Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

American Journal of Infection Control 49 (2021) 1435–1437

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Brief Report

Environmental testing for SARS-CoV-2 in three tertiary-care hospitals during the peak of the third COVID-19 wave

Helena C. Maltezou MD [a,*], Maria Tseroni RN [a], Charalampos Daflos RN [b], Cleo Anastassopoulou PhD [c], Antonios Vasilogiannakopoulos MD [d], Olga Daligarou RN [d], Maria Panagiotou MD [d], Evanthia Botsa MD [e], Nikolaos Spanakis MD [c], Athanasia Lourida MD [f], Athanasios Tsakris MD [c]

[a] Directorate of Research, Studies and Documentation, National Public Health Organization, Athens, Greece
[b] Infection Control Committee, Red Cross General Hospital, Athens, Greece
[c] Department of Microbiology, Medical School, National and Kapodistrian University of Athens, Athens, Greece
[d] Infection Control Committee, Henry Dunant Hospital Center, Athens, Greece
[e] First Department of Pediatrics, National and Kapodistrian University of Athens, Aghia Sophia Children's Hospital, Athens, Greece
[f] Infection Control Committee, Aghia Sophia Children's Hospital, Athens, Greece

Key Words:
SARS-CoV-2
COVID-19
Environmental contamination
Hospitals
Fomites
Inanimate surfaces
Disinfection
B.1.1.7

Contamination of surfaces has been implicated in transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). We tested by real-time PCR for SARS-CoV-2 contamination environmental samples from three hospitals during the peak of the third pandemic wave. Overall, 19 of 463 (4.1%) samples tested positive: 12 of 173 (6.9%) samples from a COVID-19 hospital, 3 of 177 (1.7%) samples from a non-COVID-19 hospital, and 4 of 113 (3.5%) samples from a pediatric hospital with dedicated COVID-19 clinics. Most positive samples originated from emergency departments (EDs) (47.3%) and the intensive care units (ICUs) (26.3%) of the COVID-19 hospital. Positive samples belonged almost exclusively (18/19) to the highly transmissible B.1.1.7 cluster, that might explain environmental contamination at this stage of the pandemic. The frequency and efficiency of disinfection in high-risk patient areas, such as EDs and ICUs, should be reinforced, especially during this period where highly transmissible variants of concern are widespread.

Almost one and a half year after the declaration of the coronavirus disease 2019 (COVID-19) pandemic, which is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), hospitals in several countries continue to face an unprecedented burden of morbidity. Although respiratory droplets constitute the main route of SARS-CoV-2 transmission, contaminated surfaces have been also implicated.[1] Although there are studies on SARS-CoV-2 contamination of surfaces in various healthcare locations,[2-4] knowledge gaps exist regarding the extent of contamination and the efficiency of infection prevention and control measures. Moreover, to our knowledge, there are no published data on environmental contamination in pediatric healthcare facilities. The estimation of contamination burden is expected to contribute to our understanding of transmission dynamics of SARS-CoV-2 within healthcare facilities at a time when vaccination efforts of the population intensify, while the virus continues to spread and evolve, giving rise to variants of concern. We assessed the SARS-CoV-2 environmental contamination in three hospitals at the peak of the third pandemic wave in Greece.

METHODS

The study was conducted in a 411-bed COVID-19 referral hospital (Hospital A), a 462-bed non-COVID-19 hospital (Hospital B) and a 673-bed pediatric hospital with COVID-19 clinics (Hospital C). Samples were collected from COVID-19 patients' rooms, intensive care units (ICUs), emergency departments (EDs), laboratories and non-patient areas, and from the hands of COVID-19 patients. Samples were collected before routine disinfection procedures. Sterile swabs were wetted with 0.9% normal saline. A mean surface area of 100 cm^3 was covered per sample. The swabs were placed in tubes containing 3 ml of viral transport medium.

RNA of the samples was extracted using the automated Maxwell RSC Viral Total Nucleic Acid Purification kit (Promega, UK)

* Address correspondence to Dr. Maltezou, Directorate of Research, Studies and Documentation, National Public Health Organization, 3-5 Agrafon Street, Athens, 15123 Greece.
E-mail address: helen-maltezou@ath.forthnet.gr (H.C. Maltezou).
Conflicts of interest: None to report.

https://doi.org/10.1016/j.ajic.2021.08.022

and SARS-CoV-2 RNA was detected by real-time RT-PCR using the genesig PCR Assay (Primer Design, UK). Genetic variations were detected by real-time RT-PCR followed by a DNA melt analysis using the CoviDetect™ COVID-19 Mutation RT-PCR Assays (Penta-Base, Denmark). The study was approved by the hospitals' Ethics Committees.

RESULTS

In total 463 samples were collected as follows: 173 from Hospital A, 177 from Hospital B, and 113 from Hospital C. Regarding samples of hospital rooms of COVID-19 patients, samples derived from six fully-occupied double-bed rooms and the ICU of Hospital A (12 and 10 COVID-19 patients, respectively); 1 single-bed room in Hospital B (where one hospitalized patient developed symptoms and tested positive for COVID-19); and two single-bed rooms in Hospital C (one child with COVID-19 in each room). Nineteen samples (4.1%) tested positive for SARS-CoV-2, 12 in Hospital A (6.9%), 3 in Hospital B (1.7%) and 4 in Hospital C (3.5%) (Table 1).

In Hospital A, positive samples were collected from a COVID-19 patient's hands; the floor, a chair, a stethoscope, and a sphygmomanometer in the ED; two bedside cabinets, two Tyvek suits and one faucet handle in the ICU; and two beds in the radiology department. In Hospital B, positive samples yielded from a door handle at the waste room, and a trolley and a pulse oximeter in the ED. In Hospital C, positive samples were derived from a chair, a stretcher and a trolley in the ED and from a computer keyboard in the nurse station outside COVID-19 patients' rooms.

Overall, the positivity rate in EDs was 6.9% and in ICUs 5.3% (8.2% in ICUs if we consider the two positive Tyvek suit samples). Most positive samples were detected in EDs (47.3%) and the ICU (26.3%). The highest positivity rates concerned PPE samples (2/20), and samples from waiting rooms (3/20), trolleys (2/11) and medical devises (3/26) in the EDs. There was no positive sample in patients' rooms, physicians' offices, nurses' locker rooms, laboratories and hospital lobbies.

The mean Ct value of the positive samples was 36.3 (range: 32-38). Eighteen positive samples belonged to cluster B.1.1.7, and one had the E484K substitution in the spike protein.

DISCUSSION

We tested for SARS-CoV-2 frequently touched surfaces and regularly used medical devices in three hospitals in the peak of the third pandemic wave. Overall, 4.1% of samples tested positive. Higher detection rates have been reported in hospitals at earlier phases of the pandemic.[2-4] For instance, 52.3% of samples tested positive for SARS-CoV-2 in a hospital in the first pandemic wave, including 63.8% of samples from patients' areas and 45.3% from other areas, indicating heavy contamination.[4] In another hospital, 14% of 275 environmental samples were contaminated.[2] In a multi-center study in England, 8.9% of surface samples tested positive (range: 0-27% across hospitals).[3] Factors that may impact contamination include the frequency of disinfection, the healthcare personnel compliance with infection control measures, and the time period of each study. The use of PPE, such as face masks that in many instances were in short supply then, and infection control measures had not been standardized early in the first pandemic wave.

In our study, the highest positivity rates were detected in PPE, EDs, and the ICU of Hospital A. At that time Hospital A hospitalized only COVID-19 patients. SARS-CoV-2 was detected in several medical devices and equipment in various areas in the EDs. In a heavily contaminated Chinese hospital, 37.5% of ICU samples were positive.[5] In a Singapore hospital, 20-25% of medical equipment tested positive.[2] Similar to our findings, 5.2% of samples from the ED of a hospital

Table 1
Samples tested positive for SARS-CoV-2 by site and by hospital

Sampling sites	Hospital A	Hospital B	Hospital C
Hands of COVID-19 patients	**1/12**		0/1
Rooms			
equipment[1]	0/8	0/8	0/4
medical devices[2]	0/3	0/10	0/6
toilet[3]	0/4	0/5	0/4
door handles	0/2	0/3	0/4
alcohol dispenser pump			0/1
Emergency Department			
waiting room equipment[4]	**1/6**	0/4	**1/7**
waiting room floor	**1/1**	0/1	0/1
examination beds	0/4	0/4	0/2
trolleys	0/4	**1/5**	**1/2**
office equipment[5]	0/3	0/5	0/3
computer equipment[6]	0/8	0/8	0/2
medical devices	**2/12**	**1/8**	0/6
telephone		0/1	0/2
stretchers and wheelchairs	0/8	0/8	**1/6**
patients' counter		0/1	0/1
stationary		0/1	
toilet	0/2	0/4	
alcohol dispenser pump	0/1		
ICU			
equipment	**2/12**	0/12	
medical devices	0/5	0/5	
office equipment	0/2		
computer equipment	0/2	0/1	
toilet	**1/1**	0/4	
door, fridge or cabinet handles	0/4	0/6	
telephones	0/1		
bedpan washer		0/1	
Physician's office			
office equipment	0/2	0/1	0/2
computer equipment	0/2	0/1	0/2
medical records[7]	0/1	0/1	0/1
door handles	0/2	0/1	0/1
telephones	0/2		0/1
toilet	0/1		
alcohol dispenser pumps	0/1		0/1
Nurse station			
office equipment	0/2	0/4	0/4
trolleys	0/4	0/4	0/1
telephones	0/2	0/5	0/3
computer equipment		0/6	**½**
toilet		0/1	
Nurses' locker room			
door locker handles	0/6	0/6	0/6
toilet	0/2	0/5	
PCR laboratory[8]			
surfaces	0/3	0/3	0/3
computer equipment	0/2	0/3	0/3
request paper forms	0/3	0/3	0/3
telephones	0/1	0/1	0/1
autoclave	0/1		
Radiology and CT Department			
surfaces	0/2	0/2	0/2
patients' surfaces	**2/2**	0/3	0/3
imaging equipment[9]	0/6	0/6	0/6
waiting room equipment	0/2	0/2	0/4
Telephone			0/1
Personal protective equipment[10,11,12]			
from non-ICU personnel	0/5	0/3	0/6
from ICU personnel	**2/5**	0/1	
Hospital lobby			
elevators' buttons	0/6	0/6	0/4
information desks	0/2	0/2	0/2
stairs handrail	0/1		
Waste Room			
doorhandles		**1/2**	

COVID-19: coronavirus disease 2019; CT: computed tomography; ICU: intensive care unit; PCR: polymerase chain reaction; SARS-CoV-2: severe acute respiratory syndrome coronavirus 2

[1]equipment: bedrail, bedside cabinet, trolley, examination bed

[2]medical devices: infusion pump monitor, sphygmomanometer, thermometer, stethoscope, monitor, respirator, defibrillator, electrocardiograph, pulse oximeter, otoscope, scale

[3]toilet: faucet handle, toilet flush button

[4]waiting room equipment: chairs, tables

[5]office equipment: desk, chair, counter

[6]computer equipment: computer keyboard, screen, mouse, scanner

[7]of COVID-19 patient

[8]for SARS-CoV-2 detection

[9]imaging equipment: keyboard, mouse, screen

[10]personal protective equipment: gown, Tyvek suit, goggles, shield, filtering face piece respirator-2, gloves

[11]used

[12]outer surface

tested positive for SARS-CoV-2.[6] In this study, 10.9% of surfaces in direct contact and medical devices tested positive.[6] The higher positivity rate of EDs samples is partially explained by the overcrowded situation, the prolonged close proximity of patients, and gaps in infection control.[7] Our findings indicate that disinfection should be performed more often in the EDs and the ICU. Disinfection procedures should also improve, cleaners should be trained accordingly and audits applied.

In our study no sample from COVID-19 rooms, non-patients areas, laboratories and lobbies tested positive, indicating sufficient disinfection. However, in two Israeli hospitals SARS-CoV-2 was detected in 52.7% of samples around symptomatic COVID-19 patients.[8] Another study found that the COVID-19 rooms were heavily contaminated (30% positivity).[2] Furthermore, SARS-CoV-2 has been detected in 40-50% of beepers, water machine buttons, elevator buttons, computer mice and telephones in a Chinese hospital, indicating heavy contamination.[5] Similarly, common equipment often tested positive in a London hospital with a 52.3% contamination rate.[4]

In accordance with others, we found high Ct values in all environmental samples.[2-4,9] The detection of viral RNA does not necessarily translate to a replication-competent virus. A cutoff value of 34 cycles using an assay targeting the RdRp gene has been suggested for SARS-CoV-2 infectivity.[10] However, Ct values may well vary across sampling conditions and utilized assays. Furthermore, almost all positive samples fell within the highly transmissible B.1.1.7 lineage. This might also explain the persistence of SARS-CoV-2 environmental contamination at this stage of the pandemic, as now we are able to implement infection control measures faster and more efficiently.

In conclusion, we found that <5% of environmental samples from three hospitals collected during the peak of the third pandemic wave were positive. Most positive samples were collected from the EDs and the ICU of the COVID-19 referral hospital. The frequency and efficiency of disinfection in high-risk patient areas should increase and cleaners should be trained accordingly.

FINANCIAL SUPPORT

No funds were received for this study.

Acknowledgement

We are thankful to the Infection Control Committees of the participating hospitals. We also thank Anastasia Tedoma for technical assistance. The opinions presented in this article are those of the authors, and do not necessarily represent those of their institutions.

References

1. Vella F, Senia P, Ceccarelli M, et al. Transmission mode associated with coronaviurs disease 2019: a review. *Eur Rev Med Pharmacol Sci*. 2020;24:7889–7904.
2. Ong SWX, Lee PH, Tan YK, et al. Environmental contamination in a coronavirus disease 2019 (COVID-19) intensive care unit—What is the risk? *Infect Control Hosp Epidemiol*. 2021;42:669–677.
3. Moore G, Rickard H, Stevenson D, et al. Detection of SARS-CoV-2 within the healthcare environment: a multi-centre study conducted during the first wave of the COVID-19 outbreak in England. *J Hosp Infect*. 2021;108:189–196.
4. Zhou J, Otter JA, Price JR, et al. Investigating SARS-CoV-2 surface and air contamination in an acute healthcare setting during the peak of the COVID-19 pandemic in London. *Clin Infect Dis*. 2021;73:e1870–e1877.
5. Wu S, Wang Y, Jin X, Tian J, Liu J, Mao Y. Environmental contamination by SARS-CoV-2 in a designated hospital for coronavirus disease 2019. *Am J Infect Control*. 2020;48:910–914.
6. Peyrony O, Ellouze S, Fontaine JP, et al. Surfaces and equipment contamination by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in the emergency department at a university hospital. *Int J Hyg Environ Health*. 2020;230: 113600.
7. Fusco FM, Schilling S, De Iaco G, et al. Infection control management of patients with suspected highly infectious diseases in emergency departments: data from a survey in 41 facilities in 14 European countries. *BMC Infect Dis*. 2012;12:27.
8. Ben-Shmuel A, Brosh-Nissimov T, Glinert I, et al. Detection and infectivity potential of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) environmental contamination in isolation units and quarantine facilities. *Clin Microbiol Infect*. 2020;6:1658–1662.
9. Ge T, Lu Y, Zheng S, et al. Evaluation of disinfection procedures in a designated hospital for COVID-19. *Am J Infect Control*. 2021;49:447–451.
10. Engelmann I, Alidjinou EK, Ogiez J, et al. Preanalytical issues and cycle threshold values in SARS-CoV-2 real-time RT-PCR testing: should test results include these? *ACS Omega*. 2021;6:6528–6536.