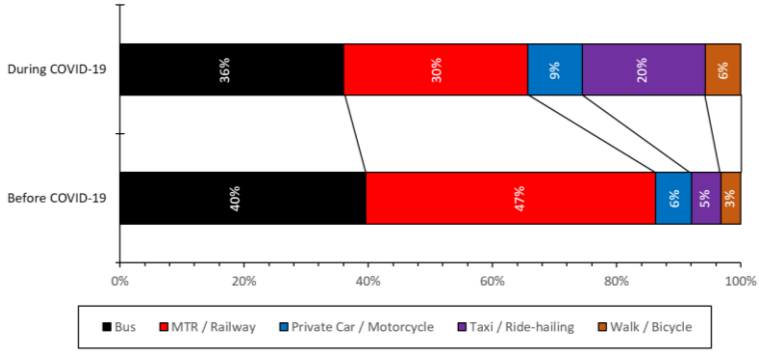
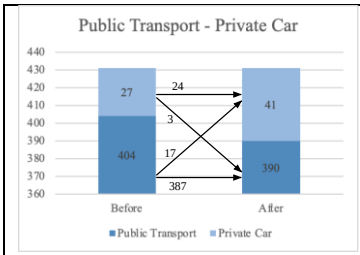
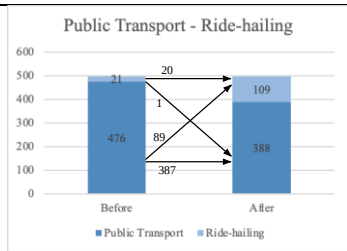


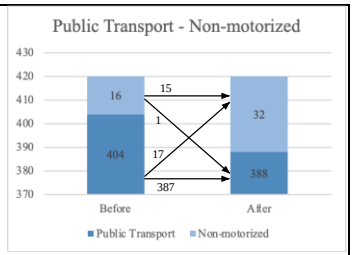
Figure 4. Mode choices before and during COVID-19 pandemic



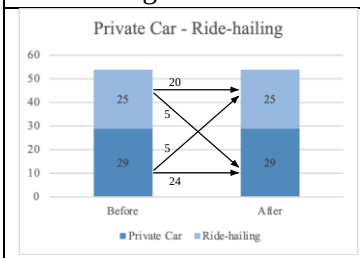
p-value=0.004<0.008, Significant



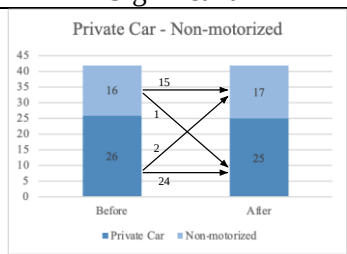
p-value=0.000<0.008, Significant



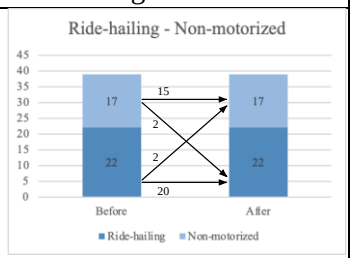
p-value=0.000<0.008, Significant



p-value=0.752>0.008, Not Significant



p-value=1.000>0.008, Not Significant



p-value=0.617<0.008, Not Significant

Figure. 5 Mode shift for the primary purpose and McNemar Test results

The shift from public transport to private cars, ride-hailing, and non-motorized are significant. People may feel unsafe in public transport with close contact. Car ownership in Hong Kong is not high, i.e., 628 thousand people, about 8.4% of the whole population. Therefore, people who cannot rely on private vehicles choose other alternatives, like taxi or Uber. Also, the number of respondents who shift to using non-motorized could be because the trips for shopping significantly increase, which means that people are likely to travel nearby shop for grocery, instead of shopping clothes. Therefore, no significant shift is observed from private cars to ride-hailing and non-motorized. The modal shift from ride-hailing to non-motorized is also not significant, due to less changing case in both modes.

Factors influencing mode preference before and during COVID-19

Under normal situations, the mode choice of people is affecting by different factors, such as travel cost, waiting, and convenience. However, several factors are also taken part during the COVID-19 pandemic period. Those pandemic-related

factors are infection concern, social distance, and cleanliness. The distribution of responses for different factors influencing mode before and during a pandemic is shown in Figure 6 and Figure 7.

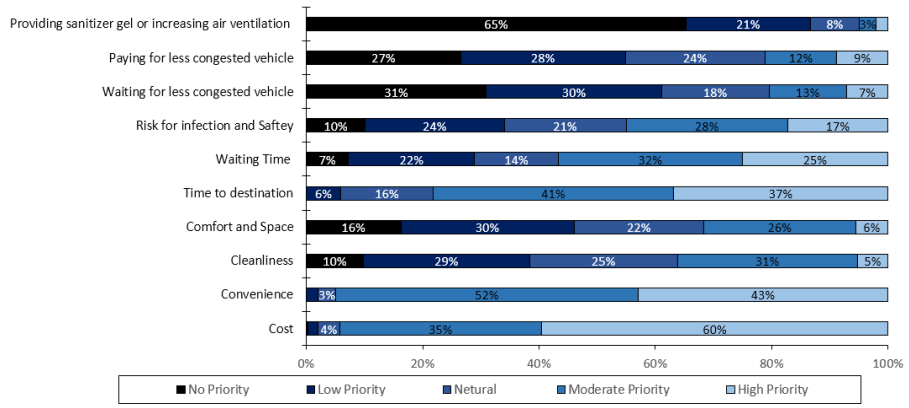


Figure 6. Distribution of responses for the factors influencing mode preferences before the pandemic

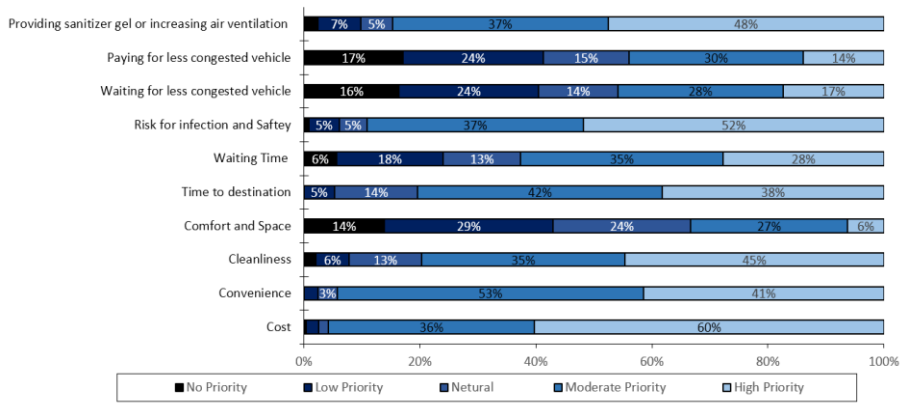


Figure 7. Distribution of responses for the factors influencing mode preferences after the pandemic

Most of the respondents put more priority on infection-related items while choosing travel mode during COVID-19. Providing sanitizer and increasing air ventilation items has a sharp increase on the priority that people may concern they will infect with a contact surface on public transport and infect through the air in a crowded environment. The mean and standard deviation of the priorities of each factor are shown in Table 3.

The general factors, such as travel time, cost, and comfort, are still keeping their priority during the pandemic. Cost is the highest priority for people to choose travel mode. Moreover, there is no significant difference of people placed priority before and during the pandemic. However, the increase in priority for the item "paying for less congested vehicle" is not significant. In other words, the change in the transport system, such as increase equipment to reduce infection chance seems to be taken for granted by the users. The users do not consider that the value of those services requires a higher payment than in the pre-COVID-19 period. The mean value shows that respondents placed more priority on the infect-related factors.

People are paying less priority to convenience during the pandemic. Those general factors are most important as before COVID-19. On the other hand, infection-related factors are not existing during normal circumstances, such as providing hand sanitizer gel, but they have become the most important factor during COVID-19.

Table 3. Mean and standard deviation of factors affecting mode choice before and during COVID-19

Item	Before COVID-19		During COVID-19	
	Mean	Std. Dev.*	Mean	Std. Dev. *
Cost	4.51	1.16	4.53	1.18
Convenience	4.36	1.01	4.33	1.00
Cleanliness	2.93	0.40	4.15	0.86
Comfort and Space	2.75	0.31	2.83	0.33
Time to destination	4.09	0.78	4.13	0.81
Waiting Time	3.46	0.48	3.61	0.56
Risk for infection and Safety	3.18	0.34	4.34	1.02
Waiting for less congested vehicle	2.36	0.12	3.06	0.35
Paying for less congested vehicle	2.49	0.15	2.99	0.35
Sanitizer and ventilation*	1.55	0.21	4.20	0.94

Std. Dev. *: Standard Deviation

Sanitizer and ventilation*: Providing sanitizer gel or increasing air ventilation

CONCLUSION

The COVID-19 pandemic has re-examined people's travel habits and priorities as the change of our living environment and fear of infection. This research has set out to shed light on the dynamics of people's travel style, including travel pattern and mode preference in a sample from Hong Kong. Data about demographics, primary travel behavior, mode choice, and factors influencing the mode preference before and during the pandemic is collected by online questionnaires. With non-parametric test methods, the results shows that the use of public transport (bus and MTR/railway) is decreased while the use of ride-hailing was increased during COVID-19. This indicates that people tend to have less contact transported which can avoid infection. The local travel behavior is significantly shifting to taxi or ride-hailing from mass transport. Additionally, from the rating on "paying more for less congested vehicle" and "waiting for less congested vehicle" significantly increased, it is indicated that travelers are willing to use money and time to have a return on the less congested vehicle following with less infection risk.

Some managerial insights for traffic administration can be obtained. Government should focus more on the regulation and policy on the handle of using a private car for charging passengers for a ride. It can protect residents when using those travel modes. Also, the company of mass transport should take more action to deal with the infection risk of COVID-19, such as increase air ventilation and provide hand sanitizer gel, to build up the confidence of people chose mass transport again, even during COVID-19. For a deep analysis of the COVID-19, further research of the impact of these travel behavior changes on traffic can investigated in the future. Meanwhile, more comparison and verification based on some real data can be conducted to figure out the difference of our analysis tendency and the real-life observed situation between a certain period to improve our study.

ACKNOWLEDGEMENT

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