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Characteristics and containment of the outbreak caused by the SARS−CoV−2 Omicron variants in Shanghai, China: A retrospective study

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ABSTRACT

Objective: The study aimed to describe the characteristics and containment of the Omicron variants in Shanghai compared with the previous severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) variants in China.

Methods: We summarized the data retrieved from the Shanghai Municipal Health Commission from January to June 2022 and the National Health Commission of the People's Republic of China from March 2020 to August 2021. Epidemiological analysis was utilized to describe the differences among SARS-CoV-2 variants and the infection situation in the outbreaks in China.

Results: The Omicron variants had the characteristics of high insidiousness, rapid transmission, high infectivity, and short incubation period, which were consistent with the characteristics of outbreaks caused by Omicron in other regions in China and abroad. There were 568 978 asymptomatic infections in Shanghai from Feburary 26 to June 30, 2022, accounting for 90.73% of the SARS-CoV-2 infections in this outbreak wave. It's significantly different from a total of 23 277 SARS-CoV-2 infections in China between March 31, 2020 and August 8, 2021, of which 41.97% of the cases were asymptomatic infections.

Conclusions: Compared with previous outbreaks emerged in China, the Omicron outbreak in Shanghai was characterized by multiple point dissemination, wide coverage, a large number of close contacts of confirmed infections and asymptomatic carriers, and difficult source tracing. The lessons from Shanghai's response to Omicron showed that the dynamic zero-COVID policy is still the most suitable response to the virus which can quickly find the infections and curb the transmission route.

KEYWORDS: Omicron BA.2/BA.2.2; SARS-CoV-2 variants; Outbreak; Shanghai

Significance

The continuous mutation and upgrading of SARS-CoV-2 variants further enhance the difficulty of prevention and control of COVID-19 in China. The study conducted a descriptive epidemiological analysis of the COVID-19 outbreak in Shanghai and discussed the effects of the performed prevention and control measures to provide valuable information to public health officials and policymakers when faced with the emergency of novel variants in the future.

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1. Introduction

The COVID-19 is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection[1,2] which belongs to the β genus of coronaviruses with an envelope and round or oval-shaped particles, 60-140 nm in diameter[3,4], and has five essential genes targeting four structural proteins of nucleoprotein (N), viral envelope (E), matrix protein (M) and spinosin (S) and RNA-dependent RNA polymerase (RdRp)[5,6]. Like other viruses, the novel coronavirus genome has undergone mutations, which affects the biological properties of the virus. For example, the binding affinity of the S protein with ACE-2 affects the ability of the virus to invade cells, replicate, and spread[7].

SARS-CoV-2 is thought to spread via respiratory droplet, aerosol particles in poorly ventilated space and contaminated surfaces, etc[8–14]. People of any age can catch COVID-19, but the risk of developing dangerous symptoms increases with age and underlying health conditions like lung, heart disease, and diabetes, etc. Symptoms may appear 2-14 days after exposure to the virus[15–17]. The most common symptoms of COVID-19 include fever, headache, dry cough and shortness of breath, tiredness, muscle or body aches, loss of taste or smell, sore throat, congestion or runny nose, nausea or vomiting, diarrhea, etc. Dyspnea and hypoxemia are the most common symptoms of severe disease that typically begin approximately one week after the onset of the symptoms, and some severe patients may even develop acute respiratory distress syndrome, septic shocks, metabolic acidosis and multifunctional organ failure, etc[18–21]. Most patients have a favourable prognosis while others may become very sick, or even die, mainly older people (⩾60), people with chronic diseases, late pregnant women and people with obesity[22–26]. The diagnosis is established based on a comprehensive analysis of the epidemiological history, clinical manifestations, and laboratory tests[27]. Nucleic acid detection is currently regarded as the golden standard for COVID-19 diagnosis, and it is an effective method for clinical diagnosis and precautionary screening[28].

Up to now, the World Health Organization (WHO) has proposed five "variants of concern", namely Alpha, Beta, Gamma, Delta and Omicron[29,30]. Since November 2021, the Omicron variant has rapidly become the most dominant SARS-CoV-2 variant due to its high transmission rate, many mutations and significant immune response evasion capabilities. As of June 2022, more than 500 million confirmed cases of COVID-19 have been reported globally, resulting in more than 6.3 million deaths[31]. The data from Global Initiative on Sharing Avian Influenza Data (GISAID) database showed that this variant was endemic in 118 countries as of January 17, 2022, and 195 countries before this article was submitted[32].

While the new variants have emerged across the globe, China has effectively contained multiple COVID-19 outbreaks since the initial Wuhan outbreak by adhering the containment policies which focus on stopping the transmission of coronavirus. From late February to June 2022, a major outbreak of SARS-CoV-2 Omicron variant spread rapidly throughout Shanghai, China. The rapid mutations of the Omicron variant has brought new challenges to China's fight against the epidemic.

2. Subjects and methods

2.1. Data source and collection

The data on the number of confirmed infections were gathered from the websites of the Shanghai Municipal Health Commission from January to June 2022 and the National Health Commission of the People's Republic of China from March 2020 to August 2021. The dynamic prevention and control strategies and measures taken were collected from press release for media briefing of the Shanghai Municipal Government by manual downloads.

2.2. Study design

A comparative analysis of the Omicron variants in this epidemic wave and the previous SARS-CoV-2 variants since 2020 was performed. Epidemiological analysis was utilized to describe the differences of epidemici situation at different stages of the outbreak. A discussion and analysis of the prevention and control strategies were conducted.

2.3. Statistical analysis

The data were graphed statistically by Microsoft Office Excel 2013. The number of infections outside quarantine, confirmed cases, asymptomatic cases and pre-symptomatic cases were shown and compared. A pre-symptomatic case was defined as an infected individual who hasn't yet developed symptoms at the time, but who later shows symptoms.

3. Results

According to the data released by the Shanghai Municipal Health Commission from January 1 to February 28, 2022, a total of 1 243 cases were imported from abroad (the exact distribution of

infectious variants was not published), which accounted for 80% of the total number of cases in Shanghai in 2021 and 38% of the total number of cases in China during the same period. As of July 1, 2022, there were 627 115 cases of SARS-CoV-2 infection, including 568 978 asymptomatic infections and 58 137 confirmed cases, 22 545 asymptomatic infections converted to confirmed cases and 588 deaths in total (Table 1).

According to the epidemic situation and the prevention and control measures taken, three phases of the epidemic were defined (Figure 1). The first phase started on Feburary 28, 2022, a 56-year-old woman came to Tongji Hospital with a fever. She became the index case in this outbreak after being confirmed positive on March 1. Shanghai reported a surging number of new local COVID-19 cases since then and raised the risk levels of some areas from "low risk" to "middle risk". The second phase covered the period from March 15 to May 31, 2022. The number of infected people continued to rise. The highest number of positive cases of community transmission (1 364 cases) reached on April 2. Although Shanghai started to implement whole-city lockdown on March 30, 2022, the new local cases started to rise exponentially from April 5. During the period from April 5 to April 25, the cumulative daily cases in Shanghai exceeded 15 000 and reached a higher level (27 719 cases) on April 13. The cumulative daily cases began to decline around mid-April and the epidemic reached a controllable level in May. The third phase started from June 1, the citywide lockdown was lifted. But, sporadic community infections were still reported.

Table 1. SARS-CoV-2 infections reported in China from March 31, 2020 to August 8, 2021 and in Shanghai from Feburary 26 to June 30, 2022.

Area	China	Shanghai
Time	31/3/2020-8/8/2021	26/2/2022-30/6/2022
Variant type	Wuhan reference strain/ Alpha/Delta variants	Omicron BA.2/BA.2.2
Total cases	23 277	627 115
Symptomatic infections n (%)	11 985 (51.49)	35 592 (5.68)
Asymptomatic (including pre-symptomatic*) infections n (%)	11 292 (48.51)	591 523 (94.32)
Pre-symptomatic* infections	2 215 (9.52)	22 545 (3.60)

*individuals who are identified as asymptomatic at their initial RT-PCR screening, but eventually experience the onset of symptoms.

4. Discussion

Omicron BA.2 and BA.2.2 of SARS-CoV-2 were the main causes of this wave of outbreak in Shanghai, China. Compared with the previous SARS-CoV-2 variants, Omicron variants have the characteristics of high insidiousness, rapid transmission, high infectivity, and short incubation period, which are consistent with the characteristics of outbreaks caused by Omicron in other regions in China and abroad (Table 2). Therefore, asymptomatic transmission has occured in the early stages of this epidemic wave before the positive infections were found. Compared with previous outbreaks emerged in China, the Omicron outbreak in Shanghai was characterized by multiple point dissemination, wide coverage, a large number of close contacts of confirmed infections and asymptomatic carriers, and difficult source tracing. In addition, the new Omicron variants caused significantly lower rates of severe disease compared to the previous variants, and people vaccinated and previously infected were less likely to develop severe infection[33–36]. Nevertheless, the ability to rapidly mutate makes the Omicron variants remain a major health threat for the large cities like Shanghai, which is a densely populated city.

The cases in this COVID-19 epidemic in Shanghai were predominantly asymptomatic infections (about 90.73%). And it's significantly different from relevant studies reporting a total of 23 277 SARS-CoV-2 infections in China between March 31, 2020, and August 8, 2021, of which nearly half of the cases were asymptomatic infections, and the specific data were shown in Table 1[37]. The reasons for this phenomenon may be related to prevention and control measures for early diagnosis and treatment, vaccination of the population, and the characteristics of the mutated virus itself, etc. Moreover, statistical analysis revealed that 22 545 asymptomatic carriers were converted to confirmed cases, accounting for 38.78% of the confirmed cases, and the conversion rate of asymptomatic infection was 3.81%.

According to the official statistics, it was found that there were 588 cumulative deaths in this period, the average age of death was 82.89 years old (the youngest of which was 33 and the oldest 101). Furthermore, the vaccination rate among the deaths was only about 5.3%, with 86.2% of the population over 80 years old; and the causes of the deaths were all underlying diseases except for one case of sudden cardiac death among the total deaths[38]. This suggests that to some extent, once infected with SARS-CoV-2, the risk of death due to the underlying disease is higher, especially in the unvaccinated population. Data from Hong Kong, China, which was also affected by the Omicron BA.2 and BA.2.2 outbreaks, from December 31, 2021 to July 27, 2022, showed that 95% of the 9 275 COVID-19 deaths were in people aged 60 years and older, and the overall mortality rate of the fifth wave of the epidemic was 0.71% while the mortality rate was 2.93% in unvaccinated patients[39].

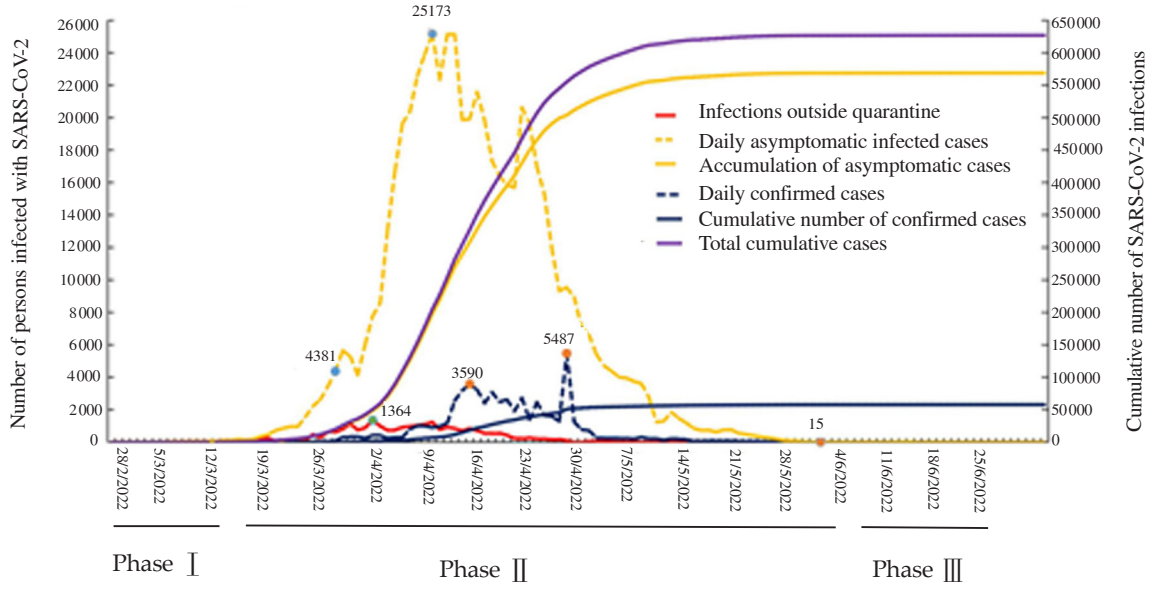

Figure 1. Number of SARS-CoV-2 infected cases in Shanghai from February 28 to June 25, 2022.

Current study found that vaccination significantly reduced the morbidity and mortality rates of SARS-CoV-2 infections in the elderly[40]. And the recent statistical analysis of outbreaks in Hong Kong and Shanghai caused by the Omicron variant indicated that for infected persons aged 18 to 59 years who completed full vaccination and booster shot, the risk of developing from mild to moderate was 63% and 65% lower than that of unvaccinated infected persons, and the risk of developing from mild and moderate to severe disease was 91% and 94% lower, respectively. As for infected patients aged 60 years or older who completed the full course of vaccination and booster vaccination, the risk of developing from mild to moderate was 73% and 82% lower than that of unvaccinated infected patients, and the risk of developing from moderate to severe disease was 89% and 95% lower than that of unvaccinated infected patients, showing that vaccination is effective in preventing morbidity, severe disease, and even death[41]. As of April 15, 2022, the full basic immunization rate of 62% and the booster immunization rate of 38% for those aged 60 years and older in Shanghai[42], it is suggested that eligible elderly people should be vaccinated in a timely manner[43,44].

As shown in Figure 1, the new local cases continued to rise in March and hit a record high of 27719 cases on April 13 although the whole-city lockdown was implemented in March. The reasons for this situation mainly included the scattered infections in communities before lockdown, hidden vrius spread chains such as the household transmission (If one person was infected in the household, other family members might expect to develop the infection who will be detected in the subsequent screening) and contact with items or goods contaminated by the virus[45]. After three months of joint efforts by people from all walks of life in Shanghai and across the country, the resumption of work and production was promoted in an orderly manner in early June (except for the key control areas where positive cases were still found).

It's estimated that if China did not take active preventive measures, it would result in about 1.5 million deaths[42]. Three factors are necessary for the infection to spread: source, susceptible people and transmission[46], and the corresponding basic principles for prevention and control are controlling the source of infection, cutting off the transmission route, and protecting susceptible population. Of course, the levels of prevention and control measures taken are also related to the infectivity and severity of the pathogen, and the degree of social harm, etc. The development and implementation of various prevention and control measures during the COVID-19 epidemic in China were in more strict compliance with the three principles as shown in Figure 2, which was an important factor in achieving zero community transmission in Shanghai.

In this paper, we summarized and described the policy changes in the three phases of the response to Omicron in Shanghai. The initial phase of this outbreak was dominated by dynamic zero-COVID policy, including contact tracing, mass nucleic acid screening, border quarantine, and digital management for a matrix of urban communities. However, due to the high infectivity and high covertness of Omicron BA.2/BA.2.2, as well as the high population density and high population mobility in Shanghai, the number of new infections has continued to rise with authorities reporting. In the second phase of the epidemic, control measures such as blocking and grid-based nucleic acid screening were implemented, further strengthening the prevention and control of the epidemic at the social level; subsequently, at the end of March, control measures

such as region-wide static management were implemented, including home isolation, antigen self-testing, early detection, and early treatment. With the gradual decline in the number of infected cases during the epidemic, the city implemented control measures such as a region-specific, multi-level targeted approach to epidemic prevention and control until the epidemic reached a controllable level. In the third phase, an alert system has been created to normalize epidemic prevention and control with nucleic acid and antigen screening, venue code and digital sentry scanning as well as monitoring at local fever clinics and pharmacies to detect any suspected cases timely.

In the Shanghai Omicron wave, the strict prevention and control measures effectively cut off COVID-19 transmission routes and dynamic zero-COVID approach has been proven successfully in containing the spread of the virus. In this paper, we analyzed the epidemiogical characteristics and containment measures for the outbreak caused by the new Omicron variants in order to provide a reference for the prevention and control of the later COVID-19 epidemic and other infectious diseases with high infectiousness and pathogenicity.

Table 2. Comparison of the epidemic variants of SARS-CoV-2 in Shanghai with the previous variants.

	Previous epidemic variants of SARS-CoV-2			Current epidemic variants of SARS-CoV-2
	Wuhan reference variant	Alpha B.1.1.7	Delta AY.4/ B.1.617.2	Omicron BA.2/BA.2.2/BA.5
Basic reproduction number (estimate)	2.5[47]	3.75[48]	5.08[47]	R_0 of BA.2 and BA.5 is 13.3 and 18.6, respectively[49]
Epidemiological characteristics	Rapid spread, strong contagiousness, and with a certain degree of insidiousness[50].	The B.1.1.7 lineage was believed to be 30%to 50% more contagious than the original SARS-CoV-2 variant[51]. According to WHO estimates, the infectiousness of B.1.1.7 has increased by 40% to 70%, and the transmission index will reach between 1.5 and 1.7, which is 0.4 to 0.6 higher than the B.1.1[52].	The Delta variant is 60% more transmissible than the mutant Alpha variant[53] and twice as likely to cause clinical symptoms as the Wuhan reference variant, and patients infected with the Delta variant appear to be at twice the risk of hospitalization as those infected with the Alpha variant[54].	The Omicron variant is about 3-4 fold more infectious than the Delta variant but is 91% less lethal and has a 51% lower risk of hospitalization[42]. The secondary attack rate of Omicron is 15.8% compared 10.3% for Delta[55].
Control measures	Targeted epidemic-control measures, dynamic clearance, etc.			Targeted epidemic-control measures, dynamic clearance + Region-specific, multi-level targeted approach to epidemic prevention and control+ Combination of antigen self-test and routine nucleic acid testing, etc.
Effectiveness of vaccinations	Current vaccines have been reported to be effective in preventing serious illness and reducing deaths[43,56–58].			

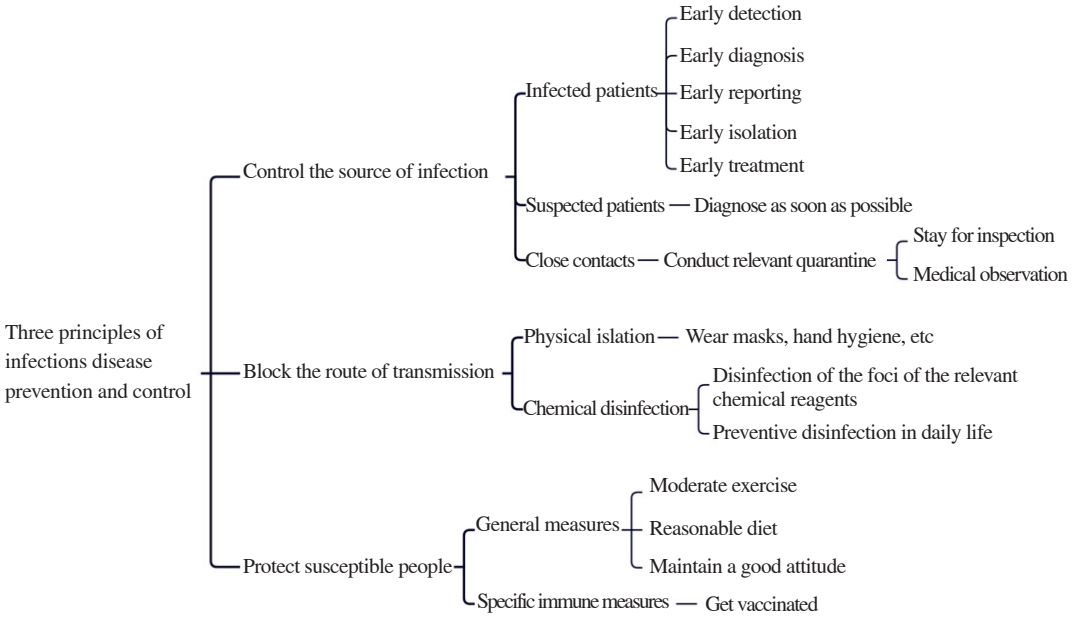

Figure 2. Specific measures to implement the three principles of COVID-19 epidemic prevention and control.

5. Conclusions

It took nearly three months to contain the Omicron outbreak in Shanghai. With the government's determination to enforce "dynamic zero-COVID" control measures, Shanghai has implemented the strict prevention and control measures such as citywide lockdown, large scale viral nucleic acid and antigen screening, and quarantine of infected cases and close contacts in makeshift hospitals. Shanghai's efforts and experiences showed that it is possible to successfully contain the Omicron outbreak in China by implementation of stringent interventions.

In the early stage of the outbreak, Shanghai implemented the closings of targeted buildings and neighborhoods instead of the total lockdown to avoid damaging the economy. However, the lack of preparation for the new Omicron variant and fatigue in fighting the epidemic put Shanghai in a grim situation for a time. The lessons from Shanghai's response to Omicron showed that the dynamic zero-COVID policy is still the most suitable response to the virus which can quickly find the infections and curb the transmission route. It also indicated that we should effectively increase the capacity of the multi-sectors to respond to severe emergencies and boost the development of early warning and emergency response systems for major emergencies in the follow-up work. In the context of normalization of epidemic situation, many provinces and cities across China took more decisive preventive measures to screen the infection cases through mass nucleic acid testing and accelerating the design and construction of makeshift hospitals to make the full preparation in wartime.

Currently, the global epidemic of COVID-19 is still serious, and the CDC reported on July 16, 2022 that two new subvariants of Omicron BA.4 and BA.5, which are probably the most infectious SARS-CoV-2 viruses to date. In the context of the global pandemic of COVID-19, there is always a continuous risk of importation of the epidemic from abroad, and the continuous mutation and upgrading of SARS-CoV-2 variants reminded us that prevention and control of the epidemic can not be relaxed. We should concurrently step up our monitoring efforts, examine the epidemic patterns, conduct genomic surveillance, and develop effective vaccines and efficient treatments in order to provide solid scientific backing for the fundamental prevention and control of the epidemic.

Conflict of interest statement

The authors declare that they have no conflict of interest.

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Authors' contributions

Zhou HR, Pan JF, Xiao N and Li GF discussed the framework of the article. Zhou HR and Wang XL were responsible for manuscript writing. Wang XM, Zhou Z, Kong W, Pan YJ, Xu XX and Ye KY contributed to the critical revision of the article. Zhou HR, Pan JF and Xiao N reviewed and edited the content of the whole paper.

References

[1] Wu D, Wu TT, Liu Q, Yang ZC. The SARS-CoV-2 outbreak: What we know. *Int J Infect Dis* 2020; **94**: 44-48. doi: 10.1016/j.ijid.2020.03.004.

[2] Li H, Liu L, Zhang DY, Xu JY, Dai HP, Tang N, et al. SARS-CoV-2 and viral sepsis: Observations and hypotheses. *Lancet* 2020; **395**(10235): 1517-1520.

[3] Zhu N, Zhang DY, Wang WL, Li XW, Yang B, Song JD, et al. A novel coronavirus from patients with pneumonia in China, 2019. *New Engl J Med* 2020; **382**(8): 727-733.

[4] Chen LJ, Liu WY, Zhang Q, Xu K, Ye GM, Wu WC, et al. RNA based mNGS approach identifies a novel human coronavirus from two individual pneumonia cases in 2019 Wuhan outbreak. *Emerg Microbes Infec* 2020; **9**(1): 313-319.

[5] Chilamakuri R, Agarwal S. *COVID–19: Characteristics and therapeutics*. *Cells* 2021; **10**(2): 206.

[6] Wu AP, Peng YS, Huang BY, Ding X, Wang XY, Niu PH, et al. Genome composition and divergence of the novel coronavirus (2019-nCoV) originating in China. *Cell Host Microbe* 2020; **27**(3): 325-328.

[7] Yalcin HC, Sukumaran V, Al-Ruweidi MKAA, Shurbaji S. Do changes in ACE-2 expression affect SARS-CoV-2 virulence and related complications: A closer look into membrane-bound and soluble forms. *Int J Mol Sci* 2021; **22**(13): 6703.

[8] Chen PZ, Bobrovitz N, Premji Z, Koopmans M, Fisman DN, Gu FX. Heterogeneity in transmissibility and shedding SARS-CoV-2 via droplets and aerosols. *eLife* 2021; **10**: e65774. doi: 10.7554/eLife.65774.

[9] World Health Organization. *Modes of transmission of virus causing COVID–19: Implications for IPC precaution recommendations*. [Online] Available from: https://www.who.int/news-room/commentaries/detail/

modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations. [Accessed on 29 March 2020].

[10]Wang CC, Prather KA, Sznitman J, Jimenez JL, Lakdawala SS, Tufekci Z, et al. Airborne transmission of respiratory viruses. *Science* 2021; **373**(6558): eabd9149. doi: 10.1126/science.abd9149.

[11]Cai J, Sun WJ, Huang JP, Gamber M, Wu J, He GQ. Indirect virus transmission in cluster of COVID-19 cases, Wenzhou, China, 2020. *Emerg Infect Dis* 2020; **26**(6): 1343-1345.

[12]Karimzadeh S, Bhopal R, Huy NT. Review of infective dose, routes of transmission and outcome of COVID-19 caused by the SARS-COV-2: Comparison with other respiratory viruses. *Epidemiol Infect* 2021; **149**: e96. doi: 10.1017/S0950268821000790.

[13]Morawska L, Cao JJ. Airborne transmission of SARS-CoV-2: The world should face the reality. *Environ Int* 2020; **139**: 105730. doi: 10.1016/j.envint.2020.105730.

[14]Ong SWX, Tan YK, Chia PY, Lee TH, Ng OT, Wong MSY, et al. Air, surface environmental, and personal protective equipment contamination by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) from a symptomatic patient. *JAMA* 2020; **323**(16): 1610-1612.

[15]Dhouib W, Maatoug J, Ayouni I, Zammit N, Ghammem R, Ben Fredj S, et al. The incubation period during the pandemic of COVID-19: A systematic review and meta-analysis. *Syst Rev* 2021; **10**(1): 101. doi: 10.1186/s13643-021-01648-y.

[16]Wei YY, Wei LM, Liu YH, Huang LH, Shen SP, Zhang RY, et al. Comprehensive estimation for the length and dispersion of COVID-19 incubation period: A systematic review and meta-analysis. *Infection* 2022; **50**(4): 803-813.

[17]Zhou HR, Wang XL, Xu QF, Wang XM, Ma YD, Shi YR, et al. An Investigation of a Confirmed Imported Case of COVID-19 Infected Abroad - Qingpu District, Shanghai Municipality, China, November, 2020. *China CDC Wkly* 2021; **3**(10): 207-210.

[18]Li GW, Chang B, Li H, Wang R, Li G. Precautions in dentistry against the outbreak of corona virus disease 2019. *J Infect Public Health* 2020; **13**(12): 1805-1810.

[19]Tu HL, Tu S, Gao SQ, Shao AW, Sheng JF. Current epidemiological and clinical features of COVID-19; a global perspective from China. *J Infect* 2020; **81**(1): 1-9.

[20]Gao ZR, Xu YH, Sun C, Wang X, Guo Y, Qiu S, et al. A systematic review of asymptomatic infections with COVID-19. *J Microbiol Immunol* 2021; **54**(1): 12-16.

[21]Feng S, Phillips DJ, White T, Sayal H, Aley PK, Bibi S, et al. Correlates of protection against symptomatic and asymptomatic SARS-CoV-2 infection. *Nat Med* 2021; **27**(11): 2032-2040.

[22]Hu KY, Lin L, Liang Y, Shao XN, Hu ZW, Luo HB, et al. COVID-19: Risk factors for severe cases of the Delta variant. *Aging (Albany N Y)* 2021; **13**(20): 23459-23470.

[23]Mehta OP, Bhandari P, Raut A, Kacimi SEO, Huy NT. Coronavirus disease (COVID-19): Comprehensive review of clinical presentation. *Front Public Health* 2021; **8**: 582932. doi: 10.3389/fpubh.2020.582932.

[24]Al-Quteimat OM, Amer AM. The Impact of the COVID-19 pandemic on cancer patients. *Am J Clin Oncol* 2020; **43**(6): 452-455.

[25]Knight M, Bunch K, Vousden N, Morris E, Simpson N, Gale C, et al. Characteristics and outcomes of pregnant women admitted to hospital with confirmed SARS-CoV-2 infection in UK: National population based cohort study. *BMJ* 2020; **369**: m2107. doi: 10.1136/bmj.m2107.

[26]Hussain A, Mahawar K, Xia ZF, Yang W, EL-Hasani S. Obesity and mortality of COVID-19. Meta-analysis. *Obes Res Clin Pract* 2020; **14**(4): 295-300.

[27]National Health Commission, National Administration of Traditional Chinese Medicine. *Diagnosis and Treatment Protocol for COVID-19 (Trial Version 9)*. [Online] Available from: https://onlinelibrary.wiley.com/doi/full/10.1002/hcs2.1. [Accessed on 15 March 2022].

[28]Yuce M, Filiztekin E, Ozkaya KG. COVID-19 diagnosis—A review of current methods. *Biosens Bioelectron* 2021; **172**: 112752. doi: 10.1016/j.bios.2020.112752.

[29]Dol J, Boulos L, Somerville M, Saxinger L, Doroshenko A, Hastings S, et al. Health system impacts of SARS-CoV-2 variants of concern: A rapid review. *BMC Health Servs Res* 2022; **22**(1): 544.

[30]Aleem A, Samad ABA, Slenker AK. *Emerging variants of SARS-CoV-2 and novel therapeutics against coronavirus (COVID-19)*. Orlando: StatPearls Publishing; **2022**.

[31]World Health Organization. *WHO coronavirus (COVID-19) dashboard*. [Online] Available from: https://covid19.who.int. [Accessed on 30 June 2022].

[32]GISAID. *Map of tracked variant occurrence*. [Online] Available from: https://www.gisaid.org/hcov19-variants/. [Accessed on 26 July 2022].

[33]South African Medical Research Council. *Tshwane district Omicron variant patient profile – Early features*. [Online] Available from: https://www.coronaheadsup.com/africa/south-africa-tshwane-district-omicron-patient-profile/. [Accessed on 4 December 2021].

[34]CDC COVID-19 Response Team. SARS-Cov-2 B. 1.1. 529 (Omicron) variant—United states, December 1–8, 2021. *Morb Mortal Wkly Rep* 2021; **70**(50): 1731-1734.

[35]Maslo C, Friedland R, Toubkin M, Laubscher A, Akaloo T, Kama B. Characteristics and outcomes of hospitalized patients in South Africa during the COVID-19 Omicron wave compared with previous waves.

JAMA 2022; **327**(6): 583-584.

[36]Christensen PA, Olsen RJ, Long SW, Snehal R, Davis JJ, Saavedra MO, et al. Signals of significantly increased vaccine breakthrough, decreased hospitalization rates, and less severe disease in patients with Coronavirus disease 2019 caused by the Omicron variant of severe acute respiratory syndrome coronavirus 2 in Houston, Texas. *Am J Pathol* 2022; **192**(4): 642-652.

[37]Gao W, Lv J, Pang Y, Li LM. Role of asymptomatic and pre-symptomatic infections in COVID-19 pandemic. *BMJ* 2021; **375**: n2342.

[38]Shanghai Municipal Health Commission. *Shanghai requires "not leaving the city unless necessary" according to the strict control measures, as 14 812 patients were discharged from mobile cabin hospitals yesterday*. [Online] Available from: http://wsjkw.sh.gov.cn/xwfb/20220426/a9e3e293bf6542e1a9e46712b6a5e1fb.html. [Accessed 26 April 2022].

[39]The Government of the Hong Kong Special Administrative Region. *Provisional data analysis on COVID−19 reported death cases*. [Online] Available from: https://www.covidvaccine.gov.hk/pdf/death_analysis.pdf. [Accessed on 28 July 2022].

[40]Jin PF, Li JX, Guo XL, Gou JB, Hou LH, Song ZZ, et al. Heterologous CoronaVac plus Ad5-nCOV versus homologous CoronaVac vaccination among elderly: A phase 4, non-inferiority, randomized study. *medRxiv* **2022**. doi: https://doi.org/10.1101/2022.06.03.22275983.

[41]The State Council of the People's Republic of China. *China's COVID−19 vaccines safe, effective*. [Online] Available from: http://www.gov.cn/xinwen/2022-07/24/content_5702635.htm. [Accessed on 24 July 2022].

[42]Cai J, Deng X, Yang J, Sun K, Liu H, Chen Z, et al. Modeling transmission of SARS-CoV-2 Omicron in China. *Nat Med* 2022; **28**(7): 1468-1475.

[43]Steele MK, Couture A, Reed C, Iuliano D, Whitaker M, Fast H, et al. Estimated Number of COVID-19 infections, hospitalizations, and deaths prevented among vaccinated persons in the US, December 2020 to September 2021. *JAMA Netw Open* 2022; **5**(7): e2220385.

[44]World Health Organization. *Interim statement on COVID−19 vaccines in the context of the circulation of the Omicron SARS−CoV−2 variant*. [Online] Available from: https://www.who.int/news/item/08-03-2022-interim-statement-on-covid-19-vaccines-in-the-context-of-the-circulation-of-the-omicron-sars-cov-2-variant-from-the-who-technical-advisory-group-on-covid-19-vaccine-composition-(tag-co-vac)-08-march-2022. [Accessed on 8 march 2022].

[45]Shanghai Municipal Health Commission. *Q&A Records of the Shanghai Municipal Government Press Conference*. [Online] Available from: http://wsjkw.sh.gov.cn/rdhy/20220415/df4079a17d65493b9dfb9949dcf6fa21.html. [Accessed on 14 April 2022].

[46]Zuo-Feng Zhang S-ZY. COVID-19 management in Shanghai, China. *One Health Bull* 2022; **2**; 5.

[47]Liu Y, Rocklöv J. The reproductive number of the Delta variant of SARS-CoV-2 is far higher compared to the ancestral SARS-CoV-2 virus. *J Travel Med* 2021; **28**(7): taab124. doi: 10.1093/jtm/taab124.

[48]Scott J. *What is the Alpha variant? What to know about this COVID−19 mutation, also known as the B.1.1.7 variant*. [Online] Available from: https://www.verywellhealth.com/uk-covid-19-variant-5179501. [Accessed on 16 August 2021].

[49]Ashley N. *These Omicron subvariants could be the most infectious human viruses, expert says*. [Online] Available from: https://www.deseret.com/coronavirus/2022/7/11/23204271/how-contagious-is-omicron-subvariant-ba4-ba5-covid-strain-new-variant-symptoms. [Accessed on 12 July 2022].

[50]The Novel Coronavirus Pneumonia Emergency Response Epidemiology Team. The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19)—China, 2020. *China CDC wkly* 2020; **2**(8): 113-122.

[51]Katella K. *Omicron, Delta, Alpha, and more: What to know about the coronavirus variants.* [Online] Available from: https://www.yalemedicine.org/news/covid-19-variants-of-concern-omicron. [Accessed 5 July 2022].

[52]European Centre for Disease Prevention and Control. *Threat assessment brief: Rapid increase of a SARS−CoV−2 variant with multiple spike protein mutations observed in the United Kingdom*. [Online] Available from: https://www.ecdc.europa.eu/en/publications-data/threat-assessment-brief-rapid-increase-sars-cov-2-variant-united-kingdom. [Accessed on 20 December 2020].

[53]Allen H, Vusirikala A, Flannagan J, Twohig K, Zaidi A, Groves N, et al. Household transmission of COVID-19 cases associated with SARS-CoV-2 delta variant (B.1.617.2): National case-control study. *Lancet Reg Health Eur* 2022; **12**: 100252. doi: 10.1016/j.lanepe.2021.100252.

[54]Sheikh A, McMenamin J, Taylor B, Robertson C. SARS-CoV-2 Delta VOC in Scotland: Demographics, risk of hospital admission, and vaccine effectiveness. *Lancet* 2021; **397**(10293): 2461-2462.

[55]National Health Commission of the People's Republic of China. *About Omicron, the latest answer from NHC on Omicron*. [Online] Available from: http://www.nhc.gov.cn/xcs/fkdt/202201/c4316f30c19e47eba988f3a284446482.shtml. [Accessed on 17 January 2022].

[56]Li J, Hou L, Guo X, Jin P, Wu S, Zhu J, et al. Heterologous AD5-nCOV plus CoronaVac versus homologous CoronaVac vaccination: A randomized phase 4 trial. *Nat Med* 2022; **28**(2): 401-409.

[57]Bowen JE, Addetia A, Dang HV, Stewart C, Brown JT, Sharkey WK, et al. Omicron spike function and neutralizing activity elicited by a comprehensive panel of vaccines. *Science* 2022; **377**(6608): 890-894

[58]World Health Organization. *COVID−19 advice for the public: Getting vaccinated*. [Online] Available from: https://www who int/emergencies/diseases/novel-coronavirus-2019/covid-19-vaccines/advice. 2021. [Accessed 13 April 2022].

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