Reduction of secondary transmission of SARS-CoV-2 in households by face mask use, disinfection and social distancing: a cohort study in Beijing, China

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Abbreviations:COVID-19: Coronavirus disease 2019

SARS-CoV-2: severe acute respiratory syndrome coronavirus 2

NPIs: non-pharmaceutical interventions

UFMU: universal face mask use

WHO: World Health Organization

IQR: interquartile ranges

RCTs: Randomised clinical trials

ABSTRACT

Introduction: Transmission of Coronavirus disease 2019 (COVID-19) within families and close contacts accounts for the majority of epidemic growth. Community mask wearing, hand washing and social distancing are thought to be effective but there is little evidence to inform or support community members on COVID-19 risk reduction within families.

Methods: A retrospective cohort study of 335 people in 124 families and with at least one laboratory confirmed COVID-19 case was conducted from 28 February to 27 March, 2020 in Beijing, China. The outcome of interest was secondary transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) within the family. Characteristics and practices of primary cases, of well family contacts and household hygiene practices were analyzed as predictors of secondary transmission.

Results: The secondary attack rate in families was 23.0% (77/335). Face mask use by the primary case and family contacts before the primary case developed symptoms was 79% effective in reducing transmission (OR=0.21, 95% CI: 0.06 to 0.79). Daily use of chlorine or ethanol based disinfectant in households was 77% effective (OR=0.23, 95% CI: 0.07 to 0.84). Wearing a mask after illness onset of primary case was not significantly protective. The risk of household transmission was 18 times higher with frequent daily close contact with the primary case (OR=18.26, 95% CI: 3.93 to 84.79), and four times higher if the primary case had diarrhea (OR=4.10, 95% CI: 1.08 to 15.60). Household crowding was not significant.

Conclusion: The study confirms the highest risk of transmission prior to symptom onset, and provides the first evidence of effectiveness of mask use, disinfection and social distancing in preventing COVID-19. We also show evidence of fecal transmission. This can inform guidelines for community prevention in settings of intense COVID-19 epidemics.

SUMMARY BOXES

What is already known?

Mitigation of the COVID-19 pandemic depends solely on non-pharmaceutical interventions (NPIs) until drugs or vaccines are available. Transmission of COVID-19 within families and close contacts accounts for the majority of epidemic growth. Community mask wearing, hand washing and social distancing are thought to be effective but the evidence is not clear.

What are the new findings?

The overall secondary attack rate in households was 23.0%. Facemasks were 79% effective and disinfection was 77% effective in preventing transmission, whilst close frequent contact in the household increased the risk of transmission 18 times, and diarrhea in the index patient increased the risk by four times. Results demonstrate the importance of pre-symptomatic infectiousness of COVID-19 patients, and shows that wearing masks after illness onset does not protect.

What do the new findings imply?

It informs universal face mask use and social distancing, not just in public spaces, but inside the household with members at risk of getting infected. This further supports universal face mask use, and also provides guidance on risk reduction for families living with someone in quarantine or isolation, and families of health workers, who may face ongoing risk.

INTRODUCTION

In the absence of a vaccine for COVID-19, non-pharmaceutical interventions (NPIs) are the only available disease control measures. We have shown that population level NPIs, including travel bans and the national emergency response, were effective in flattening the COVID-19 epidemic curve in China.[1] However, the effect of other NPIs such as mask use and hygiene practices have not been well studied in the COVID-19 pandemic.

In the United States, the use of face masks in the community has been recommended.[2]It is thought that universal face mask use (UFMU) may reduce outward transmission from asymptomatically infected people and protect well people from becoming infected. However, the World Health Organization (WHO) and Public Health England recommend against UFMU on the grounds that there is little evidence from randomized controlled trials to support this. Some experts suggest that in a pandemic the precautionary principle should be used and universal face masks use encouraged as it is unlikely to cause harm and may result in public health gain.[3,4] In countries where personal protective equipment is scarce, people are making their own masks.

In China, over 70% of human-to-human transmission of SARS-CoV-2 occurred in families.[5,6]However, data to inform COVID-19 risk reduction in households is unavailable. Given epidemic growth is dominated by household transmission,[5,6] studying the use of NPIs such as face masks, social distancing and disinfection in the household setting may inform community epidemic control and prevent transmission of COVID-19 in households.

METHODS

Study population and design

We conducted a retrospective cohort study involving families of laboratory confirmed COVID-19 cases in Beijing, China. We defined family members as those who had lived with primary cases in a house 4 days before and for more than 24 hours after the primary cases developed illness related to COVID-19. As of 21 February 2020, all laboratory-confirmed COVID-19 cases reported in Beijing were enrolled in our study and followed up. The outcome of interest was secondary transmission in the household. Families with secondary transmission were defined as those where some or all of the family members become infected within one incubation period (2 weeks) of symptom onset of the primary case.

To analyze the predictors of household transmission, we compared families with and without secondary transmission for various measured risk factors, preventive interventions and exposures.

Definition of confirmed case

According to national prevention and control guideline (the 5th edition),[7] confirmed cases were those who met the clinical, epidemiological and laboratory testing criteria for COVID-19 simultaneously.

1. Clinical criteria included: a. fever and/or one or more respiratory symptoms; b. radiological evidence of pneumonia; c. WBC count was normal or decreased, and lymphocyte count was decreased at the early stage of illness.

2. Epidemiological criteria included: a. visits to/living in Wuhan or cities around Wuhan or other communities which had already reported COVID-19 cases in the 14 days prior to onset

of symptom; b. having contact with a person known to have infection with SARS-CoV-2 in the 14 days prior to onset of symptoms; c. having contact with a person who had fever or respiratory symptom and came from Wuhan or adjacent cities or other communities which had already reported COVID-19 cases in the 14 days prior to onset of symptom; d. being one of the cluster cases.

Suspected cases either met one of the epidemiological criteria and any two of the clinical criteria, or just met all of clinical criteria. Confirmed cases were those suspected cases who met one of the following criteria: a. respiratory or blood specimen tested positive for SARS-CoV-2 by real-time RT-PCR; b. virus in respiratory or blood specimen was highly homologous with known SARS-CoV-2 through gene sequencing.

Data collection

A three-part structured questionnaire was developed. The first part included demographic and clinical information of the primary case. The second part was mainly focused on primary case's knowledge about and attitudes toward COVID-19, and their self-reported practices (mask wearing, social distancing, living arrangements) and activities in the home. The third part was about self-reported behaviors of all family members, as well as the family's accommodation and household hygiene practices from 4 days before the illness onset to the day the primary case was isolated, including room ventilation, room cleaning and disinfection. Close contact was defined as being within 1 meter or 3 feet of the primary case, such as eating around a table or sitting together watching TV. The frequency of contact, disinfection and ventilation was measured.

After diagnosis, the primary case was hospitalized as per standard practice in Beijing. Eligible primary cases and their family members were interviewed between 28 February and 8 March. Data on the primary case was extracted from epidemiological investigating reports from Beijing Center for Disease Prevention and Control and supplemented by interview.

Clinical severity of COVID-19 case was categorized as mild, severe, or critical. Mild disease included non-pneumonia and mild pneumonia cases. Severe disease was characterized by dyspnea, respiratory frequency≥30/minute, blood oxygen saturation≤93%, PaO2/FiO2 ratio<300, and/or lung infiltrates >50% within 24–48 hours. Critical cases were those who exhibited respiratory failure, septic shock, and/or multiple organ dysfunction/failure.[8]

Statistical analysis

Risk factors for secondary transmission were analyzed by characteristics of the primary case, characteristics of well family members and household hygiene practices. Categorical variables were presented as counts and percentages, and continuous variables were presented as medians and interquartile ranges (IQR). Chi-squared test and Fisher exact test were applied to compare difference between groups when necessary. A composite COVID-19 knowledge score and hand hygiene score were created with multiple sub-questions. A multivariable logistic regression model was used to identify risk factors associated with SARS-CoV-2 household transmission.Univariable analysis was first performed with all measures and only those variables significant at $P< 0.1$ could be selected in the following multivariable logistic regression analysis. Backward elimination was performed to establish a final model retaining those with $P< 0.05$ in the model. Statistical analyses were performed using SAS software

(Version 9.4).

Ethical statement: Since our study was imbedded within COVID-19 prevention and control practice within public health units, and the telephone interview was a supplementary survey of the epidemiological field investigation, ethical approval was not required.We obtained subjects' verbal informed consent before the start of interviews.

Patient and public involvement

No patients or the public were involved in the study design, setting the research questions, interpretation or writing up of results, or reporting of the research.

RESULTS

As of21 February 2020,399 confirmed COVID-19 cases in 181 families were reported in Beijing. Four family clusters were excluded because we were unable to determine whether there was secondary transmission or co-exposure, leaving 177 families. After reviewing information in the epidemiological investigation reports and survey calls, 40 families were excluded as they did not meet the study inclusion criteria. A further 13 families declined to be interviewed were also excluded, leaving 124 families for study (Figure 1).

Over the two weeks follow up from onset of the primary case, secondary transmission occurred in 41/124 families (77 secondary cases), and 83/124 families had no secondary transmission.

The overall secondary attack rate in families was of 23.0% (77/335). In the secondary transmission group 41 primary cases caused 77 secondary cases, with a median secondary case number in families of 2 (IQR: 1-2). In the secondary transmission group, the secondary attack rate of children under 18 was 36.1% (13/36), compared to 69.6% (64/92) in adults, with the difference between these two age groups being significant (χ^2=12.08, P< 0.001). The median age of the 13 secondary child cases was 3 years (IQR: 2-6), 12/13 were mild and 1/13 was asymptomatic. Of 64 secondary adult cases, 82.8% (53/64) were mild, 10.9% (7/64) were severe, 1.6% (1/64) was critical, and 4.7% (3/64) were asymptomatic. No statistically significant difference was observed in clinical severity between 41 index adult cases (Table 1) and 64 secondary adult cases for the secondary transmission group (P = 0.18).

The univariable analysis for association with secondary transmission of SARS-CoV-2 within families is shown in Table 1. Significant associations were:

1. Characteristics, behaviors and knowledge of the primary case: having diarrhea, interval from illness onset to medical isolation > 2 days, self-awareness of being infected with SARS-CoV-2 when developed illness, lacking knowledge of their own infectiousness, mask wearing in the home after illness onset, failing to self-isolate and not eating separately were associated with transmission. (Table 1)

2. Behaviors of family members: having daily close contact with primary case at home, and number of family members wearing mask in the home before and after primary case's illness onset date were associated with transmission. (Table 2)

3. Household practices: frequency of using chlorine or ethanol-based disinfectant for household cleaning and household ventilation duration were protective. (Table 3)

In multivariable logistic regression model, 4 factors remained significantly associated with secondary transmission. The primary case having diarrhea in the home and daily close contact with primary case in the home increased the risk. Transmission was significantly reduced by frequent use of chlorine or ethanol-based disinfectant in households and family members (including the primary case) wearing a mask at home before the primary case developed illness. (Table 4)

DISCUSSION

This study confirms the highest risk of household transmission being prior to symptom onset, but that precautionary NPIs such as mask use, disinfection and social distancing in households can prevent COVID-19 transmission during the pandemic. This study is the first to confirm the effectiveness of mask use prior to symptom onset by family members, daily household disinfection and social distancing in the home. This could inform precautionary guidelines for families to reduce intrafamilial transmission in areas where there is high community transmission or other risk factors for COVID-19. Household transmission is a major driver of epidemic growth. [5,6] Further, in countries where health system capacity is exhausted, many people with infection are required to self-isolate at home, where their household contacts will be at risk of infection. In our study, the median family size of the 124 families was 4 with a range from 2 to 9, usually with children, parents and grandparents, which is similar to the social structure of most Chinese families.[9] Therefore, the risk of SARS-CoV-2 household transmission is high if a primary case was introduced and no measure was adopted. We show that NPIs are effective at preventing transmission, even in homes that are crowded and small. UFMU is a low-risk intervention with potential public health benefits.[3,4]The results suggest that community face mask use is likely to be the most effective inside the household during severe epidemics.

Almost a quarter of family members became infected, and the findings suggest that the risk was highest either before symptom onset or early in the clinical illness, as most primary cases were hospitalized after diagnosis, and interventions were not effective if applied after symptom onset. In the univariate analysis, wearing a mask after illness onset was significant, but in multivariate analysis, only wearing it before symptom onset was effective. Viral load is highest in the two days before symptom onset and on the first day of symptoms and up to 44% of transmission is during the pre-symptomatic period in settings with substantial household clustering.[10, 11] This supports UFMU, probably by reducing onward transmission from people in the pre-symptomatic phase of the illness[12,13] as well as protecting well mask users. Randomised clinical trials (RCTs) of face masks in the household have confirmed protection against other respiratory viruses if compliant, if used within 36 hours of primary case symptom onset, and alone or in combination with hand hygiene.[14,15] This study now provides specific evidence for UFMU in settings of high epidemic growth to protect against COVID-19. In our study, 91.2% (103/113) primary cases had a high score on hand hygiene,

but it was not effective, confirming the results of previous RCTs which showed hand hygiene alone did not protect against respiratory transmissible viruses, but masks and hand hygiene.[16]

As thecompliance of UFMU would be poor in the home, there was difficulty and also no necessityfor everyone to wear masks at home. We recommended those families with members who were at risk of getting infected with SARS-CoV-2 (such as ever havingcontact with a COVID-19 patient, medical workers caring for COVID-19 patient, or having history of travelling to high-risk areas) to apply UFMU to reduce risk of household transmission.

This study showed that social distancing within the home is effective and having close contact (within 1 meter or 3 feet, such as eating around a table or sitting together watching TV) is a risk factor for transmission. The study also provides evidence of effectiveness of chlorine or ethanol based household disinfection in areas with high community transmission, or where one family member is a health worker, or where there is a risk of COVID-19, such as during home quarantine, consistent with advice provided by local health authorities or organizations.[17]Diarrhea as a symptom in the primary case is also a risk factor for SARS-CoV-2 transmission within families, which highlights the importance of disinfection of bathroom and toilet, as well as closing the toilet lid when flushing to prevent aerosolization of the virus.

Our study has limitations. Telephone interview has inherent limitations including recall bias. It would take about 20 minutes to complete an interview, and 95% (118/124) of interviews were rated as informative by the interviewers. The evaluation results of mask wearing were reliable, but we did not collect data on the concentration of disinfectant used by families. The strengths of the study were that we had complete follow up data and were able to accurately ascertain incidence of secondary transmission in the cohort.

CONCLUSIONS

Household transmission in the pre-symptomatic or early symptomatic period of COVID-19 is a driver of epidemic growth and any measure aimed at reducing this can flatten the curve. This study reinforces the high risk of transmission in households but importantly, shows that UFMU and hygiene measures can significantly reduce the risk of household transmission of COVID-19, independent of household size or crowding. This is the first study to show effectiveness of precautionary mask use, social distancing and regular disinfection in the household, and can inform guidelines for prevention of household transmission. The results may also be informative for families of high-risk groups such as health workers, quarantined individuals or situations where cases of COVID-19 have to be managed at home.

Contributors: PY, QW, YW, LZ designed the study, YW, LZ, MZ, DG,WW, XZ, LJ, DH, BL, XW, YS were responsible for data collection, QW, HT, CRM offered technical and material support, YW, PY analyzed data, YW drafted the manuscript, CRM, QW, PY, HT, LG revised the final manuscript. All authors approved the final draft of the manuscript. PY and QW are the guarantors. The corresponding authors attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.
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Figure 1 Title: Selection and inclusion of interviewing subjects

Figure Legends

Summary of household enrollment, inclusion and interview response in the analysis of SARS-CoV-2 household transmission in Beijing, China.

Table 1 Characteristics of primary cases of COVID-19 –univariable analysis

Primary cases	Total, No. (%) (n=124)	Family without transmission, No. (%) (n=83)	Family with transmission, No. (%) (n=41)	*P*	Unadjusted OR (95%CI)
Age, median (IQR), years	45.0 (35.7–60.0)	42.0 (34.0–57.5)	52.0 (39.3–61.0)	..	..
<18	0	0	0	..	..
18–59	92 (74.2)	63 (75.9)	29 (70.7)	..	Ref
≥60	32 (25.8)	20 (24.1)	12 (29.3)	0.54	1.30 (0.56 to 3.02)
Sex	..	..	..	..	..
Male	61 (49.2)	40 (48.2)	21 (51.2)	..	Ref
Female	63 (50.8)	43 (51.8)	20 (48.8)	0.75	0.89 (0.42 to 1.87)
Education level	..	..	..	..	..
High school or lower	26 (21.0)	18 (21.7)	8 (19.5)	..	Ref
Bachelor degree	69 (55.6)	47 (56.6)	22 (53.7)	0.53	0.75 (0.30 to 1.86)
Graduate degree	29 (23.4)	18 (21.7)	11 (26.8)	0.65	0.77 (0.25 to 2.38)
Clinical severity	..	..	..	..	..
Mild	96 (77.4)	63 (75.9)	33 (80.4)	..	Ref
Severe	20 (16.1)	16 (19.3)	4 (9.8)	0.22	0.48 (0.15 to 1.54)
Critical	8 (6.5)	4 (4.8)	4 (9.8)	0.38	1.91 (0.45 to 8.13)
Fever (≥37.3°C)	..	..	..	..	..
No	18 (14.5)	9 (10.8)	9 (22.0)	..	Ref
Yes	106 (85.5)	74 (89.2)	32 (78.0)	0.11	0.43 (0.16 to 1.19)
Cough*	..	..	..	..	..
No	66 (53.2)	45 (54.2)	21 (51.2)	..	Ref
Yes	58 (46.8)	38 (45.8)	20 (48.8)	0.75	1.13 (0.53 to 2.39)
Diarrhea†	..	..	..	..	..

No	109 (87.9)	76 (91.6)	33 (80.5)	..	Ref
Yes	15 (12.1)	7 (8.4)	8 (19.5)	0.08	2.63 (0.88 to 7.85)
Comorbidity	..	..	..	..	..
No	103 (83.1)	72 (86.7)	31 (75.6)	..	Ref
Yes	21 (16.9)	11 (13.3)	10 (24.4)	0.13	2.11 (0.81 to 5.48)
Time interval from illness onset to first hospital visit, median (IQR), days§	3.0 (1.0–7.0)	3.0 (1.0–7.0)	4.0 (2.0–7.0)	..	..
≤2	47 (37.9)	35 (42.2)	12 (29.3)	..	Ref
>2	77 (62.1)	48 (57.8)	29 (70.7)	0.17	1.76 (0.79 to 3.93)
Time interval from illness onset to medical isolation, median (IQR), days	5.0 (2.0–7.0)	5.0 (2.0–7.0)	5.0 (3.0–9.0)	..	..
≤2	32 (25.8)	26 (31.3)	6 (14.6)	..	Ref
>2	92 (74.2)	57 (68.7)	35 (85.4)	**0.05**	2.66 (1.00 to 7.12)
Time interval from illness onset to lab confirmation, median (IQR), days	7.0 (4.7–10.2)	7.0 (4.4–9.9)	8.0 (5.6–12.9)	..	..
≤3	16 (12.9)	13 (15.7)	3 (7.3)	..	Ref
>3	108 (87.1)	70 (84.3)	38 (92.7)	0.20	2.35 (0.63 to 8.77)
Knowledge score on COVID–19 before illness onset (14 in total), median (IQR) ¶	5 (0–9)	5 (0–9)	5 (0–10)	..	..
≥10	31 (25.0)	18 (21.7)	13 (31.7)	..	Ref
3–9	45 (36.3)	32 (38.6)	13 (31.7)	0.24	0.56 (0.22 to 1.47)
≤2	48 (38.7)	33 (39.7)	15 (36.6)	0.33	0.63 (0.25 to 1.61)
Self-awareness of being infected with	..	..	..	..	..

SARS-CoV-2 when developed illness					
Likely	45 (36.3)	35 (42.2)	10 (24.4)	..	Ref
Unlikely	79 (63.7)	48 (57.8)	31 (75.6)	0.06	2.26 (0.98 to 5.21)
Knowledge of their own infectiousness after illness onset	..	..	..	..	..
Likely	84 (67.7)	62 (74.7)	22 (53.7)	..	Ref
Unlikely	40 (32.3)	21 (25.3)	19 (46.3)	0.02	2.55 (1.16 to 5.61)
Wear mask at home after illness onset **	..	..	..	..	..
Never	41 (33.1)	24 (28.9)	17 (41.5)	..	Ref
Sometime	37 (29.8)	21 (25.3)	16 (39.0)	0.76	1.15 (0.46 to 2.87)
All the time	46 (37.1)	38 (45.8)	8 (19.5)	0.02	0.30 (0.11 to 0.82)
Self-isolated in after illness onset	..	..	..	..	..
Yes	79 (63.7)	58 (69.9)	21 (51.2)	..	Ref
No	45 (36.3)	25 (30.1)	20 (48.8)	0.05	2.17 (1.00 to 4.70)
Eat separately at home after illness onset	..	..	..	..	..
Yes	70 (56.5)	54 (65.1)	16 (39.0)	..	Ref
No	54 (43.5)	29 (34.9)	25 (61.0)	0.008	2.86 (1.32 to 6.19)
Eat with separate tableware	..	..	..	..	..
Yes	81 (65.3)	58 (69.9)	23 (56.1)	..	Ref
No	43 (34.7)	25 (30.1)	18 (43.9)	0.14	1.78 (0.82 to 3.88)
Score on hand hygiene (8 in total) (with 11 missing value), median (IQR)††	8 (7–8)	8 (7–8)	7 (6–8)	..	..
≥6	103 (91.2)	68 (93.2)	35 (87.5)	..	Ref

4–5	7 (6.2)	4 (5.5)	3 (7.5)	0.63	1.46 (0.31 to 6.88)
≤3	3 (2.6)	1 (1.3)	2 (5.0)	0.28	3.88 (0.34 to 44.29)

* Primary case ever had the symptom of cough when living with others at home.

† Primary case ever had the symptom of diarrhea (change of character of stool) when living with others at home.

§ Date of illness onset: the date on which cases self-reported the appearance of either fever (≥37.3°C) or any respiratory symptom during epidemiological investigation. Date of hospital visit was the earliest date that cases sought medical service for COVID-19 related illness.

¶Knowledge score on COVID–19: A composite variable involving primary case's knowledge on the infectivity of SARS-CoV-2, contagious population, transmission route, susceptible population, incubation period, common symptom and preventive measures.

** Mask wearing: refers to primary case or family members wear a facemask at home, no matter it's a N95 mask, disposable surgical mask or just a common mask including cloth mask. Wearing masks all the time means primary case wear a mask all the time except having dinner or sleep at home.

†† Score on hand hygiene: A composite variable involving primary case' hand washing practice, including using running water, washing frequency, using sanitizer, under what conditions.

Table 2 Characteristics of well family members –univariable analysis

Family members	Total, No. (%) (n=121)	Family without transmission, No. (%) (n=81)	Family with transmission, No. (%) (n=40)	*P*	Unadjusted OR (95% CI)
Family size, median (IQR)	4 (3–5)	3 (3–5)	4 (3–6)	..	..
≤3	56 (46.3)	41 (50.6)	15 (37.5)	..	Ref
>3	65 (53.7)	40 (49.4)	25 (62.5)	0.18	1.71 (0.79 to 3.71)
Close contact with primary cases at home (within 1 meter or 3 feet), times *	..	..	..	..	..
0	41 (33.9)	36 (44.4)	5 (12.5)	..	Ref
1–3	61 (50.4)	38 (46.9)	23 (57.5)	**0.005**	4.55 (1.57 to 13.20)
≥4	19 (15.7)	7 (8.7)	12 (30.0)	**< 0.001**	12.34 (3.30 to 46.23)
Number of family members wearing mask at home before primary case's illness onset date, median (IQR) †	0 (0–1)	0 (0–2)	0 (0–0)	..	..
none	90 (74.4)	54 (66.7)	36 (90.0)	..	Ref
1 or more	31 (25.6)	27 (33.3)	4 (10.0)	**0.009**	0.22 (0.07 to 0.69)
Number of family members wearing mask at home after primary case's illness onset date, median (IQR) §	1 (0–3)	2 (0–3)	0 (0–3)	..	..
None	47 (38.8)	26 (32.1)	21 (52.5)	..	Ref
Some	38 (31.4)	24 (29.6)	14 (35.0)	0.47	0.72 (0.30 to 1.73)
All	36 (29.8)	31 (38.3)	5 (12.5)	**0.004**	0.20 (0.07 to 0.60)

* Close contact with primary cases at home: Family members stay with primary case in a short distance (within 1 meter or 3 feet) for more than 10 minutes a time. For example, they have dinner with primary case around a table or watch TV sitting near.

† Family members wearing masks at home before primary case's illness onset date: Before primary case developed illness, the primary case or his/her family contacts wear

masks all the time at home.

§ Family members wearing mask at home after primary case's illness onset date: When primary case developed illness, primary case's family contacts wear masks all the time living with primary case at home.

Table 3 Characteristics of the residence and household practices–univariable analysis between two family groups

Residence and household practices	Total, No. (%) (n=121)	Family without transmission, No. (%) (n=81)	Family with transmission, No. (%) (n=40)	*P*	Unadjusted OR (95% CI)
Residential area per capita, median (IQR), square meter	25.0 (17.3–35.0)	28.0 (18.0–35.8)	20.0 (16.9–31.8)	..	..
≤20	50 (41.3)	30 (37.1)	20 (50.0)	..	Ref
20–40	49 (40.5)	36 (44.4)	13 (32.5)	0.16	0.54 (0.23 to 1.27)
≥40	22 (18.2)	15 (18.5)	7 (17.5)	0.51	0.70 (0.24 to 2.02)
Number of bedrooms per person, median (IQR)	0.7 (0.5–1.0)	0.7 (0.5–1.0)	0.7 (0.5–1.0)	..	..
≥1	39 (32.2)	28 (34.6)	11 (27.5)	..	Ref
<1	82 (67.8)	53 (65.4)	29 (72.5)	0.49	1.34 (0.59 to 3.08)
Number of washrooms, median (IQR)	1 (1–2)	1 (1–2)	1 (1–2)	..	..
2 or more	34 (28.1)	23 (28.4)	11 (27.5)	..	Ref
1	87 (71.9)	58 (71.6)	29 (72.5)	0.87	1.07 (0.46 to 2.49)
Frequency of room cleaning (wet–type)	..	..	..		..
Once in 1 to 2 days	83 (68.6)	59 (72.8)	24 (60.0)	..	Ref
Once in more than 2 days	38 (31.4)	22 (27.2)	16 (40.0)	0.11	1.90 (0.86 to 4.19)
Frequency of chlorine or ethanol based disinfectant use for house cleaning*	..	..	..	..	..
Once in 2 or more days	86 (71.1)	50 (61.7)	36 (90.0)	**..**	Ref
Once a day or more	35 (28.9)	31 (38.3)	4 (10.0)	**0.003**	0.18 (0.06 to 0.55)
Ventilation duration per day median (IQR), hour†	2.0 (1.0–6.0)	3.0 (1.5–8.0)	1.8 (1.0–4.0)	..	..
>1	85 (70.2)	62 (76.5)	23 (57.5)	..	Ref

≤1	36 (29.8)	19 (23.5)	17 (42.5)	**0.02**	2.55 (1.14 to 5.70)

* Chlorine or ethanol based disinfectant use for house cleaning: When doing house cleaning, disinfectant which contains chlorine or ethanol is used to disinfect the floor, door and window handles, indoor air, tables and toilets.

† Ventilation means the practice of opening the window to allow convection of indoor air.

Table 4 Risk factors of SARS-CoV-2 household transmission in multivariable analysis

Risk factors	Adjusted OR	95% CI	*P*
Primary case having diarrhea	..	..	..
No	..	..	Ref
Yes	4.10	(1.08 to 15.60)	**0.04**
Close contact at home with primary cases (within 1 meter or 3 feet), times	..	..	..
0	..	..	Ref
1–3	3.30	(1.05 to 10.40)	**0.04**
≥4	18.26	(3.93 to 84.79)	**＜0.001**
Number of family members (including primary case) wearing mask at home before primary case's illness onset date	..	..	..
none	..	..	Ref
1 or more	0.21	(0.06 to 0.79)	**0.02**
Frequency of chlorine or ethanol based disinfectant use for house cleaning	..	..	..
Once in 2 or more days	..	..	Ref
Once a day or more	0.23	(0.07 to 0.84)	**0.03**