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ORIGINAL ARTICLE

SARS-CoV-2 – environmental contamination and evaluation of the possibility of air disinfection using the flow-through UV-C method – study in units treating patients with COVID-19 of two hospitals in southern Poland.

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Introduction

The SARS-CoV-2 virus, responsible for the COVID-19 pandemic which most countries of the world are currently facing, is not the only new infectious agent in recent decades. Serious problems have also been caused in the past years by other coronaviruses, especially SARS-CoV and MERS-CoV. All corona-viruses (CoV), the so-called ß-CoV: MERS-CoV, SARS-CoV and SARS-CoV-2, which cause infections in humans, lead to severe and potentially fatal respiratory infections [1]. The main route of transmission of the virus is the droplet route – through contamination of the oral, nasal or conjunctival mucosa during direct contact with an infected person (who is symptomatic or asymptomatic) – and through indirect contact with environmental elements contaminated with biological material containing the virus – dirty hands, and surfaces or objects used by an infected person [2]. Infection can also take place in the course of executing procedures that generate bioaerosols, such as: endotracheal intubation, bronchoscopy, manual pre-intubation ventilation, disconnection of the patient from the ventilator, mechanical oral hygiene, non-invasive hypertensive ventilation, tracheostomy and cardiopulmonary resuscitation [3]. A characteristic transmission route is also the airborne route. The virus is detectable in the air up to 3 hours after it is sprayed in the form of bioaerosol as a result of the activities that are carried out [4]. Infectivity does not only concern a symptomatic patient – transmission of the virus commences as early as 1–2 days before the first symptoms and may continue with a mild course for up to 8 days following the appearance of the first symptoms or even up to 2 weeks in severe cases [3]. Medical workers, especially hospital staff, are particularly exposed to the virus. Detailed rules of conduct, types and usage of personal protective equipment have been developed and published by various national and international institutions and agencies. They indicate the need to employ extraordinary and rational protective measures, both standard and extraordinary precautions, which means the so-called standard and non-standard isolation of

the microorganism, i.e. the source of the infection [5].

Human coronaviruses can remain infectious on inanimate surfaces for 9 days, and their animal counterparts even for 28 days [6]. Hence, surfaces that are frequently touched are potential reservoirs of the virus and can be a route of transmission of infection. Various SARS viruses examined previously, which were not only human (SARS-CoV 229E, SARS CoV-FFM1, SARS-CoV P9), demonstrate high resistance under inanimate environment conditions; some remain active for up to 5 days on steel, silicone rubber, ceramics, Teflon, PVC or glass surfaces, and for up to 6 days on plastic [7].

During the current pandemic, it is more and more important to maintain hand hygiene and environmental hygiene, especially with reference to decontamination of hospital surfaces.

Hand hygiene in the COVID-19 pandemic should be carried out primarily by washing with water and soap. Selecting a method for hand hygiene – washing instead of disinfecting – stems from exposure to the presence of respiratory secretions, which may contain the virus – characteristic of COVID-19, i.e. if the symptoms include, among others, cough and shortness of breath. Hand disinfection with alcohol-based preparations is equally effective. The most effective alcohol solutions contain 60–80% alcohol [5].

To disinfect the inanimate environment, as well as surfaces and elements that are often touched, WHO, as well as ECDC (European Centre for Disease Prevention and Control), recommend 0.1% sodium hypochlorite, which effectively kills the virus in the first minute, and 70% ethanol; additionally, 2% glutaraldehyde is suggested [5]. In such special conditions of the functioning of health care, particularly hospitals, as the COVID-19 pandemic, it might be especially advisable to employ non-standard methods of disinfecting the hospital environment, including surfaces and air, also known as non-contact methods. No-touch automated disinfection (NTD) is a promising approach for hospital usage. NTD systems are based on vaporised hydrogen peroxide (VHP), hydrogen peroxide vapour (HPV), chlorine dioxide, gaseous ozone, dry mist of hydrogen peroxide (DMHP), or aerosolised hydrogen peroxide (aHP), often complemented with silver cations, aerosolised peracetic acid, quaternary ammonium compounds, high-intensity narrow-spectrum (405 nm) light, and pulsed-xenon UV (PX-UV) radiation [8].

Among the above-mentioned factors, UV-C radiation deserves special attention. It is commonly employed to disinfect surfaces by direct exposure, and in the flow-through variant, it might be applied to disinfect air, even indoors when people are present, e.g. in hospital units. The effectiveness of UV-C radiation has been confirmed in numerous laboratory tests, against a wide spectrum of microorganisms, starting from bacteria, through spores and fungi, and finishing with viruses [9, 10, 11]. Rapid and complete inactivation of SARS CoV-2 by ultraviolet-C irradiation was confirmed in latest studies, among others by Storm *et al.* [12] and Bianco *et al.* [13].

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The aim of the study is to assess environmental contamination, in particular of touch surfaces and air, in hospital wards (rooms) in which patients diagnosed with COVID-19 are being treated and the effectiveness of elimination of the SARS-CoV-2 virus from air by the flow-through UV-C method.

Materials and methods

The study consisted in sampling the air in the rooms of COVID-19 patients in two hospitals in the south of Poland, before air disinfection with the flow-through UV-C method used in the Sterylis device and after a specified time of the operation of the device. The hospitals in which the research was conducted were Marta Wiecka District Hospital in Bochnia (hospital no. I) and John Paul II Krakow Specialist Hospital (hospital no. II). In order to assess the contamination of the patient room environment, swabs were collected from touch surfaces in the immediate vicinity of the patient, such as the bedside table top, bed frame, remote, ladder, IV pole, floor. Additionally, facial swabs were taken from the patients hospitalised in these rooms during the study.

In hospital no. 1, the studies were conducted at the turn of October and November 2020, from 30 October to 1 November and from 27 to 28 November, while in Hospital 2, they were done in December, on 9–10 and 21–22 December. On 30.10.2020–1.11.2020, samples were collected in a five-person patient room with all the beds occupied. Three patients were hospitalized due to full-blown pneumonia in the course of SARS-CoV-2 infection, while the two other patients – due to other internal diseases. In all patients, routine swab RT-PCR tests for COVID-19 were positive. All patients were admitted to the department immediately after a positive RT-PCR result. At the time of sampling, two symptomatic patients were three days after the swab, one patient's swab was 13 days before, and asymptomatic patients were four days after the swab. The general condition of the patients varied. Some were moving around the room independently, and some were bedridden. All patients required passive oxygen therapy continuously or periodically (aerosol). On 27–28.11.2020, samples were taken in a five-person patient room, with 40% bed occupancy – two female patients were staying there. The patients were hospitalized due to full-blown pneumonia in the course of SARS-CoV-2 infection. Both patients were admitted immediately after a positive RT-PCR result; during the collection of samples, 17 and 8 days had passed from their swabs. The general condition of the patients: moving around the room independently. Both patients required continuous passive oxygen therapy (aerosol).

At the John Paul II Hospital samples were collected in a four-person patient rooms, room 1 with all the beds occupied during both periods of sample taking and room 2 with three hospitalized patients on December 9 and 21, four – on December 10, two – on December 22. All patients were hospitalized due to COVID-19 with symptoms of pneumonia. In all patients, routine swab RT-PCR tests for COVID-19 were positive. At the time of sampling, in both sampling periods there were one patient three days after swab and the rest between six and even thirty days after the swab in room 1. In room 2, during first period one patient was after two days of sampling and

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other after six and seven days, and during second sampling period – patients were from five to fourteen days after the swab. The general condition of the patients: moving around the rooms independently.

Air samples were collected on Petri dishes by the collision method using the MAS-100 device in three different variants. The premise of collecting material for the SARS CoV-2 virus using RT-PCR was to recover particles of the virus that settle on the plate as a result of forced air sedimentation, by collecting the material with a swab, placing it in a dedicated transport medium and determining it by RT-PCR. The method of collecting air samples was dictated by the available resources, therefore, in the course of the study, both the method of preparing the substrates in Petri dishes and the volume of air samples underwent modification. The volume of air samples collected ranged from 500 to 1500 l. The surface of the Petri dishes, on which samples were placed using the collision method in the first variant, was covered with 3 g/l albumin solution. In the second variant, it was tryptic soy agar (TSA). And in the third, a filter was placed on the TSA. Directly after collecting a specified volume of air onto the plates, a sample was collected with a flocked swab, which, after securing it in a transport medium, was handed over to laboratories for PCR testing for SARS-CoV-2. As regards the samples collected on the filter placed on TSA, the filter was transferred to the transport medium using sterile forceps, and then, any remaining material from the substrate was collected by rubbing with a flocked swab, which was placed in the same test tube as the filter.

Other samples were taken as swabs, i.e. from touch surfaces in the immediate vicinity of the patient, device filters, patient masks, or by rubbing the bed frame/bedside table/another element of the surface with a swab several times. The swabs used in the study were flocked swabs, and prior to sampling, they were moistened with sterile saline solution.

In patient rooms, from which air and touch surface samples were collected, Sterylis devices were in operation, types: Basic or Ultra (Miloo-Electronics sp. z o.o., Nowy Wiśnicz, Poland), at specific time periods (after 24h) in the UV-C disinfection (two hospitals) and filtration (one hospital) modes. In Sterylis devices, a battery of high-performance UV-C lamps, located between the filters, emits a high intensity of UV-C radiation with a wavelength of 253.7 nm in the sterilization channel. Owing to the special enclosed construction of the disinfection channel, made of radiation-reflecting materials, the produced high-energy source of UV-C radiation efficiently emits the required effective dose of radiation [J/m2] which does not go beyond the inside of the device, allowing for safe operation in this mode in rooms in which people are present. The air sucked into the sterilization chamber goes through the inlet filter, and it is released from the disinfection chamber through the carbon filter (outlet).

In this study, the contamination of the device filters was assessed based on samples collected by means of flocked swabs from the entire surface of the filters.

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Detection of SARS-CoV-2 viral RNA

RNA isolation

Isolation of the genetic material of the virus in the laboratory working for hospital no. 1 was carried out in the Gene Pure automatic system using MagaBio plus Virus DNA/RNA Purification Kit II (Cat#.BSC71) or manually with the use of Biospin Virus DNA/RNA Extraction Kit (Cat#.BSC77). The laboratory working for hospital no. 2 conducted isolation of the genetic material of the virus in the compact automated Maelstrom 4800 (TANBead) system. Special sets of extraction plates and reagents (proteinase K and carrier RNA) dedicated to the extractor are available. All necessary reagents are contained within the extraction plate.

Polymerase chain reaction (PCR)

The studies were carried out using the SARS-CoV-2 Nucleic Acid Detection Kit, Hangzhou Bioer Technology (HBRT) Co. Ltd., in the laboratory working for hospital no. 1 and Vitassay qPCR SARS-CoV-2 (Vitassay Healthcare S.L.U.) in the laboratory working for hospital no. 2.

Both kits enable qualitative detection of SARS-CoV-2, with the use of RT-PCR. The tests are based on real-time amplification of certain conserved fragments of two genes, ORF1ab and N, on separate detection channels. Detection of amplification of the target sequence of the gene ORF1ab is observed on the FAM channel, whereas that of the gene N, on the HEX or ROX (for the Vitassay kit) channels. Additionally, the tests have an internal control (IC), which allows one to detect a possible inhibition process – suppressing the reaction in the sample. IC detection takes place on the Cy5 or HEX (for the Vitassay kit) channels. The kits contain reagents for positive and negative controls of the amplification process. The analytical sensitivity of the kit was determined by analysing a series of 10-fold dilutions of the SARS-CoV-2 standard ranging from 107 to 101 copies/rxn. The detection limit of the Vitassay test is >= 10 copies of the viral RNA per reaction, while for the HBRT test, 500 copies of the viral RNA per millilitre. The analytical specificity of the test for SARS-CoV-2 was tested in the microorganism panel indicated by the manufacturer, where no cross-reactivity was observed between species.

The thermal profile is specified by the manufacturer of the kit and includes 45 cycles. The Vittassay kit was used on the ROTOR Gene Q (Qiagen) and StepOnePlus RT-PCR (Applied Biosystems) instruments and the HBRT kit – on the Bioer QuantGene 9600 system.

Results

The total number of air samples amounted to 29. There were 6 samples from touch surfaces in the immediate vicinity of the patient, 4 samples from the floor, and 4 from the masks used by patients. The results of test determinations for the genetic material of SARS-CoV-2 in these samples are shown in Table 1. Using the filtration mode, the Sterylis device was tested in two patient rooms and the total number of samples collected from the filters of the device was 4 (2 inlet and 2 outlet filters), while operation in the UV-C disinfection mode based on the presence of the genetic material of SARS-CoV-2 on the device

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filters was assessed five times in total, including once in hospital no. I and four times in hospital no. II. The cumulative breakdown of the swab test results from the filters of the devices operating in the filtration and disinfection modes are presented in Table 2.

All air samples from hospital no. I were negative. In hospital no. II, the majority of air samples (five out of six) collected in both rooms prior to the disinfection process were negative. One air sample was presumably positive. All samples taken from touch surfaces in hospital no. I, in the immediate vicinity of the patient, were also negative. In hospital no. II, among the samples collected from touch surfaces by swabbing on 9 December, two samples were positive, i.e. swabs from the bedside table top and ladder in room 1 (Table 3). The swab from the remote used by a patient in room 1 and the swab from the bedside table top in room 2 were presumably positive (Table 3). Presumably positive test results were obtained from a patient mask swab in hospital no. I and from one of two samples from patient masks in hospital no. II. The sample taken from a patient mask in room 1 of hospital no. II was negative. Two samples taken in room 2 were not described while one of the results was presumably positive. However, it could not be determined whether the presumably positive result was obtained in the case of an air sample or a swab from the remote used by a patient. The samples taken from patient masks on 10 December, i.e. after 24 h of the operation of the Sterylis device in the UV-C disinfection mode in both rooms, did not demonstrate the presence of SARS-CoV-2 viral genes. Swabs from the device filters in room 1 were also negative, while swabs from the device filters in room 2 were presumably positive.

On 21 and 22 December, additional tests were performed, including testing of floor contamination and the device filters. On 20 December, the device was turned on in the filtration mode, and then, on 21 December, materials were collected in both rooms: two floor swabs and two device filter swabs from each room. Three samples taken from the floor gave a positive result and one was presumably positive. Samples from the carbon filters of both devices were negative, and as regards inlet filters – the device in room 1 gave a negative result and the device in room 2 gave a presumably positive result. On 21 December, filters were replaced in both devices, and the devices were switched on in the UV-C disinfection mode. On 22 December, swabs were taken from the filters of both devices and all samples turned out to be negative.

Discussion

The results obtained using RT-PCR for the presence of SARS-CoV-2 viral RNA in the air and on touch surfaces do not differ significantly from the results of other authors (the majority of studies). In the studies by other authors, when air contamination was tested using samples with a volume of 1000 l, the presence of SARS-CoV-2 viral RNA was only sporadically confirmed. Wang *et al.* [14], among 36 samples – swabs from touch surfaces – and further 9 – swabs from staff masks and gloves – did not confirm the presence of SARS-CoV-2 viral genes. Samples taken from containers used for disinfection of contaminated equipment gave rise to four positive results. The studies were carried out in

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Table 1. Contamination of surfaces and air with the genetic material of SARS-CoV-2.

Hospital	Touch surfaces in the immediate vicinity of the patient		Air		Patient masks		Floor	
	N	n_1 (%) n_2 (%)	N	n_1 (%) n_2 (%)	N	n_1 (%) n_2 (%)	N	n_1 (%) n_2 (%)
I	6	0 (0) 0 (0)	29	0 (0) 0 (0)	1	0 (0) 1 (100)	-	-
II	5	2 (40) 2 (40)	5	0 (00) 1 (20)	4	0 (0) 1 (25)	4	2 (50) 2 (50)
Total	11	2 (20) 2 (20)	34	0 (0) 1 (3)	5	0 (0) 2 (40)	4	2 (50) 2 (50)

Legend: N – the number of all samples of a given type, n_1 – the number of positive samples, i.e. those in which the presence of two genes was confirmed, n_2 – the number of presumably positive samples, i.e. those in which the presence of one gene of SARS-CoV-2 was confirmed.

Table 2. The presence of the genetic material of SARS-CoV-2 on the filters of the Sterylis device.

Hospital	Operation in the UV-C disinfection mode				Operation in the filtration mode			
	Inlet filter		Outlet filter		Inlet filter		Outlet filter	
	N	n_1 (%) n_2 (%)	N	n_1 (%) n_2 (%)	N	n_1 (%) n_2 (%)	N	n_1 (%) n_2 (%)
I	1	0 (0) 1 (100)	0	0 (0) 0 (0)	-	-	-	-
II	4	1 (25) 1 (25)	4	0 (0) 1 (25)	2	0 (0) 1 (50)	2	0 (0) 0 (0)
Total	5	1 (20) 2 (40)	5	0 (0) 1 (10)	2	0 (0) 1 (50)	2	0 (0) 0 (0)

Legend: N – the number of all samples of a given type, n1 – the number of positive samples, i.e. those in which the presence of two genes was confirmed, n2 – the number of presumably positive samples, i.e. those in which the presence of one gene of the SARS-CoV-2 virus was confirmed.

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Table 3. List of touch surfaces in patients close surroundings in two Rooms in Hospital II.

No.	Sample type	Results
Room 1		
1	Remote	Presumably positive
2	Ladder	Positive
6	Patient mask	Negative
Room 2		
7	Bedside table top	Positive
8	Patient mask	Presumably positive
9	Bedside table top	Presumably positive
14	IV pole	Negative

Legend: Positive samples - those in which the presence of two genes was confirmed, presumably positive samples - those in which the presence of one gene of SARS-CoV-2 was confirmed.

the observation ward where 33 patients with confirmed COVID-19 were hospitalized. In a study by Colaneri *et al.*, among 26 collected samples, which were environmental swabs collected with Copan flocked swabs from an enhanced surveillance unit, where patients with a high probability of viral shedding were treated, only 2 samples were positive (by RT-PCR) [15]. Ben-Shmuel *et al.* examined a total of 55 environmental samples – swabs (49) and air samples (6) – collected in two different hospitals: hospital A – 23 samples, hospital B – 32 samples [16]. The proportion of positive RT-PCR test results totalled 51%, however, it differed significantly for samples collected in both hospitals. In hospital A, 6 positive samples (26%) were recorded, and in hospital B, there were 23 positive results (72%). As for air samples, two out of six were positive. Swabs were taken from surfaces with dimensions of 20×20 cm, and for small objects (e.g. door handles) from the entire surface. Air samples were collected with the application of the MD8 sampler, using gel filters, for 20 min, air flow at 50 l/min (1000 l). Samples cooled to the temperature of 4–8°C were processed within 2–3 h from the time of collection. A similar study was conducted by Wu *et al.* in Hospital No. 7 in Wuhan, one of the first hospitals dedicated to the treatment of COVID-19 patients in the Hubei province [17]. Various types of touch surface swabs were tested, including gloves and air samples. Samples were collected using flocked swabs. Air samples were collected by free sedimentation according to the national Chinese standard. The presence of SARS-CoV-2 viral genes was not confirmed in any of the 44 air samples by RT-PCR. Out of 200 samples collected as various swabs from different types of surfaces, 38 samples (19%) were positive.

During the first wave of the epidemic, in the period from 2 to 20 April, Zhou *et al.* collected air and touch surface samples from seven different hospital units (including the operating room, intensive care unit), in which patients with confirmed COVID-19 infection were cohorted, and in the public space of the hospital [18]. Samples from touch surfaces were collected as swabs from areas of approx. 25 cm^2, while air was sampled using a Coriolis µ sampler (Bertin Technologies). Air samples with the volume of 1000 l were sampled into 5 ml Dulbecco's Modified Eagle Medium (DMEM), from where the volume of 140 µl was then removed for viral RNA isolation. PCR was conducted in duplicate for each sample. Samples were defined as positive when both replicate values amounted to Ct<40.4, and as presumably positive when one repetition gave Ct<40.4 for one gene. Tests

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were performed for 218 samples from touch surfaces and 31 air samples. 91 samples from surfaces (41.7%) were presumably positive, and 23 (10.6%) were positive. As for air, 12 (38.7%) samples were presumably positive, and 2 (4.4%) – positive.

The presence of SARS-CoV-2 was also assessed using RT-PCR in swabs from surfaces and air by Ahn *et al.* [19]. Swabs from surfaces and air samples were collected from the immediate vicinity of three different patients hospitalized in a tertiary referral hospital in Korea. Additionally, the infectivity of the virus detected in environmental samples was also assessed. As regarding the air, two methods of sampling were employed. The first one used the SKC Biosampler for 20 ml phosphate-buffered saline (PBS). The sensitivity of capturing particles 100 nm in size amounts to approx. 30–40% for this method. Air samples were also collected with the use of a swabbing probe, in which cotton swabs act as a filter capturing the virions present in the air with a sensitivity of approx. 99%. Air samples were taken with the parameters of the flow at 12.5 – 10 l/min for 20 min for both methods. As for the swabbing probe, the captured particles were recovered by shaking the swab in 1 ml of PBS, and then freezing it at -80°C in order to preserve it for testing. Out of 48 samples collected as swabs from surfaces surrounding two patients (patients 1 and 2), only tracheostomy tube samples were positive. In the vicinity of the third patient, 13 out of 28 swabs were positive. All air samples were negative.

Contamination of the environment with SARS-CoV-2 in three isolation wards in which patients with confirmed COVID-19 infection were treated was also investigated by Chia *et al.* [20]. Air samples were taken with the use of the NIOSH BC 251 bioaerosol sampler. Air samples were collected with the volume of 5040 l (flow rate 3.5 l/min, duration of collection 4 h). Touch surface samples were taken as swabs. Immediately after collection, all samples were placed at 4°C prior to handing them over to a laboratory with the required degree of safety. In two out of three (66.7%) air samples, the presence of SARS-CoV-2 viral RNA was confirmed. Environmental swabs were collected in 27 isolation rooms and, in 56.7% of rooms, at least one positive sample was obtained. Most often, a positive result in samples from surfaces was determined for floors (65%), followed by ventilation equipment (n=5, 60%), bed wheels (59%) and bedside tables (47%). The presence of viral RNA was confirmed significantly more often when patients staying in the rooms were undergoing their first week of the disease, but surface contamination was not significantly dependent on patients' symptom presentation.

Similar studies were also conducted by Cheng *et al.* [21]. Air samples and surface swabs were collected in the vicinity of patients staying in an isolation unit, in the period from 24 January to 9 April 2020. On the day of air sampling, six patients with confirmed infections gave their samples of exhaled air by sneezing/coughing onto gel filters such as those used for air sampling. Air samples were collected with the use of the MD8 sampler (Sartorius AG, Germany) onto gel filters, 80 mm in size, pore size 3 μm with the air flow at 5 l/min, total sample volume – 1000 l. Environmental samples were collected by swabbing. 19 out of 377 (5%) environmental samples were positive

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(RT-PCR); however, the presence of SARS-CoV-2 viral genes was not confirmed in any of the air samples. Among the material collected from patients on gel filters, only one sample was positive.

Studies at Blessed Marta Wiecka Hospital in Bochnia and John Paul II Specialist Hospital in Cracow were aimed at assessing the effectiveness of disinfection using the flow-through UV-C method employed in the Sterylis Basic and Ultra devices. Therefore, apart from air samples and swabs from touch surfaces, materials were collected from the surface of the device inlet and outlet filters, from the facial part of the masks of patients hospitalized in the wards, and the floors of these rooms were swabbed.

At Blessed Marta Wiecka Hospital in Bochnia, the presence of SARS-CoV-2 viral RNA was not found in any of the materials taken from touch surfaces. The RT-PCR test proved the presence of SARS-CoV-2 genes on a patient mask in the second stage of the study, hence, it was confirmed that the virus was secreted as bioaerosol. This fact was also corroborated by the presence of a SARS-CoV-2 gene on the device inlet filter, which initially cleans the air before exposure to UV-C rays. SARS-CoV-2 genes were not demonstrated in a swab from the device outlet filter, which confirms the elimination of viral particles as a result of the UV-C disinfection used in the Sterylis device.
Research carried out at John Paul II Specialist Hospital in Cracow confirms the presence of SARS-CoV-2 RNA in the majority of materials collected from touch surfaces and floor swabs, and as for air samples, only one out of six gave a presumably positive result. The results of swabs from the device filters varied. In the first stage of the study, the swab of the inlet filter of one of the devices indicated a positive result, while the carbon filter, i.e. the outlet filter showed a negative outcome. In the second device, samples from both filters gave inconclusive results. During re-examination, following operation in the filtration mode, a presumably positive result was obtained from the inlet filter of one of the devices and a negative from the outlet filter, while the samples from both filters of the other device were negative. Afterwards, swabs from filters from both devices operating in the disinfection mode were negative. This might be associated with the fact that the filtration mode employed the previous day might have led to such elimination of viral RNA from the air that the material did not reach a level detectable in swabs from the device filters in any of the patient rooms.

There are some limitations of our study. Firstly, this is air sampling method which, within a reasonable time, did not permit sampling volumes of 5000 l. Additionally, the air sampling in our study was a kind of experimental one, we had air samples taken in different ways (modifications of method). Perhaps this is the reason for practically all negative results in case of air samples. But, on the other hand, these results are similar to results of some other similar studies. Secondly, total number of samples taken from surfaces, air in hospital no. II and filters was rather small. Consequently our results should be regarded as preliminary.

However, the main value of our research is evaluation of specific device based on UV-C flow disinfection method in real conditions,

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together with checking the level of hospital wards contamination by SARS-CoV-2.

Conclusions

The degree of air contamination by SARS-CoV-2 in patient rooms is strictly dependent on the condition of patients and the intensity of viral shedding, which is related to the stage of the disease and the procedures applied. The detection of the genetic material of SARS-CoV-2 requires the employment of advanced automated air sampling methods enabling the collection of samples with a volume of 5000 l. The results obtained by us indicate that Sterylis devices eliminate the particles of the virus present in the air in enclosed spaces. However, taking into account the diverse conditions accompanying the operation of the devices, especially associated with the state of the patients hospitalized, as well as collecting materials and type of results, including the percentage of presumably positive results, additional studies in this field are recommended.

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