Air, Surface Environmental, and Personal Protective Equipment Contamination by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) From a Symptomatic Patient

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JAMA. 2020;323(16):1610-1612. doi:10.1001/jama.2020.3227

Methods

From January 24 to February 4, 2020, 3 patients at the dedicated SARS-CoV-2 outbreak center in Singapore in airborne infection isolation rooms (12 air exchanges per hour) with anterooms and bathrooms had surface environmental samples taken at 26 sites. Personal protective equipment (PPE) samples from study physicians exiting the patient rooms also were collected. Sterile premoistened swabs were used.

Air sampling was done on 2 days using SKC Universal pumps (with 37-mm filter cassettes and 0.3-µm polytetrafluoroethylene filters for 4 hours at 5 L/min) in the room and anteroom and a Sartorius MD8 microbiological sampler (with gelatin membrane filter for 15 minutes at 6 m^3/h) outside the room (eFigure in the Supplement).

Specific real-time reverse transcriptase–polymerase chain reaction (RT-PCR) targeting RNA-dependent RNA polymerase and E genes[4] was used to detect the presence of SARS-CoV-2 (see detailed methods in the eAppendix in the Supplement). Cycle threshold values, ie, number of cycles required for the fluorescent signal to cross the threshold in RT-PCR, quantified viral load, with lower values indicating higher viral load.

Samples were collected on 5 days over a 2-week period. One patient's room was sampled before routine cleaning and 2 patients' rooms after routine cleaning. Twice-daily cleaning of high-touch areas was done using 5000 ppm of sodium dichloroisocyanurate. The floor was cleaned daily using 1000 ppm of sodium dichloroisocyanurate.

Clinical data (symptoms, day of illness, and RT-PCR results) and timing of cleaning were collected and correlated with sampling results. Percentage positivity was calculated for rooms with positive environmental swabs. Institutional review board approval and written informed consent were obtained as part of a larger multicenter study.

Results

Patient A's room was sampled on days 4 and 10 of illness while the patient was still symptomatic, after routine cleaning. All samples were negative. Patient B was symptomatic on day 8 and asymptomatic on day 11 of illness; samples taken on these 2 days after routine cleaning were negative (Table 1).

Patient C, whose samples were collected before routine cleaning, had positive results, with 13 (87%) of 15 room sites (including air outlet fans) and 3 (60%) of 5 toilet sites (toilet bowl, sink, and door handle) returning positive results (Table 2). Anteroom and corridor samples were negative. Patient C had upper respiratory tract involvement with no pneumonia and had 2 positive stool samples for SARS-CoV-2 on RT-PCR despite not having diarrhea.

Patient C had greater viral shedding, with a cycle threshold value of 25.69 in nasopharyngeal samples compared with 31.31 and 35.33 in patients A and B (Table 1).

Only 1 PPE swab, from the surface of a shoe front, was positive. All other PPE swabs were negative. All air samples were negative.

Discussion

There was extensive environmental contamination by 1 SARS-CoV-2 patient with mild upper respiratory tract involvement. Toilet bowl and sink samples were positive, suggesting that viral shedding in stool[5] could be a potential route of transmission. Postcleaning samples were negative, suggesting that current decontamination measures are sufficient.

Air samples were negative despite the extent of environmental contamination. Swabs taken from the air exhaust outlets tested positive, suggesting that small virus-laden droplets may be displaced by airflows and deposited on equipment such as vents. The positive PPE sample was unsurprising because shoe covers are not part of PPE recommendations. The risk of transmission from contaminated footwear is likely low, as evidenced by negative results in the anteroom and clean corridor.

This study has several limitations. First, viral culture was not done to demonstrate viability. Second, due to operational limitations during an outbreak, methodology was inconsistent and sample size was small. Third, the volume of air sampled represents only a small fraction of total volume, and air exchanges in the room would have diluted the presence of SARS-CoV-2 in the air. Further studies are required to confirm these preliminary results.

Significant environmental contamination by patients with SARS-CoV-2 through respiratory droplets and fecal shedding suggests the environment as a potential medium of transmission and supports the need for strict adherence to environmental and hand hygiene.