

Outbreak Reports

A COVID-19 Outbreak Emerging in a Food Processing Company — Harbin City, Heilongjiang Province, China, January–February 2021

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Summary

What is already known about this topic?

The coronavirus disease 2019 (COVID-19) epidemic in China had been effectively controlled for several months, but as the ambient temperature dropped, large gathering-initiated epidemics occurred in northern China, including Hebei, Liaoning, and Jilin provinces.

What is added by this report?

A sudden epidemic emerged in Wangkui County, Suihua City, Heilongjiang Province, on January 9, 2021. An asymptotically-infected resident of Harbin City returned from Suihua and triggered a large-scale outbreak in the Zhengda Food Processing Company in Harbin, Heilongjiang. The epidemic was associated with widespread community transmission inside and outside the company, eventually leading to 260 persons being infected (87.8% of 296 patients in Harbin).

What are the implications for public health practice?

This study demonstrates the importance of screening for infections in the COVID-19 prevention and control system, shares experiences identifying and managing asymptomatic infections, and recommends food processing enterprises like the Zhengda Company to improve preventative measures. Our evidence-based epidemiological analyses provide methods for finding high-risk settings and evaluating epidemic situations when many asymptomatic patients are identified in a short period of time.

Evidence supports the notion that community outbreaks of coronavirus disease 2019 (COVID-19) follow temperature gradients in a way that is consistent with outbreaks of other seasonal respiratory viruses (1). With the seasonal decrease in ambient temperature and prior to initiation of the current COVID-19 vaccination campaign, large gathering-based epidemics occurred in northern China in Hebei, Liaoning, and

Jilin provinces (2–3). After 182 COVID-19 cases had been reported, the government of Harbin City, Heilongjiang Province, requested assistance investigating this outbreak and were assisted by the Joint Mechanism for COVID-19 Prevention and Control of the State Council on January 26, 2021, a working group that included China CDC professionals arrived in Harbin on January 27. China CDC and Harbin CDC jointly launched an epidemiological investigation and traced the outbreak. The joint investigation found that as of February 8, 2021, among the 296 known infected individuals, 292 (98.6%) were from Wangkui County, and the other 4 (1.4%), caused by the alpha variant of COVID-19, were from Daxing District, Beijing; 87.8% were associated with Zhengda Food Processing Company, a chicken processing facility, and 59.1% were asymptomatic but were able to be identified by various screening techniques (Figure 1). At the first sign of the epidemic, the local government had initiated their emergency measures, including containment, screening, and vaccination. After the joint epidemiological investigation, these measures were strengthened — isolation and quarantine, in particular, were utilized so that close contacts were isolated from their close contacts (secondary close contacts) for quarantine due to diverse infection risk and limited resources. These two different generations of contacts were quarantined in different hotels or in the same hotels with a partition between different contacts.

INVESTIGATION AND RESULTS

Based on the investigation of cases and fields, COVID-19 genome sequencing, and big data from mobile phone signals provided by the local public security bureau, a transmission chain was able to be elucidated. The chain started in Suihua City where Wangkui County was the epidemic center in

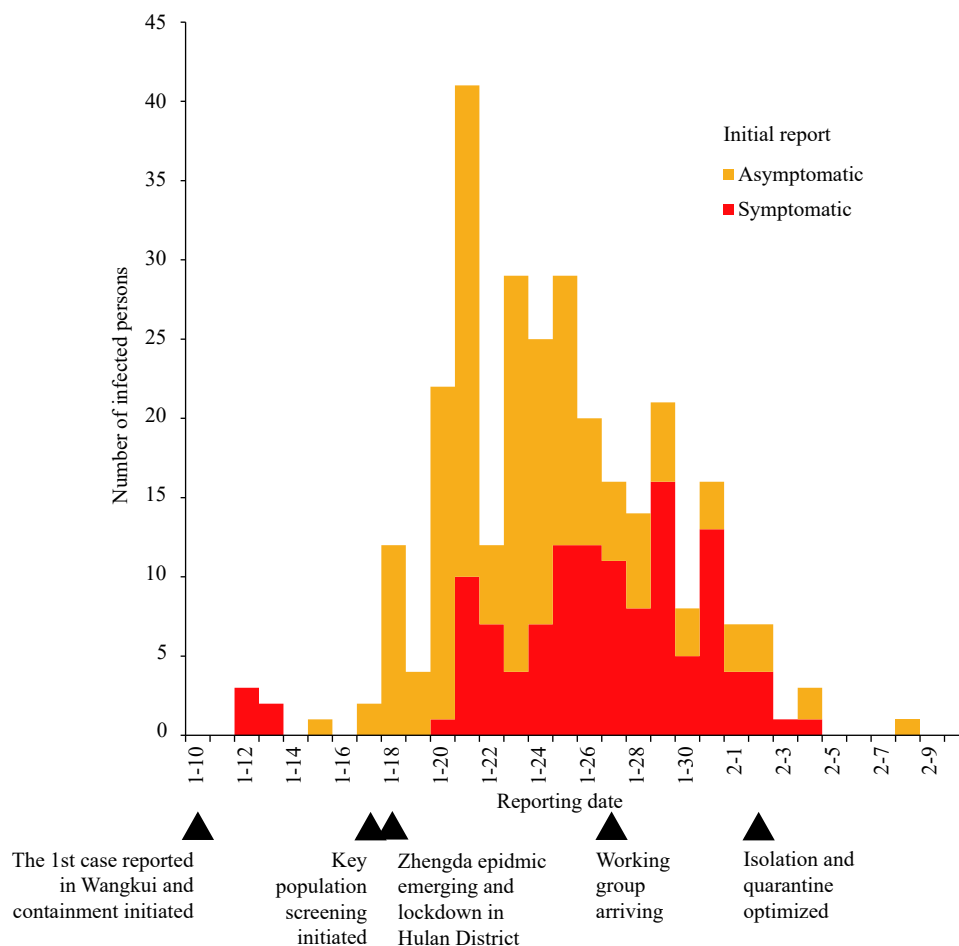


FIGURE 1. COVID-19 epidemic circumstances of infections in Harbin City, January–February, 2021.

Note: Classification of cases was based on the initial report. There were 296 cases identified from January 12 to February 8, among which 175 were initially asymptomatic, and of these, 25 developed eventually symptoms.

Heilongjiang Province since the end of 2020; Wangkui was locked down on January 11, 2021. The transmission chain led to communities in Harbin through Zhengda. In this article, we illustrate the chain hypothesized through two representative examples with available evidence — one example was from Suihua to Zhengda Company (Mr. A, B, and F working at this company) by Mr. A to Mr. B then to Mr. B's community; the second one was from Zhengda Company to individuals not related to the company by Mr. F.

Example One

In this example (Figure 2), the first-identified infected individual was asymptomatic, living in Mr. B's building that shared a common stairwell. This individual was diagnosed as infected through routine polymerase chain reaction (PCR) testing on January 16 when going to a hospital for unrelated treatment. On January 17, following a positive PCR report, all

residents in the building sharing a common stairwell were quarantined and screened with PCR; more cases were found through this screening. On January 18, the Zhengda-Company-based epidemic was identified by a screening program organized by the local government. Mr. A and Mr. B were key patients in the 2 outbreak areas (the company and the building) (Table 1).

Stage 1: Mr. A was infected in Suihua City between January 1 and 5

Mr. A tested positive on January 18 and was diagnosed with COVID-19 after becoming symptomatic on January 21. His wife had a slight cough before January 19 and tested positive on January 28; she had a history of traveling and living in Suihua during January 1 and 5 where she and her husband, Mr. A, attended a funeral for Mr. A's father-in-law. The couple may have had close contact with an asymptotically-infected individual for approximately 10 minutes at a station entrance outside of Wangkui County on January 5, 2021.

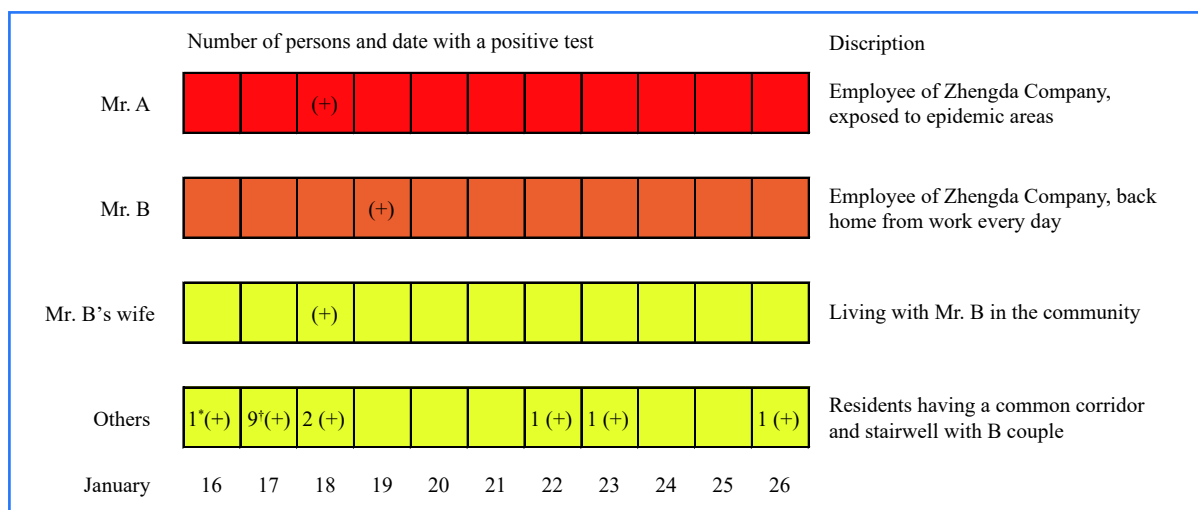


FIGURE 2. COVID-19 transmission relationships for Example One, Zhengda Company, Harbin City, January, 2021.

* Asymptomatic index case in this community who was found when seeing an orthopedic doctor on January 16 and who had been in Harbin City during this epidemic.

† Includes three symptomatic patients. The dates are of collecting positive samples.

Furthermore, as shown in Figure 1, most individuals infected before Mr. A was infected had an epidemiological history of being in Wangkui County; none were associated with the Zhengda Company. Other cases in Mr. A's community were found after January 21 and mostly were Zhengda employees, living in different buildings, with different job positions.

Finally, viral genome sequencing showed that Mr. A had been infected with a strain from Wangkui County, Suihua City. Positive IgG and IgM testing on January 29 provided evidence that infection likely occurred at the beginning of January.

Stage 2: Mr. A transmitted the virus to Zhengda Company employees between January 6 and 17

First, Mr. A returned from Suihua City on January 5 and went to work on the evening of January 6 in the Zhengda Company slaughterhouse. His and his colleagues' dressing room was in the clean area of the workshop and was about 7–8 square meters (m²) in size. The dressing room was not routinely disinfected; disposable work clothes were not used by staff. The dressing room was used for changing and resting by all employees working in this area. Our environmental sample identified COVID-19-positive areas in the men's room and outside the women's room. 70% (90/129) of the Zhengda employees infected had an association with the clean area of the workshop.

Second, Mr. A usually worked the night shift but occasionally worked the day shift during January 6–17. Infections were more common among night-shift workers than day-shift workers (48.3% vs. 8.2%,

$P < 0.001$). The night-shift exposure infection odds ratio (OR) was 10.51, with a confidence interval (CI) of 5.90–18.71. The attack rate among Mr. A's 10 material preparation team colleagues was 60.0%, compared with 45.8% for other night shift workers.

Finally, viral genome sequencing showed that Zhengda cases including Mr. A and Mr. B were highly homologous with the Wangkui strain.

Stage 3: Mr. B was infected in the men's dressing room or on a Zhengda commuter bus between January 7 and 17

First, Mr. B and Mr. A both worked in the clean area during January 7 and 17, and despite working on different shifts or locations, they used the same men's dressing room. There was a 77% increased risk of infection among men compared to risk among women (OR=1.77, 95% CI: 1.17–2.68; attack rate 17.1% vs. 10.4%, $P=0.006$). The OR of infection in the clean area compared with a dirty area that has its own dressing room was 3.68 (95% CI: 1.33–10.20).

Second, Mr. B took the commuter bus to and from work at 05:40 and 17:30 every day. Mr. B stated that he heard people coughing on the bus around January 14. A survey showed that the attack rate among bus line passengers was 9.5%, similar to the 8.2% attack rate at the clean work area during day shifts ($P=0.859$). Another possible exposure location for Mr. B was the staff dining hall, but comparable data are not available.

Stage 4: Mr. B infected others in his community between January 7 and 17

First, no individuals in Mr. B's community in

TABLE 1. Comparisons of the first example transmission chain in the COVID-19 outbreak in Harbin City, Heilongjiang Province, China, January 2021.

Groups per links in the transmission chain	Number of persons		Total*
	Infected	Not infected	
Mr. A to Zhengda Company			
Shifts in Mr. A's workshop			
Night shift (Mr. A's shift)	28	30	58
Day shift (non-Mr. A's shift)	62	698	760
OR (95% CI)	-	-	10.51 (5.90–18.71)
Night shift in the clean work area			
Mr. A's team (material preparation)	6	4	10
Non-Mr. A's team (packing and cleaning)	22	26	48
OR (95% CI)	-	-	1.77 (0.44–7.09)
Zhengda Company to Mr. B			
(Mr. A and Mr. B said that they had to change clothes before entering the workshop every time and they did not know each other due to working in different shift)			
Work areas in Mr. A's workshop			
Clean area (Mr. A's)	90	728	818
Dirty area (not Mr. A's)	4	119	123
OR (95% CI)	-	-	3.68 (1.33–10.20)
Dressing room in the clean area			
Men's room (multiple indoor environmental samples positive)	49	237	286
Women's room (one outdoor environmental sample positive)	57	489	546
OR (95% CI)	-	-	1.77 (1.17–2.68)
Mr. B to his community			
Possible exposure sites			
Commuter car (non-Mr. A's)	8	76	84
Clean work area at the day shift	62	698	760
OR (95% CI)	-	-	1.19 (0.55–2.57)
Residents sharing the common corridor and stairwell with Mr. B			
Go out often	10	5	15
Stay at home occasionally; go out occasionally or never go out	5	19	24
OR (95% CI)	-	-	7.60 (1.77–32.63)

*: Numbers of exposed persons were obtained by asking for Zhengda Company and checking name lists in duty rosters. Odds ratios (ORs) with 95% confidence intervals (CIs) were based on a chi-square test.

Hulan District of Harbin had ever been to a COVID-19 high-risk area, and no individuals from Suihua entered the community within the previous month. Mr. B commuted between home and Zhengda every day.

Second, Mr. B's wife tested PCR positive on January 18, with a strain shown to be the Wangkui strain. She was infected despite being vaccinated (two HB02 vaccines, provided by Beijing Institute of Biological Products Co, Ltd, about one month before infection) and paying great attention to personal protection for occupational reasons. This observation supports an

intrafamily infection from Mr. B to his wife.

Finally, the common corridor was usually closed, and its door handle tested negative for COVID-19.

Stage 5: Virus spread in Mr. B's building between January 7 and 17

First, there were no cases other than families using the common stairwell among the families of this building or this community. Of total of 15 infected individuals, 13 had a history of going out; 1 individual, who never went out, lived with his mother who was infected; and the last individual had 4 infected neighbors living in different houses on the same floor.

Second, a supplementary investigation conducted on February 1 among 39 residents, excluding a couple including Mr. B, sharing the common stairwell showed that the attack rate of people who often went out was higher than the attack rate among people who did not often go out (66.7% vs. 20.8%; OR=7.60, 95% CI: 1.77–32.63; $P=0.005$).

Example Two

In this example, none of the persons infected had a history of travel outside of Harbin during the outbreak, but social activities outside Zhengda resulted in new infections that were not among Zhengda employees or their relatives (Figure 3).

Stage 1: Mr. F was infected in Zhengda between January 6 and 17

First, Zhengda employee Mr. F experienced cough, headache, sore throat, and a runny nose; he self-medicated on January 15 and tested positive on January 20; he was diagnosed with COVID-19 pneumonia on January 22. Mr. F worked the night-shift in the clean area from January 6 to 17. His frequent use of the men’s dressing room and night-shift work placed him at high-risk of infection.

Second, Mr. F was a close contact of his mother suffering COVID-19 pneumonia, who had been diagnosed on January 21; she was a Zhengda employee on the same team as Mr. F, working the same shift.

Stage 2: Mr. G was infected by Mr. F on January 15

First, on the evening of January 15, the date that Mr. F developed symptoms and was likely most infectious, Mr. F took a bus (defined as a closed space) with Mr. G after work for 7 stops (Hulan District Government to Zhengda). A surveillance system on the vehicle showed that Mr. G was sitting in front of the lower door while Mr. F passed by, stood at the lower door, pulled down his mask, and shouted towards the

front.

Second, on the evening of January 21, Mr. G tested positive, and a virus isolated from his throat swab had a genetic sequence identical to Mr. F’s virus sequence — the Wangkui strain that showed Mr. G’s infection was later than Mr. F.

Stage 3: Ms. H was infected by Mr. G on January 20

First, Mr. G was a bank security guard; at 10:24 on January 20, Mr. G opened a door and scanned a QR code for Ms. H, a customer of the bank, who tested positive test with a confirmed diagnosis on January 25.

Second, the viral genome sequencing showed the virus isolated from Mr. G and the virus isolated from Ms. H were Wangkui-strain viruses with identical mutation sites (C24621T).

DISCUSSION

A major challenge COVID-19 prevention and control is the detection of asymptomatic infections and infections having long incubation periods. This challenge can be overcome by early and timely screening with PCR. In this outbreak, the first person known to be infected was asymptomatic and was identified in a clinic focusing on non-infectious diseases on January 16. The infected person had neither contact with the Zhengda Company nor travel to high-risk areas outside Harbin. Identification of an asymptomatic index case contrasts with initial diagnoses in other outbreaks, such as the Huanan Seafood Wholesale Market in Wuhan and the Xinfadi Wholesale Market in Beijing (4–5), in which the index cases were symptomatic and were found by infectious diseases clinics. The 12 days of silent transmission were interrupted by key population screening, resulting in identification of many infections with unclear transmission patterns and quarantine of Zhengda

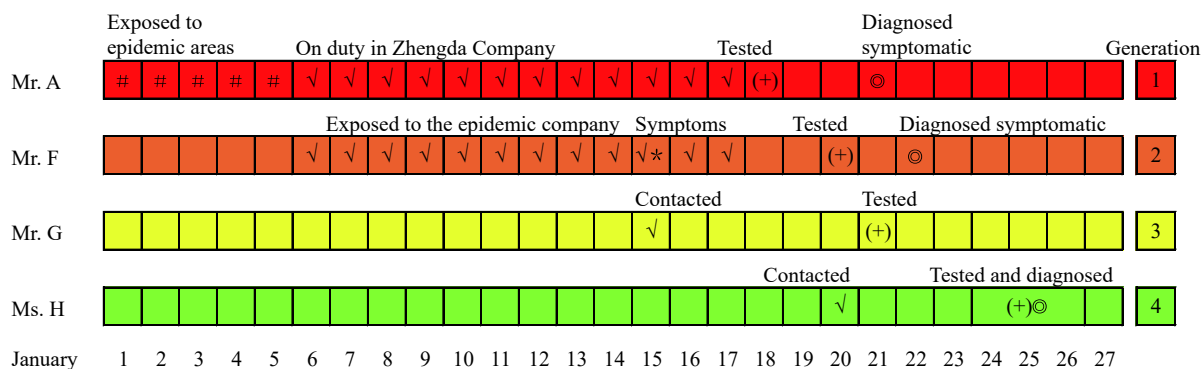


FIGURE 3. COVID-19 transmission chain generations for Example Two, in Harbin City, January, 2021.

employees. Despite the identification of initial cases, at least 3 generations of secondary cases occurred in the company, in residential areas, and in other companies. Respiratory droplets or contaminated air in confined spaces, such as dressing rooms, dining halls, resident corridors, and vehicles, played an important role in the chain of infection.

Food processing companies like Zhengda usually have “clean” areas that can provide an environment suitable for COVID-19 transmission. Our study showed that some measures, such as actively reporting to one’s own community a history of having returned from an epidemic area, key-population screening, symptom reporting and monitoring, ventilation of confined spaces, regular disinfection of indoor environments and coveralls in dressing rooms, and good personal protection habits, can slow the epidemic spread.

Among the earliest cases in the company, a night shift worker in the clean area developed his first symptoms on January 13, preceding the January 16 diagnosis in which the asymptomatic index case was found. Residents sharing a common stairwell with the index case were quarantined and tested; they did not have a history of contact in Zhengda. This means that it is unlikely to have been backpropagation. We searched but did not find evidence of infection to humans from chickens, including live chickens and chicken products. In the most important transmission settings — the men’s dressing room and adjacent corridor, the transmission mode appeared to be from the human respiratory system. This suggests that it is more important to guard against person-to-person infection than infection from fomites.

China CDC developed a method for analyzing generations of infection, as shown in [Figure 3 \(6\)](#). Our evidence-based examples supplemented standard epidemiological methods for finding high-risk areas and evaluating epidemic situations ([Table 1](#)). The method was comparable to John Snow’s investigation of the cholera epidemic in London in the mid-19th century. When transmission links are uncertain, for example after identifying many unrelated cases following wide-scale population screening with PCR, this method is useful. Nevertheless, analysis depending on accurate and detailed investigations usually lags behind an outbreak, and onsite fast disposal following field investigations are vital.

This study was subject to some limitations. The investigation was conducted under a state of emergency, with a priority for first controlling the

epidemic. Some data, such as on dining hall contacts, could not be fully collected. Within Zhengda, the transmission relationship was complex (e.g., from person to person or from environment to person), making it difficult to judge the transmission of intergenerational relationships. We obtained little information on vaccine effectiveness, even though the local government prioritised vaccinating key populations, including medical staff and cold chain practitioners. Our study was conducted in the middle and late stages of the epidemic. An earlier, rapid but imperfect epidemiological investigation, nevertheless, may be superior to a later but more thorough investigation for controlling the epidemic.

In conclusion, the Zhengda epidemic was quickly contained within three weeks of its discovery, showing the effectiveness of China’s precision containment strategy. However, the COVID-19 prevention and control can be improved, for example by strengthening supervision and management of food-processing and cold-chain storage companies, outpatient services, and confined spaces. Our experience and findings will be useful next winter, and our quarantine practices for close contacts and their close contacts should be implemented with standardized guidelines for COVID-19 prevention and control.

Conflicts of interest: No conflicts of interest.

Acknowledgments: Songbei Center for Disease Control and Prevention, Hulan Center for Disease Control and Prevention, Harbin Bureau of Public Security, Hulan Sub-Bureau of Public Security, Songbei Sub-Bureau of Public Security, and Harbin Medical University; Harbin people, including patients surveyed, medical staff, governmental staff, and all persons that supported our work and helped us; Miss Yumeng Wang.

doi: [10.46234/ccdcw2021.153](https://doi.org/10.46234/ccdcw2021.153)

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Submitted: May 23, 2021; Accepted: June 04, 2021

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