Epidemiological characteristics of sporadic nosocomial COVID-19 infections from June 2020 to June 2021 in China: an overview of vaccine breakthrough infection events

Epidemiological characteristics of sporadic nosocomial COVID-19 infections from June 2020 to June 2021 in China: An overview of vaccine breakthrough infection events

Zhigang He[1], Hong-bing Xiang[1], Anne Manyande[2], Weiguo Xu[1], Li Fan[3], Boqi Xiang[4*]

[1]Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, China, [2]University of West London, United Kingdom, [3]Department of Orthopedics, Union Hospital of Tongji Medical College, Huazhong University of Science and Technology, China, [4]Rutgers University, United States

Submitted to Journal:
Frontiers in Medicine

Specialty Section:
Infectious Diseases – Surveillance, Prevention and Treatment

Article type:
Brief Research Report Article

Manuscript ID:
736060

Received on:
04 Jul 2021

Revised on:
21 Sep 2021

Journal website link:
www.frontiersin.org

Conflict of interest statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest

Author contribution statement

All the authors contributed to the paper presented methodology and conceptualization. They all contributed to data analysis and paper writing.

Keywords

COVID-19 disease, Asymptomatic carrier, Nosocomial infection, Scientific protective strategy, vaccine breakthrough infection

Abstract

Word count: 108

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic has wreaked havoc to human beings around the world. Although China quickly brought the Coronavirus disease (COVID-19) pandemic under control, there have been several sporadic outbreaks in different regions of China since then. This article describes the chronological nosocomial COVID-19 infection events that related to several sporadic outbreaks of SARS-CoV-2 in different regions of China. We reported epidemiological characteristics and management measures of sporadic nosocomial COVID-19 infections from June 2020 to June 2021 in China, specially focused on domestic COVID-19 breakthrough infection in China — a vaccinated healthcare professional working in the isolation ward of a designated COVID-19 hospital.

Contribution to the field

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic has wreaked havoc to human beings around the world. Although China quickly brought the Coronavirus disease (COVID-19) pandemic under control, there have been several sporadic outbreaks in different regions of China since then. This article describes the chronological nosocomial COVID-19 infection events that related to several sporadic outbreaks of SARS-CoV-2 in different regions of China. We reported epidemiological characteristics and management measures of sporadic nosocomial COVID-19 infections from June 2020 to June 2021 in China, specially focused on domestic COVID-19 breakthrough infection in China — a vaccinated healthcare professional working in the isolation ward of a designated COVID-19 hospital.

Funding statement

This work is funded by the National Natural Science Foundation of China (81873467, 81670240, and 81271766).

Ethics statements

Studies involving animal subjects

Generated Statement: No animal studies are presented in this manuscript.

Studies involving human subjects

Generated Statement: No human studies are presented in this manuscript.

Inclusion of identifiable human data

Generated Statement: No potentially identifiable human images or data is presented in this study.

Data availability statement

Generated Statement: The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Epidemiological characteristics of sporadic nosocomial COVID-19 infections from June 2020 to June 2021 in China: An overview of vaccine breakthrough infection events

Zhigang He[1], Hongbing Xiang[1], Anne Manyande [2], Weiguo Xu [3], Li Fan[4,*], Boqi Xiang [5,*]

[1] Department of Anesthesiology, Tongji Hospital of Tongji Medical College, Huazhong University of Science and Technology, Wuhan, 430030 Hubei, PR China;
[2] School of Human and Social Sciences, University of West London, London, United Kingdom;
[3] Department of Orthopedics, Tongji Hospital of Tongji Medical College, Huazhong University of Science and Technology, Wuhan 430030, PR China;
[4] Department of Orthopedics, Union Hospital of Tongji Medical College, Huazhong University of Science and Technology, Wuhan 430030, PR China;
[5] School of Public Health, Rutgers University, New Brunswick, NJ 08854, USA.

*Correspondence: Boqi Xiang, E-mail: bx67@sph.rutgers.edu; Li Fan, E-mail: fanleeeee@163.com.

Abstract

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic has wreaked havoc to millions of people around the world. Although China quickly brought the Coronavirus disease (COVID-19) under control, there have been several sporadic outbreaks in different regions of China since June 2020. This article describes the chronological nosocomial COVID-19 infection events related to several sporadic outbreaks of SARS-CoV-2 in different regions of China. We report epidemiological characteristics and management measures of sporadic nosocomial COVID-19 infections from June 2020 to June 2021, and specially focused on the domestic COVID-19 breakthrough infection in China including domestic COVID-19 breakthrough infection - a vaccinated healthcare professional working in the isolation ward of a designated COVID-19 hospital.

Keywords: COVID-19 disease; asymptomatic carrier; nosocomial infection; Scientific protective strategy; vaccine breakthrough infection

Introduction

The outbreak of the COVID-19 virus was first reported in Wuhan, China, in December 2019. The COVID-19 pandemic led China to quarantine the population in order to protect them [1]. Chinese authorities decided to adopt extraordinary measures to contain and limit the spread of the SARS-CoV-2 virus. From 1 January to 8 April 2020, >8,000 patients with COVID-19 were hospitalized and the Chinese government imposed the Wuhan lockdown on January 23, which ended on April 8, 2020.

With the COVID-19 epidemic quickly under control in the early stages of 2020, importing the SARS-CoV-2 virus could pose great challenges to the control and prevention of nosocomial COVID-19 infection in healthcare settings. Our previous report showed the impact of the novel coronavirus SARS-CoV-2 among healthcare workers in hospitals during the early phase of the COVID-19 epidemic[2], and suggested that local authorities need to be extremely cautious and implement stringent protective measures to safeguard healthcare workers in order to counteract the threats brought by the pandemic[3-5]. Though medical staff belong to the susceptible population to a certain extent, hospitals have practiced cohorting in accordance with recommendations from COVID-19 infection prevention and control professional societies, which has reduced the risk of hospital-acquired COVID-19. Because healthcare workers are at the interface between hospitals and the community, where there is significant COVID-19 transmission, they may be infected by asymptomatic carriers with COVID-19 or COVID-19 patients. Furthermore, in the designated hospital admitting COVID-19 patients or asymptomatic carriers, medical staff are highly exposed to nosocomial COVID-19 acquisition and SARS-CoV-2 transmission. Therefore, healthcare staff may play a key role in initiating or amplifying sporadic COVID-19 outbreaks in healthcare settings including hospitals and other care facilities.

The importing of the SARS-CoV-2 virus from overseas, induced sporadic outbreaks with COVID-19 from June 2020 to June 2021 in China[6, 7]. This article describes the chronological events that led to several sporadic nosocomial COVID-19 infections in different regions of China from June 2020 to June 2021, including domestic COVID-19 breakthrough infection — a vaccinated healthcare professional working in the isolation ward of a designated COVID-19 hospital[8]. Lastly, we provide an overview of local COVID-19 outbreak induced by the B.1.617.2 (Delta) variant of the COVID-19 virus in China.

Methods

From the beginning of June 1, 2020, every day, we prospectively focused on the COVID-19 epidemic data from the Chinese Center for Disease Control and Prevention. Once we had the new report of nosocomial COVID-19 infection in China, we tracked this epidemic and collected its epidemiological characteristics from announcements by the local Health Commission and presented a narrative research for geographical and epidemiological characteristics of nosocomial COVID-19 infection from June 2020 to June 2021.

We searched epidemiologic data published on the website of WHO, the China Center for Disease Control and Prevention, National Health Commission, the Health Commission of Qingdao, Shenyang, Shijiazhuang, and Dalian city, Jilin, Shaanxi, and Guangdong Province from June 2020

to January 2021. Using the keywords “nosocomial infection”, “COVID-19 variant”, “SARS-CoV-2”, “B1.617.2 (Delta) lineage”, and Boolean operator ‘AND’, we periodically searched the published medical literature using the PubMed service maintained by the U.S. National Library of Medicine of NIH. Confirmed COVID-19 cases are defined as persons who tested positive for SARS-CoV-2 and had clinical symptoms. Asymptomatic carriers refer to persons without clinical symptoms who tested positive for SARS-CoV-2.

Results

Regional distribution of nosocomial COVID-19 infections from June 2020 to June 2021

From June 2020 to June 2021, regional distribution of the sporadic nosocomial COVID-19 infections is shown in Figure 1, 2 and Table 1. Most of these cities are located in coastal or airline hub areas, for example, Dalian, Qingdao, Shanghai are coastal cities, and Xi’an, Shenyang, Shijiazhuang, and Guangzhou are airline hub cities.

Occupational distribution of nosocomial COVID-19 infections from June 2020 to June 2021

From June 2020 to June 2021, six cities in China had reported over 45 cases with nosocomial COVID-19 infections, including 39 confirmed cases and 6 asymptomatic cases (Table 2). Among them, nursing staff (3), doctors (6), patients (12), accompanying staff (22), and laboratorian (2) were diagnosed. The route of these nosocomial infections mainly included workplace accidental exposure to COVID-19, cross infection among healthcare workers, patients, and accompanying staff.

SARS-CoV-2 gene sequencing results of nosocomial COVID-19 infections from June 2020 to June 2021

SARS-CoV-2 gene sequencing is crucial work for nosocomial COVID-19 infections in new sporadic outbreak regions. The virus strain of nosocomial COVID-19 infection found in Qingdao city is the virus strain lineage B.1.1 imported from overseas (Table 2). Gene sequencing results showed that the coronavirus found in Dalian, Shenyang, and Shijiazhuang cities is similar to the strain imported from Europe; The virus strain found in Xi’an city is a COVID-19 variant B.1.1.7 lineage; SARS-CoV-2 strain found in Guangzhou city is the imported virus strain B1.617.2 (Delta) lineage (Table 2).

A report from Fang et al[9] showed that the strains associated with specific outbreak in Dalian City were as follows: LNDL-BHQ-0722-Y_S12_L001_R1_001, LNDL-SFL-0722-Y_S9_L001_R1_001, LNDL-WY-0722-Y_S11_L001_R1_001, and LNDL-XY-0722-Y_S10_L001_R1_001; The parent strain from Wuhan was NC_045512.2_Severe_acute_respiratory_syndrome_coronavirus_2_isolate_Wuhan-Hu-1_complete_genome. After accessing the public database GISAID and GenBank, 3 Russian strains detected in July were found to share the 10 variation sites with the 2 Hebei strains (GISAID IDs: EPI_ISL_596266, EPI_ISL_569792, and EPI_ISL_569793)[10]. Evidence indicates that these the Shijiazhuang strains may have originated from these Russian strains[10].

Discussion

This paper provides us with an inspiring vision regarding the current COVID-19 pandemic. The main findings of sporadic nosocomial COVID-19 infections from June 2020 to June 2021 are listed below: (1) the importance of rolling out an overall nucleic acid test campaign to all staff in healthcare

settings, is a crucial part of the COVID-19 surveillance; (2) The case of coronavirus transported onto the workplace warns us that the current hospital disinfection concept urgently requires updating, especially in designated hospitals, and there is an urgent demand of the management of staff accompanying patients in non-designated hospitals ; (3) The phenomenon about COVID-19 vaccine breakthrough infection deserves our great attention.

For healthcare workers, patients/accompanying staff, and cleaner, their COVID-19 infection may be from hospital (hospital-acquired infection, also nosocomial infection) or community (community-acquired infection). Distinguishing nosocomial infection and community-acquired infection is an important base to control the epidemic in nosocomial COVID-19 infections. Because healthcare workers are at the interface between hospitals and the community, where there is significant COVID-19 transmission, they may be infected by asymptomatic carriers from the community with COVID-19 or COVID-19 patients. These healthcare workers (infected in the community) do not belong to nosocomial infection (also called hospital-acquired infection). For example, in Figure 1, the infected cases (including healthcare workers, cleaner, etc.) in Beijing, Dalian (27 Dec. 2020) and Shanghai were community-acquired infection, not nosocomial infection. For nosocomial infection of healthcare workers, patients/accompanying staff, and cleaner, as the effective control measures taken by the local government must include: (1) these hospitals imposed lockdown, especially in the designated COVID-19 hospital; (2) rolling out an overall nucleic acid test campaign to all staff is key in healthcare settings.

Among 9 sporadic nosocomial COVID-19 infections, our results showed that 8 series cases were found by rolling out overall a nucleic acid test campaign to all hospital staff, suggesting the importance of regular screening for all staff in healthcare settings. As part of efforts to control the COVID-19 infections, one of the effective prevention measures taken by local authorities is that all hospital personnel labeled a key population are closely monitored[7]. Whether the epidemic in nosocomial COVID-19 infections can be brought under control depends on how many new infections emerge of their close contacts and secondary close contacts in the next two weeks. If these hospitals imposed lockdown as the effective control measures taken by the local government, then ideally, new confirmed cases with COVID-19 infections will see a downward trend within two weeks. Cases such as hospital-acquired infection in the designated hospital of Qingdao city are a warning that workplace storage and transport could be a hotbed for the coronavirus, or other pathogens. There is an urgent demand for workplace disinfection to protect the health safety of medical staff, patients, and accompanying staff in the current pandemic or into another worse outbreak.

Our data also showed that a vaccinated healthcare professional who received inactivated vaccine was infected with COVID-19 while working in the isolation ward of a designated COVID-19 hospital, and the coronavirus strain was determined to be the imported COVID-19 variant strain B.1.1.7[8], suggesting that there exists the domestic COVID-19 vaccine breakthrough infection in China, and this phenomenon deserves our serious attention. Vaccination is well-known to be key to stopping the virus from circulating and more variants from popping up[11-13]. The vaccine breakthrough infection case was defined as an individual with positive SARS-CoV-2 nucleic acid amplification tested after receiving at least one dose of a SARS-CoV-2 vaccine[14-16]. Jacobson et al[17] addressed post-vaccination SARS-CoV-2 infections and the incidence of the B.1.427/B.1.429

variant among healthcare personnel at a northern California academic medical center. Hacisuleyman et al[18] reported two women with vaccine breakthrough infection in a cohort of 417 persons who had received the second dose of BNT162b2 (Pfizer–BioNTech) or mRNA-1273 (Moderna) vaccine at least two weeks previously, and the viral sequencing showed that they were infected with the new variant virus including E484K in 1 woman and three mutations (T95I, del142–144, and D614G) in both. These observations revealed a potential risk of COVID infection with the variant virus after successful vaccination.

Vaccine breakthrough cases with SARS-CoV-2 were reported in many countries[19-21]. An analysis from Israel's vaccination campaign showed that COVID-19-related hospitalizations, severe disease, and death were reduced in infected cases with SARS-CoV-2 after vaccination, including symptomatic and asymptomatic infections[21]. Antonelli et al[22] identified risk factors for post-vaccination SARS-CoV-2 infection and describe the characteristics of post-vaccination illness, and found that Almost all symptoms were reported less frequently in infected vaccinated individuals than in infected unvaccinated individuals, and vaccinated participants were more likely to be completely asymptomatic, especially if they were 60 years or older. Our vaccine breakthrough case from Xi'an supported vaccine effectiveness and cautioned around relaxing physical distancing and other personal protective measures in the post-vaccination era.

SARS-CoV-2 virus delta variants have drawn worldwide attention. The WHO proposed three labels for global SARS-CoV-2 variants, including variant of concern (VOC), variant of interest (VOI), and variant under monitoring, to be used alongside the scientific nomenclature in communications about variants to the public[23]. The B.1.617 variant of the COVID-19 virus has been called a triple mutant variant since it splits into three lineages including the B.1.617.1 (Kappa) variant, the B.1.617.2 (Delta) variant, and the B.1.617.3 variant[24]. The delta COVID-19 variant, which was first detected in India in October 2020, had been reported in more than 80 countries on June 20, 2021[25]. The WHO declared the delta variant a "variant of concern" on May 10, 2021. In Mid-June 2021, the US Centers for Disease Control and Prevention upgraded its classification of the delta from a "variant of interest" to a "variant of concern."[26] Our results showed that two medical staff (1 laboratorian and 1 emergency doctor), infected with COVID-19 in the designated hospital, occurred due to workplace accidental exposure to COVID-19, and the coronavirus strain was determined to be the imported B.1.617.2 (Delta) variant.

To conclude, our findings add to the accumulating evidence regarding the importance of regular screening for all staff in healthcare settings. Furthermore, our study highlights the need for an update of the current hospital disinfection procedures in designated hospitals to prevent the nosocomial spread of SARS-CoV-2 infection. Finally, the epidemiological exposure of vaccinated medical staff should draw concern in order to minimize the impact of a new outbreak induced by virus mutants.

Table 1: Epidemiological characteristics of sporadic nosocomial COVID-19 infections

Date	City	Number of hospital/ cases	Hospital type	Profession	Classification of infection	Route of infection	Database
19 Jun. 2020	Beijing	1/1	Designated hospital	nurse	Community-acquired infection	family member exposure with COVID-19	Link 1

11 Oct. 2020	Qingdao	1/12	Designated hospital	Patients and accompanying staff	hospital-acquired infection	nosocomial infection	Link 2
29 Oct. 2020	Qingdao	1/1	Designated hospital	nurse	hospital-acquired infection	workplace accidental exposure to COVID-19	Link 3
18 Dec. 2020	Dalian	1/3	Non-designated hospital	Patients	hospital-acquired infection	nosocomial infection	Link 4
27 Dec. 2020	Dalian	1/1	Non-designated hospital	Cleaner	Community-acquired infection	cold-chain environment-to-human transmission	Link 5
3 Jan. 2021	Shenyang	1/12	Non-designated hospital	Medical staff, patients and accompanying staff	hospital-acquired infection	nosocomial infection	Link 6
14 Jan. 2021	Shijiazhuang	2/14	Non-designated hospital	Medical staff, patients and accompanying staff	hospital-acquired infection	nosocomial infection	Link 7
20 Jan. 2021	Shanghai	2/2	Non-designated hospital	Logistics support staff	Community-acquired infection	imported from overseas	Link 8
17 Mar. 2021	Xi'an	1/1	Designated hospital	laboratorian	hospital-acquired infection	Mild Breakthrough Infection	Link 9
14 Jun. 2021	Guangzhou	1/2	Designated hospital	Laboratorian and Emergency doctor	hospital-acquired infection	nosocomial infection	Link 10
27 Jul. 2021	Nanjing	1/4	Non-designated hospital	accompanying staff	hospital-acquired infection	nosocomial infection	Link 11
10 Aug. 2021	Yangzhou	1/3	Non-designated hospital	Doctor	hospital-acquired infection	nosocomial infection	Link 12

Designated hospital: a hospital designated for treatment of imported COVID-19 cases

Link 1: https://finance.sina.com.cn/china/gncj/2020-06-19/doc-iircuyvi9385332.shtml?r=9&tj=none&tr=9

Link 2: https://www.zhihu.com/question/425220159

Link 3: https://new.qq.com/omn/20201030/20201030A05GXU00.html

Link 4: http://www.xinhuanet.com/politics/2021-01/06/c_1126953634.htm

Link 5: https://new.qq.com/omn/20201229/20201229A0259M00.html

Link 6: https://new.qq.com/omn/20210111/20210111A0DFD500.html

Link 7: https://news.sina.com.cn/c/2021-01-20/doc-ikftpnnx9631142.shtml

Link 8: https://new.qq.com/omn/20210131/20210131A0071200.html

Link 9: https://news.sina.com.cn/c/2021-03-18/doc-ikkntiam4831560.shtml

Link 10: https://news.sina.com.cn/c/2021-06-14/doc-ikqcfnca0979774.shtml

Link 11: http://med.china.com.cn/content/pid/281087/tid/1026

Link 12: http://news.hexun.com/2021-08-18/204179459.html

Table 2: Epidemiological characteristics of sporadic nosocomial COVID-19 infections

Date	City	Confirmed/ asymptomatic cases	How to discover the source of infection	Virus type	Database
19 Jun. 2020	Beijing	1/0	Nucleic acid testing for close contacts of people with infection cases	One ancestral virus strain (XFDM strain) [27]	Link 1
11 Oct. 2020	Qingdao	6/6	Regular screening for medical staff	Imported virus strain Lineage B.1.1[28]	Link 2
29 Oct. 2020	Qingdao	1/0	Regular screening for medical staff	Imported virus strain Lineage B.1.1[28]	Link 3
18 Dec. 2020	Dalian	3/0	Regular screening for medical staff	European family branch 1 of the L genotype	Link 4
27 Dec. 2020	Dalian	1/0	Regular screening for medical staff	European family branch 1 of the L genotype	Link 5
3 Jan. 2021	Shenyang	12/0	Regular screening for medical staff	Imported virus strain	Link 6
14 Jan. 2021	Shijiazhuang	14/0	Regular screening for medical staff	the strain imported from Europe[29]	Link 7
20 Jan. 2021	Shanghai	2/0	Nucleic acid testing for close contacts of people with infection cases	Imported virus strain	Link 8
17 Mar. 2021	Xi'an	1/0	Regular screening for medical staff	Imported virus strain B.1.1.7[8]	Link 9
14 Jun. 2021	Guangzhou	2/0	Regular screening for medical staff	Imported virus strain B1.617.2 (Delta) Lineage	Link 10
27 Jul. 2021	Nanjing	4/0	Regular screening for medical staff	Imported virus strain B1.617.2 (Delta) Lineage	Link 11
10Aug. 2021	Yangzhou	3/0	Regular screening for medical staff	Imported virus strain B1.617.2 (Delta) Lineage	Link 12

Delta Lineage: the highly contagious Covid-19 variant first identified in India

Link 1: http://weekly.chinacdc.cn/en/article/doi/10.46234/ccdcw2020.246

Link 2: http://weekly.chinacdc.cn/en/article/doi/10.46234/ccdcw2020.224

Link 3: https://new.qq.com/omn/20201030/20201030A05GXU00.html

Link 4: http://www.xinhuanet.com/politics/2021-01/06/c_1126953634.htm

Link 5: https://new.qq.com/omn/20201229/20201229A0259M00.html

Link 6: https://new.qq.com/omn/20210111/20210111A0DFD500.html

Link 7: http://weekly.chinacdc.cn/en/article/doi/10.46234/ccdcw2021.006

Link 8: https://new.qq.com/omn/20210131/20210131A0071200.html

Link 9: http://weekly.chinacdc.cn/en/article/doi/10.46234/ccdcw2021.094

Link 10: https://news.sina.com.cn/c/2021-06-14/doc-ikqcfnca0979774.shtml

Link 11: http://med.china.com.cn/content/pid/281087/tid/1026

Link 12: http://news.hexun.com/2021-08-18/204179459.html

Authors contribution

All the authors contributed to the paper presented methodology and conceptualization. They all contributed to data analysis and paper writing.

Funding

This work is funded by the National Natural Science Foundation of China (81873467, 81670240, and 81271766).

Declaration of competing interest

The 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

References

1. Feng M, Li Z, Xiong J, Xu W and Xiang B. Geographical and Epidemiological Characteristics of 3,487 Confirmed Cases With COVID-19 Among Healthcare Workers in China. *Frontiers in Public Health*. 2021;8.

2. Xiang B, Li P, Yang X, Zhong S, Manyande A and Feng M. The impact of novel coronavirus SARS-CoV-2 among healthcare workers in hospitals: An aerial overview. *American Journal of Infection Control*. 2020;48:915-917.

3. Abbas M, Nunes TR, Martischang R, Zingg W, Iten A, Pittet D and Harbarth S. Nosocomial transmission and outbreaks of coronavirus disease 2019: the need to protect both patients and healthcare workers. *Antimicrobial Resistance and Infection Control*. 2021;10.

4. O'Leary N, Kingston L, Griffin A, Morrissey A-m, Noonan M, Kelly D, Doody O, Niranjan V, Gallagher A, O'Riordan C and Lynch A. COVID-19 healthcare policies in Ireland: A rapid review of the initial pandemic response. *Scandinavian Journal of Public Health*. 2021.

5. Ran L, Chen X, Wang Y, Wu W, Zhang L and Tan X. Risk Factors of Healthcare Workers With Coronavirus Disease 2019: A Retrospective Cohort Study in a Designated Hospital of Wuhan in China. *Clinical Infectious Diseases*. 2020;71:2218-2221.

6. Feng M, Ling Q, Xiong J, Manyande A, Xu W and Xiang B. Geographical and Epidemiological Characteristics of Sporadic Coronavirus Disease 2019 Outbreaks From June to December 2020 in China: An Overview of Environment-To-Human Transmission

Events. *Front Med*. 2021;8：654422.
7. Feng M, Ling Q, Xiong J, Manyande A, Xu W and Xiang B. Occupational Characteristics and Management Measures of Sporadic COVID-19 Outbreaks From June 2020 to January 2021 in China: The Importance of Tracking Down "Patient Zero". *Frontiers in Public Health*. 2021;9.
8. Outbreak Reports: Mild Breakthrough Infection in a Healthcare Professional Working in the Isolation Area of a Hospital Designated for Treating COVID-19 Patients — Shaanxi Province, China, March, 2021. China CDC Weekly. 2021, 3(19): 397-400. http://weekly.chinacdc.cn/en/article/doi/10.46234/ccdcw2021.094.
9. Fang FH, Song Y, Hao LP, Nie K and Sun XD. A Case of COVID-19 Detected in a Cargo Worker at Pudong Airport - Shanghai Municipality, China, November 8, 2020. *China Cdc Weekly*. 2020;2:910-911.
10. Qi S, Zhao X, Hao P, Liu N, Gao GF, Song Y, Xu W and Li Q. Two Reemergent Cases of COVID-19-Hebei Province, China, January 2, 2021. *China Cdc Weekly*. 2021;3:25-27.
11. Kashte S, Gulbake A, El-Amin Iii SF and Gupta A. COVID-19 vaccines: rapid development, implications, challenges and future prospects. *Hum Cell*. 2021.
12. Inchingolo AD, Inchingolo AM, Bordea IR, Malcangi G, Xhajanka E, Scarano A, Lorusso F, Farronato M, Tartaglia GM, Isacco CG, Marinelli G, D'Oria MT, Hazballa D, Santacroce L, Ballini A, Contaldo M, Inchingolo F and Dipalma G. SARS-CoV-2 Disease through Viral Genomic and Receptor Implications: An Overview of Diagnostic and Immunology Breakthroughs. *Microorganisms*. 2021;9.
13. van der Lubbe JEM, Huber SKR, Vijayan A, Dekking L, van Huizen E, Vreugdenhil J, Choi Y, Baert MRM, Feddes-de Boer K, Gil AI, van Heerden M, Dalebout TJ, Myeni SK, Kikkert M, Snijder EJ, de Waal L, Stittelaar KJ, Tolboom J, Serroyen J, Muchene L, van der Fits L, Rutten L, Langedijk JPM, Barouch DH, Schuitemaker H, Zahn RC and Wegmann F. Ad26.COV2.S protects Syrian hamsters against G614 spike variant SARS-CoV-2 and does not enhance respiratory disease. *npj Vaccines*. 2021;6:12.
14. Ioannou P, Karakonstantis S, Astrinaki E, Saplamidou S, Vitsaxaki E, Hamilos G, Sourvinos G and Kofteridis DP. Transmission of SARS-CoV-2 variant B.1.1.7 among vaccinated health care workers. *Infectious diseases (London, England)*. 2021:1-4.
15. Blachere NE, Hacisuleyman E and Darnell RB. Vaccine Breakthrough Infections with SARS-CoV-2 Variants REPLY. *New England Journal of Medicine*. 2021.
16. Kustin T, Harel N, Finkel U, Perchik S, Harari S, Tahor M, Caspi I, Levy R, Leshchinsky M, Ken Dror S, Bergerzon G, Gadban H, Gadban F, Eliassian E, Shimron O, Saleh L, Ben-Zvi H, Keren Taraday E, Amichay D, Ben-Dor A, Sagas D, Strauss M, Shemer Avni Y, Huppert A, Kepten E, Balicer RD, Netzer D, Ben-Shachar S and Stern A. Evidence for increased breakthrough rates of SARS-CoV-2 variants of concern in BNT162b2-mRNA-vaccinated individuals. *Nature Medicine*. 2021.
17. Jacobson KB, Pinsky BA, Rath MEM, Wang H, Miller JA, Skhiri M, Shepard J, Mathew R, Lee G, Bohman B, Parsonnet J and Holubar M. Post-vaccination SARS-CoV-2 infections and incidence of the B.1.427/B.1.429 variant among healthcare personnel at a northern California academic medical center. *medRxiv : the preprint server for health sciences*. 2021.
18. Hacisuleyman E, Hale C, Saito Y, Blachere NE, Bergh M, Conlon EG, Schaefer-

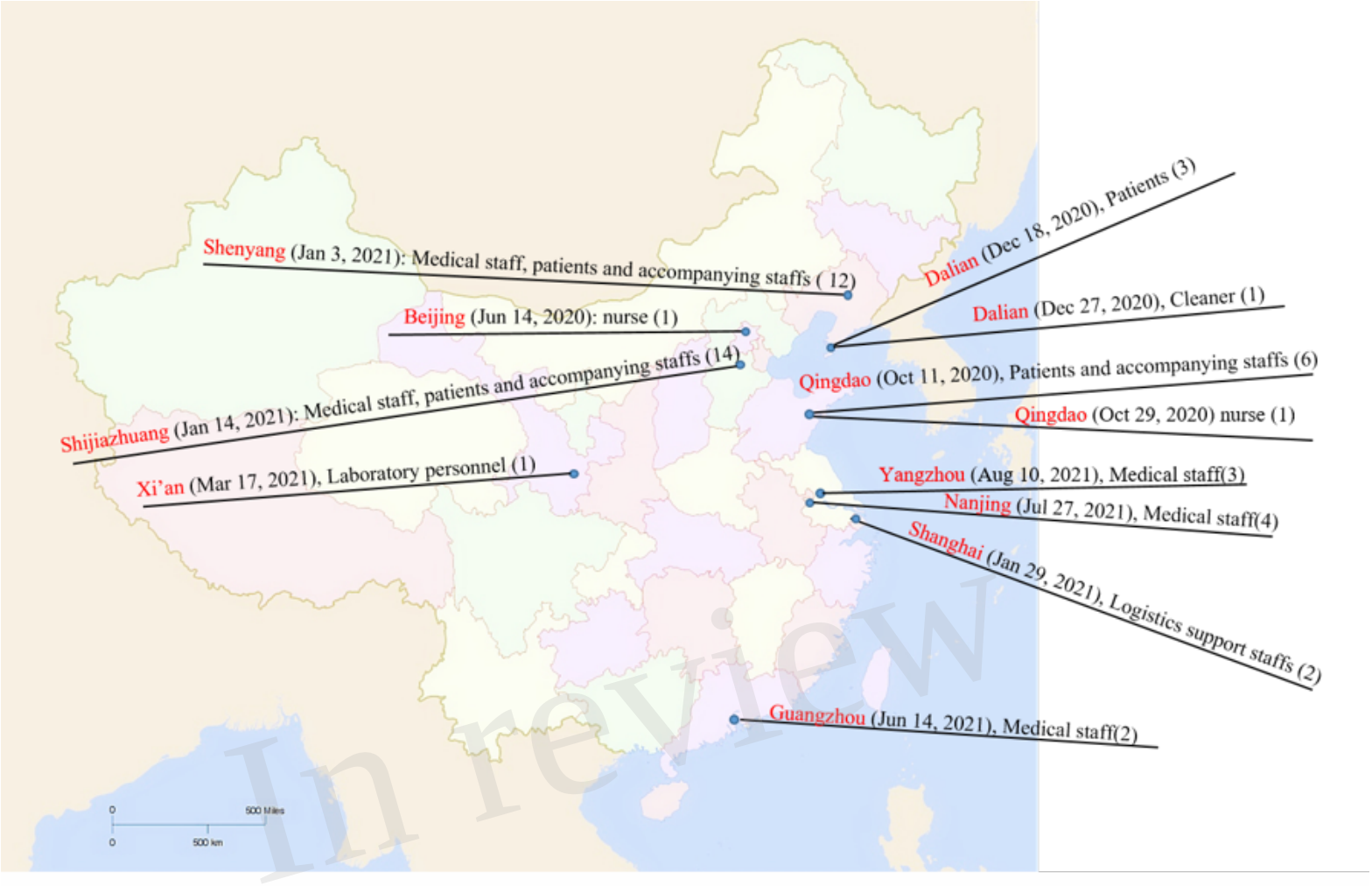
Babajew DJ, DaSilva J, Muecksch F, Gaebler C, Lifton R, Nussenzweig MC, Hatziioannou T, Bieniasz PD and Darnell RB. Vaccine Breakthrough Infections with SARS-CoV-2 Variants. *New England Journal of Medicine*. 2021;384:2212-2218.
19. Menni C, Klaser K, May A, Polidori L, Capdevila J, Louca P, Sudre CH, Nguyen LH, Drew DA, Merino J, Hu C, Selvachandran S, Antonelli M, Murray B, Canas LS, Molteni E, Graham MS, Modat M, Joshi AD, Mangino M, Hammers A, Goodman AL, Chan AT, Wolf J, Steves CJ, Valdes AM, Ourselin S and Spector TD. Vaccine side-effects and SARS-CoV-2 infection after vaccination in users of the COVID Symptom Study app in the UK: a prospective observational study. *Lancet Infectious Diseases*. 2021;21:939-949.
20. Bernal JL, Andrews N, Gower C, Robertson C, Stowe J, Tessier E, Simmons R, Cottrell S, Roberts R, O'Doherty M, Brown K, Cameron C, Stockton D, McMenamin J and Ramsay M. Effectiveness of the Pfizer-BioNTech and Oxford-AstraZeneca vaccines on covid-19 related symptoms, hospital admissions, and mortality in older adults in England: test negative case-control study. *BMJ-British Medical Journal*. 2021;373.
21. Haas EJ, Angulo FJ, McLaughlin JM, Anis E, Singer SR, Khan F, Brooks N, Smaja M, Mircus G, Pan K, Southern J, Swerdlow DL, Jodar L, Levy Y and Alroy-Preis S. Impact and effectiveness of mRNA BNT162b2 vaccine against SARS-CoV-2 infections and COVID-19 cases, hospitalisations, and deaths following a nationwide vaccination campaign in Israel: an observational study using national surveillance data. *Lancet*. 2021;397:1819-1829.
22. Antonelli M, Penfold RS, Merino J, Sudre CH, Molteni E, Berry S, Canas LS, Graham MS, Klaser K, Modat M, Murray B, Kerfoot E, Chen L, Deng J, Osterdahl MF, Cheetham NJ, Drew DA, Nguyen LH, Pujol JC, Hu C, Selvachandran S, Polidori L, May A, Wolf J, Chan AT, Hammers A, Duncan EL, Spector TD, Ourselin S and Steves CJ. Risk factors and disease profile of post-vaccination SARS-CoV-2 infection in UK users of the COVID Symptom Study app: a prospective, community-based, nested, case-control study. *The Lancet Infectious diseases*. 2021.
23. Hao Y, Guan XH, Liu TT, He ZG and Xiang HB. Hypothesis: the central medial amygdala may be implicated in sudden unexpected death in epilepsy by melanocortinergic-sympathetic signaling. *Epilepsy Behav*. 2014;41:30-2.
24. Liu TT, He ZG, Tian XB and Xiang HB. Neural mechanisms and potential treatment of epilepsy and its complications. *Am J Transl Res*. 2014;6:625-30.
25. Liu TT, He ZG, Tian XB, Liu C, Xiang HB and Zhang JG. Hypothesis: Astrocytes in the central medial amygdala may be implicated in sudden unexpected death in epilepsy by melanocortinergic signaling. *Epilepsy Behav*. 2015;42:41-3.
26. Xiang HB, Liu C, Liu TT and Xiong J. Central circuits regulating the sympathetic outflow to lumbar muscles in spinally transected mice by retrograde transsynaptic transport. *Int J Clin Exp Pathol*. 2014;7:2987-97.
27. Pang X, Ren L, Wu S, Ma W, Yang J, Di L, Li J, Xiao Y, Kang L, Du S, Du J, Wang J, Li G, Zhai S, Chen L, Zhou W, Lai S, Gao L, Pan Y, Wang Q, Li M, Wang J, Huang Y, Wang J, Grp C-FR and Grp C-LT. Cold-chain food contamination as the possible origin of COVID-19 resurgence in Beijing. *National Science Review*. 2020;7:1861-1864.
28. Liu P, Yang M, Zhao X, Guo Y, Wang L, Zhang J, Lei W, Han W, Jiang F, Liu WJ, Gao GF and Wu G. Cold-chain transportation in the frozen food industry may have

caused a recurrence of COVID-19 cases in destination: Successful isolation of SARS-CoV-2 virus from the imported frozen cod package surface. *Biosafety and health*. 2020;2:199-201.
29. Liu C, Liu TT, He ZG, Shu B and Xiang HB. Inhibition of itch-related responses by selectively ablated serotonergic signals at the rostral ventromedial medulla in mice. *Int J Clin Exp Pathol*. 2014;7:8917-21.

Figure 1: Geographical distribution of sporadic nosocomial COVID-19 infections from June 2020 to June 2021 in China. Seven cities (Dalian, Beijing, Qingdao, Shijiazhuang, Xi'an, Guangzhou, and Shanghai) reported the nosocomial COVID-19 infections. Medical staff, patients and accompanying staff (12) in Shenyang (Jan 3, 2021), patients (3) in Dalian (Dec 18, 2020), patients and accompanying staff (6) in Qingdao (Oct 11, 2020), laboratory personnel (1) in Xi'an (Mar 17, 2021), medical staff, patients and accompanying staff (14) in Shijiazhuang (Jan 14, 2021), and Medical staff (2) in Guangzhou (Jun 14, 2021) were diagnosed as infected cases.

Figure 2: The graph's left-right axis is used as a timeline of the key events and dynamic profile of sporadic nosocomial COVID-19 infections from June 2020 to June 2021 in China.
From June 2020 to June 2021, five cities in China had reported 10 series cases with nosocomial COVID-19 infections, including 39 confirmed cases and 6 asymptomatic cases.
The delta COVID-19 variant was first detected in India in October 2020. The World Health Organization designated Delta as a variant of interest in April and a variant of concern on 11 May 2021. In Mid-June 2021, the US Centers for Disease Control and Prevention upgraded its classification of delta from a "variant of interest" to a "variant of concern."

Figure 1.TIF



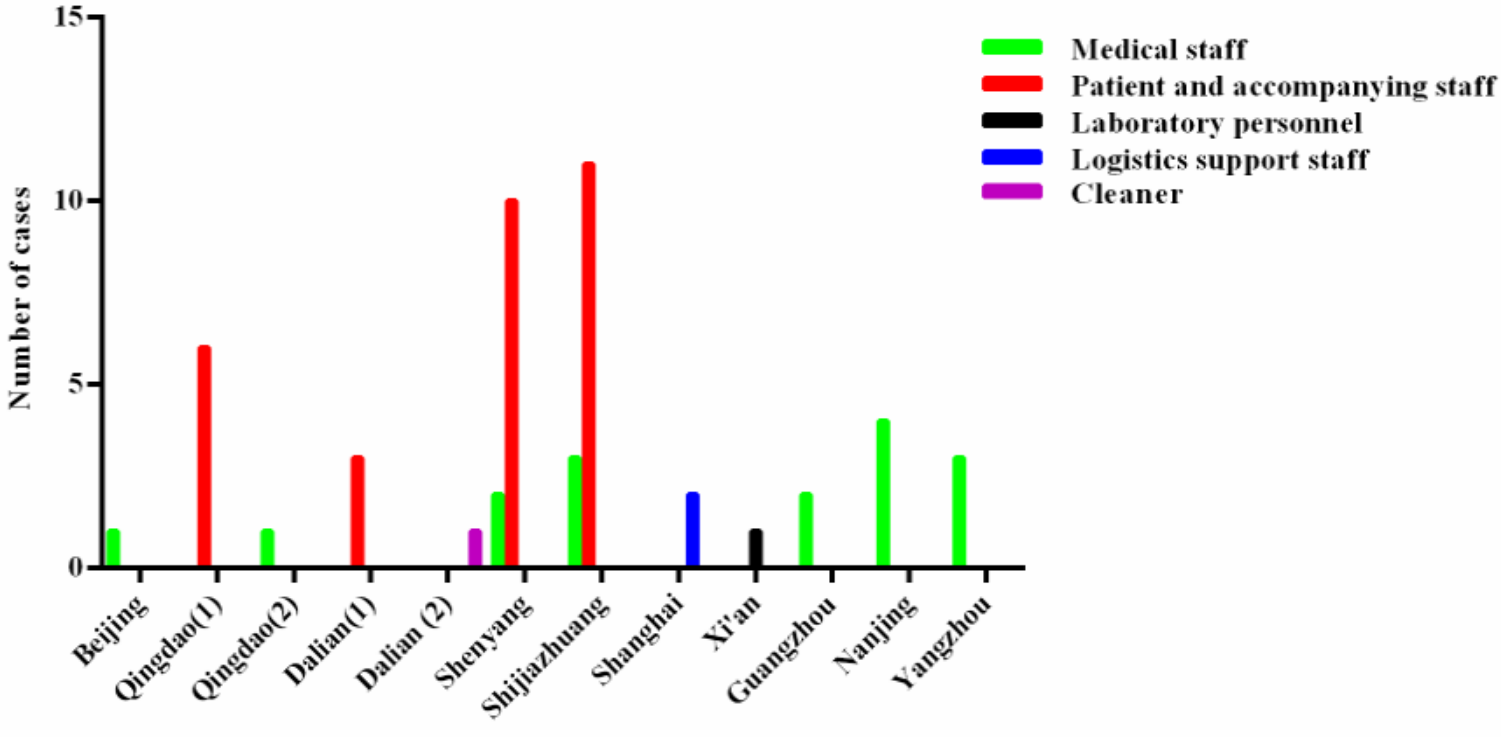


Figure 2.TIF