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Investigation of SARS CoV-2 virus in environmental surface

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ABSTRACT

The prevalent respiratory viruses such as SARS-CoV-2 probably persist for a long time on fomites and environmental surfaces. Some recent studies have detected SARS-CoV-2 RNA on the surface of cell phones, door handles and other items in the inhabited sites of confirmed cases. For the aim of this study, a total of 50 environmental surface samples of SARS-CoV-2 was collected from Imam Khomeini Hospital in Ardabil. Forty-one environmental surface samples were proved negative for SARS-CoV-2 RNA while nine surface samples were positive. Our findings regarding surfaces contaminated with the virus are consistent with the results of recent similar researches as it was revealed that a number of different samples taken from hospital surfaces such as handles, cupboards, light switches, and door handles were positive for the presence of SARS-Cov-2.

1. Introduction

Coronavirus disease 2019 (COVID-19) is the name for the disease that was originally recognized as SARS-CoV-2. (Organization, 2020b; Ren et al., 2020). Although specific isolation efforts have been observed, the COVID-19 pandemic has stirred extensive concerns regarding its fast spread. (Chia et al., 2020a). Transmission of SARS-CoV-2 can occur by direct, indirect, or close contact with infected people through infected secretions such as respiratory secretions and saliva or their respiratory droplets, which are ousted when an infected person sneezes, coughs, sings or talks. (Organization, 2020a). Overall, the persistence of a given virus over surfaces affects the rate of its transmission. Typically, the characteristics of surfaces that coronavirus contaminates and the environmental conditions are significant aspects that determine the infectivity maintenance, the extent and speed of the virus spread (Guo et al., 2020). The persistence time of SARS-CoV-2 on plastic and hard surfaces can vary. Waste materials originating from quarantine and households services with positive or suspicious COVID-19 patients may transmit viable SARS-CoV-2 and can be a cause of infection. Thus, the virus long persistence on fomites and environmental surfaces is alarming and should be tracked. So far, the RNA of SARS-CoV-2 has been identified on the surface of cell phones, door handles and other substances in the inhabited sites of definite cases (Banik and Ulrich, 2020). To date, limited amount of data is available on the environmental survival of SARS-CoV-2. However, precise perception of the virus persistence on surfaces can be accomplished through results obtained from different research.

2. Material and method

2.1. Approval statement

The project was approved by the ethical code IR. ARUMS. REC.1399.312 in accordance to the ethical principles, national norms and standards for conducting medical research in Iran.

This study was performed in corona ward of Imam Khomeini
Hospital in Ardabil city. Ardabil, one of the cities affected by the corona outbreak, is the capital of Ardabil province, located in the northwest of Iran. Its population is about 625,000 people.

2.2. Specimen collection, storage, and transfer

For this study, 50 samples were taken from 14 critical points. The samples were taken from different surfaces in hospitals including ambulance, handles, faucets, nursing station platforms, files, computer keyboards, soaps and alcohol tanks, blood pressure equipment, pulse oximetry and thermometers. Several samples were also taken from wall surfaces and roofs. In the first step, we took the swap out of the package and moistened it with the virus transmission medium. We rotated the wet swap with sufficient pressure in at least two different directions and prevented the swap from drying out. A minimum surface of 25 cm² was selected for swapping. After sampling, each swap was placed in Eppendorf tubes containing 300 μL of sterile viral transport medium (containing 200 mL of double distilled sterile water mixed with protein stabilizer, antibiotic, and buffer solution). The swap samples were placed in a clean bag and sealed. The outer surface of the bag was disinfected with 80%-60% ethanol, 80% isopropyl alcohol or 5% sodium hypochlorite solution and then placed in another package. The prepared samples were maintained at 4 °C until delivery to the virology laboratory. We also collected control samples along with the experimental samples.

2.3. Positive and negative control

The first set of control sample collection was performed in the same way including opening the package and removing the swap from the tube, but no sampling was done from any surface. Environmental samples were collected from the potentially contaminated surfaces. The second set of control samples were closed swap packages which were stored and tested with surface samples.

The samples were centrifuged in the laboratory for 4 min at 12,000 rpm and then the supernatant was discarded and the remaining microtubule was extracted using the High pure viral nucleic acid kit. Using the cDNA synthesis kit, we made cDNA and used appropriate primers designed for N and ORF1ab genes to perform PCR and Real-time.

2.4. Viral genome extraction

Virus genome extraction was performed using a nucleic acid extraction kit (Gene favor) and the extracted genomes were preserved in the freezer at -70 °C for the next step.

2.5. Running real-time PCR and data analysis

The extracted genome was placed in the reaction micro-tube along with other reaction components to detect the SARS-CoV-2 virus. The real-time PCR results were interpreted based on the kit protocol and the positive and negative results were accordingly determined.

The following steps were performed for virus identification: At the first stage, the appropriate concentrations of reagents, temperature cycling and sufficient number of replication (40 cycles) were used for initial screening stage. The specific primer and probe real-time reverse transcriptase-polymerase chain reaction (RTPCR) targeting ORF1ab and N genes (Nucleoprotein gene) were applied to detect viral genomes of the SARS-CoV-2 virus in the air samples of the hospital indoor air samples. Applied Biosystems™ Real-Time PCR System 7500 with software v2.0.5 was used to run RTPCR. Appropriate concentrations of the synthesis reaction for real time PCR MasterMix are as follows: Per reaction H2O (RNase free) 0.6 μl 2x Reaction mix* 12.5 μL MgSO4 (50 mM) 0.4 μL BSA (1 mg/ml)** 1 μL Primer ORF1ab/b SARSr-F (10 μM stock solution) 1.5 μL GTGARATGGTCTAGTGTTGGCGG Primer ORF1ab/b SARSr-R (10 μM stock solution) 2 μL CARATGTTAASACTATTTAGCATA Probe RdRP_SARSr-P1 (10 μM stock solution) 0.5 μL FAM-CCAGTTGACRTACMCMTTGTATGCG-BBQ Probe RdRP_SARSr-P2 (10 μM stock solution) 0.5 μL FACAGTTGAAACTCTACGAGATG-BQQ, 2019 nCOV_N-F AAAATTGTGGGACCCAGAAC, 2019 nCOV_N_RTGGCAGTGTGGTAGTCAAC, 2019-nCOV_N_PFAM-ATGTCGCGCATTTGCGTGA-BHQ 2. SSIITAq EnzymeMix* 1 μl Total reaction mix 20 μl Template RNA, add 5 μl Thermal Cycler: 55 °C 10′ 94 °C 3′ 94 °C 15′ 58 °C 30′ 45x. It is worth mentioning that all tests were taken under national safety protocols.

3. Results

The results obtained from different detected cases and sampling sites are summarized in Table 1. A total of 50 surface-contamination samples of SARS-CoV-2 was collected from Imam Khomeini Hospital in Ardabil (Table 1). These specimens were collected from frequently-touched surfaces such as telephones, patient rooms, chairs, and door handles in wards, trolleys where patients with COVID-19 stayed. Among the collected samples, 14 environmental ones taken from the hospital were negative for SARS-CoV-2 RNA. Overall, nine surface contamination samples were confirmed to be positive in terms of SARS-Cov-2 infection, which revealed a high risk of infection from various surfaces in hospital wards (Table 1). The schematic of positive points of surfaces samples (yellow cycle shows exact sample points) are presented in Fig. 1.

Furthermore, at the time of sampling, temperature and relative humidity in different wards of the hospital were between 19.5 and 28 °C and 33–42%, respectively (Table 2). A comparison of the environmental surfaces contaminated by COVID-19 patients in literatures is presented in Table 3.

4. Discussion

A laboratory study (Van Doremalen et al., 2020) has explicated that viability of SARS-CoV-2 can last in aerosols for about 3 h. In addition, this virus can be observed on dry surfaces for 8–72 h, depending on the surface material (Aytogan et al., 2020; Carraturo et al., 2020; Van Doremalen et al., 2020). It is also reported that human coronaviruses SARS-CoV-2 remains on inanimate surfaces infectious for up to 9 days at room temperature (Kampf et al., 2020). A key strength of the present study was that dacron and cotton swabs were used for sampling. Cotton swabs have a high adsorption capability though they are PCR inhibitors. Concerning their ability in adsorption, several results were positive for samples taken with these swaps. In addition to the surface materials, it can also be affected by other conditions, such as temperature and humidity, as well as existence of the condition for generating droplet or aerosol (Aytogan et al., 2020). It appears that the viability of SARS-CoV-2 on dry surfaces is identical to that of SARS-CoV-1 and MERS-CoV (Chan et al., 2011; Rabenau et al., 2005; Van Doremalen et al., 2013). Significant environmental contamination with SARS-CoV-2 may be considered a possible way of transmission. This fact highlights the need for environmental and hand hygiene (Ong et al., 2020). Despite the fact that there is a limited level of effectiveness for environmental epidemiological investigations during outbreaks, risk assessment of additional contamination and spreading of the pathogens is essential (Chia et al., 2020b). Likewise, the data reported on the transmission of SARS-CoV-2 from infected surfaces to hands is limited. In the present investigation, the identification of SARS-CoV-2 RNA in 50 environmental samples collected before disinfection and cleaning suggest that due to transmissibility of this novel coronavirus, exploring fomites to determine the risks of COVID-19 infection is of great importance. As the results indicated (Table 1), the surface contamination samples taken from the door handle and room floor can be labeled as ultra-high risk. Hence, the bathroom door handles should be sanitized and disinfected on a daily basis. When positive contamination results are reported for the collected samples taken from a door handle, an enhanced hygienic...
Table 1
Recommended sampling sites based on location in the hospital for SARS-CoV-2.

| Raw          | Essential sampling sites                                   | Results | Ct- ORF1ab | Ct- N gene |
|--------------|------------------------------------------------------------|---------|------------|------------|
| 1            | Patient room                                              | Positive| 33.91      | 30.88      |
| 2            | Patient room                                              | Negative| -          | -          |
| 3            | Patient room                                              | Negative| -          | -          |
| 4            | Patient room                                              | Negative| -          | -          |
| 5            | Patient room                                              | Negative| -          | -          |
| 6            | Patient room                                              | Positive| 35.09      | 32.23      |
| 7            | Patient room                                              | Negative| -          | -          |
| 8            | Cash box                                                  | Negative| -          | -          |
| 9            | Corona wards                                              | Negative| -          | -          |
| 10           | Corona wards                                              | Positive| 37.2       | 32.93      |
| 11           | Nurse station                                             | Negative| -          | -          |
| 12           | Corona Emergency- examination                             | Negative| -          | -          |
| 13           | Corona emergency room                                     | Positive| 36.81      | 32.77      |
| 14           | Corona emergency room                                     | Positive| 38.16      | 35.16      |
| 15           | Corona emergency room                                     | Negative| -          | -          |
| 16           | Corona emergency room                                     | Negative| -          | -          |
| 17           | Corona Emergency- examination                             | Negative| -          | -          |
| 18           | Corona Emergency- examination                             | Negative| -          | -          |
| 19           | Acute Respiratory Patient Room                            | Negative| -          | -          |
| 20           | Wards 2 Respiratory                                        | Negative| -          | -          |
| 21           | Isolated double patient room                              | Negative| -          | -          |
| 22           | Isolated double patient room                              | Positive| 34.83      | 31.65      |
| 23           | Isolated double patient room                              | Negative| -          | -          |
| 24           | Elevator No. 2                                             | Negative| -          | -          |
| 25           | Elevator No. 2                                             | Negative| -          | -          |
| 26           | The intensive care unit (ICU) room                        | Negative| -          | -          |
| 27           | ICU room                                                  | Negative| -          | -          |
| 28           | ICU room                                                  | Negative| -          | -          |
| 29           | ICU patient bedside                                        | Negative| -          | -          |
| 30           | Bathroom door                                              | Positive| 35.77      | 32.82      |
| 31           | Bathroom door                                              | Negative| -          | -          |
| 32           | Bathroom door                                              | Negative| -          | -          |
| 33           | Laboratory Reception Room                                 | Negative| -          | -          |
| 34           | Laboratory sampling room                                  | Positive| 36.09      | 35.15      |
| 35           | Laboratory sampling room                                  | Negative| -          | -          |
| 36           | CT Scan Reception Room                                    | Negative| -          | -          |
| 37           | CT Scan                                                   | Negative| -          | -          |
| 38           | CT Scan                                                   | Positive| 36.61      | 35.92      |
| 39           | Laboratory sampling room                                  | Negative| -          | -          |
| 40           | Laboratory sampling room                                  | Negative| -          | -          |
| 41           | Laboratory                                                 | Negative| -          | -          |
| 42           | Laboratory                                                 | Negative| -          | -          |
| 43           | CT Scan                                                   | Negative| -          | -          |
| 44           | CT Scan                                                   | Negative| -          | -          |
| 45           | Laboratory                                                 | Negative| -          | -          |
| 46           | Laboratory sampling room                                  | Negative| -          | -          |
| 47           | Wards 2 Corona Nursing                                    | Negative| -          | -          |
| 48           | Ambulance                                                  | Negative| -          | -          |
| 49           | Ambulance                                                  | Negative| -          | -          |
| 50           | Ambulance                                                  | Negative| -          | -          |
challenge is expected in corresponding ward poses. Moreover, we believe that examination room floor and corona wards floor are high-risk surfaces that contribute in spreading the virus and need to be targeted for extra cleaning. Wan et al. (2020) attempted to identify the coronavirus at different surfaces of the hospital and revealed that a number of different samples taken from hospital surfaces such as handles, cupboards and light switches, door handle were positive for coronavirus (Bloise et al., 2020), which was consistent with the results of the present study. Chia et al. (2020a, b) also examined the identification of SARS-CoV-2 in hospital rooms of infected patients. In this study, the floor (65%), bed rail (58%), locker handle (46%) and cardiac table (41%) were the most infected surfaces. Lee et al. (2020) found that places not previously disinfected were positive for SARS-CoV-2. Their study showed only 2 door handle samples were positive among the environmental samples (Lee et al., 2020). Further, Jiang et al. detected SARS-CoV-2 RNA on environmental surfaces of a symptomatic patients’ household. They identified SARS-CoV-2 RNA on 8 (36%) of 22 surfaces, as well as the pillow, cover, sheet, and duvet cover. This study showed that effective cleaning can reduce the risk of fomite (contact) transmission but some surface types may facilitate the survival, persistence and/or dispersal of SARS-CoV-2 (Jiang et al., 2020). In fact, multiple surface contamination samples were from different wards before the daily cleaning and disinfection processes. These tests confirmed that 31 patients contaminated seven sites and among the collected sampled surfaces, the electrocardiogram fingertip presented a 72.7% positive rate, indicating that this surface should be considered as an important hygiene site, where more viruses can concentrate (Wan et al., 2020). Moreover, SARS-CoV-2 RNA was detected on 30 (8.9%) of 336 environmental surfaces. Moore et al. (2020) found that toilet door handles, nurse call buttons, portable vital signs monitors, cell phones, bed rails, and bed controls were infected surfaces (Moore et al., 2020). Other studies have approved that door handles, bathroom toilet seat cover, bathroom door handle were the most contaminated environment although the chi-square p-value is only 0.064 (Ding et al., 2020). The detection of more positive surface samples in the bathrooms than elsewhere suggests that these samples may be fecal in origin. The previous detection of the virus in stools supports this interpretation, as does the fact that stools obtained from the first COVID-19 patient in the United States also proved positive (Ding et al., 2020). The results showed that among the various surfaces studied (bed rail, locker handle, cardiac table, electric switch, chair, toilet seat and flush, air exhaust vent and floor), the most infected samples with the virus were related to floor (Mouchtouri et al., 2020), which confirms the results of the present study. Riddell et al. (2020) reveal that SARS-CoV-2 can stay potentially infectious for significantly longer periods than commonly are believed to exist but the scope of their study was limited in terms of evaluating the persistence of virus in different environmental conditions. They also showed increasing the temperature while keeping humidity extreme reduced the survivability of the virus to 24 h at 40 °C (Riddell et al., 2020). The effect of temperature on persistence of SARS-CoV-2 on common surfaces has been investigated in some studies, however, further study of the issue is still required.

5. Conclusion

This study provides important insight into the persistence of human coronaviruses at different hospital surfaces and are consistent with the results of recent similar researches. It revealed that a number of different samples taken from hospital surfaces such as handles, cupboards and light switches, door handle were positive. However, the likelihood of infection from various surfaces in hospital wards remains threatening. This study has raised important questions about the nature of the virus persistence in the environment and its relationship with various environmental conditions. Appropriate protective strategies such as hands hygiene, physical distancing and wearing masks are essential to control COVID-19 pandemic.

Credit author statement

Abdollah Dargahi: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Supervision, Funding acquisition. Farhad Jeddi: Methodology. Mehdi Vosoughi: Methodology,
Table 2
Additional information on environmental status of different types of inanimate surfaces with confirmed SARS-CoV-2.

| Type of surface                     | Status of windows | Ventilation system | Temperature (°C) | Relative humidity (%) |
|-------------------------------------|-------------------|--------------------|------------------|-----------------------|
| Patient bed handle                 | Close             | Mechanical/Natural | 19.5             | 33.0                  |
| The wall in front of the patient   | Close             | Mechanical/Natural | 25.0             | 36.0                  |
| Patient room switch and socket     | Close             | Mechanical/Natural | 26.5             | 35.0                  |
| Toilet/bed pan                     | Close             | Mechanical/Natural | 25.8             | 42.0                  |
| Patient's dining trolley           | Close             | Mechanical/Natural | 28.0             | 38.0                  |
| Patient's room floor               | Close             | Mechanical/Natural | 21.7             | 34.0                  |
| Oxygen mask                        | Close             | Mechanical/Natural | 24.3             | 38.0                  |
| Cash box                           | Close             | Mechanical/Natural | 25.6             | 39.0                  |
| Triage table                       | Close             | Mechanical/Natural | 26.9             | 42.0                  |
| Examination room floor             | Close             | Mechanical/Natural | 20.8             | 35.0                  |
| Station table                      | Close             | Mechanical/Natural | 28.0             | 38.0                  |
| Door knob                          | Close             | Mechanical/Natural | 27.4             | 41.0                  |
| Corona wards floor                 | Close             | Mechanical/Natural | 22.6             | 34.0                  |
| Corona wards Trolley Table         | Close             | Mechanical/Natural | 21.9             | 33.0                  |
| Bedside handle                     | Close             | Mechanical/Natural | 25.3             | 40.0                  |
| Station phone                      | Close             | Mechanical/Natural | 26.5             | 37.0                  |
| Patient examination table surface  | Close             | Mechanical/Natural | 23.7             | 35.0                  |
| Barometer                          | Close             | Mechanical/Natural | 27.2             | 40.0                  |
| Drug Trolley wards 2               | Close             | Mechanical/Natural | 24.9             | 42.0                  |
| Trolley                            | Close             | Mechanical/Natural | 26.1             | 38.0                  |
| Toilet handle                      | Close             | Mechanical/Natural | 27.5             | 38.0                  |
| Toilet/bed pan                     | Close             | Mechanical/Natural | 24.3             | 36.0                  |
| Dining table                       | Close             | Mechanical/Natural | 26.5             | 40.0                  |
| Elevator floor                     | Close             | Mechanical/Natural | 23.8             | 35.0                  |
| Elevator Buttons                   | Close             | Mechanical/Natural | 24.0             | 39.0                  |
| Trolley                            | Close             | Mechanical/Natural | 27.1             | 42.0                  |
| Station                            | Close             | Mechanical/Natural | 25.7             | 40.0                  |
| ICU room floor                     | Close             | Mechanical/Natural | 26.1             | 38.0                  |
| Door knob                          | Close             | Mechanical/Natural | 23.0             | 41.0                  |
| Bathroom door handles              | Close             | Mechanical/Natural | 21.4             | 35.0                  |
| Faucet handles                     | Close             | Mechanical/Natural | 24.8             | 39.0                  |
| Toilet bowl                        | Close             | Mechanical/Natural | 25.5             | 35.0                  |
| Station                            | Close             | Mechanical/Natural | 26.0             | 39.0                  |
| Chair handle                       | Close             | Mechanical/Natural | 24.1             | 36.0                  |
| Laboratory floor                   | Close             | Mechanical/Natural | 23.8             | 41.0                  |
| Station                            | Close             | Mechanical/Natural | 26.2             | 38.0                  |
| Ct scan bedside                    | Close             | Mechanical/Natural | 25.6             | 35.0                  |
| CT scan of the floor               | Close             | Mechanical/Natural | 22.7             | 33.0                  |
| Toilet taps                        | Close             | Mechanical/Natural | 24.5             | 36.0                  |
| toilet/bed pan                     | Close             | Mechanical/Natural | 23.6             | 38.0                  |
| Sampling toilet handles            | Close             | Mechanical/Natural | 24.6             | 42.0                  |
| Trolley carrying urine samples     | Close             | Mechanical/Natural | 27.5             | 40.0                  |
| Waiting room floor to enter CT     | Close             | Mechanical/Natural | 25.6             | 38.0                  |
| Reception waiting chairs           | Close             | Mechanical/Natural | 22.9             | 35.0                  |
| Reception waiting chairs           | Close             | Mechanical/Natural | 24.7             | 39.0                  |
| Work desk                          | Close             | Mechanical/Natural | 25.1             | 34.0                  |
| Rest room levels                   | Close             | Mechanical/Natural | 27.8             | 37.0                  |
| Patient stretcher handle           | Close             | Mechanical/Natural | 26.5             | 40.0                  |
| Ambulance floor                    | Close             | Mechanical/Natural | 25.3             | 42.0                  |
| Trolley handles and dressing       | Close             | Mechanical/Natural | 28.0             | 38.0                  |
Table 3

| Raw Country | Positive objects | Temperature (°C) | Humidity (relative Humidity %) | Ref |
|-------------|------------------|-----------------|-------------------------------|-----|
| Republic of Korea | door handle | at room temperature | - | Lee et al (2020) |
| 2 China | Pillow, cover, sheet, and duvet cover. | - | - | Ding et al (2020) |
| 3 China | Floor, Bed rail, Locker handle and Cardiac table | 23 | 53-59 | Chia et al (2020) |
| 4 China | electrocardiogram fingertip | - | - | Wan et al (2020) |
| 5 England | toilet door handle, nurse call button, portable vital signs monitor, mobile phone, bed rail, bed control | 21-25 | 21-41 | Moore et al (2020) |
| 6 China | ward door handles, one bathroom toilet seat cover, and one bathroom door handle | 19-23 | 27-34 | Ren et al (2020) |
| 7 Iran | Patient bed handle, Patient’s room floor, Corona wards floor, Corona wards Trolley Table, Toilet/bed pan, Bathroom door handles, CT scan of the floor | 19.5-24.3 | 33-36 | This study |

Validation, Formal analysis, Writing – original draft. Chiman karami Validation, Formal analysis, Supervision. Aidin Hadisi: Methodology. S. Ahamad Mokhtari: Writing – original draft. Hasan Ghobadi: Methodology, Validation, Formal analysis, Writing – original draft. Morteza Alighadrí: Formal analysis, Investigation. Somayeh Biparva Haghighi: Formal analysis, writing and text revision. Hadi Sadegh: Formal analysis, Investigation.

Declaration of competing interest

The authors declared no conflict of interest.

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References

Aytogar, H., Ayintap, E., Yilmaz, N.O., 2020. Detection of coronavirus disease 2019 viral material on environmental surfaces of an ophthalmology examination room. J JAMA ophthalmology.

Banik, R.K., Ulrich, A., 2020. Evidence of short-range aerosol transmission of SARS-CoV-2 and call for universal airborne precautions for anesthesiologists during the COVID-19 pandemic. Anesth. Analg. 131, e102-e104.

Bloise, I., García-Bujalance, S., Bueno, E.C., Toro-Rueda, C., Ruiz-Carrascoso, G., Perona, F.L., 2020. Detection of SARS-CoV-2 on high-touch surfaces in a clinical microbiology laboratory. J Journal of Hospital Infection 105, 784-786.

Carraturo, F., Del Giudice, C., Morelli, M., Cerullo, V., Libralato, G., Galdiero, E., Guida, M., 2020. Persistence of SARS-CoV-2 in the environment and COVID-19 transmission risk from environmental matrices and surfaces. J Environ. Pollut. 115010.

Chan, K.-H., Peiris, J.M., Lam, S., Poon, L., Yuen, K., Sethi, W.H., 2011. The effects of temperature and relative humidity on the viability of the SARS coronavirus. J Advances in virology 2011.

Chia, P.Y., Coleman, K.K., Tan, Y.K., Ong, S.W.X., Gum, M., Lau, S.K., Lim, X.F., Lim, A.S., Sujitjo, S., Lee, P.H., 2020a. Detection of air and surface contamination by SARS-CoV-2 in hospital rooms of infected patients. J Nature communications 11. 1-7.

Ding, Z., Qian, H., Xu, B., Huang, Y., Miao, T., Yin, H.-L., Xiao, S., Cui, L., Wu, X., Shao, W., 2020. Toilets dominate environmental detection of severe acute respiratory syndrome coronavirus 2 in a hospital. J Science of the Total Environment 753, 141710.

Guo, Z.-D., Wang, Z.-Y., Zhang, S.-F., Li, X., Li, L., Li, C., Cui, Y., Fu, R.-B., Dong, Y.-Z., Chi, X.-Y., 2020. Aerosol and surface distribution of severe acute respiratory syndrome coronavirus 2 in hospital wards, Wuhan, China, 2020. Emerg. Infect. Dis. 26, 10-3201.

Jiang, F.-C., Jiang, X.-L., Wang, Z.-G., Meng, Z.-H., Shao, S.-F., Anderson, B.D., Ma, M.J., 2020. Detection of severe acute respiratory syndrome coronavirus 2 RNA on surfaces in quarantine rooms. J Emerging Infectious Diseases 26, 2162.

Kampf, G., Todt, D., Pfaender, S., Steinfatt, E., 2020. Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents. J Journal of Hospital Infection 104, 246-251.

Lee, S.-E., Lee, D.-Y., Lee, W.-G., Kang, B., Jang, Y.S., Ryu, B., Lee, S., Bahk, H., Lee, E., 2020. Detection of novel coronavirus on the surface of environmental materials contaminated by COVID-19 patients in the Republic of Korea. J Osoo Public Health Research Perspectives 11, 1-28.

Moore, G., Rickard, H., Stevenson, D., Bou, P.A., Pitman, J., Crook, A., Davies, K., Spencer, A., Burton, C., Easterbrook, L., 2020. Detection of SARS-CoV-2 in the healthcare environment: a multicentre study conducted during the first wave of the COVID-19 outbreak in England. J Journal of Hospital Infection.

Mouchtouri, V.A., Koureas, M., Kyritsi, M., Vontas, A., Kourentis, L., Sapounas, S., Rigakos, G., Petinaki, E., Tsiodras, S., Hadjidichristodoulou, C., 2020. Environmental contamination of SARS-CoV-2 on surfaces, air-conditioner and ventilation systems. J JAMA ophthalmology.

Organization, W.H., 2020a. Cleaning and Disinfection of Environmental Surfaces in the Context of COVID-19: Interim Guidance, 15 May 2020. Report No. World Health Organization, Organization, W.H., 2020b. Cleaning and Disinfection of Environmental Surfaces in the Context of COVID-19: Interim Guidance, 15 May 2020. Report No. World Health Organization.

Organization, W.H., 2020. Modes of Transmission of Virus Causing COVID-19: Implications for IPC Precaution Recommendations: Scientific Brief, 27 March 2020. Report No. World Health Organization.

Rabehbou, H., Cinatl, J., Morgenstem, B., Bauer, G., Preiser, W., Doerr, H., immunology, 2005. Stability and inactivation of SARS coronavirus. J Medical microbiology 194, 1-6.

Ren, S.-Y., Wang, W.-B., Hao, Y.-G., Zhang, H.-R., Wang, Z.-C., Chen, Y.-L., Gao, R.-D., 2020. Stability and infectivity of coronaviruses in inanimate environments. J World Journal of Clinical Cases 8, 1391.

Riddell, S., Goldie, S., Hill, A., Eagles, D., Drew, T.W., 2020. The effect of temperature on persistence of SARS-CoV-2 on common surfaces. J Virology Journal 17, 1-7.

Van Doremalen, N., Bushmaker, T., Morris, D.H., Holbrook, M.G., Gamble, A., Williamson, B.N., Tamin, A., Harcourt, J.L., Thornburg, N.J., Gerber, S.L., 2020.
Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. J New England Journal of Medicine 382, 1564–1567.
Van Doremalen, N., Bushmaker, T., Munster, V., 2013. Stability of Middle East respiratory syndrome coronavirus (MERS-CoV) under different environmental conditions. J Eurosurveillance 18, 20590.

Wan, B., Zhang, X., Luo, D., Zhang, T., Chen, X., Yao, Y., Zhao, X., Lei, L., Liu, C., Zhao, W., 2020. On-site analysis of COVID-19 on the surfaces in wards. J Science of The Total Environment 753, 141758.