Report 11: Evidence of initial success for China exiting COVID-19 social distancing policy after achieving containment

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Summary

The COVID-19 epidemic was declared a Global Pandemic by WHO on 11 March 2020 [1]. As of 20 March 2020, over 254,000 cases and 10,000 deaths had been reported worldwide. The outbreak began in the Chinese city of Wuhan, Hubei in December 2019. In response to the fast-growing epidemic, China imposed strict social distancing in Wuhan on 23 January 2020 [2, 3] followed closely by similar measures in other provinces. At the peak of the outbreak in China (early February), there were between 2,000 and 4,000 new confirmed cases per day. For the first time since the outbreak began there have been no new confirmed cases caused by local transmission in China reported for five consecutive days up to 23 March 2020 [4-7]. This is an indication that the social distancing measures enacted in China have led to control of COVID-19. These interventions have also impacted economic productivity, and the ability of the Chinese economy to resume without restarting the epidemic is not yet clear. Here, we estimate transmissibility from reported cases and compare those estimates with daily data on within-city movement, as a proxy for economic activity. Initially, within-city movement and transmission were very strongly correlated in the 5 provinces most affected by the epidemic and Beijing. However, that correlation fell away quickly, especially outside Hubei, and is no longer apparent even though within-city movement has started to increase. A similar analysis for Hong Kong shows that intermediate levels of local activity can be maintained while avoiding a large outbreak. These results do not preclude future epidemics in China, nor do they allow us to estimate the maximum proportion of previous within-city activity that will be recovered in the medium term. However, they do suggest that after very intense social distancing which resulted in containment, China has successfully exited their stringent social distancing policy to some degree. Globally, China is at a more advanced stage of the pandemic. Policies implemented to reduce the spread of COVID-19 in China and the exiting strategies that followed can inform decision making processes for countries once containment is achieved.

SUGGESTED CITATION

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We analyse daily reported COVID-19 cases for each province in mainland China and for Hong Kong SAR and Macau SAR [7] (Figure 1). The reproduction number (R_t) measures transmissibility and is defined as the average number of new cases generated by each case. When the number of cases is growing, R_t is greater than 1; when the number of cases is decreasing, R_t is less than 1. Changes in R_t are not immediately evident in case data for two reasons. First, there are delays from infection to the onset of symptoms and from the onset of symptoms to seeking care. Second, people must be tested, and those tests reported to become a case in these data.

As a proxy for economic activity we obtained daily within-city movement data from 1 January to 17 March 2020 for major metropolitan cities within each province in mainland China (Figure 1), Hong Kong SAR, and Macau SAR. These data, provided by Exante Data Inc [8], measured travel activity relative to the 2019 average (excluding lunar new year). The underlying data are based on near real-time people movement statistics from Baidu. Based on GPS tracking, the data allow quantification of the number of trips taken per person in the population. At the country level, ~5 trips per person was normal. If that went down to 3 daily trips per person, that would be described as a 40% drop. We calculated the weighted average movement within each province using city population size (see Supporting Table S1).

Estimates of R_t over time for each region were obtained using the EpiEstim R package [9]. We assumed a mean serial interval of 6.48 days with a standard deviation of 3.83 days [10]. To account for the delay between symptom onset and report of confirmed cases, we calculated the cross-correlation between daily movement and R_t for Hubei province (where 84% of all confirmed cases in China, Hong Kong, and Macau occurred as of 22 March) for time lags between 0 and 20 days. Cross-correlations were calculated using the ccf function in the stats R package. The highest correlation was observed for a 4-day lag (Figure S1). Next, we determined biweekly rolling Pearson intra-region correlation coefficients between R_t and movement data for each province. To determine how the movement patterns in Hubei province (where the most cases were observed) influenced the R_t in other regions, we also calculated biweekly rolling Pearson inter-region correlation coefficients between R_t in each region and movement in Hubei. All analyses were performed in R 3.6.2 [11].

We found that as movement restrictions were put into place within mainland China from late January to early February 2020, within-city movement and R_t were highly positively correlated (Figure 2, i.e., a decrease in movement was highly correlated with a decrease in R_t). However, as movement resumed within each province/region, the correlation between within-city movement and R_t declined steeply and became strongly negative (intra-region correlation). We also evaluated the correlation between within-city movement in Hubei and R_t in other regions (inter-region correlation). Movement in Hubei was initially strongly positively correlated with R_t in other provinces/regions. However, as movement resumed within each province/region, inter-region correlations became weaker.

In Hong Kong, where less strict movement restrictions were implemented and a lessened, but consistent level of economic activity has been maintained, we observed no correlation between intra-Hong Kong movement and R_t (Figure 3).

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It is important to note that this work is an analysis of correlation, not causation. While within-city movement undoubtedly affects R_t, this analysis does not infer causation. To estimate R_t, we used confirmed case reports; however, confirmed cases are only a proportion of the total number of infected individuals. Therefore, our estimates of R_t may be biased if the proportion of cases being detected varied substantially over short periods of time.

We assessed the correlation between daily movement and estimated R_t over time and observed strong positive correlation between movement and R_t initially and then observed a decoupling of this correlation as China began to remove movement restrictions and restart their economy. These results provide evidence that China's containment strategies are continuing to be effective as they restart their economy. In Hong Kong, movement and R_t within Hong Kong were not correlated, suggesting that they are able to maintain economic activity while simultaneously containing COVID-19 effectively.

References

1. World Health Organization. *WHO Director-General's opening remarks at the media briefing on COVID-19*. 11 March 2020; Available from: https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020
2. Wuhan Epidemic Prevention and Control Centre for Novel Coronavirus-infected Pneumonia. *Notice for the epidemic of novel coronavirus-infected pneumonia in Wuhan city*. 22 March 2020; Available from: http://www.hubei.gov.cn/zhuanti/2020/gzxxgzbd/zxtb/202001/t20200123_2014402.shtml.
3. BBC News. *China coronavirus: Lockdown measures rise across Hubei province*. 23 January 2020; Available from: https://www.bbc.co.uk/news/world-asia-china-51217455.
4. National Health Commission of the People's Republic of China. *March 19: Daily briefing on novel coronavirus cases in China*. 2020; Available from: http://en.nhc.gov.cn/2020-03/19/c_77945.htm.
5. National Health Commission of the People's Republic of China. *March 20: Daily briefing on novel coronavirus cases in China*. 2020; Available from: http://en.nhc.gov.cn/2020-03/20/c_78006.htm.
6. National Health Commission of the People's Republic of China. *March 21: Daily briefing on novel coronavirus cases in China*. 2020; Available from: http://en.nhc.gov.cn/2020-03/21/c_78058.htm.
7. Chinese Center for Disease Control and Prevention, *Distribution of the novel coronavirus-infected pneumonia*. 2020.
8. Exante Data Inc, *Electronic Data*. 2020.
9. Cori, A., *Estimate Time Varying Reproduction Numbers from Epidemic Curves. R package version 2.2-1*. 2019.
10. Ferguson, N.M., et al., *Impact of non-pharmaceutical interventions (NPIs) to reduce COVID19 mortality and healthcare demand.* 2020. DOI: 10.25561/77482.
11. R Core Team. *R: A language and environment for statistical computing*. Available from: https://www.R-project.org/.

Figures

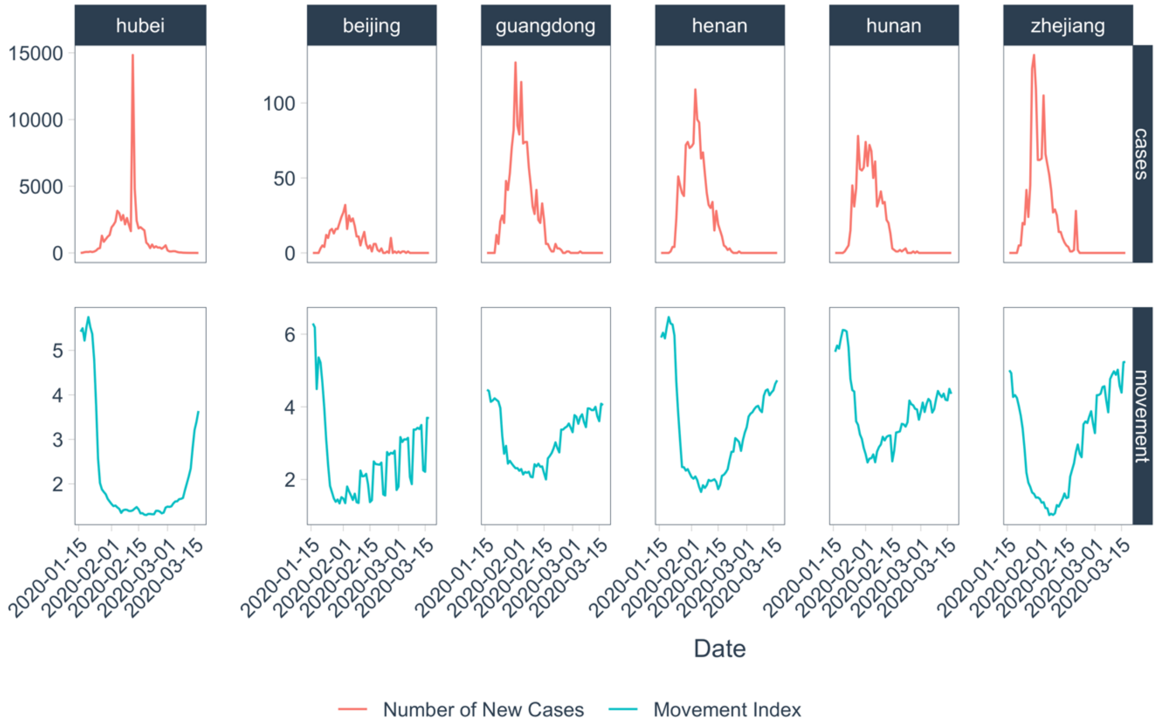

Figure 1. Plots of daily new confirmed cases (red line, top row) and daily movement index (Exante Data Inc, NY, blue line, bottom row) for Hubei, Beijing, Guangdong, Henan, Hunan, and Zhejiang. The cyclic movement patterns seen in Beijing and toward the end of February in Zhejiang are the result of decreased travel on weekends.

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Figure 2. Plots of estimated reproduction number, movement, and correlation in the 5 provinces in mainland China with the highest numbers of cumulative confirmed cases and Beijing (top: Beijing, Guangdong, Henan; bottom: Hubei, Hunan, Zhejiang). Light blue: mean daily movement index (Exante Data Inc, NY, green: mean effective reproduction number estimated using daily confirmed case reports (grey shading: 95% credible interval), dark blue: intra-region correlation between movement index and effective reproduction number, pink: inter-region correlation between movement index in Hubei and effective reproduction number in each province. Reproduction number was estimated assuming a lag of -4 days. Dashed lines indicate the upper and lower bounds of the correlation coefficients (-1, 1).

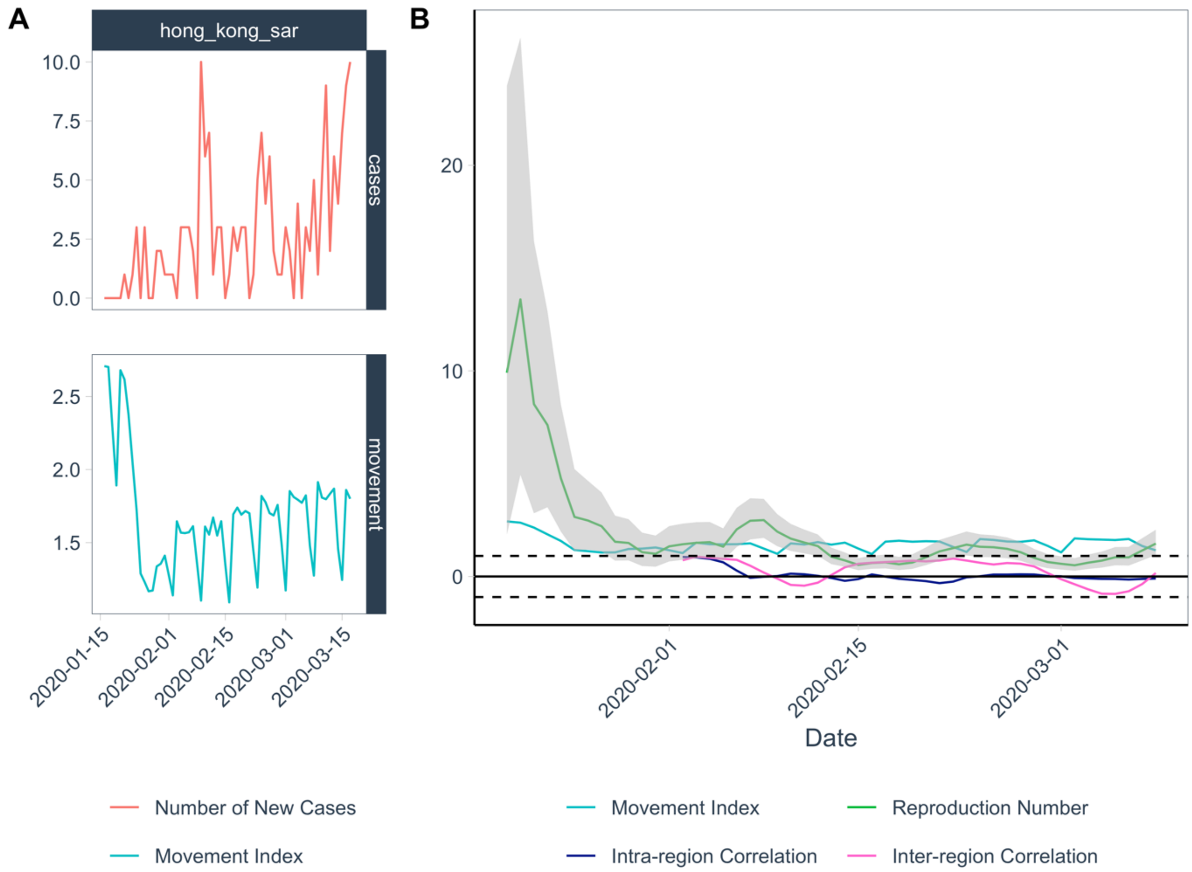

Figure 3. (A) Plots of daily new confirmed cases (top) and daily movement index (bottom) for Hong Kong. (B) Plots of estimated reproduction number, movement, and correlation in Hong Kong. Light blue: mean daily movement index, green: mean effective reproduction number estimated using daily confirmed case reports (grey shading: 95% credible interval), dark blue: intra-region correlation between movement index and effective reproduction number, pink: inter-region correlation between movement index in Hubei and effective reproduction number in Hong Kong. Dashed lines indicate the upper and lower bounds of the correlation coefficients (-1, 1).

Supplemental Material

S1. City-level population size data

Table S1. Province and source of population size data. Numbers of total residents at the end of 2018 in each city were extracted from the provincial Statistical Yearbooks.

Province	Source
Guangdong	http://stats.gd.gov.cn/gdtjnj/content/post_2639622.html
Henan	http://www.ha.stats.gov.cn/hntj/lib/tjnj/2019/zk/indexch.htm
Hubei	http://tjj.hubei.gov.cn/tjsj/sjkscx/tjnj/qstjnj/
Hunan	http://222.240.193.190/19tjnj/indexch.htm
Zhejiang	http://zjjcmspublic.oss-cn-hangzhou-zwynet-d01-a.internet.cloud.zj.gov.cn/jcms_files/jcms1/web3077/site/flash/tjj/Reports1/2019%e5%b9%b4%e7%bb%9f%e8%ae%a1%e5%b9%b4%e9%89%b4%e5%85%89%e7%9b%9820200121_2146/indexch.htm

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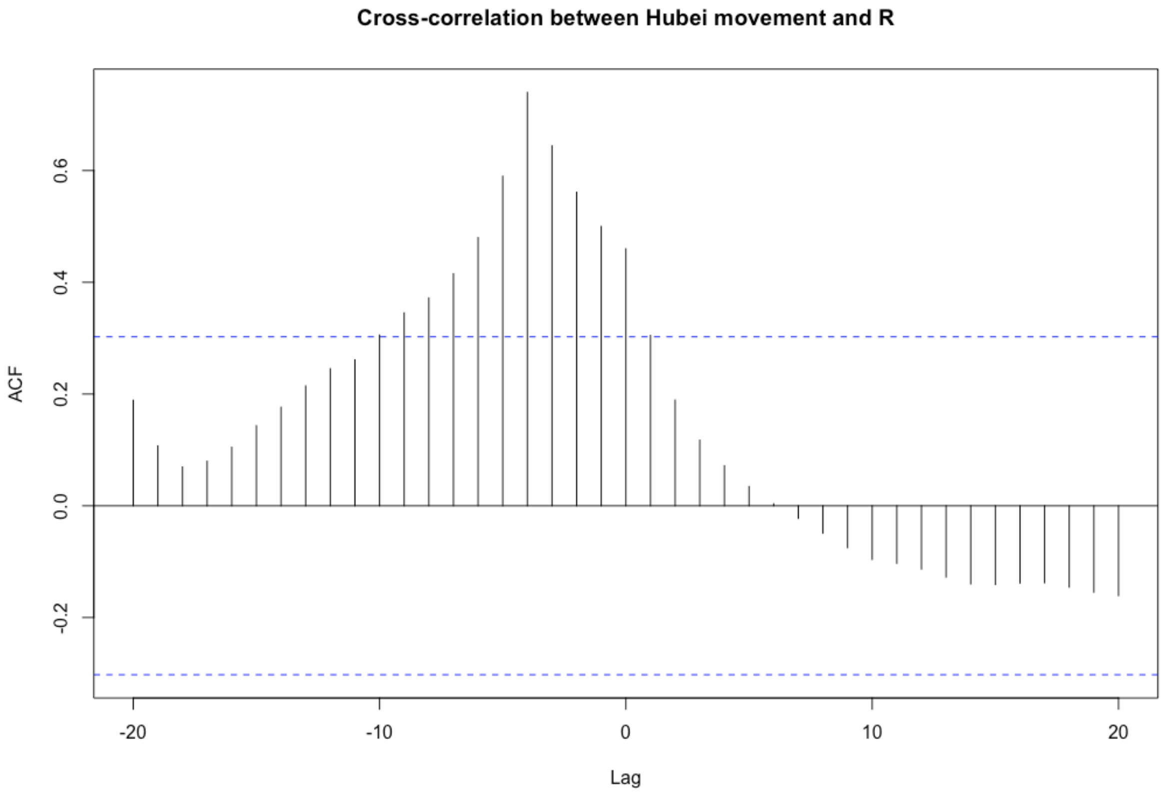

Figure S1. Cross-correlation between Hubei movement and reproduction number for different lag times. The highest correlation is for a lag of -4 days.