Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Measuring the impact of mitigation measures on infection risk of covid-19 in Hong Kong since February 2020

Jianfa Shen

Department of Geography and Resource Management, The Chinese University of Hong Kong, Hong Kong SAR, China

ARTICLE INFO

Keywords:
Covid-19 pandemic
Infection rate
Infection risk
Mitigation measure
Hong Kong

ABSTRACT

Is it possible to control the covid-19 pandemic in large cities like Hong Kong? Many cities have adopted various mitigation measures to contain the covid-19 pandemic. But few studies have been made to measure the impact of mitigation measures on infection risk at city level such as Hong Kong. This paper introduced three indicators to measure the infection risk of covid-19 under mitigation measures: the infection rate, the primary risk of infection and daily risk of infection. Two factors are introduced to consider the impact of mitigation measures on infection risk in Hong Kong. They are the number of trips per day and the percentage of people wearing face masks. With these two mitigation measures, the daily risk of infection was reduced from 1826.11 per million to 644.58 per million in the peak of covid-19 infection on 2 August 2020. The covid-19 infection risk would be 2.83 times higher if above mitigation measures were not adopted. The covid-19 pandemic continues in 2021 and city governments are strongly recommended to take effective measures to encourage the public to reduce unnecessary trips and wear face mask before the pandemic is fully controlled.

1. Introduction

Urban population growth, population size and high population density are considered key factors in the spread of disease although there are controversial results (Coker, Hunter, Rudge, et al., 2011; Hamidi, Sabouri, & Ewing, 2020; Rocklov & Sjödin, 2020). The covid-19 pandemic has swept the world since December 2019. People living in cities are particularly vulnerable due to large population size and intense population flows (Hamidi et al., 2020). Hamidi et al. (2020) demonstrated that it is the metropolitan population size, not the population density, that had a significant impact on the covid-19 infection rate. Some studies examined the diffusion of covid-19 and the effect of transmission control measures in China (Chen, Yang, Yang, Wang, & Bärnighausen, 2020; Jia et al., 2020).

Many cities have adopted various mitigation measures to contain the covid-19 pandemic. But few studies have been made to measure the impact of mitigation measures on infection risk at city level. An important academic and practical question is: Is it possible to control the covid-19 pandemic in large cities like Hong Kong? Hong Kong is a large city with a population over 7 million. It is one of the earliest areas to receive imported cases from Wuhan. Two cases were first detected on 23 January 2020 and the total number increased to 9798 by 20 January 2021 (Worldometer, 2021). This paper will address the following three research questions. How to measure infection risk of covid-19 in a city? What is the impact of mitigation measures on the infection risk of covid-19 in a city? Is it possible to control the covid-19 pandemic in large cities like Hong Kong? As a large city with 7 million population, the Hong Kong case shows great challenges to fight the pandemic as some imported cases have generated four waves of community infection. But it is still possible to mitigate and even control the extent of covid-19 pandemic as the daily infection in each wave was reduced to zero or a few cases.

2. Research methodology and data

Two statistics are commonly reported on the covid-19 pandemic in a city. They are the number of accumulated covid-19 cases and the number of active covid-19 cases. Three indicators can be defined. The infection rate is defined as the number of accumulated covid-19 cases per unit of population. The primary risk of infection is defined as the number of active covid-19 cases per unit of population. The daily risk of infection, to measure the total infection risk of a person in a day, is equal to the primary risk of infection multiplied by the total people a person met in a day and can be reduced by reducing the number of trips per day and wearing face masks. The following equations define various...
Infection rate = Number of covid-19 cases/Population (1)

Primary risk of infection = Number of active covid-19 cases/Population (2)

Daily risk of infection without mitigation = P × Primary risk of infection (3)

Daily risk of infection = T × M × P × Primary risk of infection (4)

P is the people met in one day;
T is the reduced percentage level of trips per person;
M is the reduced percentage level of infection due to wearing masks.

The covid-19 data are from Worldometer (2021). The data accuracy depends on the coverage of covid-19 testing (Hasell, Mathieu, Beltekian, et al., 2020). From 15 November to 19 December 2020, 514 samples tested preliminarily positive, accounting for 0.17% of 308,000 persons tested in Community Testing Centres in Hong Kong indicating a high testing coverage (HKSAR Government, 2020).

The number of mechanised trips per person was estimated to be reduced from 1.83 in 2011 to 1.80 in 2019 as the daily public transport trips per person decreased by 1.48% (Transport Department, 2014, 2020). If a person meets 5 people in each trip, the people a person met in a day would be 9.

The monthly data on average weekday number of passengers is used to calculate the travel level from February 2020 to January 2021 (MTR Corporation Limited, 2021). The travel level in December 2019, before the covid-19 pandemic, was set as 100%. The travel level was reduced to the lowest of 61.06% in February 2020, and three low levels, 64.59%, 64.18% and 71.80%, in April, August and December 2020 respectively.

It is estimated that wearing face mask can reduce 50% of the risk of infection (Turak, 2020). Due to the experience of SARS in 2003, about 90% people wear face masks in Hong Kong. It can reduce the risk of infection to 55% (100%x100% + 90%x50%) level.

3. Measuring infection risk with and without mitigation measures

After the outbreak of covid-19 in Wuhan in December 2019, the number of covid-19 cases in Hong Kong increased from 2 on 23 January 2020 to 56 on 15 February 2020, 3512 on 2 August 2020 and 9798 on 20 January 2021. The infection rate increased from 7.48 per million on 15 February 2020 to 469.12 per million on 2 August 2020, and 959.07 per million on 9 December 2020. The primary infection rate increased from 7.21 per million on 15 February 2020 to 92.97 per million on 7 April 2020, 202.90 per million on 2 August 2020, and to a lower peak of 171.38 per million on 9 December 2020.

The government and the public have taken various measures to mitigate the pandemic including social distancing, wearing face masks, encouraging working from home, changing to on-line teaching, closing bars and restaurants in some periods, in addition to rigorous control and quarantine of passengers coming from outside Hong Kong. These measures contribute to the reduction of travel and infection levels in Hong Kong. But different from other cities, no ban has imposed on residents from leaving their home or travelling within the city. The public transport continues to provide the service. Thus the mitigation measures in Hong Kong have been mild and mostly voluntary. But Hong Kong has still managed to control the pandemic as shown in Fig. 1, although more slowly than Wuhan and Beijing in mainland China which adopted very rigorous control measures.

Fig. 1 shows the daily risk of infection with and without mitigation measures. If there are no mitigation measures, the daily risk of infection increased to a peak of 836.72 per million on 7 April 2020, 1826.11 per million on 2 August 2020, and to a lower peak of 1542.40 per million on 9 December 2020. The risk of infection with 90% people wearing masks was reduced to 55% of the original risk level, 1004.36 per million, on 2 August 2020. The risk of infection with reduced trips was reduced to 1171.97 per million on 2 August 2020.

With these two mitigation measures, the daily risk of infection was reduced from 1826.11 per million to 644.58 per million on 2 August 2020. This means that the covid-19 infection risk would be 2.83 times higher if above measures were not adopted. The trip reduction had not been maintained at the lowest level of 61% in February 2020 for the whole period up to January 2021. If the lowest level of 61% was maintained, the risk of infection with 61% trips would be reduced to 612.66 per million on 2 August 2020. The risk of infection would be 517.47 per million on 9 December 2020, lower than 609.09 per million with actual higher travel level of 71.8%.

4. Conclusion

There are increasing studies on the diffusion of covid-19 with controversial results on the role of urban population size and high population density in the spread of disease (Chen et al., 2020; Coker et al., 2013; Hamidi et al., 2020; Rocklov & Sjödin, 2020). But there are few covid-19 studies focusing on individual cities like Hong Kong. This paper introduced three indicators to measure the infection risk of covid-19 in Hong Kong: the infection rate, the primary risk of infection and daily risk of infection. Two factors, number of trips per day and the percentage of people wearing face masks, were introduced to consider the impact of mitigation measures on infection risk. With these measures, the daily risk of infection was reduced from 1826.11 per million to 644.58 per million on 2 August 2020. The covid-19 pandemic would be 2.83 times higher if above mitigation measures were not adopted.

The Hong Kong experience shows clearly that the pandemic is quite difficult to handle as some imported cases can generate new waves of community infection in the city, such as the second to fourth waves in Hong Kong. But it is still possible to mitigate and even control the extent of covid-19 pandemic in large cities if persistent measures are taken by the government and the public. The covid-19 pandemic continues in 2021 and city governments are strongly recommended to take effective measures to encourage the public to reduce unnecessary trips and wear face mask before the pandemic is full controlled.

Funding

This work was supported by the RGC Senior Research Fellow Award 2020/21, Research Grant Council, Hong Kong SAR, China [grant number SRFS2021-4H02].
Declaration of competing interest

None.

Acknowledgements

Thanks are due to helpful comments from reviewers and the editor.

References

Chen, S., Yang, J., Yang, W., Wang, C., & Barnighausen, T. (2020). COVID-19 control in China during mass population movements at new year. Lancet, 395(10226), 764-766.

Coker, R. J., Hunter, B. M., Rudge, J. W., et al. (2011). Emerging infectious diseases in Southeast Asia: Regional challenges to control. The Lancet, 377(9765), 599-609.

Hamidi, S., Sabouri, S., & Ewing, R. (2020). Does density aggravate the COVID-19 pandemic? Early findings and lessons for planners. Journal of the American Planning Association, 86(4), 495-509.

Hasell, J., Mathieu, E., Beltekian, D., et al. (2020). A cross-country database of COVID-19 testing. Scientific Data, 7(10), 1-7.

HK SAR Government (2020). Nineteen community testing centres across territory in full operation. Press release, 21 December.

Jia, J. S., Lu, X., Yuan, Y., Xu, G., Jia, J., & Christakis, N. A. (2020). Population flow drives spatio-temporal distribution of COVID-19 in China. Nature, 582, 389-394.

MTR Corporation Limited (2021). Historic patronage figures. https://www.mtr.com.hk/en/corporate/investor/patronage.php#search. accessed on 22 January 2021.

Rocklov, J., & Sjödin, H. (2020). High population densities catalyse the spread of COVID-19. Journal of Travel Medicine, 27(3), 1-2.

Transport Department. (2014). Travel characteristics survey 2011 final report. HK SAR Government.

Transport Department. (2020). Annual Transport Digest 2020. HK SAR Government.

Turak, N. (2020). Wearing a mask can significantly reduce coronavirus transmission, study on hamsters claims. CNBC, (19 May 2020).

Worldometer (2021). COVID-19 Coronavirus Pandemic. https://www.worldometers.info/coronavirus/, 2021. accessed on 21 January 2021.