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Coronavirus Pandemic

COVID-19 outbreak prevention by early containment in Shantou, China

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Abstract

Introduction: To report about the successful outbreak containment of COVID-19 in Shantou, one of the prefectural cities of Guangdong province in the mainland China.

Methodology: All patients confirmed as having COVID-19 between 23 January and 25 March 2020 by RT-PCR assay in the clinical lab of Shantou CDC were included and divided into three groups based on the source of identification: hospital diagnosis, contact tracing, and community screening. Collected data was analyzed and compared among these three groups.

Results: A total of 25 COVID-19 cases were identified in Shantou. The first case was identified on 14 January 2020 at one of two COVID-19 dedicated hospitals in Shantou. The majority of the cases were either imported from Wuhan or linked to Wuhan/Hubei. The median lag time for diagnosis (i.e., the time between symptom onset and case confirmation) was 2 days (IQR, 2.0-4.0) for all cases, 9 days (IQR, 7.0-10.0) for the cases diagnosed in hospitals, 2 days (IQR, 1.5-2.0) for the cases in contact tracing, and 4 days (IQR, 2.5-4.5) for cases in community screening, with a significantly longer diagnosis lag time in hospitals ($p = 0.003$). Multivariate linear regression models showed larger family size and severe cases as the significant predictor for increasing number of close contacts.

Conclusions: The current pandemic appears to exist for an uncertain period. The early containment measures applied in Shantou, a city with insufficient healthcare resources for COVID-19, seems to be appropriate for cities or areas with similar profiles.

Key words: COVID-19; SARS-Cov-2; interventive measures; prevention and control.

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Introduction

The ongoing pandemic coronavirus disease 2019 (COVID-19) has caused 15,012,731 infections and 619,150 deaths as of Dec, 2019 in 216 countries and territories in the world [1]. The healthcare systems in the affected countries are overstretching their capacities to meet unprecedented needs. The fatality rate of COVID-19 correlates with the infrastructure and preparedness of the healthcare system concerned [2, 3].

It is no doubt about the importance of the early interventions during this outbreak, especially many of the world's health systems and services are fragile [2]. Although WHO recommends a combination of measures: rapid diagnosis, immediate isolation of cases, rigorous tracking, and precautionary self-isolation of close contacts [4], it would be difficult to implement these measures in different settings. Therefore, studies sharing successful containments of COVID-19 outbreak in cities, areas, or countries with the international community are needed for the regions still fighting against the outbreak.

This study aimed to report about the successful outbreak containment of COVID-19 in Shantou—one of the prefectural cities of Guangdong province in the mainland China. Equivalent to an international first-class city [5], Shantou had a population of 5.7 million as of 2019 [6]. There were 52 hospitals (16872 beds) and 33 health centers (1713 beds) in 2019, but only three tertiary general hospitals are eligible for critical care of severe COVID-19 cases [6].

Methodology

Study design

An observational study with Shantou Center for Disease Control and Prevention (CDC) databases on COVID-19 cases in Shantou.

Ethics statement

This study was approved by the Ethic Committees of Shantou CDC.

Study population

All patients confirmed to have COVID-19 by RT-PCR assay in Shantou city between 23 January and 25 March 2020 were included in the study. Data including demographics, case classification, dates of disease onset and diagnosis were collected.

Epidemiological Definitions

Following the guideline of diagnosis and treatment of COVID-19 (version 7) [7], a confirmed case was defined as a suspicious case having a relevant epidemiological history and clinical manifestations positive for SARS-Cov-2 in the respiratory specimens by RT-PCR assay. A close contact was defined as someone who has been in the same closed space with a suspicious or confirmed case. Two or more cases in one family with fever and/or respiratory symptoms within 14 days were considered a family cluster as defined in the guideline of prevention of COVID-19 (version 6) [8].

Case Classification

Confirmed COVID-19 cases were divided into three groups based on the source of identification: 1) hospital diagnosis - people who made a voluntary visit to healthcare centers for suspected symptoms and then became COVID-19 test positive; 2) contact tracing - those who had a contact with a confirmed case and became COVID-19 test positive during 14-day quarantine or isolation; 3) community screening - those who were identified as suspected and tested positive for COVID-19 on screening by local community surveillance program.

Data analysis

Collected data was recorded by Microsoft Excel 2016 and analyzed by R (Version 3.5.3). Continuous variables, such as age and duration between symptoms onset and case confirmation, were analyzed by Kruskal-Wallis test. Categorical variables, such as gender, occupation or social status, location, disease severity, exposure history, identification approaches, and case identification based on New Year Festival were analyzed by Chi-square test. Linear regression model was used to identify predictors of close contacts. All statistical tests were two-tailed, and p-value <0.05 was considered statistically significant.

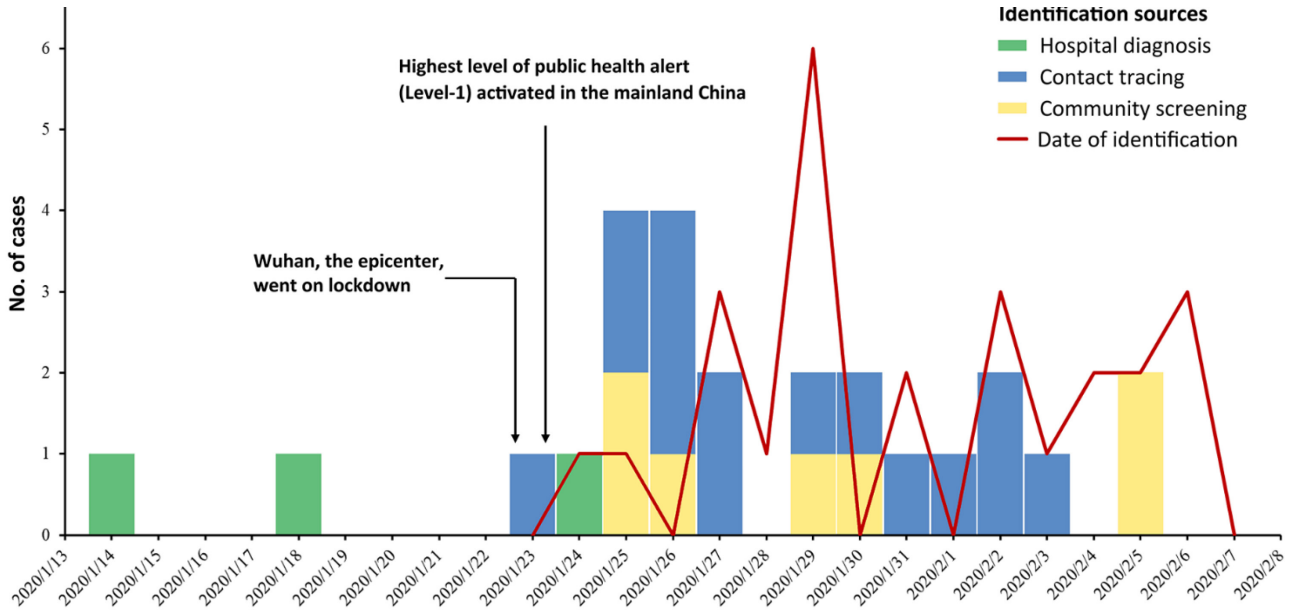
Results

A total of 25 COVID-19 cases were identified in Shantou. The first case was identified on the 14 January 2020 at one of two COVID-19 dedicated hospitals in Shantou. The majority of cases (92.0%) were diagnosed over a 2-week period between 23rd Jan and 5th Feb 2020 (Figure 1).

Socio-demographic characteristics

A total of 25 COVID-19 cases were reported to Shantou CDC between 23 January and 30 March 2020, with 21 cases as mild, 3 cases as severe, and 1 case as

Figure 1. Time distribution of COVID-19 confirmed cases in Shantou.



very severe. Male and female ratio was 1.08:1 (13:12). More than 55% of cases (13/25) were housewife/househusband or jobless and 32% (8/25) of them were businessmen. No healthcare personnel were included (Table 1).

The majority of the cases were either imported from Wuhan or linked to Wuhan/Hubei; 19 cases were Wuhan residents and 5 cases were visitors to Wuhan at the time of outbreak. One case had a history of contact with a COVID-19 case in Xiamen/Fujian. Case identification history showed 12% from hospital diagnosis, 60% from household contact tracing, and 28% from community screening. More than half of the cases (60%, 16/25) were identified during Jan 21 to Jan 30, 2020 (i.e., during the Chinese New Year Festival).

Diagnosis Lag Time

The median lag time for diagnosis (i.e., the time between symptom onset and case confirmation) was 2 days (IQR, 2.0-4.0) for all cases, 9 days (IQR, 7.0-10.0) for the cases diagnosed in hospitals, 2 days (IQR, 1.5-2.0) for the cases in contact tracing, and 4 days (IQR, 3.0-5.0) for cases in community screening, with a significantly longer diagnosis lag time in hospitals (p = 0.003) (Figure 2a).

The number of close contacts per index case

Measures of rigorous close contact tracing was implemented after identification of the first case. The number of close contacts per an index case ranged between 0 and 21, with the median number of 2 (IQR,

Table 1. Characteristics of confirmed cases of COVID-19 in Shantou city, China (N=25).

Characteristics	Total	Identification sources		
		Hospital diagnosis (N = 3)	Contact tracing (N = 15)	Community screening (N = 7)
Age (year)	35 (31-47)	58 (43-63)	35 (31-38)	32 (30-50)
Age groups				
≤ 29	6 (24.0)	1 (33.3)	3 (20.0)	2 (28.6)
30-39	11 (44.0)	0 (0)	9 (60.0)	2 (28.6)
40-49	3 (12.0)	0 (0)	2 (13.3)	1 (14.3)
50-59	3 (12.0)	1 (33.3)	0 (0)	2 (28.6)
≥ 60	2 (8.0)	1 (33.3)	1 (6.7)	0 (0)
Gender				
Male	13 (52.0)	2 (66.7)	7 (46.7)	4 (57.1)
Female	12 (48.0)	1 (33.3)	8 (53.3)	3 (42.9)
Family size (members)	4 (3-5)	6 (5-6)	3 (3-5)	4 (3-5)
Frequency of taking transportation after disease onset	0 (0-1)	1 (1-5)	0 (0-1)	0 (0-1)
Resident				
Urban	8 (32.0)	1 (33.3)	6 (40.0)	1 (14.3)
Downtown	17 (68.0)	2 (66.7)	9 (60.0)	6 (85.7)
Occupation				
Businessman	7 (28.0)	2 (66.7)	3 (20.0)	2 (28.6)
Teacher	1 (4.0)	0 (0)	0 (0)	1 (14.3)
Student	2 (8.0)	0 (0)	1 (6.7)	1 (14.3)
Housewife/househusband or Jobless	15 (60.0)	1 (33.3)	11 (73.3)	3 (42.9)
Disease severity				
Mild	21 (84.0)	2 (66.7)	12 (80.0)	7 (100)
Severe	3 (12.0)	1 (33.3)	2 (13.3)	0 (0)
Very severe	1 (4.0)	0 (0)	1 (6.7)	0 (0)
Exposure history				
Lived in Wuhan	19 (76.0)	3 (100)	10 (66.7)	6 (85.7)
Visited Wuhan during the outbreak	5 (20.0)	0 (0)	4 (26.7)	1 (14.3)
Had a close contact with a suspected patient	1 (4.0)	0 (0)	1 (6.7)	0 (0)
Case identification [#]				
Before new year festival (Jan 11-20, 2020)	2 (8.0)	2 (66.7)	0 (0)	0 (0) **
During new year festival (Jan 21-31, 2020)	16 (64.0)	1 (33.3)	10 (66.7)	5 (71.4)
After new year festival (Feb 1-10, 2020)	7 (28.0)	0 (0)	5 (33.3)	2 (28.6)
Case no. in family clusters	17 (68.0)	3 (100)	11 (73.3)	3 (42.9)

Categorical variables shown as n (%) were analyzed by Chi-square test, while continuous variables shown as median (IQR) were analyzed by Kruskal-Wallis test; [#] Chinese New Year Festival in 2020 was from Jan 25 to Jan 31 but the travel rush started as early as Jan 21; * P<0.05; ** P<0.01; *** P<0.001.

0-5) for all cases, 9 (0-3) for the cases diagnosed at hospitals, 0 (0-3) for the cases from contact tracing, and 2 (1-3) for the cases from community screening. The close contact number is highest in the hospital setting ($p = 0.031$) (Figure 2b).

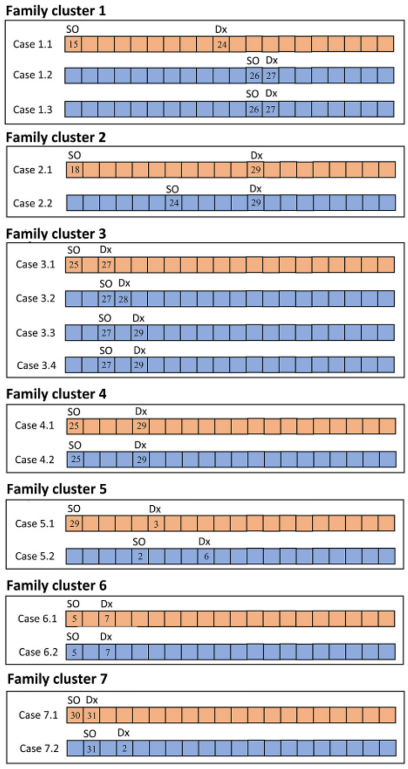
Family clusters

There were 7 family clusters of COVID-19, accounting for 17 cases, including 3 diagnosed from hospitals (17.6%), 11 from contact tracing (64.8%), and 3 from community screening (17.6%). The median serial interval (the time between the symptom onset of the index case and subsequent cases in a household) was 2 days (IQR, 1.3-5.5). The median diagnosis lag time was 4 days (IQR, 2.0-7.0) for the family index cases and 2 days (IQR, 1.3-3.5) for subsequent cases. No significant difference in diagnosis lag time was observed among the family clusters ($p = 0.237$) (Figure 3).

Predictor of the number of close contacts

With the number of close contacts as the dependent variable and the characteristics of COVID-19 cases as the independent variables, multivariate linear regression models showed larger family size and severe cases as the significant predictors for increasing number of close contacts (Table 2).

Figure 3. Case characteristics of family clusters during COVID-19 outbreak.



Diagnosis lag time

Case	Diagnosis lag time (day)
1.2	1
1.3	1
2.2	5
3.2	1
3.3	2
3.4	2
4.2	4
5.2	4
6.2	2
7.2	2

The serial interval in family cluster

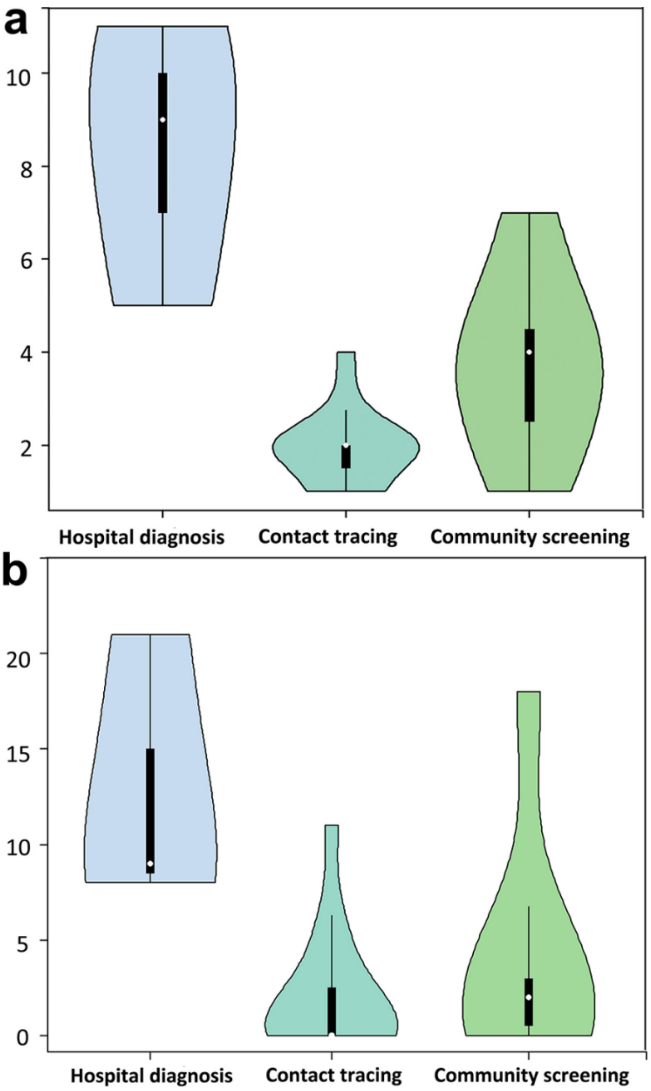
Case	The serial interval (day)
1.2	11
1.3	11
2.2	6
3.2	2
3.3	2
3.4	2
4.2	0
5.2	4
6.2	0
7.2	1

Exposure to Wuhan

Exposure to Wuhan and contact to first family case

SO: Symptom Onset; Dx: Diagnosis.

Figure 2. Time and case distribution of COVID-19 cases by three identification methods (a) Distribution of the length from disease onset to confirmation of COVID-19 cases; (b) Distribution of close contacts.



Discussion

The overall goal of containing the ongoing COVID-19 outbreak is quick response in the countries under threat and readiness in the geographic areas not yet affected [4]. This study reports the COVID-19 containment measures applied in Shantou city at the very beginning of outbreak (13 January 2020) leading to breaking the transmission chain by 7 February 2020.

Being a city with more than 5.7 million population and inadequate capacity for critical care [6], Shantou could have had similar consequences of COVID-19, such as rapid transmission with a significant morbidity

and fatality observed in other countries or regions, without its early and effective containment measures [2]. Shantou was not an epicenter of COVID-19, but rather drawn into an outbreak by family clusters from imported COVID-19 cases. For family clusters in Shantou, the median serial interval of disease was 2, which is much lower than 7.5 days reported in Wuhan [9]. The shorter serial interval in family clusters was attributable to the early and intensive containment measures, such as close contact tracing, investigation in communities, and monitoring the family members of a positive case. One study also reported two measures - early virus detection and quarantine at the early stage - in a rapid control of the spread in family clusters [10].

The timing of the outbreak in China is relatively similar across the country, for example, the number of cases started to increase in mid-January, reaching its peak on 25 January [11, 12]. Transmission chain was established in a wide diversity of settings, from mega-cities in the north and south of the country, to remote communities [4].

Most COVID-19 cases in Shantou were mild, which is consistent with the previous study [13]. However, mild COVID-19 cases can prolong the identification time, which in turn allows the activities of infected people unchecked, thus imposing a higher risk of transmission to health people. But Shantou started the containment measures much earlier than the announcement of Level I public health alert raised by the Guangdong provincial government on Jan 23 [14], which effectively interrupted the transmission chain in Shantou. Major containment measures applied in Shantou included case identification by contact tracing and 14 day isolation/quarantine [15]; monitoring them for COVID-19 symptoms; and test their throat swabs for SARS-CoV-2 during and/or at the end of quarantine. As reported in one study on the transmission risk assessment of SARS that compliance of effective prevention can reduce up to three fourth of spread [16], Shantou's containment measures might have slowed down the spread greatly.

Besides, the median time from symptoms onset to confirmation for COVID-19 cases was found variable in different cities. For example, the median diagnosis lag time of 2-day in Shantou is much lower than that (7.5 day) of Wuhan [17] and other areas in China [10].

The significantly longer length of case identification in healthcare settings than in contact tracing in this study can be explained by strict isolation (one person one room policy) and intensive monitoring (health surveillance and virus detection) of close contacts for 14 day. It has been demonstrated that the shorter time for case confirmation, and thus less exposure opportunities to the public, can lower the risk of further spread to the uninfected population [13].

Our study also found the duration between the appearance of symptoms and case confirmation as the risk factors for the higher no. of close contacts. Taking together, early prevention is proven critical in shortening the time for case identification.

Limitation

With only a few confirmed COVID-19 cases, Shantou`s outbreak containment strategy may not be a perfect example of containment measures for the hard-hit regions. Moreover, most of the family clusters were with the experience or direct links to Wuhan/Hubei, which would complicate their contact tracing.

Conclusions

The current pandemic appears to exist for an uncertain period. The early containment measures applied in Shantou, a prefectural city without adequate healthcare resources for COVID-19, seems to be appropriate for cities or areas with similar profiles.

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Table 2. Linear regression model of no. of close contacts during COVID-19 outbreak.

Variables	*B*	$S_{\bar{\chi}}$	β	*t*	*P*
Gender (male as reference)	-0.616	1.523	-0.055	-0.404	0.692
Age	0.114	0.066	0.289	1.729	0.106
Occupation (businessman as reference)	-0.059	1.119	-0.009	-0.053	0.959
Resident (urban as reference)	1.391	1.772	0.117	0.785	0.446
Family size	-1.302	0.601	-0.298	-2.168	0.048
Duration of case identification	0.731	0.369	0.328	1.982	0.067
Frequency of taking transportation	0.879	0.469	0.281	1.874	0.082
Disease severity (mild as reference)	4.695	1.644	0.394	2.856	0.013
Date of case identification (Jan 11-20, 2020 as ref)	0.353	2.238	0.023	0.158	0.877

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