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Letter to the Editor

Risk factors for SARS-CoV-2 transmission in non-household clusters

Ladhani et al. assessed occupational risk factors for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection among staff in care homes. [1] They identified SARS-CoV-2 clusters involving staff; staff working across different care homes had a 3-fold higher risk of SARS-CoV-2 positivity than those who were working in single care homes. In South Korea, three waves of coronavirus disease 2019 (COVID-19) pandemic has been repeated, and each of them was associated with several large clusters in working places, churches and sports centers.[2] In this study, we aimed to evaluate the risk factors for SARS-CoV-2 transmission in non-household clusters of COVID-19 through a thorough epidemiological investigation.

From 1 March to 30 August of 2020, we recruited adult patients aged ≥19 years with COVID-19 and their close contacts in the non-household clusters. We defined clusters as two or more confirmed infections with reported close contact. Close contacts were identified through a rigorous epidemiological investigation, including tracking cellular-phone locations, credit-card usage, closed-circuit television images, and in-depth interviews of patients with COVID-19. Those who had been exposed to SARS-CoV-2 in their households or abroad were excluded from this study. In order to evaluate the risk factors of SARS-CoV-2 infection, the SARS-CoV-2-positive group and the SARS-CoV-2-negative group were compared. Participants who were negative for SARS-CoV-2 at the time of a cluster development and were negative for anti-SARS-CoV-2 antibodies in the convalescent phase were included in a SARS-CoV-2-negative group.

For all the study participants, SARS-CoV-2 quantitative reverse transcription polymerase chain reaction (qRT-PCR) was conducted using Allplex 2019-nCoV assay (Seegene, Seoul, South Korea), and each sample was defined as negative if the Cycle threshold values exceeded 40 cycles. For serological diagnoses, antibodies were measured with convalescent blood serum for all study participants using the anti-SARS-CoV-2 nucleocapsid IgG assay (Abbott Laboratories, Chicago, IL, USA).[3] For participants positive for IgG antibodies, the plaque reduction neutralization test (PRNT) was conducted to confirm SARS-CoV-2 infection as described previously.[4]

Statistical analyses were performed using SPSS Statistics (version 20.0; IBM Corp., Armonk, NY, USA). Univariate analysis was performed using either the chi-square test or Fisher's exact test. Forward stepwise logistic regression analysis was conducted to investigate independent risk factors for SARS-CoV-2 transmission. The Institutional Review Boards of Korea University Guro Hospital approved the study (approval number: 2020GR0130). All study participants provided written informed consent.

A total of 224 study participants who had been involved in COVID-19 outbreaks at a call center, churches, hospitals, and a research building were investigated. This study population comprised 76 patients with COVID-19 (SARS-CoV-2-positive group) and 148 close contacts who tested negative for SARS-CoV-2. Among the SARS-CoV-2-positive group of 76 patients, most cases were confirmed using qRT-PCR, while four (5.3%) cases were diagnosed using serologic assays. The mean ages of the participants in the SARS-CoV-2-positive group and SARS-CoV-2-negative group were 46.75 (19–65 years) and 41.53 years (19–67 years), respectively ($P < 0.001$).

We found that actions associated with close contact, such as face-to-face conversations, eating together, and using the same toilet as that used by a COVID-19 patient, were significantly more frequent in the SARS-CoV-2-positive group than in the SARS-CoV-2-negative group ($P < 0.001$ for all three variables). Meanwhile, there was no significant difference in the frequencies with which objects were shared with persons with SARS-CoV-2 infection between the SARS-CoV-2-positive and SARS-CoV-2-negative groups ($P = 0.779$).

On multivariable analysis, persons aged ≥ 40 years had a higher risk of SARS-CoV-2 infection than those aged < 40 years (odds ratio [OR]: 5.55), and workers at a call center had a higher risk of SARS-CoV-2 infection than workers at a research building (OR: 14.39). Conversing face-to-face with a COVID-19 patient was revealed to be an independent risk factor for SARS-CoV-2 transmission (OR: 4.11) (Table 1).

With respect to the age, persons aged ≥ 40 years had a higher risk of SARS-CoV-2 infection than those aged < 40 years. Although case fatality rates of COVID-19 were presented as an age-based exponential increase pattern, the incidence of COVID-19 by age varied according to country.[5] It is possible that the age-related difference in behavioral patterns within a group might affect the risk of SARS-CoV-2 transmission. When clusters were compared according to their location, in this study, the risk of SARS-CoV-2 transmission was found to be significantly higher in a call-center cluster than in a research-building cluster. Call-center workers usually talk continuously when making and receiving phone calls at their workplace. A crowded space and prolonged exposure to respiratory particles from infected patients may facilitate viral transmission. Regarding the transmission mode of SARS-CoV-2, in consistent with our results, a previous study in Singapore showed that verbal interactions were significantly associated with SARS-CoV-2 transmission.[6] The possibility of SARS-CoV-2 transmission by fomites appears to be low in the real world.[7]

Notably, five individuals (6.6%) in the SARS-CoV-2-positive group denied that they had participated in face-to-face conversations, eating together, using the same toilets, and sharing objects with patients with COVID-19; these individuals included four from the call center and one from a church. Although close contact events were not identified through investigation, it is uncertain whether these patients might have been infected by the airborne transmission of SARS-CoV-2. Droplets exist across a contin-

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Table 1
Investigation of risk factors for SARS-CoV-2 infection among COVID-19 patients and their contacts.

	SARS-CoV-2-positive group (n = 76), n (%)	SARS-CoV-2-negative group (n = 148), n (%)	Univariable analysis OR (95% CI)	P-value	Multivariable analysis[a] OR (95% CI)	P-value
Sex						
Male	10 (13.2)	44 (29.7)	Ref			
Female	66 (86.8)	104 (70.3)	2.79 (1.32–5.93)	0.007	–	–
Age						
< 40 years	11 (14.5)	69 (46.6)	Ref			
≥ 40 years	65 (85.5)	79 (53.4)	5.16 (2.52–10.56)	<0.001	5.55 (2.12–14.54)	<0.001
Clusters						
Research building	3 (3.9)	49 (33.1)	Ref		Ref	
Call center	60 (78.9)	21 (14.2)	46.67 (13.14–165.71)	<0.001	14.39 (3.66–56.54)	<0.001
Church	9 (11.8)	64 (43.2)	2.30 (0.59–8.94)	0.230	0.62 (0.14–2.83)	0.537
Hospital	2 (2.6)	10 (6.8)	3.27 (0.48–22.15)	0.225	1.19 (0.15–9.33)	0.870
Others	2 (2.6)	4 (2.7)	8.17 (1.04–64.02)	0.046	4.13 (0.48–35.86)	0.198
Modes of contact with patients with COVID-19						
Face-to-face conversation						
No	12 (15.8)	80 (54.1)	Ref			
Yes	64 (84.2)	68 (45.9)	6.28 (3.13–12.59)	<0.001	4.11 (1.69–10.00)	0.002
Eating together						
No	24 (31.6)	116 (78.4)	Ref			
Yes	52 (68.4)	32 (21.6)	7.85 (4.22–14.63)	<0.001	–	–
Using the same toilet						
No	11 (14.5)	76 (51.4)	Ref			
Yes	65 (85.5)	72 (48.6)	6.24 (3.05–12.76)	<0.001	–	–
Sharing the same objects						
No	69 (90.8)	136 (91.9)	Ref			
Yes	7 (9.2)	12 (8.1)	1.15 (0.43–3.05)	0.779	–	–

[a] Forward stepwise logistic regression.

uum of sizes, and airflow is crucial in determining the travel distance of droplets.[8] Nonetheless, there is increasing evidence for the airborne transmission of SARS-CoV-2, which demands changes in infection-control measures.[7] Airborne transmission of SARS-CoV-2 can occur in special circumstances, such as those involving enclosed spaces, prolonged exposures to respiratory particles, and inadequate ventilation or air handling.[9]

This study has some limitations. First, environmental samples were not taken due to access restrictions when an outbreak occurred. Second, because viral isolates were unavailable, we could not carry out whole-genome sequencing, which is a useful tool to clarify the transmission dynamics in each cluster.

In conclusion, this study shows that face-to-face conversations with a patient with COVID-19 was the most significant risk factor for SARS-CoV-2 transmission in non-household clusters. The possibility of fomite-mediated SARS-CoV-2 transmission appears very low in an environment where hand hygiene is emphasized.

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Declaration of Competing Interest

All authors: No reported conflicts of interest. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest.

CRediT authorship contribution statement

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