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Rapid epidemic expansion of the SARS-CoV-2 Omicron BA.2 subvariant during China's largest outbreaks

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Abstract

A complete and accurate statistical analysis of cases of contraction with SARS-CoV-2, under the conditions of strict mandatory quarantine and isolation and of a high rate of full vaccination, during the largest COVID-19 outbreaks driven by the Omicron BA.2 subvariant in China are given. SARS-CoV-2 is still new, and little is known about either its directions of variations or its laws of propagation. No country other than China has been able to disclose every case of infection in every epidemic or outbreak since April of 2020. Here, this study reveals that Omicron BA.2 subvariant can still spread very fast and wide in areas with strict "dynamic zero-COVID strategy"¹ in China, that there exist cities twenty-fold differences in morbidity rates unrelated to any of the known factors contributing to incidence of infectious diseases, and that Omicron BA.2 subvariant is unpredictable in its virulence, although its severity rate of symptomatic cases is low. This analysis provides first-hand original and valuable information for further research on similar epidemics in the future. It may bring new thoughts for correction of present epidemiological theory and mathematical models. It may also give other countries time to be better prepared for the coming 6th wave driven by Omicron BA.2.

Methods

I analyzed daily domestic cases (cases of infection between domestic travelers, as called indigenous cases in China) of SARS-CoV-2 in mainland China from 21 February 2022 to 14 May 2022 (hereafter also called the March outbreaks) from publicly released data provided by the National Health Commission of the People's Republic of China (NHC). This was accessible through the website of the National Health Commission News Daily Briefing (<Http://en.nhc.gov.cn>). The National Health Commission releases daily updates on the number of confirmed (here meaning symptomatic) and asymptomatic new cases, with a breakdown by province and cities, and severe cases, deaths and recoveries nationwide. Sources of more information about this analysis are COVID-19 epidemiological reports published daily by Provincial/Territorial branches of NHC and press conferences held by Provincial/Territorial governments. CDC is a department of NHC in China and the same is for its Provincial/Territorial branches. All data were updated to 14 May 2022.

Due to deficiency of COVID-19 testing or medical workers in some jurisdictions in some days, there were sudden surges of cases in some days during the March outbreaks. A sudden surge of cases might indicate a belated report but did not indicate a skew or underestimation of the total number of COVID-19 in the population because all related cases were reported late when testing and medical workers were sufficient. There may be some normalization of data or curves according to need of appearance of figures or charts, but the original numbers of cases will be

stated in the supplementary files.

The same Criteria² have been followed all over China for all COVID-19 related work including testing, diagnosing, and classification of cases of infection. This analysis uses the word "symptomatic" instead of the word "confirmed" (as NHC called), so as the word "confirmed" instead of the word "infected", as shown in the following related definitions and explanations:

1. Confirmed cases are laboratory confirmed (SARS-CoV-2 PCR-positive) cases of infection by double samplings (nasal and pharyngeal swab specimens) and tests. Confirmed cases are composed of asymptomatic cases, symptomatic cases, and deaths.
2. Asymptomatic cases are cases of infection without symptom or symptoms. Symptomatic cases are cases with symptom or symptoms, and are composed of mild cases, moderate cases, and severe cases (including critical cases).
3. Morbidity rate is the ratio of symptomatic cases in confirmed cases in percentage.
4. Case fatality rate is the ratio of deaths in confirmed cases, unless specifically stated.
5. Severity rate is the ratio of severe cases, either in symptomatic cases or in confirmed cases in percentage. It is usually stated specifically as in symptomatic or in confirmed cases.

The converting of asymptomatic cases to symptomatic cases may happen at any time. The daily numbers of such conversion are reported in some jurisdictions, specifically in Shanghai, Changchun and Jilin, nationwide as a whole, but are not reported in others. Because of a repeated report of daily converting cases (symptomatic cases converted from asymptomatic cases days before are reported again in daily report as new asymptomatic cases once they are diagnosed with symptom or symptoms), the numbers and ratios of the asymptomatic cases and the confirmed cases should be deducted by daily numbers or ratios of conversion relatively so as to get the actual numbers and ratios in the jurisdictions with daily conversion reported. Percentages of conversion are shown in the section "Asymptomatic cases conversion" of this study for estimation of impact to the related actual numbers and ratios in the jurisdictions with conversion not reported.

Main

China had been struggling with its largest COVID-19 outbreaks driven by the SARS-CoV-2 Omicron BA.2 subvariant reported by the Chinese Center for Disease Control and Prevention and its Provincial Centers in press conferences since 21 February 2022, with over 738,000 people infected in mainland China within 66 days. Although there were more than a hundred disseminations (independent local outbreaks with cases of infection less than one hundred usually) and several moderate outbreaks before March 2022, China had maintained to its "dynamic zero-COVID strategy" by reducing to zero the number of each active chain of transmission, and it seemed to work well even during the period of the 5th wave driven by Omicron in the world³ from October 2021 to February 2022. These outbreaks, driven by Omicron BA.2 subvariant, started in Shenzhen and Dongguan, adjacent to Hong Kong, two of the most industrialized cities in southern China, at the end of February 2022. Hong Kong had just recorded the most severe attack in February (Lewis, 2022), with close to 900 cases of COVID-19 per 100,000 residents in Hong Kong, the highest level recorded anywhere in the world during the

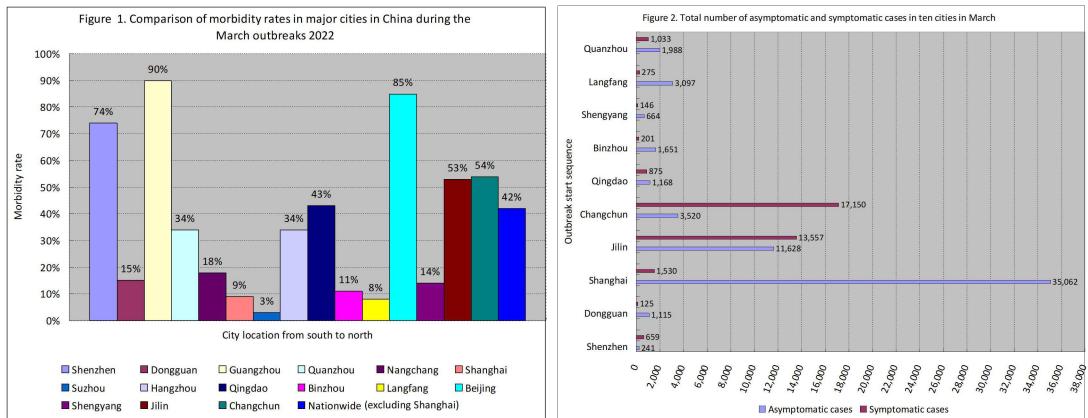
pandemic. The virus swept rapidly across 100 cities in 30 provinces of the country, causing 105,546 people to be infected in March and a total of 738,944 confirmed cases during the March Outbreaks till 14 May 2022. Among those, thirteen cities had over 1,000 people infected, and Shanghai, Changchun and Jilin were the most affected with over 28,000 confirmed cases each, while Shanghai alone had 619,259 people infected.

China's "dynamic zero-COVID strategy" had been evolving for a year. More mandatory quarantine and isolation measures were implemented and were said to be precise, being able to track every individual and his or her possibility of contracting the virus on every chain of transmission, to disclose, quarantine, and isolate and classify by symptoms every person of infection with support of the most updated app and a large quantity of fully-trained epidemiological investigators and dedicated doctors. China had already reached its high rate of full vaccination before these large outbreaks. As press conferences of the Department of State reported, over 87% of the population was fully vaccinated by mid-February 2022. The full vaccination rate was 87.45% overall by 05 February and 87.77% by 14 March 2022. This rate of full vaccination was 88.01% in the overall population by 24 March 2022, with 84.36% or 222.72 million of those aged 60 and above. A total of 138.24 million (or 52.36% of) people over 60 years old received booster shots. China's 7th census published its population as 1.412 billion on 1st November 2020, among them 264 million or 18.70% were aged 60 or above⁴.

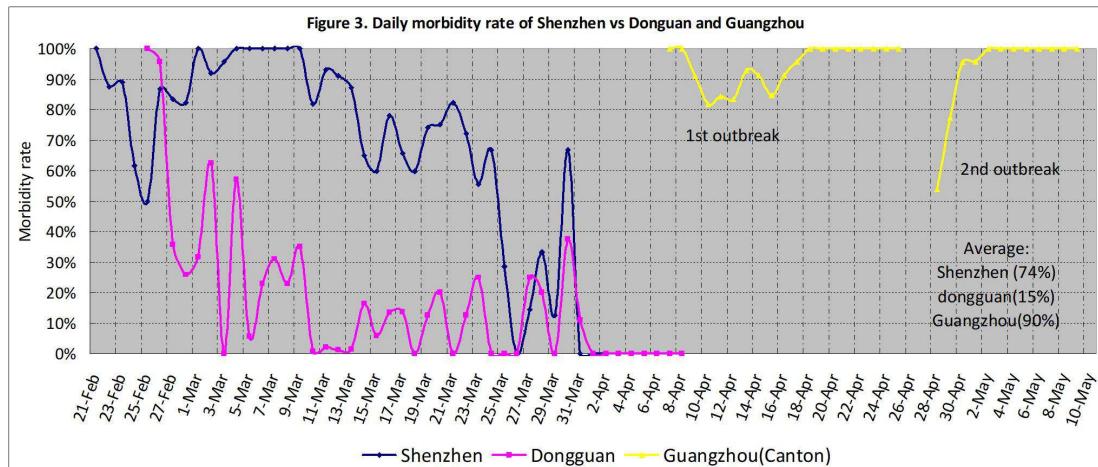
Data in this study cover all daily reported numbers of new PCR-positive cases from February 21st to May 5th of 2022. All major cities with over 800 cases of infection are chosen for this statistical analysis. These major cities are located from north to south, and some are close to each other, while some are very far away from each other. All cities follow the same mandatory policy and the same test and diagnosis standards published by the nation. Genome analysis reveals that all outbreaks in March were driven by Omicron BA.2 subvariant according to the report from press conferences by the Department of State and NHC of China. There are enough doctors to diagnose and classify all cases of infection daily except for a single one-day delay in Jilin. Every essential event will be described in the related section to avoid missing possible information relevant to influencing factors of transmission, infection or morbidity. During the March outbreaks, the features of the epidemics are different in many aspects in different cities, and some are contradictory of their morbidity rates.

Large differences in morbidity rates in main cities

Mainland China reported 629,818 domestic COVID-19 cases of infection by Omicron BA.2 subvariant from 21 February 2022 to 14 May 2022. There were major differences in morbidity rates between the sixteen cities since the start of the March outbreaks. Their morbidity rates varied from 3% (in Suzhou) to 90% (in Guangzhou). Since Shanghai had a relatively low morbidity rate of 9% but the highest number of total cases of infection (619,259), the nationwide average morbidity rate excluding Shanghai rose to 42%. Guangzhou was the highest, 90%, which was twenty nine times higher than Suzhou (Fig. 1 and Fig. 2)

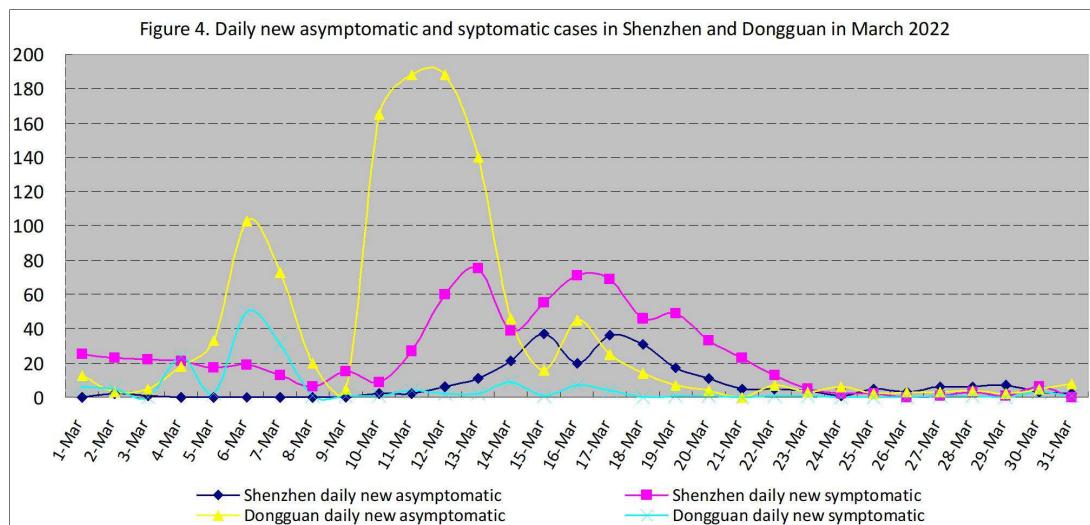


The reasons why there are such differences are unknown. None of the reasons is related to any of the influencing factors of epidemics known today. There are two pairs of cities that can be compared since two cities of each pair are very close to each other, and both have the same climate, population density and characteristics, diet and living habits, religious background, educational background and medical resources. Shenzhen and Dongguan, both adjacent to Hong Kong, are also adjacent. Both are located on the eastern bank of the Zhujiang Delta, which has a very high population density of 11 to 18 million people on approximately 960-770 square miles of land each (^{5,6,7}). Both being immigration cities (portion of domestic immigrants being 50% and above in the population), the average ages of their population are relatively young, Shenzhen at 32.5 years and Dongguan at 34 years on 1st November 2020 (^{6,7}).



They have also had almost the same level of transportation of people and cargo back and from Hong Kong. A large quantity of cargo and drivers arrived in Shenzhen and Dongguan with an unknown quantity of virus every day during the surge of cases of infection of Omicron BA.2 in Hong Kong in the early stage of its COVID-19 outbreak in February 2022. When its medical system was brought to breakdown by the epidemic, Hong Kong was unable to admit all COVID-19 patients who needed hospitalization. People wished to escape from the outbreak. The border between Hong Kong and Shenzhen or Dongguan was strictly controlled to allow a certain limited number of travelers across through, which was approximately 10% of that in 2019. Illegal entries

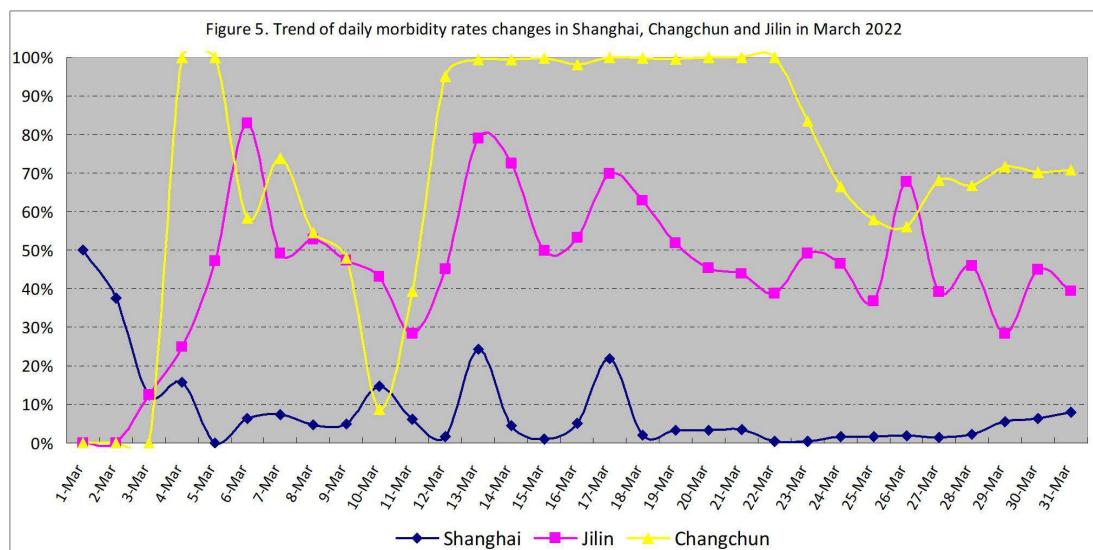
from Hong Kong to Shenzhen and Dongguan were reported as many dozens according to news release by Public Security Bureau of Shenzhen. “Hide and seek” followed-up to implement mandatory isolation and PCR tests, because travelers by illegal entry did not wish to be found and medical workers wished to call everybody for tests. Outbreaks started from the end of February in both Shenzhen and Dongguan and resulted in 994 cases of infection in Shenzhen and 1,314 cases of infection in Dongguan within one month. Contradictory figures of the morbidity rate of the two cities appeared from the very beginning, starting from 100% to 92% in Shenzhen and 68% to 0% in Dongguan (Fig. 3). Each of these two outbreaks developed simultaneously on its own trend of morbidity rate, and their rates seemed unlikely to change much until their outbreaks were close to being contained by stronger anti-epidemic measures. The difference in their final rates, which were 75% in Shenzhen and 12% in Dongguan by 31st March, was still enormous. Their final morbidity rates were close to their own initial rates, although daily rates showed strong fluctuation due to fewer daily new cases in the late stage of outbreaks. One essential event was a whole-area lockdown in Shenzhen, including 11 districts, for one week starting from 14 March 2022, which was announced in the evening of 13 March 2022. On 18 March 2022, the Shenzhen authority cancelled the lockdown of 5 districts with “zero active COVID-19 cases”. The final termination of the lockdown started at 00:00 on 21 March 2022.



Dongguan’s outbreaks did not follow the trend of expansion of its neighbor Shenzhen and had two extraordinary surges of asymptomatic cases (Fig. 4, the red triangle line). The first wave was from 03 March to 06 March, and the second was from 09 March to 12 March. There were belated prevention measures disclosed later on, but this kind of belated measures usually brought to society more hidden transmission between cases of infection that were not diseased or did not consult a doctor, likely with an outcome of a higher morbidity rate. However, this did not happen in Dongguan. Its morbidity rate remained steadily low (fig. 3)

Similar pairs of cities are Changchun and Jilin, which are the first two large cities in Jilin Province in northeastern China and are approximately 111 kilometers apart, with a much larger scale of outbreaks in March 2022, reaching a total number of cases of infection of 20,675 in Changchun and 25,227 in Jilin.

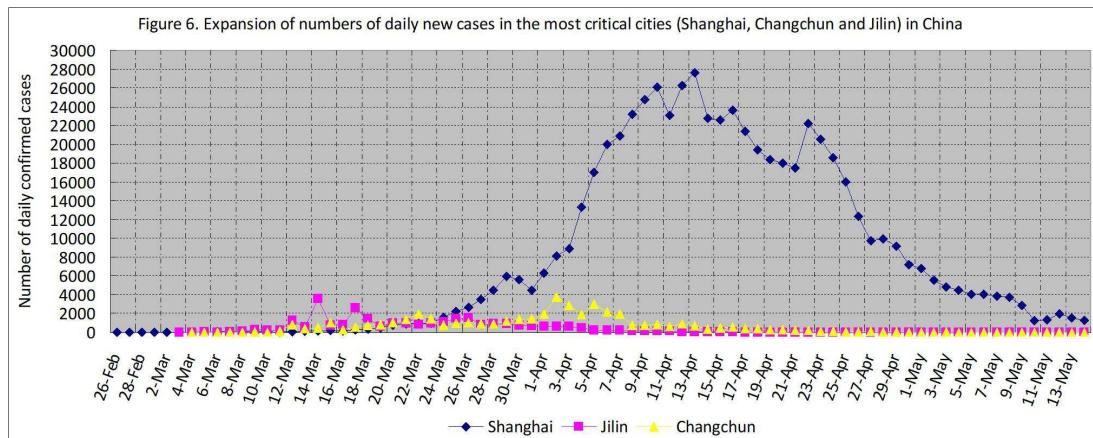
The outbreaks started in Jilin on 03 March 2022 with an unknown source, though a possible source was later reported by local media as from South Korea. Before 03 March, cases of infection had been cleared to zero in Jilin and Changchun for days. Changchun's outbreaks followed one day after Jilin. Their morbidity rates also differed from the beginning, and their levels seemed steady too, with Changchun's approximately 85% and Jilin's approximately 50% in March. Jilin's number of daily new cases declined steadily from its peak on 26 March 2022 while Changchun was on its platform. By 31th March 2022, the morbidity rates were 83% in Changchun and 54% in Jilin (Fig. 5).



The morbidity rates in the cities with the same origin (Shanghai origin) in middle and late stages of the March outbreaks also vary much (Fig. 1), with the highest of 90% in Guangzhou and the lowest of 3% in Suzhou. Such large differences of morbidity rates are not related to the location of cities which are greatly different in distances from Shanghai and some are in the far north in China while some in the far south.

Morbidity rate did not fluctuate much

Morbidity rates did not fluctuate much in some cities as described above. And Shanghai was the one with the least fluctuation among all the major cities. Shanghai's outbreaks had a relatively slow start with one or two cases daily from 26 February to 01 March 2022, reaching over 100 cases on 13 March. Rapid expansion of numbers of daily confirmed new cases appeared, and the number reached nearly 6,000 per day within a period of 17 days (Fig. 6), with a total number of cases of 36,548 by 31 March 2022. Daily number of cases kept growing fast to 27,605 by 13 April 2022 and reached a total of 619,259 on 14 May 2022. The morbidity rates of daily new cases here ranged from 8% to 0% over 24 days of the whole month of March (31 days) (Fig. 5). The average morbidity rate of total confirmed cases by 14 May was 9%. As a city with the most critical number of cases of infection among the three (the other two are Changchun and Jilin), Shanghai's morbidity rate is one of the steadiest among all major cities with statistical significance.



Rapid spread under strict measures

China managed COVID-19 prevention well by adhering to its “dynamic zero-COVID Policy” until Omicron BA.2 attacked it. The daily new confirmed domestic cases remained no more than 100 before 21 February 2022. There was no easing of strict mandatory quarantine and isolation. However, the rapid expansion of daily reported new infection cases revealed that Omicron BA.2 subvariant could still spread very fast and widely in China, with over 738,000 people infected in mainland China within 66 days, and with the fastest in Shanghai where 619,259 people infected with SAR-CoV-2 Omicron BA.2 (Fig. 6). Current strict prevention measures were not able to stop the rapid epidemic expansion of Omicron BA.2. China once again had to face the choice of whether to take a higher economic and social cost to control transmission.

Omicron BA.2 transmission unpredictable

The transmission of Omicron BA.2 is unpredictable, nor is its morbidity rate. Chinese cities are more like isolated islands than those of other countries because of strict prevention measures. This Omicron BA.2 subvariant seems to have developed a different pattern of virulence and transmission in these isolated cities of China. Among the twenty major cities with outbreaks of Omicron BA.2, nearly half of them have very low morbidity rates (Fig. 1), including Suzhou (3%), Langfang (8%) and Shanghai (9%). On the other hand, these ten cities have very high percentages of asymptomatic cases in confirmed cases, including Suzhou (97%), Langfang (92%) and Shanghai (91%). Three cities have very high morbidity rates: Guangzhou (90%), Beijing (85%) and Shenzhen (74%). The average morbidity rate nationwide excluding Shanghai is 42%.

There are good aspects of the data, as summarized in the following:

Low severity rate and case fatality rate

Nationwide data show no available information for daily new severe cases in China. During the March outbreaks in China, a percentage of 0.20% for the ratio of severe cases to symptomatic cases (0.10% for severe cases to confirmed cases) is reported in Jilin Province (Number of

accumulated severe cases drops from 19 on 01 March to 6 on 12 March due to recovery or converting of hospitalized COVID-19 patients from February). The case fatality rate is 2.6/20,000 in symptomatic cases (or 1.38/20,000 in confirmed cases) in Jilin, as 2 deaths being reported on 18 March 2022, and 1.68/50,000 in symptomatic cases (or 4/50,000 in confirmed cases) nationwide excluding Shanghai and 1% in symptomatic cases (or 0.09% in confirmed cases) in Shanghai.

Fewer cases need hospitalization

Only Jilin Province publishes data on the classification of diagnosed COVID-19 patients daily. Jilin's data shows that 98.72% of the symptomatic cases were diagnosed as mild. A total of 1.09% of the symptomatic cases (or 0.56% of the confirmed cases) are moderate, and 0.20% of those (or 0.10% of the confirmed cases) are severe in Jilin Province. A total of 0.66% of confirmed cases need hospitalization (following guidance of the national Diagnosis and Treatment Protocol for COVID-19 Patients⁸), including 0.10% of severe or critical cases. Recovered cases retested positive have not been reported but are estimated to be approximately 1%, close to the figure announced by Shenzhen 3rd People's Hospital on a news release in March 2022.

Asymptomatic case conversion

The ratios of asymptomatic cases converting to symptomatic cases are 6.20%, 3.76% and 5.31%, 3.93%, respectively in Jilin Province (including Changchun and Jilin), Shanghai and nationwide excluding Shanghai, nationwide including Shanghai, during the March outbreaks till 14 May 2022. These percentages may indicate the impact to the related actual numbers and ratios in the jurisdictions where such converting data are not reported

Possible contribution to epidemiology

No present mathematical models can tell or predict the features of transmission of SARS-CoV-2 Omicron BA.2 stated above. Rapid epidemic expansion has been observed during the March outbreaks driven by Omicron BA.2 subvariant in China. Some new features of the outbreaks are also revealed by data analysis, including large differences of morbidity rates with steadiness in cities, unpredictable transmission, and low severity rate and low hospitalization need. The study above may bring new thoughts for correction of present epidemiological theory and mathematical models. It may also give other countries time to be better prepared for the coming 6th wave driven by Omicron BA.2, including preparation and allocation of medical personnel and equipment, cabin laboratories and isolation facilities, and supply of daily necessities, etc.

Conclusion

SARS-CoV-2 Omicron BA.2 subvariant can transmit rapidly even under the conditions of very strict mandatory measures. Its transmission and morbidity rate in a specific area is unpredictable. Enormous differences in morbidity rates may appear in different areas and may not be related to any of the influencing factors known. There are no laws of transmission found for it yet.

Fifty-eight percent of the cases of infection were asymptomatic in China during the March outbreaks of Omicron in 2022, among them 3.93% convert to symptomatic. The percentage of mild cases in symptomatic cases may be as high as 98.72%, and the percentage of severe cases in symptomatic cases may be as low as 0.20% under the circumstances of strict mandatory measures and of a vaccination rate over 87% in the population. Thus, only 2% of the symptomatic cases need to be hospitalized. Deaths may be very rare in some cities but situations may be very different in other cities. Case fatality rate is unpredictable too, with large differences in Jilin, Shanghai and nationwide excluding Shanghai. Finally, 1% of recovered symptomatic cases may be retested positive in a short time after their recovery from COVID-19.

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