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All five COVID-19 outbreaks during epidemic period of 2020/2021 in China were instigated by asymptomatic or pre-symptomatic individuals

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ABSTRACT

Introduction: The significance of asymptomatic or pre-asymptomatic individuals in driving the COVID-19 epidemic in China or other countries remains uncertain.

Method: We collected and analyzed all the epidemiologic and virological diagnostic details of the infected individuals released by public health authorities and reiterated every episode of outbreak on a timeline. All individuals associated with the five outbreaks had tested positive for SARS-CoV-2 infection.

Results: In this study, all five COVID-19 outbreaks reported in China since October 2020 were analyzed. The Kashgar outbreak in Xinjiang province came into light for the first time on October 22, 2020. However, it was initiated before October 11, 2020, by a local asymptomatic import and export worker, who was infected at the working place. Subsequently, his wife caught the infection, which led to 430 more infections reported in the outbreak. The Beijing outbreak with 41 cases was noticed for the first time on December 22, 2020. However, our analysis revealed that it was initiated by an asymptomatic individual from Indonesia on December 10, 2020. The Shenyang outbreak, with 38 cases, noticed for the first time on December 23, 2020, was initiated by a pre-symptomatic individual from South Korea on December 13, 2020.

Conclusion: The asymptomatic or pre-symptomatic individuals during the asymptomatic period were unsuspectedly infected by SARS-CoV-2, and unintentionally transmitted the virus to a large number of people. These findings suggest that early detection of asymptomatic or pre-symptomatic individuals is of critical importance in preventing future outbreaks or epidemics.

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1. Introduction

The COVID-19 asymptomatic individuals are referred to as those individuals who assess positive for the SARS-CoV-2 infection via polymerase chain reaction (PCR) test but lack the clinical symptoms typical of the infection. As early as the beginning of the COVID-19 pandemic in 2020, asymptomatic individuals have been frequently noticed, who were unaware of their infection and thus unknowingly resulted in the transmission of the virus to other people. At the time it was perceived unfamiliar that the viral load in throat swabs of the patients could reach the highest peak at the time of or before the onset of symptoms. Thus, the patients began to be contagious even before the onset of symptoms. The first COVID-19 outbreak caused by an asymptomatic individual was noticed in Heilongjiang Province of China in March 2020, who had returned from an international trip, leading to over 71 infections. It has been reported that among all the SARS-CoV-2 positive international entrepreneurs who entered China in 2020, 51.9% were asymptomatic.

While asymptomatic transmission has been described as the “Achilles’ heel” of the COVID-19 pandemic: the significant role played by the asymptomatic individuals in driving the pandemic...
remains indiscernible and overlooked. Here, we report that all five COVID-19 outbreaks that occurred in China since October 2020 till date were initiated in asymptomatic individuals, indicating that the identification of asymptomatic individuals and prevention of asymptomatic transmission is the key to control the epidemic. Moreover, detection of asymptomatic individuals or the first few confirmed cases of infection transmitted by asymptomatic individuals in the early phase of the outbreak has been instrumental in the prevention of a large-scale epidemic.

2. Materials and methods

The confirmed COVID-19 cases were defined as individuals who tested positive for SARS-CoV-2 and had clinical symptoms. On the other hand, asymptomatic cases were classified as those individuals who tested positive for SARS-CoV-2 but were without any clinical symptoms. The pre-symptomatic cases were defined as individuals who reported no symptoms at the time of the initial positive test result but subsequently developed symptoms. We collected and analyzed epidemiologic data published in the newspaper and on the website of the Health Commission of Xinjiang, Liaoning, Hebei, Heilongjiang Provinces, and Beijing City, from October 2020 to February 2021 (Table S1 and Fig. S1).

3. Results

3.1. The SARS-CoV-2 outbreak in the Kashgar city of Xinjiang province was initiated by a local asymptomatic individual working in an import and export firm.

On October 22, 2020, active PCR screening for SARS-CoV-2 virus in individuals with possible high risk in Shufu County, Kashgar Prefecture, Xinjiang Province, had identified one individual as positive for the infection. However, the individual did not present any clinical symptoms, and was thus diagnosed as asymptomatic. On the following day (October 24, 2020) in the same county, an additional 137 individuals were found to be positive for SARS-CoV-2 infection, and none of them presented any clinical symptoms. Up to November 17, 2020, a total of 430 individuals tested positive for SARS-CoV-2 in the same geographical unit; of which, 352 (81.9%) were diagnosed as asymptomatic cases.

The epidemiological investigation revealed that the index patient was a stevedore who worked at Karasu Port bordering the Republic of Tajikistan. In addition, the container he worked at tested positive for SARS-CoV-2. The whole-genome sequences of the virus obtained from the contaminated container and patients were classified as lineage B.1.9, which has not been detected in China. The epidemiological investigation further revealed that the asymptomatic individual transmitted the virus to his wife by living together before October 11, 2020, who later tested positive for SARS-CoV-2 virus by PCR on November 2, 2020. His wife transmitted the virus to her mother and sister when they had dinner together on October 11, 2020. Her sister and mother tested positive for SARS-CoV-2 on October 25 and October 31, 2020. They worked for clothing factory A since October 12, 2020 when they were asymptomatic, leading to the infection of 190 of 251 employees, including 159 asymptomatic and 31 pre-symptomatic cases.

One patient in the clothing factory A visited the hospital during the period from October 20 to October 24, 2020, leading to asymptomatic infection of seven out of eight people who came in close contact. Seven asymptomatic individuals transmitted the virus to nine family members as a result of co-living. 75 asymptomatic individuals from clothing factory A shopped in a large farm market event held on October 18, 2020, leading to 18 asymptomatic and 2 pre-symptomatic cases. Five individuals, who were infected in the farm market, attended a wedding ceremony on October 23, 2020. This eventually resulted in the infection of 36 out of 265 attendees; all of which were found to be asymptomatic. Six family members were infected, including five asymptomatic individuals and a pre-asymptomatic patient (Fig. 1).

One individual from clothing factory B visited clothing factory A on October 17, 2020, who later tested positive for the virus on October 22, 2020. The infected individual then worked in clothing factory B since October 19, 2020, and led to the transmission of virus to 11 of 866 employees, including 10 asymptomatic and one per-asymptomatic individual. In short, the Kashgar outbreak was initiated by an asymptomatic individual, which later on spread to other individuals as a result of eating together, co-habitation, co-working, shopping at farmer’s market, attending weddings or social gatherings, and visiting the hospital during the asymptomatic period.

3.2. The SARS-CoV-2 outbreak in Beijing was initiated by an asymptomatic individual of Indonesian nationality

Epidemiological investigation reveals that the index asymptomatic patient from Indonesia arrived in Fujian Province of China on November 10, 2020. The patient initially tested negative for SARS-CoV-2 virus and arrived at Beijing on December 10, 2020 after completing 14 days of quarantine. The investigation further suggests that the index patient resulted in the initiation of Beijing outbreak with 40 infection cases starting from December 23, 2020, to January 16, 2021. These cases included 32 confirmed, 2 pre-asymptomatic, and 7 asymptomatic cases (Fig. 2).

After arriving in Beijing, the index patient transmitted the virus to his housemate, who had rented the same apartment. He transmitted the virus to a saleswoman when he went for shopping in a mall on December 13, 2020. The saleswoman then infected two individuals by visiting friends when she was asymptomatic (Dec. 20, 2020). These three infected individuals transmitted the virus to their family members as a result of co-living. During the asymptomatic period, these three individuals also transmitted the virus to eight individuals by eating together in a restaurant, and to five individuals through co-working, which included one asymptomatic and four confirmed cases. The saleswoman transmitted the virus to a taxi driver by taking a taxi during the asymptomatic period. The infected taxi driver then transmitted the virus to two additional taxi drivers by eating together. One of the infected taxi drivers infected two customers during the asymptomatic period. The family members of the two taxi customer were then infected as a result of co-living. The saleswoman shopped in a supermarket on December 20, 2020, when she was asymptomatic. A family with seven members was subsequently infected as a result of shopping with the saleswoman in the same supermarket on the same day, leading to an additional three cases (Fig. 2).

3.3. The SARS-CoV-2 outbreak in Shenyang city of Liaoning Province was initiated by a pre-symptomatic individual with a travel history associated with South Korea

The SARS-CoV-2 outbreak of Shenyang city lasted from December 23, 2020, to January 10, 2021, leading to 38 cases, which included 1 asymptomatic and 5 pre-symptomatic individuals. The index patient was an individual who had returned from South Korea on November 29, 2020, when she was asymptomatic. The epidemiological investigation had revealed that the index patient had tested negative for the virus after two weeks of quarantine. However, upon release form quarantine, the index patient infected two individuals as a result of co-living, two individuals by socializing, and 17 individuals by visiting hospitals during the period from
December 13 to 22, 2020. The infected individuals further transmitted the infection to 14 individuals by means of co-living, shopping, traveling via public transport, and visiting the hospital (Fig. 3).

3.4. The SARS-CoV-2 outbreak in Shijiazhuang city of Hebei province was initiated by an asymptomatic individual infected by the virus strain predominant in Russia

The SARS-CoV-2 outbreak of the Hebei province was initiated by an asymptomatic individual who contacted a businessman from Russia on December 15, 2020. Epidemiological and the virus genome sequence analysis show that the virus responsible for this outbreak of SARS-CoV-2 in Hebei province was endemic to Russia.

The asymptomatic individual transmitted the virus to his mother as a result of co-living. His mother was confirmed to be infected by SARS-CoV-2 on January 2, 2021. Meanwhile, she attended a wedding ceremony on December 28, 2020 and three social gatherings from December 25 to December 31, 2020, at the time when she was asymptomatic. The epidemiological investigation found that 20 were infected out of about 250 individuals who had attended the wedding ceremony, which included four pre-symptomatic individuals. It was also revealed that in about 50 individuals who has participated in the social meetings, 31 were infected which included 10 pre-symptomatic individuals. It is noteworthy that 200 individuals in the same village, where the index patient’s mother lived, were also infected by a still unidentified transmission mechanism and included 49 pre-symptomatic individuals.
Subsequently, through various social activities, such as visiting relatives, visiting friends, shopping at farmer-markets and supermarkets, drug-store shopping, co-working, and going to school; a total of 70 and 115 individuals were infected in Liujiazuo and Nanqiao villages respectively. Thus, these three villages became hot spots of the Shijiazhuang outbreak. A total of 211 confirmed cases have appeared in other villages in Gaocheng District, Xinle high-tech zone, Yuhua District, Luquan District, Qiaoxi District, Xinhua District, and Luancheng District. A total of four cities in Hebei Province (Shijiazhuang City, Xingtai City, Langfang City, and Dingzhou City) and 20 villages were infected. Furthermore, from January 2 to February 2, 2021, a total of 868 confirmed cases were reported in the Shijiazhuang outbreak, which is the capital city of Hebei Province (Fig. 4).

3.5. The SARS-CoV-2 outbreak of Heilongjiang Province was a result of inadvertent infection of individuals while visiting an infested city

The outbreak of Wangkui County in Heilongjiang Province was the source of additional outbreaks in the northeast region of China. As of February 10, 2021, 802 cases of the Wangkui outbreak were diagnosed, which included 367 (45.7%) asymptomatic individuals. The first case tested positive for SARS-CoV-2 as a result of visiting the hospital on January 9, 2021 was diagnosed as asymptomatic. The epidemiological investigation reported that the index patient was infected by a family member who had come into contact with an infected person from the city of Liaoning Province. Genome sequences from the Wangkui outbreak were identified as B.1.1, which had been identified in patients at Dalian City previously (Fig. 5).

Five individuals from Changchun City were inadvertently infected while visiting Wangkui County during the outbreak period and brought the virus back to Jilin province on Jan 5 and 6, 2021, when they were asymptomatic. All five asymptomatic individuals were confirmed to be positive for SARS-CoV-2 on January 10, 2021. The virus was further transmitted as a result of co-living, using same public transport such as the same train, and participating in indoor product promotion activities. In addition, another individual in Songyuan City was unknowingly infected by visiting Wangkui County and brought the virus back on January 9, 2021. The two outbreaks in Jilin province caused 434 cases, including 18 asymptomatic and 309 pre-symptomatic cases.

Four individuals in Qiqihar in Heilongjiang province were inadvertently infected by the virus when visiting Wangkui County and brought the virus back to Jilin Province from December 28, 2020, to January 5, 2021, when they were asymptomatic. These four asymptomatic individuals were confirmed to be positive for SARS-CoV-2 virus from January 12 to 16. The virus was then further transmitted due to co-living, socializing with friends, supermarket shopping, co-working, and coming in close contact. The Qiqihar outbreaks caused 32 infections, of which 31 were asymptomatic (Fig. 5).

4. Discussion

Surprisingly, all of the outbreaks reported so far in China during the 2020/2021 epidemic period were caused by asymptomatic or pre-symptomatic individuals. They were inadvertently infected and unknowingly resulted in the transmission of the virus to other people. It is clear that asymptomatic carriers can transmit the virus to others, and asymptomatic infections constitute a serious public health problem8. Further, it has been documented that many people with asymptomatic infections develop symptomatic infections at later stages9.

In our study, the asymptomatic infection rate in Kashgar was 81.9%, but the asymptomatic rate at the time of testing was higher at 99.8% due to some pre-asymptomatic individuals. The rate of asymptomatic cases at the time of testing in Heilongjiang Province was 65.3%, which was significantly higher than that in previous studies in China10. A total of 6,764 asymptomatic infections were reported across China as of April 14, 2020, which accounted for approximately 8% of all confirmed SARS-CoV-2 cases (approximately 83,000 cases)11. Some studies have reported intra-household transmission through shared dinners among asymptomatic infected individuals, but no community transmission has been detected12,13. Cases transmitted by pre-symptomatic patients...
have been reported in other countries, such as Germany\textsuperscript{14}, where the transmission occurred at a meeting, when the index patient was asymptomatic during the meeting, but eventually developed symptoms. Moreover, in Singapore\textsuperscript{15}, several cases of pre-symptomatic transmission have resulted in seven clusters. Under certain conditions, asymptomatic individuals can transmit the virus to a large numbers of other people\textsuperscript{4}. The highest level of SARS-CoV-2 shedding in the upper respiratory tract, especially among asymptomatic or pre-symptomatic individuals, has been noticed\textsuperscript{16,17}. However, the overall degree to which asymptomatic
transmission contributes to local COVID-19 epidemics likely varies in different contexts and has not been well studied.

It must be mentioned that asymptomatic individuals were unaware that they were infected and transmitted the virus to other individuals. Initially, an outbreak was initiated imperceptibly. However, the possibility cannot be denied that the asymptomatic cases that were detected may represent the tip of an epidemiological ‘iceberg’ which is composed primarily of asymptomatic carriers.

It is well known that early detection of the virus is critical for containment of the outbreak. If timely actions had been implemented, the outbreak could have been prevented or greatly reduced in size. However, the current outbreak detection strategy is symptom-based and subsequent testing of the virus. Our studies thus, proposes that massive testing or screening for viruses in high-risk populations can serve as an effective and economical strategy to prevent large outbreaks in future.

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.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jobb.2021.04.001.

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