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A sequential re-opening of provinces for China's zero-COVID policy

To the Editor – As countries around the world gradually relax their prevention and control policies against COVID-19 and choose to co-exist with the virus, China has also ended its strict zero COVID policy.

This followed debates that centered on whether China should insist on the zero-COVID strategy or switch to a more open strategy. The zero-COVID strategy was to detect and control cases as early as possible and to cut off transmission at the community level by taking stringent control measures such as large-scale nucleic acid testing, compulsory case isolation, rapid tracing and quarantine of close contacts. The major challenge of continuing with the zero-COVID strategy was that economic recovery might be delayed[1,2], and so it was unclear for how long that this strategy could be maintained for[3,4]. The greatest concern from ending the zero-COVID strategy is that COVID-19 cases will surge rapidly[5], which may result in failure of the healthcare system and massive loss of life, notwithstanding the relatively low pathogenicity of the Omicron variant[6].

In principle, containment measures such as closing public facilities, enforcing wearing masks and maintaining social distancing could be fine-tuned, but implementation of this faces challenges. Hong Kong failed to prevent an outbreak of the Omicron variant at the start of 2022, which was followed by a large number of infections in Shanghai, Jilin, and in other regions of China[7]. If the zero-COVID strategy is ended in all regions of China simultaneously, the surge of infections could cause a collapse of the healthcare system, including a shortage of healthcare workers and intensive care unit beds.

We therefore propose a sequential opening strategy by region, which can reduce economic loss, while keeping peak case numbers low. The underlying rationale for a sequential opening strategy is threefold. Firstly, it should avoid a nationwide failure of the healthcare system, as many regions would maintain the zero-COVID policy. The government would still have the opportunity to stop or adjust the opening process promptly if SARS-CoV-2 cases surge so much that the healthcare system is overwhelmed. Secondly, under a sequential opening strategy, when an outbreak occurs in one region, the Chinese government could rely on its strong organizational capability and advanced transportation system to coordinate resources from other regions to provide sufficient human and medical resources for the affected region. This will allow less developed regions to be supported and more lives to be saved. Thirdly, a sequential opening strategy would allow pilot tests in designated regions before the expansion of the policy at a larger scale.

To determine the optimal order of opening China's regions, several important factors should be considered, such as the supply of agricultural products between regions, the interdependency of the manufacturing industry, medical resources and transportation networks, among others, each of which are correlated with gross domestic product (GDP). A simplified mathematical model based on GDP could determine the optimal opening order of provinces, for example. This could use data from supply networks such as the 2021 GDP of China by province from the National Bureau of Statistics of China[8], as well as the geographical distances between provinces, which can be derived from the coordinate of each province's capital city. The supply that a province receives from another province is proportional to the other province's GDP and inversely proportional to its distance from the other province, which can allow a supply network among provinces to be constructed. Details can be found in ref. [9].

Some restrictions should be maintained in order to prevent epidemic transmission from opened to unopened provinces. Opened provinces should be free to supply each other; unopened provinces can freely supply each other; unopened provinces can only unidirectionally supply opened provinces; and opened provinces cannot supply unopened provinces. These restrictions might lead to insufficient supply of essential manufacturing parts to some provinces, which would result in an economic shutdown in those places. These provinces would then fail to supply other provinces, which would lead to a cascade of economic shutdowns. The optimal sequence of re-opening should therefore aim to limit economic shutdowns.

Using this framework, we used a simulated annealing algorithm, based on the constructed supply network, to propose an optimal sequence of re-opening. The optimal sequence of the 31 provinces in mainland China obtained from our model was: Heilongjiang, Jilin, Liaoning, Shanghai, Hainan, Guangxi, Yunnan, Sichuan, Chongqing, Guizhou, Hunan, Tianjin, Beijing, Inner Mongolia, Shanxi, Shaanxi, Ningxia, Gansu, Qinghai, Tibet, Xinjiang, Hebei, Jiangxi, Fujian, Anhui, Hubei, Henan, Zhejiang, Shandong, Jiangsu and Guangdong. This is not the only possible sequence of re-opening, and more data would undoubtedly improve the model. This model is very sensititve to order changes of the second half of the sequence, while it is not sensitive to order changes of the first half of the sequence. According to this model, this re-opening sequence will reduce the overall economic loss by a factor of 10 or more, compared with a random or directional (north to south, or east to west) sequence of re-opening. The re-opening order can be flexibly adjusted according to the evolving situation, for example, depending on population mobility or existing large-scale outbreaks.

If a re-opening sequence was initiated in China, provinces could be opened one after another, when the daily existing infections in the previously opened province start to decrease, which would suggest that a peak had been reached. This should mitigate the total national number of infections at a relatively low and stable level, compared with opening all provinces simultaneously.

In summary, we propose that an appropriate sequential opening strategy would significantly reduce economic loss, compared with a country-wide re-opening, and would suppress the peak of SARS-CoV-2 cases. The opening order of regions is likely to be crucial and it should be comprehensively informed by data, with the timing of opening dynamically adjusted to match available medical resources.

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Competing interests

The authors declare no competing interests.