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Concise Communication

Risk factors for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) RNA environmental contamination in rooms of patients with coronavirus disease 2019 (COVID-19)

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Abstract

The risk factors of environmental contamination by SARS-CoV-2 are largely unknown. We analyzed 1,320 environmental samples obtained from COVID-19 patients over 1 year. The risk factors for contamination of COVID-19 patients' surrounding environment were higher viral load in the respiratory tract and shorter duration from symptom onset to sample collection.

Coronavirus disease 2019 (COVID-19) is a novel zoonotic disease caused by infection with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[1] The primary methods of SARS-CoV-2 transmission are respiratory droplets and close contact.[2] Several studies have shown that environmental contamination by SARS-CoV-2 can occur in quarantine rooms.[3,4] However, previous studies have analyzed only a relatively small number of samples. We analyzed the risk factors for contamination of SARS-CoV-2-infected patients' environmental surface using a large number of participants and samples.

Methods

This study was conducted at Chosun University Hospital between February 6, 2020, and February 28, 2021. Environmental specimens were tested using specific real-time reverse transcriptase-polymerase chain reaction (RT-PCR) targeting the nucleocapsid protein (NP) gene, with a cutoff cycle threshold (Ct) value of >40. The respiratory specimens were evaluated using a specific RT-PCR (STANDARD M nCoV Real-Time Detection Kit, SD BIOSENSOR, Republic of Korea), targeting the envelope (*E*) genes and RNA-dependent RNA polymerase (RdRp) of SARS-CoV-2.[5] The PCR methods that we used generally detect the presence of a microorganism regardless of that microorganism's viability to cause new infections. The cycle threshold (Ct) values (ie, the number of cycles required for the fluorescent signal to cross the threshold in RT-PCR) were used to quantify the viral load. Lower values indicate a higher viral load.

Nurses disinfected the quarantine room in which the patient was hospitalized once daily using benzethonium chloride with 2-butoxyethanol and isopropanol (ED wipes, MH Healthcare, Republic of Korea, and CaviWips, Metrex Research, Orange, CA). Swab samples from the patient's environment were collected from 10 sites inside the isolation room: telephone, bed railing, table, intravenous (IV) pole handle, toilet handle, television remote control, refrigerator handle, light switch, sink–drainage hole, and wardrobe handle. Environmental samples were collected twice per week, and additional samples were collected before and after each aerosol-generating procedure. Smear samples from environmental surfaces were collected using sterile cotton swabs (Noble Biosciences, Republic of Korea), and the specimens were immediately placed in ENAT Copan viral transport medium (Copan Diagnostics, Carlsbad, CA). At the same time, the nasopharyngeal swabs of patients were collected on the day of environmental surveillance.

We used multiple logistic regression analysis to determine risk factors for environmental contamination: age (≥65 years), sex, presence of underlying disease, initial viral load in the respiratory tract (Ct value, 25), history of remdesivir administration, duration from symptom onset to sample collection (10 days), and presence of COVID-19–related symptoms (eg, cough, sputum, fever, sore throat, shortness of breath, muscle aches, etc). A 2-sided $P \leq .05$ was considered statistically significant. The statistical analyses were performed using SPSS version 26.0 software (IBM, Armonk, NY).

We attempted to incubate the virus found in the environmental samples of COVID-19 patients with a Ct value <35 to evaluate the viability of SARS-CoV-2 on environmental surfaces. The mean number of samples collected per patient was 27.5 (range, 22.5–30). The surface of the room was cleaned every day, and if it was a sampling day, cleaning was performed after sampling. Unfortunately, control samples were not obtained after cleaning to evaluate whether residual contamination could be detected after final washing and disinfection.

The Institutional Review Board of Chosun University Hospital approved the study protocol (IRB no. NON2020-001).

Results

Environmental specimens were collected during 48 of 105 stays of patients with COVID-19. In total, 1,320 environmental samples were obtained from 48 patient stays. SARS-CoV-2 RNA was identified in 103 environmental samples (7.8%) from 28 separate patient stays (58.3%). Of these 28 patient stays, contamination of telephone, bed railing, table, and toilet handles was confirmed in 7 patient stays (25%), respectively. In addition, contamination of IV pole handle was confirmed in 8 patient stays (28.6%), television remote control contamination was confirmed in 10 patient stays (35.7%), refrigerator handle contamination was confirmed in 6 patient stays (21.4%), light switch contamination was confirmed in 5 patient stays (17.9%), and sink contamination was confirmed in 15 patient stays (53.6%). The Pearson correlation coefficient of Ct value and the number of contaminated sites was −0.497, with a *P* value of .007. This result is moderate correlation with statistical significance. The most contaminated site was the sink, for which the sample was positive for SARS-CoV-2 in 20 (15.2%) of 132 samples, followed by the IV pole handle, which was positive in 13(9.8%) of 132 samples, and the TV remote control, which was positive in 12 (9.1%) of 132 samples. The average Ct value of most places where viral SARS-CoV-2 RNA was identified was 34 or higher (Table 1).

Multilogistic regression analysis showed the higher patient viral load in the respiratory tract at the time of their stay (ie, admission) and shorter the duration from patient symptom onset to patient sample collection were associated with higher risk of SARS-CoV-2 virus contamination in the surrounding environment (Table 2).

In several studies, attempts have been made to culture a viable virus on an environmental surface, and the results have varied. Some studies have shown that a culture is viable and some have shown that it is not.[6,7] We attempted to cultivate the virus from 15 samples with a Ct value <35 using real-time RT-PCR targeting SARS-CoV-2 virus-specific NP genes. No cultivable virus was detected in any of these samples.

Discussion

Proper prevention of SARS-CoV-2 transmission is an important part of epidemic prevention and control in this global pandemic. Several studies have shown that the main transmission methods for SARS-CoV-2 are droplets and close contact. However, studies on contamination in the surrounding environment of confirmed patients by close contact transmission are limited, and they have included only relatively small sample sizes.[8,9] For this reason, we sought to identify the risk factors associated with environmental contamination in many patients and environmental samples. Viruses are commonly detected in the environment in places where patients touch (eg, television remote controls) and in places that are frequently touched by medical staff (eg, sinks, IV poles, and handles). Our results indicated that medical staff can transfer virus by touching an environmental surface near the patient when performing care activities. Thus, it very important to perform all contact precautions. The most contaminated surface in our study was the sink. Respiratory specimens (saliva or sputum) have high viral loads that can easily contaminate humid sites, such as a sink, where retention time may also be longer.

The initial viral load of SARS-CoV-2 in the COVID-19 patient's respiratory tract was related to contamination of the patient's environment. These results highlight the importance of environmental

Table 1. Characteristics of 1,320 Swab Samples From Environmental Surfaces

Sampling Site	Total Specimen Counts	Positive Sampling Specimens	% Positive	Average Ct Value
Sink	132	20	15.2	36.2
IV pole handle	132	13	9.8	35.9
TV remote control	132	12	9.1	37
Telephone	132	11	8.3	34.3
Bed railing	132	10	7.6	35.5
Table	132	10	7.6	36.2
Toilet handle	132	8	6.1	34.4
Refrigerator handle	132	8	6.1	35.9
Wardrobe handle	132	8	6.1	36
Light switch	132	3	2.3	37.6

Note. Ct, cycle threshold; IV, intravenous.

Table 2. Multivariable Logistic Regression Analysis of the Factors Associated With the Contamination of COVID-19 Patient Environment

Variables	Environmental Contamination		
	OR	95% CI	*P* Value
Age ≥65 y	1.008	0.964–1.053	.738
Sex, male	0.705	0.160–3.113	.644
Presence of comorbidity	0.717	0.143–3.597	.686
Initial Ct value in respiratory tract, <25	0.901	0.814–0.998	.046
Remdesivir administration	0.728	0.109–4.845	.743
Duration from symptom onset to sampling, ≤10 d	0.835	0.710–0.982	.029
Presence of COVID-19–related symptoms	3.763	0.233–6.778	.350

Note. OR, odds ratio; CI, confidence interval; Ct, cycle threshold.

disinfection, especially in the early phase of admission of patients with confirmed COVID-19 (who recently developed symptoms and thus have high viral loads). However, we were unable to demonstrate the viability of SARS-CoV-2 in environmental specimens. Therefore, further research should include cell-culture tests to assess viral viability using more samples in the surrounding environment of patients who have short durations of symptom onset and high viral loads.

In conclusion, we found SARS-CoV-2 on surfaces in the patient environment that were likely to be contaminated through exposure to respiratory specimens and on objects that were prone to frequent patient contact. Environmental disinfection of places that are likely to be exposed to saliva or sputum, such as sinks, is important.

Mun, Seung Hyun Lee, Seo Hee Seo, Yeong Ji Lim, Geum Bit Hwang, Eun Jeong Gong, Han Sol Hong, Ji Seon Jeong, Su Yeon Go, Na Ri Lee, Ja In Moon, Min Seo Kim, Hyun Young Lee, Sang Young Kim, Bo Ra Lim, Song Won Lee, Ju Jin Kim, Ha Neul Seon, Yea Ji Moon, Jin Young Jo, and Da Min Park from a nationally designated quarantine ward at Chosun University Hospital) and patients involved in the study.

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