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Environmental contamination by SARS-CoV-2 in a designated hospital for coronavirus disease 2019

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Background: Coronavirus disease 2019 (COVID-19) is characterized by risk of nosocomial transmission; however, the extent of environmental contamination and its potential contribution of environmental contamination to SARS-CoV-2 transmission are poorly understood. This study aimed to investigate whether environmental contamination may play a role in SARS-CoV-2 transmission.

Methods: Air samples were collected by natural precipitation, and environmental surface samples were collected by conventional surface swabbing. SARS-CoV-2 RNA detection was performed using reverse transcription polymerase chain reaction.

Results: Viral RNA was not detected in the 44 air samples. The positive rates in 200 environmental surface samples in medical areas (24.83%) was higher than that in living quarters (3.64%), with a significant difference (P < .05). The positive rates were 25.00% and 37.50% for the general isolation ward and intensive care unit, respectively, and no significant difference was observed between them (P = .238). The top 5 sampling sites with a positive rate in medical areas were beepers (50.00%), water machine buttons (50.00%), elevator buttons (42.86%), computer mouses (40.00%), and telephones (40.00%).

Conclusions: Most of the touchable surfaces in the designated hospital for COVID-19 were heavily contaminated, suggesting that the environment is a potential medium of disease transmission. These results emphasize the need for strict environmental surface hygiene practices and enhanced hand hygiene to prevent the spread of the virus. © 2020 Association for Professionals in Infection Control and Epidemiology, Inc. Published by Elsevier Inc. All rights reserved.
of this contamination to SARS-CoV-2 transmission are poorly understood. The present study was performed in a designated hospital to evaluate environmental contamination in the air and surfaces by SARS-CoV-2 RNA qualitative detection and to investigate whether environmental contamination may play a role in SARS-CoV-2 transmission.

METHODS

Study setting

This study was conducted in Wuhan No. 7 Hospital, which was originally a comprehensive Grade 2A hospital and then became one of the first batch designated hospitals for COVID-19 in Hubei Province. The hospital started to treat patients with COVID-19 on January 22, 2020. It comprises general isolation wards, intensive care unit (ICU), fever clinic, clinical laboratory, office areas, and restrooms (Fig 1). All regions of the hospital were divided into 2 categories: (1) moderate- and high-risk regions, including the medical areas such as patient room, nurses’ station, buffer room for taking off personal protective equipment (PPE), and fever clinic, and (2) low-risk regions, including the living quarters such as the restrooms, office areas, and buffer room for taking on PPE.

Sample collection

Flocked swabs, premoistened with viral transport medium, were collected from environmental surfaces that were frequently touched by patients or healthcare workers. The surfaces included beeper, keyboard, computer mouse, telephone, door handle, desktop, medical
equipment, bedrail, bedside table, oxygen cylinder valve, elevator button, and others such as refrigerator, IV port, and sample transfer box. Air samples from medical areas were collected through natural precipitation according to the Hygienic Standard for Disinfection in Hospitals.

All samples were collected under emergency conditions around 8:00 AM before routine cleaning and disinfection and were delivered to the clinical laboratory immediately after collection.

**Statistical analysis**

Statistical analyses were performed using SPSS version 20.0 software (SPSS Inc.). The differences in the positive rates between the medical areas and the living quarters and the general isolation ward and ICU were compared by the χ² test; the Fisher exact test was used when data were limited. A 2-sided α of less than 0.05 was considered significant.

**RESULTS**

**Air samples**

Of the 44 air samples collected in medical areas, none of all was positive for SARS-CoV-2 as assessed by RT-PCR (Table 1).

**Environmental surface samples**

The positive rates of samples from environmental surfaces in different areas are shown in Table 2. Of the 200 swab samples taken from environmental surfaces, 38 were positive for SARS-CoV-2 RNA. Thirty-six (24.83%) of the 145 samples collected in medical areas and 2 (3.64%) of the 55 collected in living quarters were positive for SARS-CoV-2 as assessed by RT-PCR (Table 1). Thirty-six (24.83%) of the 145 samples collected in medical areas and 2 (3.64%) of the 55 collected in living quarters were positive for SARS-CoV-2 RNA.

Aerosol transmission of the virus could lead to the spread of an epidemic infectious disease. However, previous studies suggested that SARS-CoV-2 is transmitted within family and hospital-associated

### Table 2

| Areas                          | No. of tests | No. of positive | Positive rate (%) |
|-------------------------------|-------------|----------------|------------------|
| Medical areas                 | 145         | 36             | 24.83            |
| General isolation ward        | 72          | 18             | 25.00            |
| Ward 1                        | 12          | 6              | 50.00            |
| Ward 2                        | 12          | 0              | 0.00             |
| Ward 3                        | 12          | 4              | 33.33            |
| Ward 4                        | 12          | 3              | 25.00            |
| Ward 5                        | 12          | 1              | 8.33             |
| Ward 6                        | 12          | 4              | 33.33            |
| Intensive care units          | 24          | 9              | 37.50            |
| Clinical laboratory           | 7           | 0              | 0.00             |
| Fever clinic                  | 42          | 9              | 21.43            |
| Emergency room                | 12          | 6              | 50.00            |
| Observation room              | 4           | 1              | 25.00            |
| Treatment room                | 4           | 0              | 0.00             |
| Infusion room                 | 4           | 0              | 0.00             |
| Diagnosis room 1              | 4           | 1              | 25.00            |
| Diagnosis room 2              | 4           | 0              | 0.00             |
| Throat swab sampling room     | 8           | 0              | 0.00             |
| Public area                   | 2           | 1              | 50.00            |
| Total                         | 200         | 38             | 19.00            |

### Table 3

| Sampling site            | No. of tests | No. of positivity | Positive rate (%) |
|--------------------------|--------------|-------------------|------------------|
| Bleepers                 | 6            | 3                 | 50.00            |
| Water machine buttons    | 8            | 4                 | 50.00            |
| Elevator buttons         | 7            | 3                 | 42.86            |
| Computer mouses          | 10           | 4                 | 40.00            |
| Telephones               | 10           | 4                 | 40.00            |
| Keyboards                | 15           | 5                 | 33.33            |
| Medical equipment        | 13           | 4                 | 30.77            |
| Oxygen cylinder valve    | 8            | 2                 | 25.00            |
| Desktops                 | 18           | 3                 | 16.67            |
| Bedrails                 | 7            | 1                 | 14.29            |
| Bedside tables           | 7            | 1                 | 14.29            |
| Gloves                   | 7            | 1                 | 14.29            |
| Door handles             | 15           | 0                 | 0.00             |
| Others                   | 14           | 1                 | 7.14             |
| Total                    | 145          | 36                | 24.83            |
Targeted measures for nosocomial infection prevention and control should be instituted and done by professional cleaning and disinfection of the crucial parts of key departments, and telephones, and keyboards. Special emphasis should be placed on the care workers. The top 5 sites with a positive infection rate were environmental surfaces frequently touched by patients and healthcare workers, using a physical barrier. Targeted measures for nosocomial infection prevention and control were carried out.

Individuals in the designated hospital were required to adhere to the regulations imposed in different areas, and crossing of those different areas was strictly prohibited. The results showed that application of physical barriers combined with behavioral management can effectively prevent the spread of SARS-CoV-2 in the designated hospital. Two positive samples taken from the living quarters indicated the effectiveness of disinfection. Significant environmental contamination by SARS-CoV-2 and demonstrated the effectiveness of disinfection. Significant environmental contamination suggests that the environment is a potential medium of transmission. We proposed the following suggestions: (1) environmental surface disinfection should include wiping in an “S”-shaped motion and not repeating the area that has already been cleaned, according to regulations for hospital-associated infection control in the ward of healthcare facilities (WS/T510-2016); (2) the frequency of disinfection should be increased appropriately, at least 3 times per day: twice during the day and once at night (disinfection should be conducted at any time in case of obvious contamination); and (3) cleaners should be trained repeatedly to ensure that they are qualified for their job.

In conclusion, our study demonstrated that environmental surfaces in designated hospitals for patients with COVID-19 were widely contaminated by SARS-CoV-2, suggesting that the environment is a potential medium of transmission. Strict environmental surface hygiene practices should be implemented to prevent healthcare workers from coming into contact with contaminated environmental surfaces, and hand hygiene should be promoted to prevent the spread of virus.

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Based on the results of our study, it can be concluded that the environment around patients with COVID-19 is widely contaminated. To protect healthcare workers, more thorough infection prevention and control guidelines are needed, as well as delivering methods to prevent contact transmission of COVID-19. Current guidelines suggest gloves, gowns, respirators, and eye protectors as PPE during COVID-19 patient care. There is also need for more careful and comprehensive procedures for putting on and removing PPE. In addition, the basic environmental hygiene and disinfection measures should be put in place. The environmental cleaning and disinfection regimes during the COVID-19 epidemic were similar in all areas: surface cleaning and disinfection using chlorine-based disinfectants were conducted twice per day. There were some limitations in the process of environmental disinfection in the designated hospital. First, environmental surface disinfection was implemented by spraying a chlorine-containing disinfectant. However, spraying cannot cover the surface evenly, such as the corners, and the effect of disinfection cannot be guaranteed without the wiping process. Moreover, spraying disinfectants may lead to harms to patients and health care workers, thus spraying disinfection should not be recommended. Second, the cleaning work in the designated hospital was mostly done by volunteer cleaners during this special period. They received the necessary training without professional experience. Third, all samples were collected under emergency conditions around 8:00 AM before routine cleaning and disinfection. The result may indicate that the usual frequency of disinfection did not meet the demand.

The data obtained in our study provided evidence of environmental contamination by SARS-CoV-2 and demonstrated the effectiveness of disinfection. Significant environmental contamination suggests that the environment is a potential medium of transmission. The data obtained in our study provided evidence of environmental contamination by SARS-CoV-2 and demonstrated the effectiveness of disinfection. Significant environmental contamination suggests that the environment is a potential medium of transmission. The data obtained in our study provided evidence of environmental contamination by SARS-CoV-2 and demonstrated the effectiveness of disinfection. Significant environmental contamination suggests that the environment is a potential medium of transmission. The data obtained in our study provided evidence of environmental contamination by SARS-CoV-2 and demonstrated the effectiveness of disinfection. Significant environmental contamination suggests that the environment is a potential medium of transmission.
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