

COVID-19, community response, public policy, and travel patterns: A tale of Hong Kong

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Abstract

The COVID-19 outbreak has necessitated a critical review of urban transportation and its role in society against the backdrop of an exogenous shock. This article extends the transportation literature regarding community responses to the COVID-19 pandemic and what lessons can be obtained from the case of Hong Kong in 2020. Individual behavior and collective responsibility are considered crucial to ensure both personal and community wellbeing in a pandemic context. Trends in government policies, the number of infectious cases, and community mobility are examined using multiple data sources. The mobility changes that occurred during the state of emergency are revealed by a time-series analysis of variables that measure both the epidemiological severity level and government stringency. The results demonstrate a high response capability of the local government, inhabitants, and communities. Communities in Hong Kong are found to have reacted faster than the implementation of health interventions, whereas the government policies effectively reduced the number of infection cases. The ways in which community action are vital to empower flexible and adaptive community responses are also explored. The results indicate that voluntary community involvement constitutes a necessary condition to help inform and reshape future transport policy and response strategies to mitigate the pandemic.

Keywords: COVID-19; government stringency; community mobility; grassroots initiatives; time series; Hong Kong

1. Introduction

COVID-19 has been the most complex public health crisis of the century. As of March 2021, more than 126 million people in over 180 countries and regions have been infected (World Health Organization (WHO), 2021), and multiple outbreak waves are expected to occur over an extended period beyond 2021. The pandemic has had a multifaceted impact on the economy and societies. In the absence of effective treatments and vaccines, non-pharmaceutical intervention (e.g., travel restrictions, social distancing policies) offers the only viable means to contain the epidemic. Many governments have responded by imposing lockdowns to control the spread of infection and reduce the number of associated deaths. While complete lockdown has negative economic and social repercussions (Arthi and Parman, 2020; Fana et al., 2020; Loo et al., 2021), some governments have been devoted to identifying and adopting possible alternative countermeasures that rely heavily on the community's voluntary protective measures and adaptive travel behavior. The avoidance of public transport and shift from collective to individual transport modes (e.g., driving, cycling) have been common tactics in countries such as the UK and USA (Bucsky, 2020; Lock, 2020; Teixeira and Lopes, 2020). The relationship between policies and societal responses amid the COVID-19 pandemic has attracted increasing attention from academics, government officials, and the general public, all of whom are all concerned regarding how to improve the efficacy of policies and citizen behavior to control the infections and associated deaths. Efficacy seems to be explained by both individual factors (e.g., partisan attitudes, demographic characteristics, risk perceptions) that explain how individuals respond to the physical distancing rules and recommendations (Beck et al., 2020; Borkowski et al., 2020; Oum and Wang, 2020), as well as by aggregate patterns, which are impacted by different public health policies (Abu-Rayash and Dincer, 2020; Beck and Hensher, 2020; Rieger and Wang, 2020).

As a Special Administrative Region (SAR) of China that operates with autonomy, Hong Kong has adopted far less strict measures to contain COVID-19 than those in mainland China. At the time of writing, the city has never been locked down, and inhabitants have always enjoyed a moderate level of mobility. Compared with other places, such as Singapore, Seoul, London, and Tokyo, Hong Kong has been relatively successful in terms of controlling the rate of infections (Lam et al., 2020; Wong et al., 2020; Wong et al., 2020). Comparative discussions of COVID-19-related policies and societal responses have largely focused on the collective memories of combating the outbreak of severe acute respiratory syndrome (SARS) in 2003. That bitter experience might explain both the government and community's preparedness and willingness to respond promptly to contain the threat of COVID-19. Preventive education, publicity, and the introduction of different control measures by the government were identified as important contributors to the success of controlling the 2003 epidemic (Hung, 2003).

A series of large-scale physical-distancing intervention measures enacted by the Hong Kong government, in addition to prior experiences of virus prevention, made efforts to convince individuals to comply with precautionary measures, such as wearing face masks and washing hands, more effective. This made the government and people believe that it remained possible to maintain daily activities and travel amid the COVID-19 pandemic (Kwok et al., 2020; Wong et al., 2020). However, to the best of our knowledge, there has been little research on the relationship between government public policies and community responses, although this could help us better understand how the community and government can work together to combat COVID-19 and similar pandemic events.

As suggested by the WHO (2020a), both government intervention and community engagement play a critical role in the effective implementation of any public health intervention. It is therefore important to investigate the complementary aspects of public health intervention measures that contributed to the early success of preparing for and responding to the COVID-19 threat.

In this article, an explorative analysis of COVID-19 policy measures and community mobility patterns in Hong Kong is conducted. Multiple sources of data and rich analyses based on empirical observations are contributed to the literature, which has focused mainly on the government-led top-down policies and community-based bottom-up participation. A dataset is constructed of epidemiology, mobility, and government stringency indicators, and the effects of local policies and pandemic situation on the community mobility patterns are estimated using dynamic time-series models. A clear relationship between government stringency and community mobility is identified. The results of a Granger causality analysis also suggest that government intervention measures affected the trend of COVID-19 cases in the subsequent period. Based on a retrospective review of the literature and reports of situational features, it is observed that (a) the Hong Kong community has been very responsive in terms of proactive self-protection measures and (b) the Hong Kong government has struck a good balance between economic recovery and public health control when was not viable to lock down the entire city. This indicates that collaborative efforts between the government and community are critical to the success of the response to and recovery from public health emergencies.

2. Methodology and datasets

Hong Kong features a high population density (7.5 million inhabitants with 7,140 people per km²), well-developed public transportation systems (covering 90% of the 16 million daily passenger trips), and a low rate of private car ownership (0.076 cars per resident as of 2018) (Legislative Council Secretariat, 2019). We selected Hong Kong as a representative example of a relatively well-performing city in terms of the total numbers of confirmed COVID-19 cases and associated deaths (Lam et al., 2020; Wong et al., 2020; Wong et al., 2020). Hong Kong offers unique opportunities to study the impacts of government policy intervention and community engagement and participation in COVID-19 containment within a resource-sufficient setting.

The data and information are obtained from government and community pandemic management websites, in addition to a review of journal articles, conference presentations, government documentation, archival records, newspapers, and internet resources. We scrutinize different types of data and information concerning three pillars of the containment of COVID-19 spread (Alamo et al., 2020):

- (1) epidemiological data to provide information regarding the local situation of dynamic spread of the infectious disease;
- (2) performance indicator data to provide an efficient means for characterizing community mobility and government responses; and
- (3) local data to serve as a supplement for verifying the technological data.

2.1 COVID-19 epidemiological data

COVID-19 epidemiological data have been released daily by the Hong Kong SAR government (Department of Health, 2020). These datasets provide specific details of each local probable/confirmed case of COVID-19, including the day of reported infection, individual demographics (gender, age, HK/non-HK resident), location (district, building location), and current status (hospitalized/discharge/deceased).

2.2 Performance indicators

2.2.1 Community mobility index

Hong Kong has a high penetration rate of mobile phone use (Statista, 2020); it is therefore possible to model mobility patterns based on location tracking (Yip et al., 2016). An aggregated measure of mobility can be derived from the usage of mobile map applications established by mapping service companies, which are based on the relative volume of direction requests or location histories. Although the data may not be generalized because user details are not available, they are sufficient to establish a mobility index that can proxy the activity and movement of the community at large (Bonaccorsi et al., 2020; Cacciapaglia et al., 2020; Kraemer et al., 2020). In this article, data have been integrated from three different mapping service providers in Hong Kong (Citymapper, Apple, and Google) from January 14 to May 10, 2020 (the first COVID-19 case in Hong Kong was first reported on January 23, 2020). Because the baselines of those indexes differ (**Table 1**), the data were normalize using the data from February 15, 2020 as the baseline.

Table 1. Mobility index details from different mapping service companies

Source	Raw information	Date in 2020	
		Baseline	Start
Citymapper (2020)	Volume of direction requests	January 6 – February 2	January 20
Apple (2020)	Volume of direction requests	January 13	January 14
Google (2020)	Time spent (location history)	January 3 – February 6	February 15

2.2.2 Government stringency index

The Oxford COVID-19 Government Response Tracker (OxCGRT) provides a systematic way to track the stringency of government responses to COVID-19 across countries over the entire pandemic period (Hale et al., 2020b). This project has assessed government policies and interventions using a standardized set of indicators and developed a composite index to measure the stringency of government responses. The results are regularly updated by the researchers at the University of Oxford.

The index comprises nine government response measures from three perspectives: (i) containment and closure policy (e.g., gathering size restrictions); (ii) economic response (e.g., income support); and (iii) health system policies (e.g., testing policy). We adopt a stringency index (*SI*) that captures the level of restrictions within containment and closure policies. The index values range from 0 to 1 and are computed by the average of nine indices *I*:

(1) School closing;

- (2) Workplace closing;
- (3) Cancellation of public events;
- (4) Restrictions on gathering size;
- (5) Closure of public transportation;
- (6) Stay-at-home requirements;
- (7) Restrictions on internal movement;
- (8) Restrictions on international travel; and
- (9) Public information campaign.

For further details, readers are referred to Hale et al. (2020). All of the response measures have been normalized, and the stringency index is computed according to

$$SI = \frac{1}{9} \sum_{j=1}^9 I_j \quad (1)$$

The SI value itself does not reflect the appropriateness or effectiveness of a government's response, nor does it capture demographic or cultural characteristics that may affect the spread of COVID-19. Nevertheless, the index has been widely used in COVID-19-related studies for benchmarking time-series government policy interventions (Bargain and Aminjonov, 2020; Hale et al., 2020a; McKenzie and Adams, 2020; Morita et al., 2020; Zhu et al., 2020). This article assesses the changes in government responses and explores their associations with the epidemic trends. The stringency of government response measures is expected to correlate with the severity level of the spread of the disease.

3. Responses to the COVID-19 pandemic

3.1 Validation of technology data with local data

The government SI values are first verified based on the government preparedness, response, and emergency operation measures implemented in the period from January to June 2020. As shown in **Table 2**, most of the measures are reflected by different categories and the corresponding SI , except for specific targeted items that cannot be generally classified. For example, category 4 (restrictions on gatherings) is classified into five levels, with I_4 ranging from 0 to 4 according to the following scale:

- 0 for no restrictions;
- 1 for restrictions on very large gatherings (more than 1000 people);
- 2 for restrictions on gatherings of 101–1000 people;
- 3 for restrictions on gatherings of 11–100 people;
- 4 for restrictions on gatherings of 10 people or less.

For example, the group gathering restriction imposed in Hong Kong on March 29 and its relaxation on May 8 can be denoted as $I_4 = 4$ and $I_4 = 3$, respectively. However, the relaxation of gathering restrictions from 8 to 50 people on June 19 is not reflected in the SI by definition because the threshold of the next restriction level is 100. Nonetheless, the SI values reflect the government public health measures in Hong Kong to a certain extent.

Table 2. Timeline of government response to the COVID-19 pandemic and the stringency index in Hong Kong from January to July 2020

Date of 2020	Public health measures	Stringency index		
		Category	Value	Change
January 4	Activated “serious response level” for a novel infectious disease of public health significance	9	0.14	-
January 15	Guidelines published on the prevention of COVID-19	-	0.14	-
January 24	Flights and high-speed rail services from Wuhan suspended	-	0.14	-
January 25	School closure (due to school holiday)	1	0.25	+0.11
	Activated “emergency response level” for preparedness and response plan	-		
January 26	Leisure facilities closed	3	0.36	+0.11
January 27	Travelers from Hubei banned	8	0.42	+0.06
January 29	Civil servants work from home	2	0.50	+0.08
February 3	Closed majority of road-based borders and ferry terminals	-	0.50	-
February 4	The Centre for Health Protection reports locations of suspected cases online	-	0.50	-
February 8	Home quarantine for travelers from mainland China	6	0.56	+0.06
February 13	Extended class suspension	-	0.56	-
February 21	Government set up the first public relief fund of HK\$30 billion	-	0.56	-
March 1	Home quarantine for travelers from Iran and Italy	-	0.56	-
March 2	Civil servants resume work	2	0.48	-0.08
March 17	Home quarantine for travelers from South Korea	-	0.48	-
March 19	Home quarantine for all inbound travelers	-	0.48	-
March 23	Reimplementation of work from home for civil servants	2	0.56	+0.08
March 25	All borders closed to incoming non-residents from overseas			
March 29	Restrictions on gatherings of more than four	4	0.67	+0.11
	Catering premises are required to implement physical distancing measures	-		
April 1	Temporary closure of karaoke lounges, nightclubs, pubs, and bars, etc.	-	0.67	-
April 6	All arrivals at the airport are required to provide a saliva sample for COVID-19 testing	8	0.70	+0.03
April 10	Restaurants to serve half their capacity, separating each table by at least 1.5 m and allowing only four people to be seated at a table until April 23	-	0.70	-
April 21	Government set up the second public relief fund of HK\$137 billion	-	0.70	-
May 4	Civil servants resume regular work	2	0.61	-0.09
May 8	Relaxation of restrictions on gathering from four to	4	0.59	-0.02

	eight			
May 27	Resumption of school	1	0.56	-0.03
June 19	Relaxation of restrictions on gathering from 8 to 50; Reopening of public leisure facilities	3	0.46	-0.10
	School closure (and summer holiday)	1		
	Reimplementation of work from home for civil servants;	2		
July 15	Temporary closure of karaoke lounges, nightclubs, pubs, and bars;	3	0.67	+0.21
	Closure of public leisure facilities;			
	Restrictions on gatherings of more than four	4		
September 11	Reopening of public leisure facilities and karaoke lounges, nightclubs, pubs, and bars, etc.;	6	0.63	-0.04
September 23	Partial resumption of school	1	0.59	-0.04
September 26	Civil servants resume work	2	0.56	-0.04
September 29	Full resumption of school	1	0.52	-0.04

The mobility data obtained from multiple sources are verified. Although these data slightly differ from the perspectives of user demographics, the sampling framework, and the tracking algorithm, the three datasets are highly correlated with high significance at the $p < 0.001$ level (**Table 3**). The high correlation indicates that the location tracking data are generally consistent. The index with a longer time span (i.e., Apple) is therefore selected for subsequent analysis, which justifies the reliability of the proposed mobility index.

Table 3. Correlation test for three mobility indexes

Index	Apple		Google		Citymapper	
	Corr.	Obs.	Corr.	Obs.	Corr.	Obs.
Apple	1	298	0.862**	291	0.730**	265
Google	0.862**	291	1	291	0.861**	265
Citymapper	0.730**	265	0.861**	265	1	265

** Correlation is significant at the 0.001 level (2-tailed).

3.2 Overview of government stringency and community mobility

The first COVID-19 case was reported in Wuhan, China in December 2019 (WHO, 2020c). Situated at the southern tip of China with close connections to the mainland, Hong Kong faced a high risk of COVID-19 epidemic influx, given the considerable passenger flow at the 11 water-based, road-based, and rail-based borders connecting to mainland China. Hong Kong can also be reached within 5 hours from Wuhan via high-speed rail, which elevated the risk of COVID-19 influx in the early stage of the outbreak (Zhang et al., 2020). In 2019, more than 236 million passengers crossed the road-based and rail-based borders between mainland China and Hong Kong (Immigration Department, 2020). Additionally, the lockdown in Wuhan occurred on January 23, which is close to the Chinese New Year, a major festival in China and a long holiday period (January 25–28) in Hong Kong. Past experience indicates high cross-boundary passenger traffic before and after the holiday. Most

schools began holidays on January 22 and were scheduled to resume classes on February 3. The government deferred class resumption several times until May 27.

When the study period is divided into three infection waves, it can be observed that both the government and community reacted quite well prior to the start of the first wave of infections (i.e., February 3 to March 15). This could be due to the regular closure of school and facilities over the Chinese New Year holiday. For the second wave (i.e., March 16 to April 19), the community was generally more sensitive to the elevated number of infection cases, compared with the government measures. For example, a drop in mobility was observed from March 23 upon the re-implementation of the work-from-home arrangement on that date. This is reasonable because the government must consider the needs and concerns of different stakeholders in society, whereas individuals are only responsible for their own well-being. The general public can therefore react more promptly. The community recovered its mobility after the number of infection cases diminished (after April 6) and the government fully resumed office work on May 4. The above discussion provides a general overview of how the government and community reacted differently to the pandemic situation. The third wave of infections started in early July and was speculated to be related to quarantine exemptions of personnel including maritime workers. According to the Marine Department, approximately 10,000 sea crew members were granted a quarantine exemption by the end of July (RTHK News, 2020a). The third wave was considerably more serious than the previous two waves in terms of the number of infections (i.e., >5,000 cases).

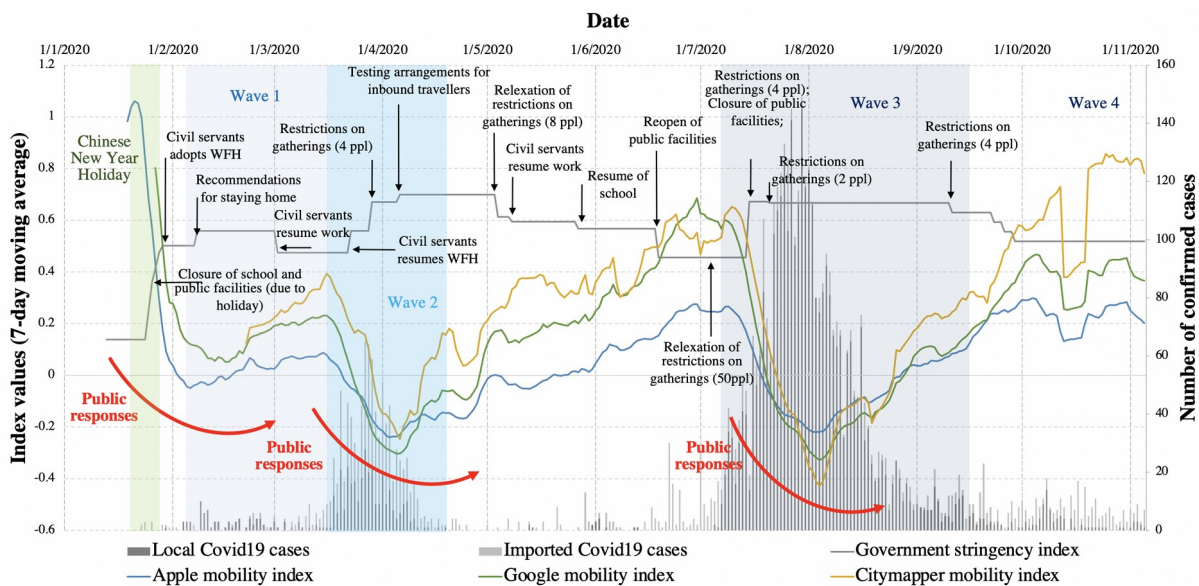


Fig. 1. Trends in the Oxford government stringency index and seven-day moving averages of the community mobility indexes from different mapping service companies

In the subsequent analysis, we focus on the dynamics of the COVID-19 cases, mobility, and government policies in Hong Kong between February and November 2020. In the study period, there were three outbreak waves of COVID-19 in Hong Kong: (1) February 3 to March 15, 2020; (2) March 13 to April 19, 2020; and (3) July 6 to September 15, 2020.

3.3 Granger causality analysis

A Granger causality analysis is conducted to measure the possible correlations and causality effects between the number of COVID-19 cases, government stringency, and community mobility. Initially introduced in the field of economics (Toda and Yamamoto, 1995), Granger causality has been widely used in transportation and health studies due to its robust nature and model flexibility (Oliveira et al., 2020; Yetkiner and Beyzatlar, 2020). In addition to identifying the existence of causal linkages, Granger causality is useful for determining the directions of causal linkages between variables.

Causality analysis generally relies on cause-and-effect relationships and is based on the concept of predictability instead of correlation between the response and associated causes (Granger, 1969). Granger causality is prevalent if the capability to predict a future response of Y increases by incorporating all of the available information except the current value of X (Eq. 2). In this case, variable X is said to Granger cause Y . Feedback between the cause and response is established when X can Granger cause Y and Y can Granger cause X (Eq. 3). To conduct a causality analysis, Granger proposed a bi-variate model between two stationary time series (X and Y), which is mathematically described as:

$$Y_t = \sum_{j=1}^m a_j Y_{t-j} + \sum_{j=1}^m b_j X_{t-j} + \varepsilon_t \quad (2)$$

$$X_t = \sum_{j=1}^m c_j X_{t-j} + \sum_{j=1}^m d_j Y_{t-j} + \eta_t \quad (3)$$

where X and Y are two stationary time series; a , b , c , and d are coefficients; and ε and η are white noise. For X to Granger cause Y , $b_j \neq 0$ in Eq. 2; for feedback between X and Y , $d_j \neq 0$ in Eq. (3).

The first step in this multivariate time-series analysis is to examine the stationary features of the data using the augmented Dickey-Fuller test for the number of COVID-19 cases, government stringency, and community mobility. The results indicate that the first-order derivatives of the series are stationary, and all are significant at the $p < 0.005$ level. As mentioned, the mobility index with a longer time span, Apple in this case, is adopted for the subsequent analysis. **Table 4** summarizes the results of the applied test for the three series.

Table 4. Results of the Dickey-Fuller test applied to the data series of the daily number of COVID-19 cases, government stringency, and community mobility.

	Ordinary series			First-order derivative		
	Case	Stringency	Mobility	Case	Stringency	Mobility
Test statistic	-2.59	-3.42	-2.30	-4.04	-14.75	-6.67
p-value	0.10	0.01	0.17	0.001	<0.001	<0.001

The stationary series are determined using Eqs. (2) and (3) based on the value on the current day and that of the series on j previous days. The appropriate lag j is then determined based on the Akaike information criterion (AIC) using the minimum root mean square error of the complete set of the adjusted series (Lütkepohl, 2005). The empirical estimation of the appropriate lag order considered all three series, for which the lag and AIC values are shown in **Table 5**.

Table 5. Akaike information criterion (AIC) and lag values for the series of confirmed cases, government stringency, and community mobility.

Dependent Independent	Variable					
	Mobility		Stringency		Case	
	Stringency	Case	Mobility	Case	Mobility	Stringency
AIC	-583.06	-476.78	-1427.87	-1430.25	2073.85	2072.62
Lag value	8	2	1	1	3	3

The correlation matrix of the stationary series and the results of the association measures using the Granger tests are presented in **Tables 6** and **7**, respectively. The positive and negative correlations are interpreted in accordance with the following intervals: (i) ± 0.00 to ± 0.10 for very low; (ii) ± 0.10 to ± 0.40 for weak; (iii) ± 0.40 to ± 0.60 for moderate; (iv) ± 0.60 to ± 0.80 for strong; (v) ± 0.80 to ± 0.99 for very strong; and (vi) ± 1.0 for perfect. For example, community mobility and government stringency (-0.727) exhibit the strongest negative correlation. The Granger test results indicate that community mobility significantly affects government stringency, with a lag of 1 day (test statistic = 1.761, p-value = 0.053). This suggests that the community response actually occurred in advance of the implementation of any government policy. The government stringency is found to Granger cause the number of COVID-19 cases with a lag of 3 days (test statistic = 1.761, p-value = 0.053). This implies that a government act (with a 3-day lag) can predict the changes in the number of new COVID cases. Such findings are reasonable. No significant associations are found between the confirmed cases and community mobility (p-value > 0.1), and weak correlations are found between COVID-19 cases and community mobility (-0.348) and between COVID-19 cases and government stringency (0.329).

Table 6. Correlation matrix of the stationary series of COVID-19 cases, government stringency, and community mobility.

Series	Mobility	Stringency	Case
Mobility	1	-0.727**	-0.348**
Stringency	-0.727**	1	0.329**
Case	-0.348**	0.329**	1

** Correlation is significant at the 0.01 level (2-tailed).

Table 7. Results of pairwise Granger tests and an exploratory search of associations between COVID-19 cases, government stringency, and community mobility.

Null hypothesis	Time lag t (day)	Test statistic	p-value	Result
<u>Community mobility and confirmed cases</u>				
Community mobility does not affect confirmed COVID-19 cases	3	0.611	0.608	Do not reject
Confirmed COVID-19 cases do not affect community mobility	2	1.34	0.264	Do not reject
<u>Mobility and government stringency</u>				
Community mobility does not affect government stringency	1	4.356	0.038	Reject

Government stringency does not affect community mobility	8	0.836	0.572	Do not reject
<u>Government stringency and confirmed cases</u>				
Government stringency does not affect confirmed COVID-19 cases	3	3.503	0.016	<u>Reject</u>
Confirmed COVID-19 cases do not affect government stringency	1	0.023	0.880	Do not reject

In conclusion, the Granger tests are capable of measuring the association between government stringency, community mobility, and COVID-19 cases to some extent. Similar attempts have been made in other COVID-19-related studies to investigate the time lag between the mobility response and government policy. However, a negative time lag of the public response in terms of community mobility has been commonly reported in most of the countries under investigation (Bian et al., 2021; Cartenì et al., 2020; McKenzie and Adams, 2020). It is relatively rare for a public response to occur before a government policy intervention is introduced, albeit with a 1-day lag. In general, the public often relies on the government and public authorities for information on the epidemic situation and guidance to control the spread of the disease. Hong Kong may have been in a slightly different position. Individuals were generally more responsive to the trend of COVID-19 cases, whereas the government is oftentimes more cautious in decision making. Governments typically announce policy changes several days in advance. Behavioral changes of the public may therefore occur before a policy is enforced. Nevertheless, it may not be appropriate to infer that government policies follow community mobility. A community might also respond to other circumstances, such as the global trend of the pandemic. This implies that it is necessary to further investigate the observed phenomena based on retrospective review of research papers, news articles, and official documentation, which are presented in the following section.

4. Discussion of policy implications

4.1 Implications of government preparedness and responses

4.1.1 *Learning from the past: responsive risk assessment and communication*

After the SARS pandemic, the Hong Kong SAR government established the Centre for Health Protection (CHP) in 2004. The CHP aims to enhance the effectiveness of the prevention and control of communicable diseases in Hong Kong. The CHP regularly uses electronic media, printed materials, and educational and promotional campaigns to disseminate guidelines and public service announcements on various public health issues, especially precautionary measures to prevent communicable diseases among the general public and healthcare workers. The general public was therefore generally aware of personal hygiene standards even before the COVID-19 pandemic (CHP, 2018).

The CHP (2020) first published the “Guidelines on the Prevention of Coronavirus Disease 2019 (COVID-19) for the General Public” soon after the first case in Hong Kong was reported on January 15, 2020, which was indeed a few days before the first case was

reported in Hong Kong (January 23, 2020). These guidelines aimed to increase the awareness of the general public of a possible COVID-19 outbreak. The government organized nearly daily press conferences to disseminate information on the pandemic situation since the first COVID-19 case was reported in Hong Kong (e.g., number of new local and imported cases), preventive measures, and economic and financial assistance. More importantly, the CHP launched an integrated dashboard for COVID-19 (CHP, 2020), which includes information regarding each confirmed case (e.g., onset and confirmation date of infection, gender, age, location, flight, train and/or ship number of imported cases, status). The spatial details of every case can also be visualized using an interactive map. This is an essential outlet for continuous monitoring of the pandemic situation, comprehensive risk assessment, and effective risk communication. This approach should be indicative of the formulation of a strategic framework of government preparedness plans, emergency operations, recovery, and public assistance schemes. More importantly, coordination can be enhanced among government agencies, non-government organizations (NGOs), community groups, private cooperation, and the general public. In late April, the government announced that the “Suppress and Lift” approach would be the main strategy for government to respond to the pandemic situation (Hong Kong Government, 2020a). This meant that the government and community would need to learn to live with the virus and adapt to the new normal. The public should be prepared for the prevalence of momentary small-scale local outbreaks from time to time, and physical distancing measures may need to be temporarily tightened.

4.1.2 Alternatives to complete lockdown: physical distancing policies and financial aid to logistics and transportation industries

A complete lockdown is difficult to impose in Hong Kong owing to its current state of political and economic fragility (Hong et al., 2020). Although all schools were suspended between February and May 2020 and the Hong Kong SAR government imposed a work-from-home policy in March, the mobility reduction has been moderate locally, compared with other cities in Europe and North America. Many travel restrictions and physical distancing policies have been imposed to contain the coronavirus, which has had a multifaceted impact on the economy and society. Tourism, trade, logistics, and transportation industries have historically been the main economic drivers in Hong Kong, which constitute three quarters of the overall income and jobs (Census and Statistics Department, 2019). To revitalize the economy and society, the Hong Kong SAR government has provided billions of dollars in financial aid to help maintain the operations of several corporations, including Cathay Pacific and Ocean Park, that were severely stricken by the pandemic. The government has also launched its most generous cash allowance, railway transit fare reduction, and two batches of wage subsidies to aid individuals, communities, and businesses. The total sum of the economic and financial relief plan amounts to 138 billion dollars.

4.1.3 Testing on the move: free coronavirus screening tests for occupational drivers (e.g., taxi and minibus drivers)

Certain actions require the government to coordinate at the macro-scale. For instance, free coronavirus screening tests have been provided to taxi and public light bus drivers since late July 2020 (Hong Kong Government, 2020b, 2020c) using a self-administered deep throat saliva test. Participants are required to go to temporary distribution points (Fig. 2) to obtain and return the specimen collection kits (Fig. 3). Nevertheless, it is expected that multiple outbreak waves of COVID-19 will occur over an extended period beyond 2021. It would be worth exploring the effectiveness of the financial relief plan and other recovery strategies in

revitalizing the economy and society in the long run when comprehensive employment, domestic product, trade, and tax revenue data are available. Transport equity, particularly the accessibility of low-mobility groups, should also be considered in the disruption context (Chan et al., 2021).



Fig. 2. Temporary distribution and specimen collection point for taxi drivers. Source: RTHK News (2020)



Fig. 3. Specimen collection kit. Source: Transport Department (2020)

4.2 Implications for community preparedness and response

The results of the exploratory time-series analysis indicate that communities in Hong Kong responded promptly to the trends of the epidemic situation, whereas the government responses sometimes lagged. People quickly adapted to any call for physical distancing and the reduction of unnecessary travel, even in Hong Kong where it was not considered viable to enforce a complete lockdown in light of the economic disruptions and public outcry (Wong et al., 2020). This section aims to illustrate the possible pathway to an effective community preparedness plan. The study is exploratory in nature, and the interpretations rely on narrative literature reviews and empirical observations and local experiences of dealing with public health crises based on multiple data sources. Authoritative claims are not made regarding the impact of the pandemic on daily mobility during the early global COVID-19 outbreak stage; rather, justifications are provided from a local perspective. Such findings improve the understanding and interpretation of the timeliness and effectiveness of community preparedness, which are discussed in the following two subsections.

4.2.1 Personal protective equipment becomes a new (travel) necessity

Face mask use is recognized to be effective in controlling the spread of COVID-19, especially in settings where physical distancing is impractical (WHO, 2020b), by reducing the probability of infecting others (83.3%) and becoming infected (66.7%) (Chan et al., 2020). The use of face masks in public areas is therefore required in many countries, especially in public transportation vehicles. This obligation has also been adopted in Hong Kong since July 2020. In many Asian countries, such as China and Japan, the use of face masks is ubiquitous and was considered hygiene etiquette even before recommendations by the WHO (Feng et al., 2020). Moreover, face mask usage in Hong Kong is among the highest worldwide (Wong et al., 2020). The results of a questionnaire survey by Wong et al. (2020) showed that 99% of respondents reported they would wear face masks for traveling immediately after the first COVID-19 case was reported in Hong Kong. The high usage of face masks can be attributed to both the demand (travel risk perception) and supply (availability) of face masks.

The risk perception of the community is rooted in social awareness, attitude, and beliefs regarding infectious disease from previous epidemic experiences, i.e., the SARS crisis in 2003 (Cheng et al., 2020; Cowling et al., 2020; Kwok et al., 2020; Wong et al., 2020). Studies have indicated that the responses (i.e., reduction of mobility) among residents in Hong Kong were more consistent than those in other jurisdictions such as Australia, Japan, and the United States. The implicit social consciousness could be because of the bitter experience with SARS in 2003, which had serious economic and social effects on the citizens of Hong Kong (Cheung and Cheung, 2020). Hong Kong is also a major regional and international transportation hub, with high local cross-border traveler flux given its close proximity to mainland China (Chan and Xu, 2003; Chong and Pan, 2020). The public was therefore sensitive to the first wave of the COVID-19 outbreak in Wuhan, China, in January 2020.

The adequate supply of face masks can be attributed to both community-led and government-led actions. In the early stage of the COVID-19 pandemic (e.g., February 2020), despite the scarce global supply of face masks owing to limited production capability and banned exports, several NGOs and private corporations were able to secure an adequate supply either by setting up designated production lines or through direct purchase and donation to low-mobility groups in Hong Kong (Cheng, 2020; Chow, 2020). However, the Hong Kong government could only provide one reusable and 10 disposable masks to every resident by online subscription, but not until May 2020. (Hong Kong Government, 2020d). To this end, people in the low-mobility group (e.g. elderly, people with physical disabilities, and people living in poverty) were disadvantaged because they often had poor internet access (Ho, 2020). This suggests that effective risk communication to the public and government preparedness for the supply and logistics of essentials are crucial to the success of any control measure against the pandemic.

4.2.2 Social mobilization: grassroots community networks for risk communication

A highly autonomous yet decentralized community network has been cultivated owing to the continuous socio-political movement in Hong Kong since June 2019 (Wang et al., 2018; Kow et al., 2020). Such online social networks are highly dynamic, adaptive, and effective in engaging the community. The networks are also used to circulate messages conveying solidarity and altruism to the community for public self-assistance (Wang et al., 2018; Kow et al., 2020). Soon after the first case of COVID-19 was reported in mainland

China in December 2019, promotional materials in both printed and electronic form were rapidly spread throughout the city to increase the public's awareness and preparation for the onset of a pandemic. For example, personal protective equipment (e.g., face masks, sterilizer) have become necessities because non-pharmaceutical intervention is the only viable way to contain such viruses before specific treatment options are available. Irrational stockpiling of necessities is recognized as a sign of coronavirus panic, and this occurred in Hong Kong and many other cities in February 2020 (Leung et al., 2020). Many NGOs, religious organizations, grassroots organizations and community groups have therefore called for donations of personal protective equipment (Wu, 2020). Informal campaigns (Fig. 4) were also conducted using the multi-dimensional communication platform, and these were influential in mobilizing the engagement and commitment of individuals and the community and benefited vulnerable groups (e.g., elderly, people in poverty, and healthcare workers; Man, 2020). Many private companies and local institutions also initiated the production of masks and other personal protective equipment (Han, 2020). The unified actions of multiple groups and organizations formed the strategic emergency plans that enhanced the resilience of individuals, society, and community, especially those in vulnerable population groups.



Fig. 4. Illustration of a comic on social media conveying the message that masking and mask sharing are important Source: Collaction Team (2020)

Such community networks not only exist virtually for risk communication but also evolve into physical logistic networks to provide necessities and public assistance to low-mobility groups, including food and personal protective equipment (e.g., face masks, gloves, detergent, sanitizers; Cheung, 2020). **Fig. 5** depicts an example of both online and offline multi-dimensional community communication in Hong Kong. Many posters were put up in public areas throughout the city (e.g., community facilities, subways, staircases, footbridges, railway stations, bus stops) to spread basic knowledge about COVID-19 and personal hygiene. This is recognized as effective albeit informal public education that can warrant the attention of the community and instigate community participation, especially regarding issues

that have a tremendous social impact, such as the COVID-19 pandemic addressed in this study. Available pandemic risk-related information included the number and spatial distribution of COVID-19 cases, mean number of infections, the government preparedness and response plan, and precautionary measures. These pieces of information were also disseminated through social media and digital platforms such as Facebook, Instagram, Twitter, and Telegram. These efficient communication and information distribution schemes explain why the general public responded promptly to the dynamics of the epidemic situation.



Fig. 5. Illustration of a poster regarding preventive measures against COVID-19 near a bus stop. Source: Collaction Team (2020)

It may not be feasible to universally assess the effectiveness of various policy intervention measures for controlling the spread of the virus, considering the differences of socio-cultural, political, and economic systems across jurisdictions. Nevertheless, the roles of both grassroots-led and government-led initiatives in responses and recovery during the post-COVID-19 period should be assessed. It will be worthwhile to explore the effectiveness of emerging transportation initiatives in terms of economic, social, and cultural recovery when time-series data of activity participation and mobility in the medium term become available.

4.3 Shared responsibility in disaster management policy: the role of grassroots communities and government

Communities and societies have demonstrated varying responses to the pandemic. Several variations in these responses have been observed, and these have led to uneven impacts among different social groups. In the first public announcement regarding the pandemic on January 25, 2020, the Chief Executive of Hong Kong emphasized the importance of unity to combat the disease, with a platform vision of “Together Fighting Disease” (Hong Kong Government, 2020e). This is consistent with the empirical findings in many other countries that community-led initiatives are often diverse but timely. Although not all of the policy measures were closely related to transportation, they affected activity participation and, in turn, mobility. Zhu and Cai (2020) indicated the importance of community engagement led by the local government in addressing the challenges associated with public health emergencies based on the outbreak and quarantine measures in Wuhan, China, and justified the role of volunteers and NGOs in relieving the shortage of manpower. The government also provided efficient and timely guidance and coordination. Miao et al. (2020) examined the crucial role of community volunteerism and the effective deployment of

voluntary services by the local and regional governments of China during the pandemic. The results demonstrate that community cooperation is more effective for leveraging human capital and technology to meet victims' needs of transportation and logistics, equipment, food and water, medicine, and other necessities. Duque Franco et al. (2020) suggested that grassroots initiatives are vital in providing immediate responses to emergencies in temporary settlements, including transport, mobility, food, and water; however, the long-term deployment of materials and services in the recovery phase requires the coordination of public authorities. Odendaal (2020) discussed the co-existence of governmental and public responses in South Africa, which they suggested could be attributed to safety concerns, system and infrastructure failure, and poor well-being of the community. She suggested that public health emergencies may also introduce opportunities for progressive social and technological evolution. The above findings emphasize the role of governments in coordinating responses, particularly regarding the accessibility of essential materials and services for low-mobility groups.

Hong Kong may be considered a place with a high level of collective identity under its unique socio-political setting (Hartley and Jarvis, 2020), which supports the timely responses of the public against the pandemic. Cheng et al. (2020) suggested that voluntary mass masking could be a symbol of "social solidarity." This justifies the focus shift from self-protection to altruism in the global response to the pandemic. Lau (2020) examined the role of "social capital" in combating the COVID-19 epidemic in Hong Kong and suggested that the community provides an important social resource that can supplement the role of the government. Hartley and Jarvis (2020) used the term "community capacity" to describe the extent to which social and institutional resources were nurtured in the community, which enabled Hong Kong to generally maintain a relatively low level of coronavirus infections without stringent mobility control. Several studies from different perspectives have all pinpointed the role of adaptation behavior within the community and a top-down approach of government policy in controlling the pandemic. Differing from the findings of transport-related epidemic literature in other jurisdictions, the case of Hong Kong justifies that it is possible to initiate public health measures primarily through community mobilization. For instance, the roles of collective social capital are illustrated at the local scale in terms of addressing the need to access essential materials and services, given the challenges of the infrastructure, transport, logistics, and socio-cultural system. Democratic legitimate avenues for action and engagement and informal networks could be essential in some circumstances.

In late February 2020, the government launched the Hong Kong Anti-epidemic Information Channel on Telegram to disseminate public information on the pandemic in an efficient manner (Hong Kong Government, 2020f). However, at the time of writing (November 2020), there were only 14,000 subscribers, which is relatively small compared with other local community Telegram channels (e.g., 30,000 subscribers for local groups, 100,000 for national groups). Although this demonstrates the government's initiative to enhance the efficiency and effectiveness of public communication and education, it was relatively unsuccessful in engaging the general public without the support of community collaboration. This also justifies the importance of building shared leadership and bidirectional trust from a socio-political perspective.

It would be premature to assess whether or not grassroots-led and/or state-led approaches have been more effective in controlling the public health emergency in the relatively early stage of the COVID-19 epidemic, given the complicated nature of the economic, cultural, and socio-political systems among different jurisdictions (Yuen et al.,

2021). Nevertheless, the role of community engagement is crucial not only at present, but also in the post-pandemic era. More empirical evidence is required to determine the effectiveness of different transportation policies and initiatives that can mitigate problems related to accessibility and social exclusion from the perspective of transport accessibility.

5. Conclusions

An explorative analysis is conducted on the public health policy measures and community mobility patterns in response to the COVID-19 pandemic in Hong Kong. The results of a time-series analysis based on empirical data show that communities have been responsive to the epidemiological situation in terms of mobility change. In particular, mobility reductions occurred earlier than the implementation of intervening policies. The stringency of government control policy has also been responsive to the prevailing epidemiological situation. In accordance with a retrospective review of research papers, news articles, and official documentation, the significant factors that determine the successful implementation of any public health intervention include social mobilization, community networks for public risk communication, responsive risk assessment, and government mitigation methods.

The roles of the government, general public, and community are crucial to successful responses to and recovery from public health emergencies (WHO, 2020b). The widespread implementation of physical distancing (e.g., work from home, distance learning, online shopping, food delivery) has reshaped urban mobility and will become the new normal in the post-pandemic era. Government authorities, public health and medical practitioners, policymakers, and researchers, in addition to the general public, have played an important role in effective risk communication and preparedness planning (Kenny, 2020; Mietzner, 2020; Ratneswaren, 2020). The interaction between public and government responses, as revealed in the current study, has stimulated the reassessment of mitigation strategies that can increase the capability and improve the effectiveness of response measures in controlling future epidemics (Verlinghieri, 2020).

This study is exploratory but should initiate discussions among stakeholders and decision makers. The aim of this article is to illustrate the community response to a public health emergency from a local perspective in Hong Kong; however, authoritative claims are not made regarding the impact on mobility in the early stage of the COVID-19 pandemic, which is expected to persist beyond 2021. It is believed that collaborative efforts of the government and community are crucial to the success of the response to and recovery from public health emergencies and the resilience of a city.

At the time of writing, the fourth outbreak wave has begun and is yet to subside in Hong Kong. It will be worthwhile to explore the preparedness of the government and public for this sudden bloom of local cases. One critical issue that should be investigated is “epidemic fatigue” (i.e., ignoring health advice and restrictions), which some scholars have proposed as the driving force of the fourth outbreak wave (Sun, 2020), especially considering that public facilities are essentially superspreading environments (Loo et al., 2021). The timeliness and effectiveness of government recovery strategies in revitalizing the economy and society should also be evaluated when comprehensive time-series data are available.

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