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Research Letter

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Impact of mass rapid antigen testing for SARS-CoV-2 to mitigate Omicron outbreaks in China

Zengyang Shao, MSc[1,2,†], Lijia Ma, PhD[1,†], Yuan Bai, PhD[2,3], Qi Tan, PhD[3], Xiao Fan Liu, PhD[4], Shiyong Liu, PhD[5], Sheikh Taslim Ali, PhD[2,3], Lin Wang, PhD[6], Eric H. Y. Lau, PhD[2,3], Benjamin J. Cowling, PhD[2,3,*] and Zanwei Du, PhD[2,3]

[1]College of Computer Science and Software Engineering, ShenZhen University, Shen Zhen, China, [2]Laboratory of Data Discovery for Health Limited, Hong Kong Science Park, Hong Kong, SAR, China, [3]WHO Collaborating Center for Infectious Disease Epidemiology and Control, School of Public Health, LKS Faculty of Medicine, The University of Hong Kong, Hong Kong, SAR, China, [4]Department of Media and Communication, City University of Hong Kong, Hong Kong, SAR, China, [5]Institute of Advanced Studies in Humanities and Social Sciences, Beijing Normal University at Zhuhai, Zhuhai, China and [6]Department of Genetics, University of Cambridge, Cambridge, UK

*To whom correspondence should be addressed. Email: bcowling@hku.hk

†Zengyang Shao and Lijia Ma contributed equally to this work

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Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) Omicron variants have a higher transmissibility and immune escape potential than previous variants, such as Delta variants, leading to their rapid spread around the world. In the mainland of China, >770 000 local cases have been reported from 1 January to 1 July 2022, compared with ∼20 000 local cases in 2021.[1] In Hong Kong, >1 200 000 local cases (greater than 15% of the population) have been reported in the same period. From early 2020, the mainland of China and Hong Kong have adopted hybrid non-pharmaceutical interventions (NPIs) (including school closures, workplace closures, public events cancellations and travel bans[2]) to contain the recurring outbreaks.[3] Here, we conducted an exploratory analysis of potential correlates of COVID-19 real-time reproduction number (R_t) and specific NPIs across four cities in China with large outbreaks of Omicron variants. We investigated these correlates in relation to R_t to disentangle the factors that prevented the spread of Omicron, among the NPIs that policy makers can control.

For the SARS-Cov-2 Omicron variants epidemics in Hong Kong, Shanghai, Changchun and Jilin City in Jilin Province, we collected epidemiology and NPIs data. The epidemiology data include the daily confirmed cases and daily asymptomatic cases (Figure 1). The NPIs data in Oxford COVID-19 Government Response Tracker provide information on Rapid SARS-Cov-2 Antigen Testing (RAT) [such as the date to start using RAT) and 15 other NPIs adopted by Chinese provinces (including School Closures, Workplace Closures, Public Event Cancellations, Gathering Restrictions, Public Transport Closures, Stay-at-Home Restrictions, Urban Travel Restrictions, International Travel Restrictions, Government Income Support, Covid Public Information Testing, Government Testing Policy, Contact Tracing Policy, Mask Policy, Vaccine Policy (such as how vaccines are funded and who to prioritize), Elderly Protection Policy].[4] The study period is from 1 January to 4 May 2022, for Hong Kong, from 1 March to 16 May 2022, for Shanghai, from 4 March to 4 May 2022, for Changchun and from 3 March to 4 May 2022, for Jilin City. Daily R_t in Hong Kong is derived from the real-time dashboard developed by the School of Public Health of The University of Hong Kong,[5] and the R_ts in Shanghai, Changchun, and Jilin City are calculated using EpiNow2 package[6] in R based on the daily confirmed cases (symptomatic with positive Polymerase chain reaction [PCR] result).

The real-time reproduction number R_ts in four study cities (Hong Kong, Shanghai, Changchun and Jilin) were tested for associations with RAT indices, asymptomatic case indicators and 18 other demographic, social and political conditions using multiple stepwise regression. For RAT indices, these study cities provide and report RAT results to citizens (0, without RAT; 1 with RAT). For asymptomatic case indicators, since many asymptomatic infected people among Omicron-infected people

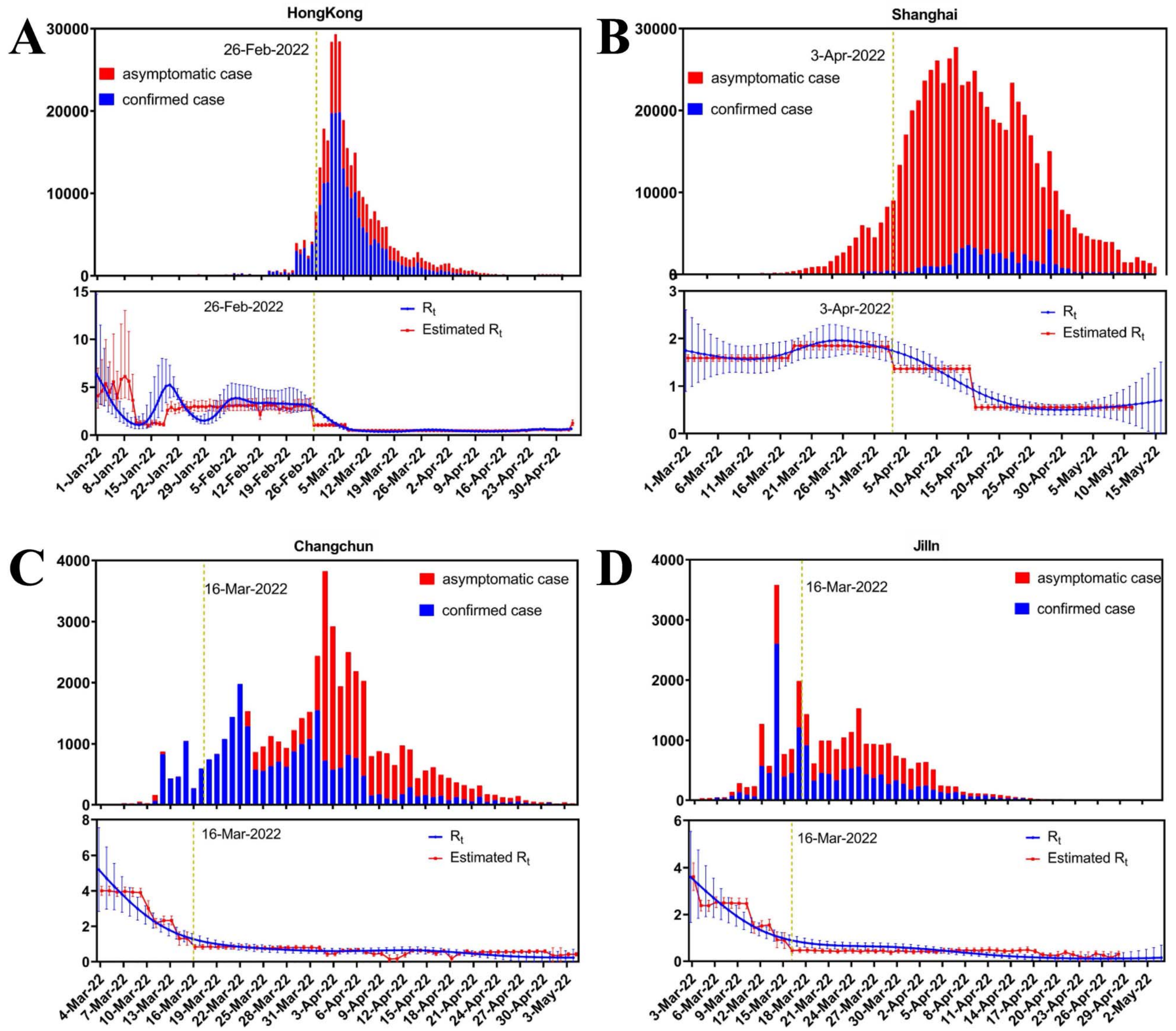

Figure 1. The numbers of daily confirmed and asymptomatic cases, empirical R_t (calculated from daily confirmed case) and estimated R_t in Hong Kong (A), Shanghai (B), Changchun (C), and Jilin City (D). Asymptomatic cases refer to cases who were asymptomatic when tested positive. And the vertical lines are the start of RAT in those cities.

will lead to the spread of the epidemic, identifying asymptomatic infected people is essential for epidemic prevention and control. We use the ratio of the number of asymptomatic cases to the number of confirmed cases to measure the government's detection capacity. If these modelled associations were to be causal, RAT might have reduced R_t by 0.788 (95% CI:−0.306, 1.880) in all four cities (Supplementary Figure S1).

We also performed a separate stepwise regression analysis for each city. To further analyse the NPIs closely related to the reduction of R_t in various cities, we compared the results under different model specifications (Supplementary Table S1). We summarized the results using the model with the highest R^2 (Supplementary Table S2) and found five NPIs (i.e. RAT, School Closures, Mask Policy, Public Transport Closures and Asymptomatic Case Indicators) are associated with the reduction of R_t in Hong Kong; four NPIs (i.e. RAT, Workplace Closures, Gathering Restrictions and Government Income Support) are associated with the reduction of R_t in Shanghai; four NPIs (i.e. RAT, Workplace Closures, Government Response Index and Asymptomatic Case Indicators) are associated with the reduction of R_t in Changchun; and five NPIs (i.e. RAT, School Closures, Workplace Closures, Government Response Index and Asymptomatic Case Indicators) are associated with the reduction of R_t in Jilin City.

In conclusion, we estimated the effect of NPIs in four cities in China, and RAT is one of the effective NPIs in those cities that has been added as one of the official COVID-19 testing methods since 11 March 2022. RAT can complement the other control measures to reduce transmission. For different cities, RAT in Hong Kong has the most considerable effect and reduces R_t by 1.853 (95% CI:1.385–2.320), 0.463 (95% CI:0.327–0.598) for Shanghai, 0.469 (95% CI:0.071–0.867) for Changchun and 0.434 (95% CI:0.075–0.793) for Jilin City. There are two possible explanations. First, RAT is more widely used and recognized in Hong Kong than in the mainland of China, where PCR is still the 'gold standard'. Compared with PCR, high-frequency testing programs by RAT offer the potential to break chains of transmission and act as an extra layer of protection in a comprehensive public health response.[7,8] Second, the manufacturers of the RAT used in Hong Kong and the mainland of China are different. As of July 2022, Hong Kong has approved 20 RAT reagents produced in the United States, France, Hong Kong and the mainland of China (with specificity between 98 and 100% and the sensitivity between 82 and 97.73%),[9] and a total of 31 domestic RAT reagents approved for use in the mainland of China (with the specificity between 93.3 and 100% and the sensitivity between 72 and 100% at $C_t < 25$).[10]

Our study has several limitations. Since Oxford's data[4] are based on the provincial level, there could be a bias in our assessment of the validity of the NPIs for individual cities. We note that multiple NPI measures are implemented simultaneously, and the potential interactions between those NPIs are not considered. If NPIs in the stepwise regression model are highly correlated, some NPIs may be excluded from the model. However, this has little effect on the analysis of the RAT effect, which is effective in all four study cities.

Supplementary data

Supplementary data are available at *JTM* online

Data availability

All data are collected from open source with a detailed description in the Methods section.

Code availability

The code used for data analysis is freely available upon request.

Author contributions

Z.S., L.M., Z.D., Y.B. and B.J.C.: conceived the study, designed statistical and modelling methods, conducted analyses, interpreted results, wrote and revised the manuscript; Q.T., X.L., S.L., S.T.A., L.W. and E.H.Y.L.: interpreted results and revised the manuscript.

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Conflict of interest

B.J.C. reports honoraria from AstraZeneca, Fosun Pharma, GlaxoSmithKline, Moderna, Pfizer, Sanofi Pasteur, and Roche. The authors report no other potential conflicts of interest.

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