



Secondary attack rate of the COVID-19: General characteristics of confirmed and probable cases



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Abstract

Introduction: The first case of COVID-19 infection in Kazakhstan was registered on March 13, 2020. At the beginning the detection methods and the load of the spread of the emerging respiratory pathogen were uncertain. This study aimed to assess the incidence of the secondary attack rate among close contacts of confirmed and probable COVID-19 cases living in the same household in Nur-Sultan, Kazakhstan. **Methods:** The prospective study included 172 participants: 122 confirmed and 50 uncertain cases of COVID-19 with varying degrees of severity as well as their close contacts identified in Nur-Sultan, Kazakhstan from November 26th, 2020 until February 15th, 2021. All participants were tested with PCR and ELISA assays at the time of inclusion and on days 14-21 of follow-up. **Results:** The most common symptoms among both cohorts of patients were fever (90%) ($p < 0.001$), cough (78.0%) ($p = 0.11$), difficulty breathing (63.3%) ($p < 0.001$), chills (60%) ($p < 0.001$). The effective reproductive R_t number for confirmed cases was 1.43 [95%CI=1.27-1.59], for probable cases 0.96 [95%CI=0.70-1.22]. The mean serial interval was 4.02 (SD 2.52), for confirmed was 4.43 (SD 2.45), for probable cases was 3.21 (SD 2.48). **Conclusion:** The infection rates following close contact with COVID-19 confirmed and probable cases were 92% and 98.1%, respectively.

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1 Introduction

Coronavirus infection (COVID-19), whose causative agent is SARS-CoV-2 (severe acute respiratory syndrome-related coronavirus 2), is an enveloped single-stranded (+) RNA virus, caused new cases of respiratory illness in Wuhan Province in China in December 2019 and subsequently evolved into a pandemic (Rolling updates on corona virus disease (COVID-19), n.d.). As of April 15, 2022, there were about 500.18 million confirmed infections worldwide, resulting in 6.19 million deaths (WHO coronavirus disease (COVID-19) sash board & Accessed on 15 April 2022., n.d.).

In Kazakhstan, the first case of COVID-19 infection was registered on March 13, 2020. A week later, a state of emergency was declared in the country, which lasted until mid-May 2020. The introduction of quarantine measures and strict self-exclusion of citizens stabilized the epidemiological situation in the country. However, the rapid lifting of restrictive measures led to a sharp increase in the incidence of the disease in July 2020. Because of this, the government of the Republic of Kazakhstan was forced to apply new restrictions. By October 2020, the situation in the country was relatively stable, but the number of infected people continued to increase. After leading COVID-19 incidence in July 2020, Kazakhstan as of April 7, 2021 had slipped to 56th place in the world with more than 258,000 cases and 3,156 deaths. According to the latest data, Kazakhstan has had 1,305,355 confirmed cases, 88,815 probable PCR-negative cases, and 13,660 deaths from coronavirus infection (Ministry of Health of the Republic of Kazakhstan, n.d.). Nevertheless, the incidence of coronavirus remains high in large cities in Kazakhstan, such as Nur-Sultan and Almaty.

At the beginning of the pandemic, the detection methods and the load of the spread of the emerging respiratory pathogen were uncertain in terms of its key epidemiological and clinical characteristics and, in particular, its ability to spread in a population. The secondary attack rate is the proportion of primary contacts who develop infection or symptoms within one incubation period after contacting an index case. The secondary attack rate contributes to the investigation and understanding of the dynamics of infectious disease transmission (Li et al., 2020).

As in the case of many new respiratory pathogens, in addition to the basic clinical and epidemiological characteristics of the virus, it was also interesting to study the dynamics of the infection outbreak in Kazakhstan. The aim of the study was to define main characteristics of the COVID-19 and to assess the secondary attack rate among close contacts of confirmed and probable COVID-19 cases living in the same household in Kazakhstan.

2 Materials and Methods

This study was a prospective study that included 122 patients with varying degrees of severity and with a confirmed diagnosis of COVID-19 by PCR who were on outpatient treatment in Nur-Sultan, as well as 50 patients who were hospitalized with a clinical picture of COVID-19 but with a negative PCR result and with signs of COVID-19 pneumonia, aged 0 to 90 years (Figure 1). Further, close contacts of confirmed and probable cases were also included in the study. A follow-up of cases and their close contacts was conducted from November 26, 2020 to February 15, 2021.

Clinical, epidemiological data were collected by interview at the time of hospitalization or during the home visit. For those who were in self-isolation the interview was conducted by telephone. Questionnaire forms used in the study were specially developed by the World Health Organization for COVID-19 cases and their close contacts (Annex).

All primary cases were selected from the database of confirmed cases of the Ministry of Health of the Republic of Kazakhstan; data on close contacts were reported by the cases themselves. Questionnaires were administered to patients with a COVID-19 diagnosis who were undergoing inpatient and outpatient treatment in medical organizations in the capital of Kazakhstan.

In addition, blood was drawn from cases and close contacts to verify the potential presence of COVID-19 by ELISA on days 1 through 7 after a positive PCR result and after inclusion in the study, as well as on days 14-21 of follow-up. Total antibody count of IgM and IgG antibodies to COVID-19 were determined by ELISA test. Data were entered using Microsoft Excel and analyzed by the R program. The variables were summarized as mean with standard deviation and frequency as a percentage. A demo version of SPSS 17.0 and MedCalc Portable was also used to analyze the data.

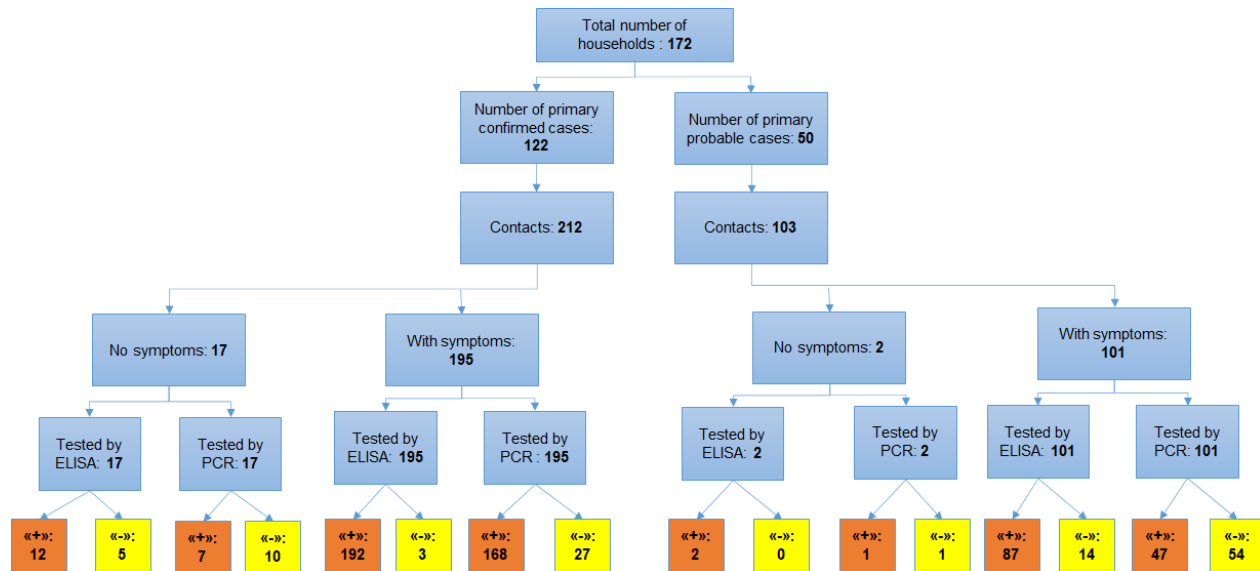


Figure 1. Flow chart of cases of COVID-19 and household contacts

3 Results and Discussions

172 COVID-19 cases were included in this study, of them 122 were confirmed cases and 50 were probable cases. The mean age of the total sample was 49.0 years (SD 17.3), the mean age of confirmed cases was 46.5 (SD 15.6), and probable cases was 55.3 (SD 19.7). The min-max age range was between 0 and 90 years.

The mean age of contacts of confirmed cases was 34.5 (SD 17.4), and contacts of probable cases was 44.8 (SD 19.2).

Among primary confirmed cases there were 60 males (49.2%), and 62 females (52.8%). Among primary probable cases the number of males and females was equal to 25 (50%). Among COVID-19-positive contacts there were 93 males (43.9%), and 119 females (56.1%). Among probable cases the number of males was 38 (36.9%), females were 65 (63.1%).

The main demographic and clinical characteristics are presented in Table 1.

Table 1
Demographics, baseline characteristics, and clinical outcomes of 172 patients with COVID-19

	Patients (n=172)
Age, years	
Mean (SD)	49,01 (17.3)
Range	2-89

≤39	56 (33%)
40-49	29 (17%)
50-59	29 (17%)
60-69	42 (24%)
≥70	16 (9%)
Sex	
Female	87 (51%)
Men	85 (49%)
Occupation	
Self-employed	8 (5%)
Employee	80 (47%)
Unemployed	22 (13%)
Retired	52 (30%)
Student	6 (3%)
Child	4 (2%)
Chronic medical illness	
Cardiovascular diseases	30 (17%)
Malignant tumor	2 (1%)
Respiratory system diseases	5 (3%)
Obesity	39 (23%)
Diabetes	8 (5%)
Chronic renal diseases	5 (3%)
Nervous system diseases	1 (0.6%)
Hospitalized	118 (67%)
Admission to intense care unit	1 (0.6%)
Clinical outcome	
Remained in hospital	56 (33%)
Discharged	62 (36%)
Died	1 (0.6%)

The average number of household members was 2.83 (0.96), 2.74 for primary confirmed and 3.06 for primary probable cases (1.03 and 0.74, respectively). The mean number of contacts per case was 1.83 (0.96), for confirmed PCR positive cases - 1.74 (1.03) contacts and for probable PCR negative cases - 2.06 (0.74) contacts (Table 2).

Table 2
Number of households with PCR + and PCR – results

Total number of patients	172
PCR positive	122
PCR negative	50
Average size of households	2.83 (0.96)
PCR positive	2.74 (1.03)
PCR negative	3.06 (0.74)
Average size of contacts per one patient	1.83 (0.96)
PCR positive	1.74 (1.03)
PCR negative	2.06 (0.74)

Clinical characteristics

The most common symptoms among the patients included in the study were cough 70%, loss of appetite 63%, fever 63%, loss of smell 56%, and fatigue 56%. The least common symptoms at the time of the study were

vomiting 2%, diarrhea 7% and nausea 8%. Among 50 hospital cases, 44 cases (26%) had manifest COVID-19-associated pneumonia according to computed tomography assessment.

On days 14-21 of follow-up, patients noted the occurrence of the following symptoms of the disease: the most common were fatigue 92%, headache 62%, persistent cough 45%, and fever 43% (Table 3).

Table 3

Clinical characteristics of 172 patients with COVID-19 at admission and during 14-21 days of supervision

		Patients (n=172)
Signs and symptoms at admission		
Fever	108 (63%)	
Cough	121 (70%)	
Muscle ache	44 (26%)	
Joint ache	29 (19%)	
Fatigue	96 (56%)	
Headache	79 (46%)	
Sore throat	65 (38%)	
Rhinorrhea	38 (22%)	
Shortness of breath	52 (30%)	
Diarrhea	12 (7%)	
Nausea	13 (8%)	
Vomiting	4 (2%)	
Loss of appetite	108 (63%)	
Loss of smell	97 (56%)	
Loss of taste	79 (46%)	
More than one sign or symptom	162 (94%)	
Fever, cough and shortness of breath	31 (18%)	
Chest x-ray and CT findings		
Bilateral pneumonia with multiple mottling and ground-glass opacity	44 (26%)	
On 14-21 days of supervision		
Fever	74 (43%)	
Cough	78 (45%)	
Muscle ache	42 (24%)	
Joint ache	20 (12%)	
Fatigue	158 (92%)	
Headache	106 (62%)	
Sore throat	31 (18%)	
Rhinorrhea	29 (17%)	
Shortness of breath	45 (26%)	
Diarrhea	7 (4%)	
Nausea	8 (5%)	
Vomiting	3 (2%)	
Loss of appetite	68 (40%)	
Loss of smell	24 (14%)	
Loss of taste	16 (9%)	

The most common complications among confirmed cases were obesity 28.9%, cardiovascular disease 23.3%, diabetes mellitus 6.6%, chronic kidney disease 4.1% and chronic lung disease (unrelated to asthma) 3.3%. The least common were oncology 1.7%, chronic liver disease, and chronic neurological disorders 0.8%. Among the probable cases, the most common were obesity 8%, cardiovascular disease 4% and chronic lung disease 2% (Table 4).

Table 4
Prevalence of chronic diseases for primary confirmed (PCR-positive) and probable (PCR-negative) cases

	PCR-positive cases, N=122	PCR-negative cases, N=50	p-value
Obesity	35 (28.9%)	4 (8.0%)	0.003
Malignant tumor	2 (1.7%)	0 (0.0%)	>0.1
Diabetes	8 (6.6%)	0 (0.0%)	>0.1
Cardiovascular disease	28 (23.3%)	2 (4.0%)	>0.1
Chronic lung diseases (except asthma)	4 (3.3%)	1 (2.0%)	0.002
Chronic liver disease	1 (0.8%)	0 (0.0%)	>0.1
Chronic renal diseases	5 (4.1%)	0 (0.0%)	.48
Nervous system diseases	1 (0.8%)	0 (0.0%)	.32

The most common diseases among close contacts of confirmed and probable cases were cardiovascular diseases 6.6% and 12.6% respectively (Table 5).

Table 5
Prevalence of chronic diseases in contacts of PCR-positive and PCR-negative cases

	Contacts of PCR-positive cases, N=212	Contacts of PCR-negative cases, N=103	p-value
Obesity	0 (0.0%)	4 (3.9%)	0.009
Cardiovascular disease	14 (6.6%)	13 (12.6%)	0.05
Bronchial asthma (requiring treatment)	2 (0.9%)	0 (0.0%)	.41
Chronic lung diseases (except asthma)	4 (1.9%)	2 (1.9%)	.34
Chronic liver disease	1 (0.5%)	0 (0.0%)	.35
Chronic hematological disease	1 (0.5%)	0 (0.0%)	.35
Chronic renal diseases	1 (0.5%)	0 (0.0%)	.35
Nervous system diseases	1 (0.5%)	1 (1.0%)	.40

In probable cases at the beginning of the follow-up period, the most common symptoms similar to confirmed cases were fever 90% ($p < 0.001$), cough 78.0% ($p = 0.11$), difficulty breathing 63.3% ($p < 0.001$), chills 60% ($p < 0.001$) and loss of appetite 94%, loss of smell 90% and taste 64% (Table 6).

Table 6
Clinical characteristics in primary confirmed (PCR-positive) and probable (PCR-negative) cases at admission and on 14-21 days of supervision

	PCR-positive cases, N=122	PCR-negative cases, N=50	p-value
At admission			
Fever ($\geq 38^\circ\text{C}$)	63 (51.6%)	45 (90.0%)	<0.001
Sore throat	43 (35.5%)	22 (44.0%)	.18
Cough	82 (67.8%)	39 (78.0%)	.11
Rhinorrhea	38 (32.5%)	0 (0.0%)	<0.001
Shortness of breath	22 (20.0%)	31 (63.3%)	<0.001
Chills	38 (31.1%)	30 (60.0%)	<0.001
Vomiting	4 (3.3%)	0 (0.0%)	.23

Nausea	13 (10.7%)	0 (0.0%)	0.02
Diarrhea	12 (9.8%)	0 (0.0%)	0.02
Headache	73 (59.8%)	6 (12.0%)	<0.001
Rash	1 (0.8%)	0 (0.0%)	.32
Muscle ache	41 (33.6%)	3 (6.0%)	<0.001
Joint ache	29 (23.8%)	0 (0.0%)	<0.001
Loss of appetite	61 (50.0%)	47 (94.0%)	<0.001
Nasal bleeding	2 (1.6%)	0 (0.0%)	.44
Fatigue	90 (73.8%)	6 (12.0%)	<0.001
Loss of smell	52 (43.0%)	45 (90.0%)	<0.001
Loss of taste	47 (38.8%)	32 (64.0%)	0.002
Altered state of consciousness	1 (0.8%)	0 (0.0%)	.32
Other neurological signs	1 (0.8%)	0 (0.0%)	.32
14-21 days			
Fever ($\geq 38^{\circ}\text{C}$)	54 (44.3%)	20 (40.0%)	.36
Sore throat	17 (14.3%)	14 (28.0%)	0.02
Cough	57 (47.5%)	21 (42.0%)	.34
Rhinorrhea	14 (11.7%)	15 (30.0%)	0.003
Shortness of breath	29 (24.2%)	16 (32.0%)	.17
Chills	53 (44.2%)	20 (40.0%)	.40
Vomiting	3 (2.5%)	0 (0.0%)	.31
Nausea	8 (6.7%)	0 (0.0%)	0.07
Diarrhea	7 (5.8%)	0 (0.0%)	0.09
Headache	61 (50.8%)	45 (90.0%)	<0.001
Rash	1 (0.8%)	0 (0.0%)	.32
Conjunctivitis	1 (0.8%)	0 (0.0%)	.32
Muscle ache	36 (30.3%)	6 (12.0%)	0.01
Joint ache	19 (16.0%)	1 (2.0%)	0.01
Loss of appetite	48 (40.3%)	20 (40.0%)	.46
Fatigue	108 (90.0%)	50 (100.0%)	0.01
Cramping	2 (1.7%)	0 (0.0%)	.44
Loss of smell	24 (20.0%)	0 (0.0%)	<0.001
Loss of taste	16 (13.3%)	0 (0.0%)	0.008
Other neurological signs	2 (1.7%)	0 (0.0%)	.44

The most frequent symptoms among contacts of confirmed and probable cases within 7 days of follow-up were headache 57.1% and 89.3% ($p < 0.001$), fatigue 55.2% and 90.3% ($p < 0.001$), loss of smell 47.6% and 60.2% ($p = 0.02$) and muscle pain 36.3% and 92.2% ($p < 0.001$). On days 14-21 of follow-up, headache 60.6% and 9.7% ($p < 0.001$), and fatigue 87% and 100% ($p < 0.001$) respectively, persisted in the close contacts of confirmed and probable cases (Table 7).

Table 7

Clinical characteristics of contacts of PCR-positive and PCR-negative cases on 0-7 days and on 14-21 days of supervision

	Contacts of PCR-positive cases, N=212	Contacts of PCR- negative cases, N=103	p-value
0-7 days			
Fever ($\geq 38^{\circ}\text{C}$)	54 (25.5%)	75 (72.8%)	<0.001
Sore throat	54 (25.5%)	61 (59.2%)	<0.001
Cough	56 (26.4%)	59 (57.3%)	<0.001
Rhinorrhea	100 (47.4%)	72 (69.9%)	<0.001

Shortness of breath	8 (3.8%)	62 (60.2%)	<0.001
Chills	93 (43.9%)	54 (52.4%)	0.09
Vomiting	3 (1.4%)	0 (0.0%)	.27
Nausea	9 (4.2%)	0 (0.0%)	0.03
Diarrhea	11 (5.2%)	0 (0.0%)	0.02
Headache	121 (57.1%)	92 (89.3%)	<0.001
Muscle ache	77 (36.3%)	95 (92.2%)	<0.001
Joint ache	54 (25.5%)	3 (2.9%)	<0.001
Loss of appetite	43 (20.3%)	1 (1.0%)	<0.001
Loss of smell	101 (47.6%)	62 (60.2%)	0.02
Loss of taste	53 (25.0%)	53 (51.5%)	<0.001
Fatigue	117 (55.2%)	93 (90.3%)	<0.001
14-21 days			
Fever ($\geq 38^{\circ}\text{C}$)	12 (5.8%)	0 (0.0%)	0.01
Sore throat	19 (9.1%)	0 (0.0%)	0.001
Cough	13 (6.3%)	1 (1.0%)	0.04
Rhinorrhea	28 (13.5%)	0 (0.0%)	<0.001
Shortness of breath	3 (1.4%)	1 (1.0%)	.42
Chills	15 (7.2%)	1 (1.0%)	0.02
Nausea	2 (1.0%)	0 (0.0%)	.40
Diarrhea	3 (1.4%)	0 (0.0%)	.42
Headache	126 (60.6%)	10 (9.7%)	<0.001
Conjunctivitis	1 (0.5%)	0 (0.0%)	.35
Muscle ache	11 (5.3%)	0 (0.0%)	0.02
Joint ache	5 (2.4%)	1 (1.0%)	.34
Loss of appetite	17 (8.2%)	0 (0.0%)	0.004
Loss of smell	25 (12.0%)	0 (0.0%)	<0.001
Loss of taste	10 (4.8%)	0 (0.0%)	<0.001
Fatigue	181 (87.0%)	103 (100.0%)	<0.001

Secondary attack rate

PCR testing and ELISA were used to confirm the presence of coronavirus infection in cases and their close contacts. Thus, 146 (68.9%) contacts of confirmed index cases presented a positive PCR after the first swab was taken between day 0 and 7 of inclusion in the study, while 37 contacts (17.9%) had confirmation of the virus at the time of the second respiratory swab collection (between days 14-21). Only 10 (8.2%) households had negative PCR results for both tests (He et al., 2020).

Among the probable contacts, 23 (22.3%) were found positive after the first PCR testing, and 27 contacts (26.2%) were found positive only at the time of the second respiratory smear collection. Overall, 48 contacts (46.6%) had a PCR result for coronavirus infection confirmed at least once in two tests. 19 (38%) households presented negative PCR results among contacts in both tests. Besides a respiratory swab patient were also blood sampled at the beginning of the study and on days 14-21 of follow-up to confirm the diagnosis by ELISA. Thus, among the PCR-positive contacts 113 (59.5%) had confirmed the presence of total antibodies in their blood by the first ELISA test (1-7 days after study inclusion), while in 179 contacts (95.7%) the result of the disease was confirmed by the second blood sampling (14-21 days). At the same time, 184 contacts (95.8%) had positive ELISA at least once and only 2 households (1.7%) had negative ELISA results for all contacts for both tests. Among contacts, 45 (44.1%) had a positive ELISA result at the first blood sampling (on days 1-7 after inclusion in the study), 85 (83.3%) had a positive ELISA result at the second examination, 88 contacts (86.3%) had a positive ELISA result at least once, and 2 households (4%) had no antibodies detected in either test (Table 8).

Table 8
PCR test and ELISA test results among contacts of PCR positive and PCR negative cases

	PCR-positive cases, N=122	PCR-negative cases, N=50
Number of contacts	212	103
PCR-positive contacts in the first testing	146 (68.9%)	23 (22.3%)
PCR-positive contacts in the second testing	37 (17.9%)	27 (26.2%)
At least one PCR-positive contact	175 (82.5%)	48 (46.6%)
ELISA-positive contacts in the first testing	113 (59.5%)	48 (44.1%)
ELISA-positive contacts in the second testing	179 (95.7%)	85 (83.3%)
At least one ELISA-positive contact	184 (95.8%)	88 (86.3%)

The percentage of contacts of confirmed cases with symptoms of the disease was 92% (195), 88.1% (177) of contacts showed symptoms between 0 and 11 days after contact with the cases. In general, 2.5% (3 households) had no symptoms. The percentage of households with asymptomatic primary contacts (i.e., contacts that developed symptoms earlier than cases or after 12 days or more) and who presented positive PCR or ELISA results was 7.4% (9 households).

Among contacts of probable cases, 98.1% (101) showed some form of coronavirus infection symptoms, and 87.3% (89) developed symptoms between 0 and 11 days after contact with a symptomatic case. All households of probable cases had at least one contact with symptoms and only 12% (6) households had no symptomatic primary contacts at the follow-up visit. Only 3 contacts of primary confirmed cases who had PCR and ELISA had all negative PCR and ELISA results and were asymptomatic (Utama et al., 2022). One contact had no positive PCR results and no symptoms, but he refused to do ELISA.

Therefore, among 315 contacts of confirmed and probable cases, 311 people (98.7%) had at least one indicator of COVID-19. All 4 contacts who did not manifest any sign of COVID-19 belonged to the 4 primary confirmed cases. These 4 households had other family members who had either a positive PCR or a positive ELISA test. This proves that SARS-CoV-2 virus transmission occurred in all households. (Table 9).

Table 9
Number of contacts of PCR positive and PCR negative cases with and no symptoms

	Contacts of PCR-positive cases, N=212	Contacts of PCR-negative cases, N=103
Number of contacts with symptoms	195 (92%)	101 (98.1%)
Number of contacts presenting symptoms on 0-11 days after contacting the case	177 (88.1%)	89 (87.3%)
Number of households with no symptoms in contacts	3 (2.5%)	0 (0.0%)
Hospitalized contacts	5 (2.4%)	1 (1.0%)

Effective reproductive number Rt

The effective reproductive number R_t for primary confirmed cases according to the study was 1.43 [95%CI=1.27-1.59], for primary probable cases 0.96 [95%CI=0.70-1.22] (Table 10).

Table 10
The effective reproductive number R_0 of PCR-positive and PCR-negative cases and their contacts

	PCR-positive cases, N=122	PCR-negative cases, N=50
R_t	1.43	0.96
	Contacts of PCR-positive cases, N=212	Contacts of PCR-negative cases, N=103
R_t	82.5	46.6

However, taking into account ELISA testing data and symptom onset, the reproductive number value was significantly higher. The mean serial interval was 4.02 (SD 2.52), for confirmed index cases 4.43 (SD 2.45), and for probable cases 3.21 (SD 2.48) (Table 11).

Table 11
The Serial interval of PCR-positive and PCR-negative cases

	N	Average	Standard deviation	Median	First quartile	Third quartile	Min	Max
Serial interval	266	4.02	2.52	4.00	2.00	5.75	0.00	11.00
Serial interval for PCR positive cases	177	4.43	2.45	4.00	2.00	6.00	0.00	11.00
Serial interval for PCR negative cases	89	3.21	2.48	2.00	2.00	4.00	0.00	10.00

The study of the spread of coronavirus infection among close contacts living in the same household provides a unique opportunity to study infection and transmission because there is often a clearer and more fixed exposure to the source of infection (Lei H, 2020; Lipsitch, Phil, Swerdlow, & Finelli, 2020). The most common symptoms of COVID-19 are fatigue, cough, headache, fever, and loss of appetite (Dahai Zhao et al., 2020; Han et al., 2020; S Kannan, P Shaik Syed Ali, A Sheeza, & K Hemalatha, 2020; Singhal, 2020; Zhu et al., 2020). The most common complications of coronavirus infection include obesity, cardiovascular disease, diabetes mellitus, chronic kidney disease, and chronic lung disease (unrelated to asthma) (Yang et al., 2020; Zhou et al., 2020)

Many countries report epidemic characteristics of coronavirus disease (COVID-19) (Choi & Ki, 2020; Flaxman et al., 2020; Lai, Shih, Ko, Tang, & Hsueh, 2020; Liu, Gayle, Wilder-Smith, & Rocklöv, 2020; Shim, Tariq, Choi, Lee, & Chowell, 2020; Zhang et al., 2020), however, the COVID-19 reproductive number should be analyzed with caution. First, the date of symptom onset rather than the date of a positive test result should be used to estimate the baseline reproductive R_0 number; however, many investigators have used the date of diagnosis to calculate this index (Lai et al., 2020).

To calculate the reproductive number more accurately, it is better to use the generation time of COVID-19, measured through the contact tracking system (Park et al., 2020), examining the exact contact connections between cases.

Our results show the high infectiousness of the virus within the family. They are consistent with the stochastic transmission model of SARS-CoV-2 where a small proportion of cases are responsible for most of the secondary transmission (Leung et al., n.d.).

It is also worth taking into account potential factors that increase the chances of transmission in the family, such as certain symptoms and severity of the disease in a COVID-19 case (Luo et al., 2020), as well as physical factors, such as the size of the home and the number of rooms, which can affect the ability of family members to maintain physical distance in the home.

It is also important to note that the number of people living in the same household in our study was small, which influenced the results (Abou Ghayda et al., 2020). Thus, a high secondary attack rate (SAR) in a

household but a modest reproductive number suggests that transmission is due to a relatively small number of high-risk contacts. A high SAR in the household also suggests that the risk of intra-household transmission is lower, otherwise the observed R_t would have been greater. Hence, our study showed that it was extremely difficult to prevent the development of secondary cases among close contacts living in the same space as the source of infection, since the vast majority of contacts had evidence of secondary infection by either PCR or ELISA.

Limitations

Data collection for the study was performed by means of a questionnaire survey of primary confirmed and probable cases and their close contacts, in which physicians of different levels (inpatient and primary care medical organizations) participated. Symptom questionnaires were filled out in person during hospitalization, as well as by telephone interview at the outpatient level, which could have affected the reliability or completeness of the data collected, given the lack of respondents' time to talk, as well as errors due to the need to recall the facts from the past. In addition, the sensitivity and specificity of laboratory testing by PCR and ELISA methods are not one hundred percent, so sporadic classification errors are possible. However, this did not affect the conclusions of the study ([Trouillet-Assant et al., 2020](#)).

Moreover, there is a possibility that the link established between primary and secondary cases for some of the secondary cases may be erroneous, since no study of the causative agents (SARS-CoV-2 viruses) to establish similarities and differences between them has been conducted. A secondary case could have been contracted not through contact in the household from a primary case, but at work or in another mass gathering place ([Song et al., 2008](#)).

4 Conclusion

The probable COVID-19 cases received indirect confirmation of an infectious etiology associated with SARS-CoV-2 infection because about half of their close contacts were PCR-test positive and more than 80% had antibodies to the virus in their blood. The study showed that COVID-19 disease had clinical symptoms for both primary and secondary cases, most of which had COVID-19 symptoms to varying degrees. Among the confirmed index cases, the most frequent symptoms were fatigue, cough, headache, fever, and loss of appetite. The secondary attack rate was 98.7%. All close contacts lived in the same space as the cases. Coronavirus infection after contact with a COVID-19 case among contacts of confirmed cases appeared at 92% and 98.1% among probable cases. Manifestation of the disease was confirmed by PCR and ELISA tests. In general, our results indicate a high infectiousness of the COVID-19 among close contacts within the households.

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