Evaluation of Work Resumption Strategies after COVID-19 Reopening in the Chinese City of Shenzhen: A Mathematical Modeling Study

Lu Bai
Xi'an Jiaotong University
Haonan Lu
Huawei Technologies Co Ltd
Hailin Hu
Huawei Technologies Co Ltd
M. Kumi Smith
University of Minnesota Twin Cities: University of Minnesota
Katherine Harripersaud
Columbia University Mailman School of Public Health
Veronika Lipkova
Oxford University: University of Oxford
Yujin Wen
Huawei Technologies Co Ltd
Xiuyan Guo
Huawei Technologies Co Ltd
Wei Peng
Huawei Technologies Co Ltd
Chenwei Liu
Huawei Technologies Co Ltd
Mingwang Shen
Xian Jiaotong University: Xi'an Jiaotong University
Alfred Chixiong Shen
Huawei Technologies Co Ltd
Lei Zhang (lei.zhang1@xjtu.edu.cn)
Xi'an Jiaotong University https://orcid.org/0000-0003-2343-084X

Research Article

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Abstract

Background

As China is facing a potential second wave of the epidemic, we reviewed and evaluated the intervention measures implemented in a major metropolitan city, Shenzhen, during the early phase of Wuhan lockdown.

Methods

Based on published epidemiological data on COVID-19 and population mobility data from Baidu Qianxi, we constructed a compartmental model to evaluate the impact of work and traffic resumption on the epidemic in Shenzhen in various scenarios.

Results

Imported cases account for the majority (58.6%) of the early reported cases in Shenzhen. We demonstrated that with strict inflow population control and a high level of mask usage following work resumption, various resumption schemes resulted in only an insignificant difference in the number of cumulative infections. Shenzhen may experience this second wave of infections approximately two weeks after the traffic resumption if the incidence risk in Hubei is high at the moment of resumption.

Conclusion

Control of imported cases and extensive use of facial masks were the key for the prevention of the COVID-19 epidemic in Shenzhen during its reopening and work resumption.

Introduction

The coronavirus SARS-COV-2 pandemic had led to more than 31 million infections, and over 960,000 individuals died of the coronavirus disease 2019 (COVID-19), as of Sep 21st 2020 [1]. The Coronavirus Disease 2019 (COVID-19) epidemic broke out in early December 2019 in Wuhan, the provincial capital city of Hubei in China. The virus proved to be capable of interpersonal transmission even in the absence of overt symptoms, which, in combination with increased travel prior to the Lunar New Year, resulted in its rapid spread to all 31 Chinese provinces [2; 3; 4; 5]. To curb the epidemic, the Wuhan authority imposed a strict metropolitan-wide ‘lockdown’ of Wuhan on Jan 23rd. During the 76 days (Jan 23rd to Apr 8th) lockdown, the operation of all public transportation in Wuhan was suspended, and all airport and railway stations were also temporarily closed [6]. Within two days of the Wuhan lockdown, all 31 Chinese provinces and regions have launched the ‘level 1 public health emergency response’, which is the highest level of state of emergency [7]. The lockdown has effectively limited the movement of the population and reduced the speed of spread of COVID-19 outside Hubei [2; 8; 9; 10]. Since the reopening of Wuhan city, the COVID-19 epidemic in China had been largely brought under control. As of Sep 21st 2020, a total 85,291 cases were reported, and 4,634 died of COVID-19 in Mainland China [1]. However, multiple small outbreaks have been reported across the country over the past three months, leading to a partial lockdown of the affected areas and vast cancellation of flights. As China is facing a potential second wave of the epidemic, we reviewed the intervention measures implemented in a major metropolitan city, Shenzhen, during the early phase of Wuhan lockdown. The past experiences may provide us with insights for future COVID-19 control and prevention.

Shenzhen was a megacity dominated by 8.5 million domestic migrants. This population accounted for 65% of its residents and formed the main labour force for Shenzhen's economy [11]. Before the implementation of 'level 1' response on Jan 23rd, Shenzhen's population outflow just peaked, with the total population outflow exceeding 9.5 million. Indeed, Shenzhen is a large city with high population mobility: during the period from Jan 1st to Feb 14th, 2020, the total population inflow to Shenzhen exceeded 8.4 million [12]. Since asymptomatic individuals can be infectious during the incubation period [5; 13; 14; 15], the return of domestic migrants may serve as a potential source of new infections. Hence, it is possible that the population influx from other parts of China, especially Hubei, may have a significant impact on the epidemic in Shenzhen in the early stages after work resumption [16].

Taking into consideration the high population mobility, we constructed a compartmental model to simulate the transmission of COVID-19 and disease progression in the Shenzhen population. Based on which, we aimed to evaluate the trend of the COVID-19 epidemic for various scenarios of work resumption strategies for the returning residents in Shenzhen.

Methods

Data sources

We collected early published epidemic data on COVID-19 cases in Shenzhen, which were obtained from the open data platform of Shenzhen Municipal Government [17]. The population mobility data were retrieved from Baidu Qianxi with location-based services having nearly 9 billion location requests each day [18], which was also in the public domain [12].

Model description

Definition of disease stages

Based on the classical epidemiological dynamic SEITR model [8; 19], we proposed a M-SEITR model to evaluate the development of the epidemic, where 'M' stands for in-time population mobility correction (Figure 1) [20]. In the M-SEITR model, the population was divided into five compartments, which include susceptible individuals (S), individuals during the incubation period (E), infected but undiagnosed individuals (I), diagnosed individuals with treatment (T), recovered individuals (R) and death individuals (D). The total population size was denoted as N, ($N=S+E+I+T+R$).

The transmission of COVID-19 in the population

The schematic disease progression diagram is demonstrated in Figure 1 (details in the Appendix). The model took into account the effects of facial mask usage $p(t)$ and interpersonal contact m per day on the COVID-19 epidemics. Specifically, we used a multinomial distribution to describe the transmission probability caused by interpersonal contact, which depends on the number of daily interpersonal contacts and the probability of transmission per contact (β). Comparing to elsewhere in the world, the Chinese Government had developed guidelines for the use of masks and enforced a more stricter facial mask-wearing practice, especially in public places and on public transports [21]. At the initiation of the simulation at Jan 1st, where there were no confirmed cases reported in Shenzhen, we assumed the background facial mask rate to be zero (Figure 1).

Impact of work resumption

We assumed that the probability of transmission decreased with the reduction of interpersonal contact and the increase in the use of facial masks. We assumed that the vast majority of citizens would maintain the habit of wearing masks until the end of the epidemic (even after work resumption). Further, work resumption would increase the frequency of interpersonal contacts, which may further affect the trajectory of the epidemic. Importantly, we assumed that contact frequency m after work resumption would increase three-fold relative to the frequency of contact with family members prior to work resumption [22]. And the various resumption of work ratio at different dates in the resumption strategies below affects the population mobility in Shenzhen. With the increase in the resumption of work ratio, the returning population in Shenzhen also increased, including people at different stages of disease (Appendix).

Simulation of population mobility

For population mobility, we assumed the population would return to Shenzhen after resumption in the same size and speed as they left the city before the strict control was implemented. We assumed that population mobility could affect three subpopulations, the susceptible individuals (S), the asymptomatic latent individuals (E) and un-diagnosed infected individuals (I) (Figure 1). The parameters and mathematical formulation for population mobility were listed in the Appendix. Imported cases first appeared in Shenzhen on Jan 4th, and the first local case of public transmission occurred on Jan 15th, considering the estimated incubation period of COVID-19 (3-7 days) [11; 15; 23; 24], we conservatively regard Jan 1st as the starting point of the Shenzhen epidemic.

Scenarios for evaluation

The epidemic situation in Hubei may impact on Shenzhen in two ways. First, since the number of confirmed cases in Hubei has increased substantially on February 12nd due to the change of diagnostic criteria and the progress of patient admission [25], it is likely that the number of latent infections among the Hubei travelers to Shenzhen in January might have been underestimated. The extent of control of the imported cases in Shenzhen in late January would impact substantially on the epidemic in Shenzhen.

Second, the inflow of asymptomatic infections to Shenzhen after work resumption may be affected by the epidemic situation in Hubei.

We created four scenarios to reflect the potential intervention status in Shenzhen. Scenario 1 represents a prompt control of the inflow of the infected population from Hubei into Shenzhen in January and a low incidence risk in Hubei in March after work resumption. Scenario 2 represents a prompt control of the inflow of the infected population from Hubei in Shenzhen in January but a high incidence risk in Hubei in March after work resumption. Scenario 3 represents a delayed control of the inflow of the infected population from Hubei in Shenzhen in January and a low incidence risk in Hubei in March after work resumption. Scenario 4 represents a delayed control of the inflow of the infected population from Hubei in Shenzhen in January but a high incidence risk in Hubei in March after work resumption.

Resumption strategies

To evaluate the possible impact of work resumption on the epidemic, we identified six stepwise resumption schemes in each scenario. These included (1) Full resumption of work from Feb 10th; (2) Scheme 1, a partial resumption of 57% on Feb 10th followed by a full resumption on Feb 17th; (3) Scheme 2, a partial resumption of 51% on Feb 10th followed by a full resumption on Feb 17th; (4) Scheme 3, a partial resumption of 51% on Feb 10th, then 63% on Feb 17th, followed by a full resumption on Feb 24th; (5) Scheme 4, an increasing partial resumption of 39%, 51% and 63% on Feb 10th, 17th, and 24th respectively, followed by a full resumption on Mar 2nd; (6) Scheme 5, a partial resumption of 57% and 74% on Feb 10th and 17th respectively, followed by a full resumption on Feb 24th. The calculation of the partial resumption is based on the type of industry, immediate urgency for the resumption and their impact on the spread of the epidemic. In general, industries related to people's daily necessities were prioritized. These were followed by industries that were essential but allowed for 'work from home', then industries that may be resumed in the near future, and those can be further delayed. The full explanation of the resumption schemes was listed in the Appendix.

Model calibration

We calibrated the model parameters based on the of confirmed cases of COVID-19 published in by Shenzhen Center for Disease Control (Appendix). Overall, the calibrated model demonstrated good consistency between the model output and the reported number of imported cases.

Results

Out of 406 confirmed cases were reported in Shenzhen, 238 cases (58.6%) were imported. Of these imported cases, 153 cases (37.7%) were from Hubei. There were 105 local cases due to household transmission and 63 due to public contacts, accounting for 25.9% and 15.5% of all reported cases. Table 1 demonstrated the composition of COVID-19 cases in Shenzhen.

Table 1
The number of reported cases of COVID-19 in Shenzhen three weeks after Wuhan's lockdown

		The number of cases	proportion
Imported cases[a]	Hubei travelers	153	37.7%
	Non-Hubei travelers	85	20.9%
Local household transmission		105	25.9%
Local public transmission		63	15.5%
Total		406	—

[a] If a family group arrived Shenzhen and more than one member was diagnosed positive, then only one case was regarded as 'imported case' and the rest were local household transmission cases.

We predicted the cumulative number of infected cases for the six resumption strategies based on the four intervention scenarios in Shenzhen. When a prompt control of the inflow of the infected population was in place, and incidence risk in Hubei was low (Scenario 1), full work resumption from Feb 10th would result in 68 additional infected cases between February 10th -April 30th, and the cumulative infected cases would reach 456 (453–458) by Apr 30th. For the other five stepwise resumption schemes in scenario 1, the cumulative number of infected individuals was reduced compared to that of full work resumption scheme, but the difference was small (3–5 fewer cases by Apr 30th). In contrast, when a prompt control of inflow of infected population was in place but the incidence risk in Hubei was high (scenario 2), the number of cumulative infected cases would reach 542 (540–544) in the event of full work resumption. However, if the control of the infected population from Hubei in Shenzhen in January was delayed, full resumption of work would result in a much higher number of cases by Apr 30th (Scenario 3, low incidence risk in Hubei: 922 [848–995]; Scenario 4, high incidence risk in Hubei: 1044 [936–1153]). In scenarios 2, 3 and 4, the differences between work resumption schemes were small, and by the end of April, the cumulative number of infected cases only differed by 2–4, 41–73 and 54–99, respectively (Table S4).

The estimated number of individuals who were infected but undiagnosed demonstrated a similar trend across all four scenarios, reaching a peak (98–158 cases) around the end of January, before gradually declining. The traffic resumption in Hubei province may lead to a second but significantly smaller peak (24–26 cases) if Hubei remains a high incidence risk in March. After the second peak, the trend would continue to decline to zero (Fig. 2).

Discussion

Our study demonstrated that imported cases account for the majority (58.6%) of all reported cases in Shenzhen. In particular, imported cases from Hubei account for 37.7%. If Shenzhen maintains strict control measures with regards to the inflow population, and its citizens maintain a high level of mask usage even after the resumption of operations, the epidemic will gradually subside, with few differences between the proposed resumption schemes. If intercity travel is restored when Hubei still has a high incidence risk, Shenzhen may experience a second wave of infections.

Our analysis indicates that the COVID-19 epidemic in Shenzhen would mainly result from imported cases and household transmission, with the local public transmission being relatively limited [26]. Notably, only one-quarter of the cases were due to household transmission, which stands in sharp contrast to the 56–61% in Hubei province [1; 27]. As the virus is highly contagious and protective measures in a household setting are usually limited, the chance of transmission due to an asymptomatic infected household member is very high. The low percentage of household transmission indicates that early public health measures in Shenzhen have been effective. In particular, strict temperature monitoring, timely isolation, contact tracing and treatment for confirmed cases seems to have played a major role [28].

We found that different work resumption strategies have little impact on the overall trajectory of the epidemic in Shenzhen. This may be for a number of reasons. First, since the number of undiagnosed infected cases in Shenzhen was small and the epidemic was well controlled in its early phase, the impact of various resumption strategies makes little difference to the epidemic. Second, as facial masks were widely used, including asymptomatic individuals, an increase in the frequency of interpersonal contacts caused by work resumption does not effectively increase the transmission of SARS-CoV-2, suggesting that the ongoing personal protective measures were crucial to the process of the city reopening [29].

Our analysis showed that if Hubei had restored traffic in early March, Shenzhen might have experienced the second wave of the outbreak at a later point that month. However, the number of imported cases is small, and the threat is limited. The Shenzhen government has imposed strict resumption strategies that encourage business to implement altered off-peak dining, such as reducing the frequency and scale of meetings and minimizing staff gatherings [28]. These measures are key in preventing a second outbreak in Shenzhen.

This study has several limitations. First, the model did not take into account the spread caused by the use of public transportation (e.g. subway and buses); consequently, the risk of transmission in public spaces may have been underestimated. Second, we modeled the population mobility model based on data from Baidu Qianxi, which may not fully account for the actual movement of the population. Third, our model did not take into consideration of overseas imported cases.

Conclusion

In the strict control of imported cases and extensive use of facial masks were essential to its successful control of the COVID-19 epidemic in Shenzhen during its reopening and work resumption.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

The data that support the findings of this study are available from the open data platform of Shenzhen Municipal Government [17] and the population mobility data were retrieved from Baidu Qianxi [18], which was also in the public domain [12].

Competing interests

All authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The funding agencies had no involvement in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; or decision to submit the manuscript for publication.

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Authors' contributions

Haonan Lu, Hailin Hu, Mingwang Shen, Alfred Chixiong Shen, and Lei Zhang conceived and designed the study. Haonan Lu, Hailin Hu, Yujin Wen, Xiuyan Guo, Wei Peng, Chenwei Liu, analyzed the data, carried out the analysis and performed numerical simulations. Lu Bai wrote the first draft of the manuscript. M. Kumi Smith, Katherine Harripersaud, Veronika Lipkova and Yujin Wen critically read and revised the manuscript. All authors contributed to writing the paper and agreed with manuscript results and conclusions.

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References

1. World Health Organization. Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19). 2020.
2. S. Ai, G. Zhu, F. Tian, H. Li, Y. Gao, Y. Wu, Q. Liu, and H. Lin, Population movement, city closure and spatial transmission of the 2019-nCoV infection in China. medRxiv (2020) 2020.02.04.20020339.
3. P. Boldog, T. Tekeli, Z. Vizi, A. Denes, F. Bartha, and G. Rost, Risk assessment of novel coronavirus 2019-nCoV outbreaks outside China. medRxiv (2020) 2020.02.04.20020503.
4. J. Cohen, and D. Normile, New SARS-like virus in China triggers alarm. Science 367 (2020) 234-235.
5. P. Wu, X. Hao, E.H.Y. Lau, J.Y. Wong, K.S.M. Leung, J.T. Wu, B.J. Cowling, and G.M. Leung, Real-time tentative assessment of the epidemiological characteristics of novel coronavirus infections in Wuhan, China, as at Jan 22nd 2020. Euro Surveill 25 (2020) 2000044.
6. M. Shen, Z. Peng, Y. Guo, L. Rong, Y. Li, Y. Xiao, G. Zhuang, and L. Zhang, Assessing the Effects of Metropolitan-Wide Quarantine on the Spread of COVID-19 in Public Space and Households. International Journal of Infectious Diseases (2020).
7. Fenghuang News. All provinces, municipalities and autonomous regions across the country have launched a first-level response. 2020.
8. M. Shen, Z. Peng, Y. Guo, Y. Xiao, and L. Zhang, Lockdown may partially halt the spread of 2019 novel coronavirus in Hubei province, China. medRxiv (2020) 2020.02.11.20022236.
9. M. Chinazzi, J.T. Davis, M. Ajelli, C. Gioannini, M. Litvinova, S. Merler, A. Pastore y Piontti, K. Mu, L. Rossi, K. Sun, C. Viboud, X. Xiong, H. Yu, M.E. Halloran, I.M. Longini, and A. Vespignani, The effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak. Science (2020) eaba9757.
10. X. Zhou, Z. Wu, R. Yu, S. Cao, W. Fang, Z. Jiang, F. Yuan, C. Yan, and D. Chen, Modelling-based evaluation of the effect of quarantine control by the Chinese government in the coronavirus disease 2019 outbreak. medRxiv (2020) 2020.03.03.20030445.
11. J. Chen, Pathogenicity and transmissibility of 2019-nCoV—A quick overview and comparison with other emerging viruses. Microbes and Infection (2020).
12. Baidu Map Smart Eyes. Baidu Migration. 2020, https://qianxi.baidu.com (accessed Feb 14th 2020).
13. J.F.-W. Chan, S. Yuan, K.-H. Kok, K.K.-W. To, H. Chu, J. Yang, F. Xing, J. Liu, C.C.-Y. Yip, R.W.-S. Poon, H.-W. Tsoi, S.K.-F. Lo, K.-H. Chan, V.K.-M. Poon, W.-M. Chan, J.D. Ip, J.-P. Cai, V.C.-C. Cheng, H. Chen, C.K.-M. Hui, and K.-Y. Yuen, A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. The Lancet 395 (2020) 514-523.

14. P. Yu, J. Zhu, Z. Zhang, and Y. Han, A Familial Cluster of Infection Associated With the 2019 Novel Coronavirus Indicating Possible Person-to-Person Transmission During the Incubation Period. The Journal of Infectious Diseases (2020).
15. W. Gao, and L. Li, Advances on presymptomatic or asymptomatic carrier transmission of COVID-19. Chinese Journal of Epidemiology 41 (2020).
16. L. Zhang, Y. Tao, J. Wang, J.J. Ong, W. Tang, M. Zou, L. Bai, M. Ding, M. Shen, G. Zhuang, and C.K. Fairley, Early characteristics of the COVID-19 outbreak predict the subsequent size. International Journal of Infectious Diseases (accepted) (2020).
17. Shenzhen Municipal Government, China. Data Open Platform of Shenzhen Municipal Government. 2020.
18. S. Lai, I. Bogoch, N. Ruktanonchai, A. Watts, X. Lu, W. Yang, H. Yu, K. Khan, and A.J. Tatem, Assessing spread risk of Wuhan novel coronavirus within and beyond China, January-April 2020: a travel network-based modelling study. medRxiv (2020) 2020.02.04.20020479.
19. M. Shen, Z. Peng, Y. Xiao, and L. Zhang, Modelling the epidemic trend of the 2019 novel coronavirus outbreak in China. bioRxiv (2020) 2020.01.23.916726.
20. D. Brockmann, and D. Helbing, The Hidden Geometry of Complex, Network-Driven Contagion Phenomena. Science 342 (2013) 1337-1342.
21. Chinese Center for Disease Control and Prevention. Guidelines for the protection of people with different risks of COVID-19. 2020.
22. J.M. Read, J. Lessler, S. Riley, S. Wang, L.J. Tan, K.O. Kwok, Y. Guan, C.Q. Jiang, and D.A.T. Cummings, Social mixing patterns in rural and urban areas of southern China. Proc Biol Sci 281 (2014) 20140268-20140268.
23. Chinese Center for Disease Control and Prevention. Report about COVID-19. 2020.
24. J.A. Backer, D. Klinkenberg, and J. Wallinga, Incubation period of 2019 novel coronavirus (2019-nCoV) infections among travellers from Wuhan, China, 20–28 January 2020. Euro Surveill 25 (2020) 2000062.
25. Sina News. The reform of diagnostic criteria has resulted in 14,800 new cases being confirmed in Hubei in one day. 2020.
26. W.-j. Guan, Z.-y. Ni, Y. Hu, W.-h. Liang, C.-q. Ou, J.-x. He, L. Liu, H. Shan, C.-l. Lei, D.S.C. Hui, B. Du, L.-j. Li, G. Zeng, K.-Y. Yuen, R.-c. Chen, C.-l. Tang, T. Wang, P.-y. Chen, J. Xiang, S.-y. Li, J.-l. Wang, Z.-j. Liang, Y.-x. Peng, L. Wei, Y. Liu, Y.-h. Hu, P. Peng, J.-m. Wang, J.-y. Liu, Z. Chen, G. Li, Z.-j. Zheng, S.-q. Qiu, J. Luo, C.-j. Ye, S.-y. Zhu, and N.-s. Zhong, Clinical Characteristics of Coronavirus Disease 2019 in China. New England Journal of Medicine (2020).
27. X. Qin, S. Qiu, Y. Yuan, Y. Zong, Z. Tuo, J. Li, and J. Liu, Clinical Characteristics and Treatment of Patients Infected with COVID-19 in Shishou, China. SSRN (2020).
28. Z. Cao, Q. Zhang, X. Lu, D. Pfeiffer, L. Wang, H. Song, T. Pei, Z. Jia, and D.D. Zeng, Incorporating Human Movement Data to Improve Epidemiological Estimates for 2019-nCoV. medRxiv (2020) 2020.02.07.20021071.

29. L. Zhang, Y. Tao, M. Shen, C.K. Fairley, and Y. Guo, Can self-imposed prevention measures mitigate the COVID-19 epidemic? PLoS medicine 17 (2020) e1003240.

Figures

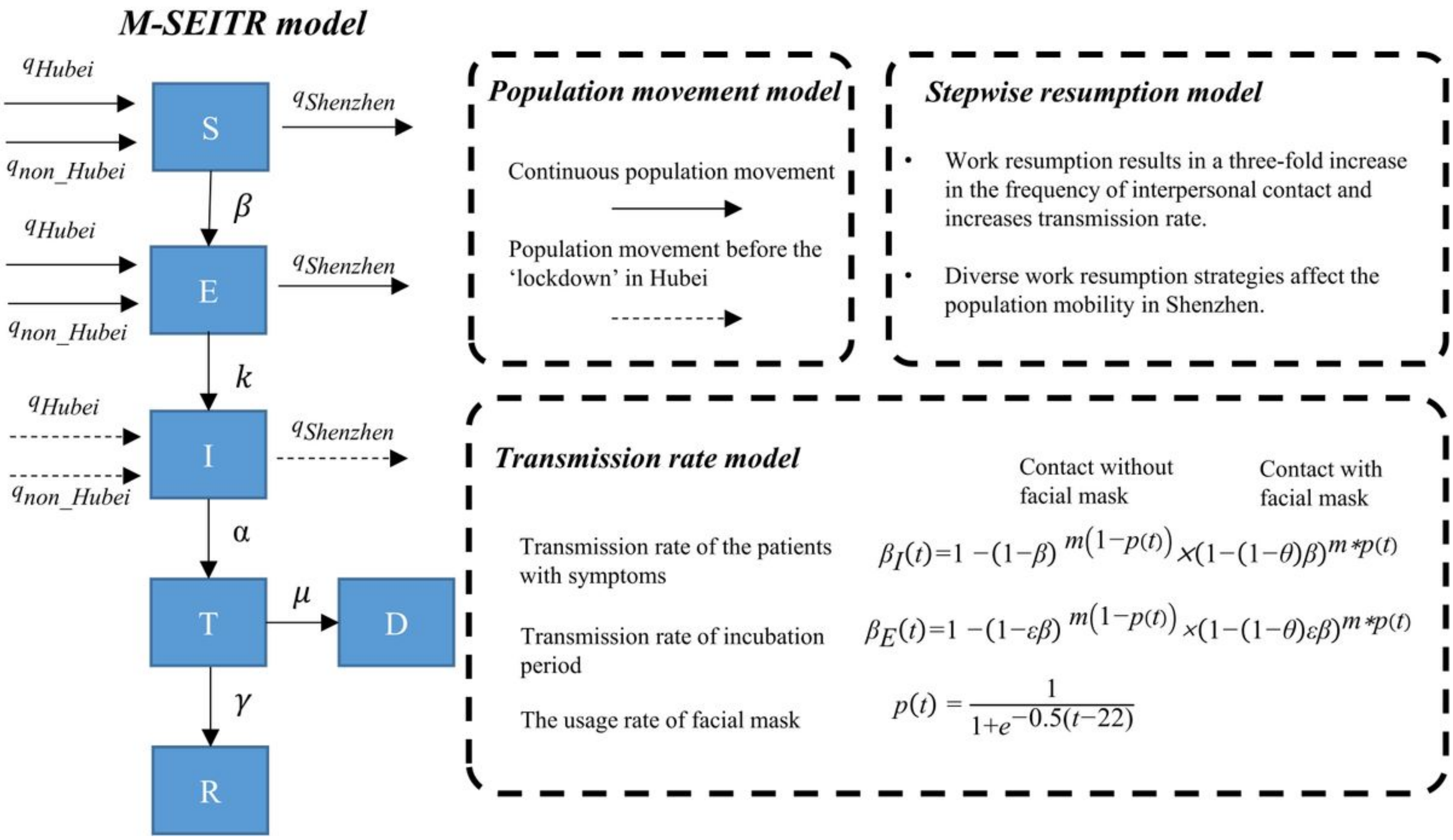
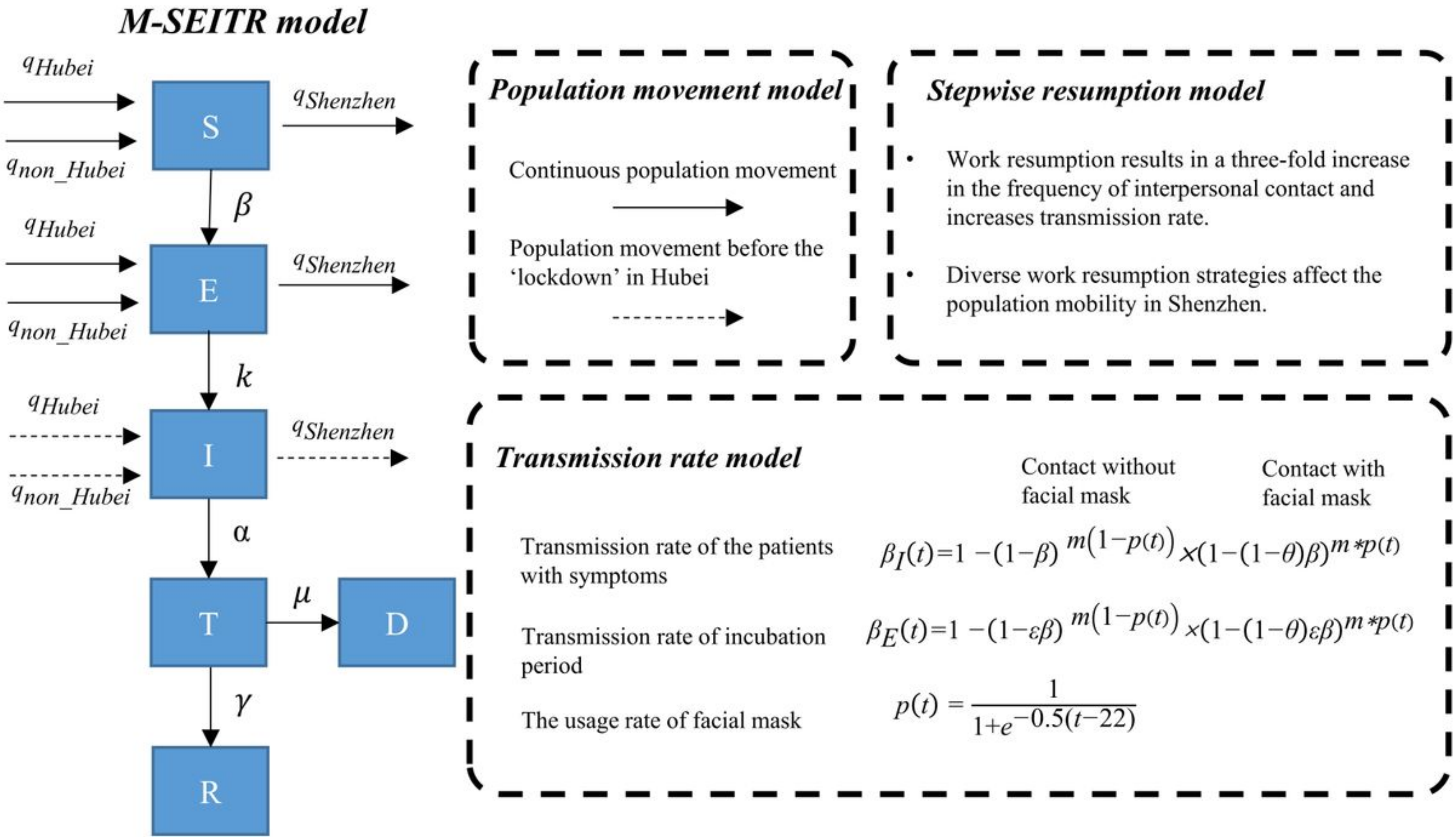


Figure 1

Schematic diagram of M-SEITR model. On the basis of SEITR model, the population migration, stepwise resumption of work strategies, and the transmission rate is simulated in detail. In the process of population movement, the model took into account the inflow to Shenzhen of Hubei travellers and non-Hubei travellers and the population outflow from Shenzhen, as well as the changing effect of the total population of Shenzhen at the same time. The transmission rate model combines the changes in the average number of interpersonal contacts per day and the effects of the facial mask usage.



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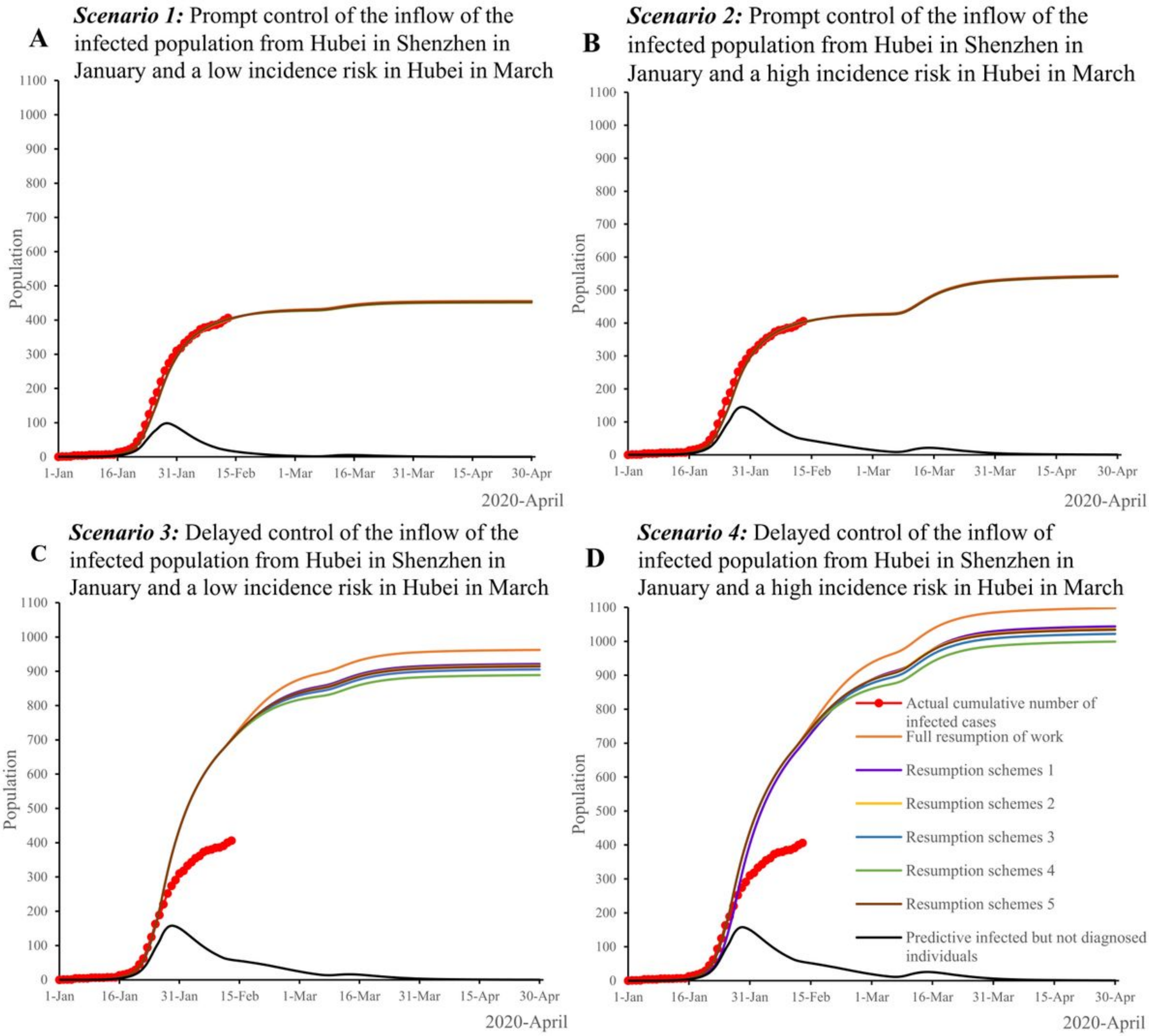
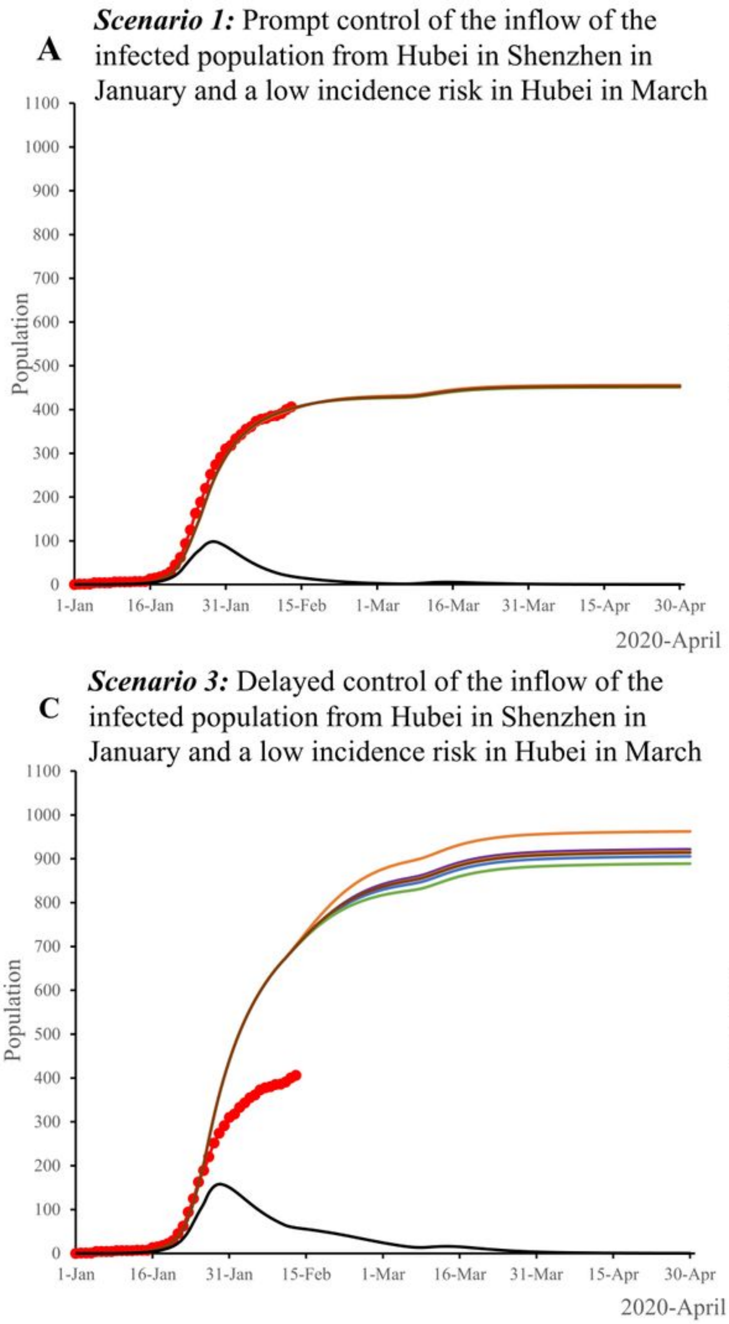


Figure 2

Under the four scenarios of the epidemic hypothesis of Shenzhen and the six resumption schemes, the changing trend of the predictive cumulative number of infected cases (C) and the predicted number of infected but undiagnosed individuals (I) in Shenzhen. (1) Full resumption of work from Feb 10th; (2) Scheme 1, a partial resumption of 57% on Feb10th followed by a full resumption on Feb 17th; (3) Scheme 2, a partial resumption of 51% on Feb 10th followed by a full resumption on Feb 17th; (4) Scheme 3, a partial resumption of 51% on Feb 10th, then 63% on Feb 17th, followed by a full resumption on Feb 24th; (5) Scheme 4, an increasing partial resumption of 39%, 51% and 63% on Feb 10th, 17th, and 24th respectively, followed by a full resumption on Mar 2nd; (6) Scheme 5, a partial resumption of 57% and 74% on Feb 10th and 17th respectively, followed by a full resumption on Feb 24th.



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