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Short Communication

Risk of SARS-CoV-2 infection among contacts of individuals with COVID-19 in Hangzhou, China

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ABSTRACT

Objectives: This study determined the rate of secondary infection among contacts of individuals with confirmed coronavirus disease 2019 (COVID-19) in Hangzhou according to the type of contacts, the intensity of contacts, and their relationship with the index patient.

Study design: This is a retrospective cohort study.

Methods: The analysis used the data of 2994 contacts of 144 individuals with confirmed severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection. The contacts were categorized according to the information source, type of contact, location, intensity of contact, and relationship with the index patient.

Results: The incidence of infection differed significantly according to contact type. Of the contacts, 186 (6.2%) developed symptoms, and 71 (2.4%) had confirmed SARS-CoV-2 infection. The main symptoms were cough and fever. Compared with those who had brief contact with the index case, those who had dined with the index case had 2.6 times higher risk of acquiring infection; those who had shared transport with, had visited, or had contact with the index case in a medical institution had 3.6 times higher risk of acquiring infection; and household contacts had 41.7 times higher risk of acquiring infection. Family members had 31.6 times higher risk of acquiring infection than healthcare providers or other patients exposed to an index case.

Conclusions: The form and frequency of contact are the main factors affecting the risk of infection among contacts of individuals with COVID-19. Centralized isolation and observation of close contacts of individuals with confirmed SARS-CoV-2 infection, in addition to population-based control measures, can reduce the risk of secondary infections and curb the spread of the infection.

In late December of 2019, a pneumonia epidemic was reported in Wuhan in Hubei Province in China, which was later confirmed to be caused by the novel coronavirus severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[1,2] By May 1, 2020, 3,175,207 cases of coronavirus disease 2019 (COVID-19), the clinical disease caused by SARS-CoV-2, had been reported worldwide from more than 200 countries and regions.[3]

In Hangzhou, a city with a population of 10.4 million, in Zhejiang Province in East China, the first confirmed case of COVID-19 was reported on January 21, 2020. Most of the early cases were imported from Wuhan in Hubei Province, the epicenter of the epidemic. On January 23, 2020, Zhejiang Province was among the first provinces to declare a major public health emergency and introduced ten policies including vigorously promoting public awareness on epidemic prevention, restricting public gatherings, and taking measures to prevent hospital-acquired infections to curb the transmission of SARS-CoV-2 infection.[4,5] After January 27, 2020, the number of imported cases in Hangzhou declined rapidly, and the majority of the cases were local cases, indicating that the prevention and control measures taken had produced effective results. On February 4, 2020, centralized isolation and medical observation of close contacts of patients with COVID-19 were initiated in Hangzhou, with one person per room, to prevent disease transmission among family members.

As no vaccines have yet been developed, rapid identification of COVID-19 cases and monitoring their close contacts are critical to restrict the spread of the infection. We analyzed the contact characteristics and the control effectiveness of contacts and provide a theoretical support for scientific prevention and control of the epidemic.

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Table 1
Relative risk of infection according to contact type, relationship to the index case, and the location where the contact occurred.

Risk factors	Total number of contacts	Number infected (%)	OR	95% CI	*P*
Sex					
Female	1530	47 (3.07%)	1.00 (ref.)		
Male	1464	35 (2.39%)	0.77	0.50–1.20	0.25
Protective measures[a]					
No	1669	78 (4.67%)	1.00 (ref.)		
Yes	1325	4 (0.30%)	0.062	0.02–0.17	<0.001
Contact type					
Brief contact	1158	6 (0.52%)	1.00 (ref.)		
Shared transport, visit, medical care	1040	19 (1.83%)	3.57	1.42–8.98	0.004
Shared transport, visit, medical care	516	7 (1.36%)	2.64	0.88–7.90	0.07
Household	280	50 (17.86%)	41.74	17.69–98.49	<0.001
Relationship to the index case					
Healthcare provider or patient	532	2 (0.38%)	1.00 (ref.)		
Coworker, friend, teacher, student, neighbor	1307	20 (1.53%)	4.12	0.96–17.7	0.04
Family	563	60 (10.66%)	31.61	7.69–130.01	<0.001
Contact location					
Medical institution	658	2 (0.30%)	1.00 (ref.)		
Public place	814	13 (1.60%)	5.32	1.20–23.67	0.01
Workplace, educational institution, place of entertainment	301	6 (1.99%)	6.67	1.34–33.25	0.01
Home and environs	1221	61 (5.00%)	17.25	4.20–70.77	<0.001

CI, confidence interval; OR, odds ratio.
[a] 'Protective measures' refers to use of a face mask.

Data were collected from 2994 close contacts of 144 individuals in Hangzhou with SARS-CoV-2 infection confirmed between January 23 and February 28, 2020, using a combination of on-site investigations ($N = 1514$) and big data provided by the public security organs on the basis of case notifications and contact tracing ($N = 1480$). A close contact was defined as a person who had been within a meter of a confirmed case, without effective protection, within the period since 5 days before the symptom onset in the index case or since 5 days before sampling if the index case was asymptomatic.[6] Each contact was followed up until the end of the 14-day observation period. A retrospective analysis was conducted to determine the characteristics of the close contact, including forms of contact, relationships, and contact locations, as well as the outcome of the exposure.

Microsoft Excel was used for data input. R version 3.6.3 (R Foundation for Statistical Computing, Vienna, Austria) and SPSS version 16 (SPSS Inc., Chicago, IL, USA) statistical software programs were used for data analyses. Categorical data were summarized as frequencies and proportions, and chi-squared tests were used for intergroup comparisons. Continuous data were summarized as medians and interquartile ranges, and t-tests were used for intergroup comparisons. *P*-values <0.05 were considered to be statistically significant.

The incidence rate of contacts with data collected by field investigation was significantly higher than that of contacts with data collected by big data (5.35% versus 0.07%, $P < 0.001$). The geographical distribution of close contacts in the districts and counties of Hangzhou is shown in Supplementary Fig. S1. During the observation period, 71 of the 186 (38%) individuals with symptoms were confirmed to have SARS-CoV-2 infection; of which, 54 (76%) had a last exposure-onset interval of <7 days. The incidence rate of SARS-CoV-2 infection in the group with symptoms was significantly higher than that in the group with no symptoms (38.17% versus 0.39%, respectively, $P < 0.05$). The most frequently reported abnormal symptoms were cough (39.8%), fever (36.0%), and sore throat and rhinorrhea (16.1%). An additional 11 contacts (0.4%) were infected with SARS-CoV-2 but remained asymptomatic. The overall incidence of infection among the contacts was 2.7%.

There was no significant difference in COVID-19 incidence among the close contacts according to age or sex, but significant differences were found according to the level of protection, type of contact, relationship with the index patient, and contact location.

The results in Table 1 show that the infection rate among those living in the same household as the index case was 41.7 times higher than that of individuals who had only had brief contact with the index case. Compared with those who only had brief contact with the index case, those who had dined with the index case had 2.6 times higher risk of acquiring infection, and those who has shared transport, had visited, or had contact with the index case in a medical institution had 3.6 times higher risk of acquiring infection. Among the relationships of contacts, family members had the highest risk of acquiring infection, with 31.6 times higher risk of acquiring infection than healthcare providers or other patients who had been exposed to an index case. In terms of contact locations, the infection rate among those who had contact with the index case in or near his/her home was 17.2 times higher than that among those who had contact with the index case in a medical institution; and the infection rate of those who had contact with the index case through work, through study, or in a place of entertainment was 6.7 times higher than that among those who had contact with the index case in a medical institution.

This incidence of disease among contacts according to age and sex was consistent with the variation in disease incidence according to age and sex in the population as a whole.[7] The incidence rate among those who wore face masks was significantly lower than that among those who did not use protective measures (0.3% vs. 4.7%, respectively, $P < 0.001$), indicating that protective measures can significantly reduce the risk of infection.

The analysis of contact characteristics showed that the incidence rate of close contacts who lived in the same residence was 17.9%, significantly higher than that of other groups with different forms of contact. The incidence rate of relatives was 10.7%, who had the highest risk of acquiring infection among all relationship groups. The results showed that the closer the contact distance and the higher the frequency of contact, the greater the risk of infection. Therefore, taking targeted isolation and observation measures for close contacts can control the source of infection and limit the risk of infection, which is an important way to prevent the secondary transmission of the disease.[8,9]

In addition, attention should be paid to the risk of infection from activities such as dining together, sharing transportation, social visits, and providing medical and nursing care to individuals with COVID-19 or SARS-CoV-2 infection.

As patients in the incubation period can be a source of infection,[4] if the criteria for determining close contacts are not adjusted in a timely manner and targeting of contacts is limited to those with symptoms, it is very likely that some people in the population with the risk of infecting others will be missed. To extend the scope of effective monitoring and control to infected individuals potentially in the contagious stage of infection,[10] the *Protocol of COVID-19 Monitoring, Prevention and Control in Zhejiang Province (Third Edition)* adjusted the time interval for identifying close contacts of a case to the period starting 5 days before the onset of symptoms.[6]

In the process of case investigation, the Hangzhou government took full advantage of the big data technology in combination with a grid management mechanism to trace cases, analyze transmission routes, and efficiently collect information of close contacts. Of the contacts identified, 49.4% were identified using big data. This improved the screening efficiency of contacts and reduced the potential for recall bias or intentional concealment. In this way, contact screening was relatively complete. Digitized epidemic prevention and control measures are likely to become more widely used in the future.

Author statements

Ethical approval

Ethical approval was not required as this research does not involve animals and human material and rights.

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Competing interests

None declared.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2020.05.016.

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