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Short Report

Do established infection prevention and control measures prevent spread of SARS-CoV-2 to the hospital environment beyond the patient room?

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SUMMARY

The role of the hospital environment in the transmission of infection is well described. With an emerging infection whose mode of transmission is under investigation, strict infection prevention and control measures, including patient isolation, hand hygiene, personal protective equipment that is doffed on exiting the patient room, and environmental cleaning should be implemented to prevent spread. Environmental testing demonstrated that COVID-19 patients contaminated the patient area (11/26, 42.3% of tests) but contamination of general ward areas was minimal (1/30, 3%) and the virus was detected after cleaning on one item only (1/25, 4%) which was noted to be in disrepair.

Introduction

Knowledge about the transmission of SARS-CoV-2, the causative agent of COVID-19 is increasing. Early reports from China indicated that transmission occurred through contact and respiratory droplet spread [1]. Transmission has occurred in the community as well as in healthcare settings. Infection prevention and control (IPC) measures have been adopted globally to prevent spread within hospitals. Current guidance recommends hand hygiene, personal protective equipment (PPE) and environmental decontamination [2–4]. There have been studies examining the contamination of environmental surfaces with SARS-CoV-2 virus [5] and modelling the potential risk for the transmission of COVID-19 in healthcare using a surrogate virus [6]. Best practice in the use of single room accommodation and PPE for preventing spread of infection is to don PPE on entering the room and doff on exiting [7] with hand hygiene performed at relevant times according to the WHO five moments for hand hygiene. In addition, environmental cleaning reduces the risk to staff and future patients.

The Mater Misericordiae University Hospital (MMUH), Dublin, is a 600-bed acute hospital and tertiary referral centre for multiple medical and surgical specialties including a quaternary referral service for extracorporeal life support (ECLS) in the intensive care unit. The hospital also houses the national isolation unit (NIU) for high-consequence infectious diseases (HCIDs). Before the first case of COVID-19 was identified in

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Ireland, the hospital began preparing by identifying suitable IPC measures such as preferred areas for patient isolation or cohorting, levels of PPE and training in its use, as well as new cleaning and disinfection agents which had been under trial at the hospital in the second half of 2019 prior to COVID-19 emerging. The hospital experienced a high proportion of the Irish cases of COVID-19 during the peak of transmission in the community in this country and continues to have acute cases presenting and occasional sporadic outbreaks. The total number of patients with COVID-19 treated as inpatients at the hospital up to 31st May was 803.

Patients were placed in single en suite rooms while undergoing assessment for COVID-19 and moved on into six-bed cohort rooms on specific wards once a laboratory confirmation of the diagnosis was made. Rooms were cleaned with a chlorine dioxide agent (Tristel FUSE®) once daily and again after discharge with a terminal clean using chlorine dioxide followed by ultraviolet-C (UVC) disinfection (SteriPro®). PPE including filtering face piece (FFP) 2 or FFP 3 masks, eye protection in the form of goggles or visors, gloves and a long-sleeved fluid-repellent gown was recommended. In each ward an area was designated as the donning areas for staff confidence. PPE was doffed on leaving the patient room. PPE was not worn while working in the general ward areas, e.g., at nurses' stations. As the number of COVID-19 cases increased throughout Ireland and internationally, the demand for PPE increased. In order to preserve its use, some centres moved to the wearing of PPE throughout ward areas, within and outside of patient rooms, doffing only on exiting the ward in accordance with WHO interim guidance [8]. We theorized that this could increase the risk of spread to healthcare workers due to widespread contamination of ward areas and inadvertent breaches in practice in relation to PPE such that healthcare staff might self-inoculate with SARS-CoV-2 once outside of the patient room in contaminated PPE.

We undertook this study to demonstrate that the infectious COVID-19 patient readily contaminates the patient area but that the combination of IPC measures introduced including hand hygiene, doffing PPE on exiting the patient room and enhanced environmental cleaning and disinfection prevented contamination of the shared working areas outside of patient rooms such that it was safe to work in these areas without donning PPE.

Methods

Environmental samples were retrieved by IPC Clinical Nurse Specialists (IPC CNS) from clinical areas where COVID-19 patients were treated including the Emergency Department (ED), Intensive Care Unit (ICU), High-dependency Unit (HDU) and six medical wards, one of which was the NIU. Samples were collected between 5th May and 15th May 2020, during which time the minimum number of infected patients in the hospital ranged from 73 to 107, with between 7 and 11 in ICU, two on ECLS.

Surface and air sampling was performed. Surface sampling was by swab of the area with a COPAN UTM-RT transport medium for viruses (Copan, Italia), similar to that used for clinical sampling of the patient airway. Surface samples were obtained using flocked swabs and transported to the laboratory in universal viral transport media (VTM) within 1–2 h of collection. Samples were refrigerated until testing was performed. To sample the air, an empty Petri dish containing 3 mL of viral transport medium (VTM) decanted from a clinical collection device was placed into the air sampler SAS Super ISO 100®. The VTM was subsequently pipetted out and replaced back into the collection device for submission to the laboratory for analysis.

Surfaces sampled were from three distinct categories of location: (1) a patient room housing a laboratory-confirmed COVID-19 patient; (2) an empty patient room following terminal cleaning and UVC decontamination that was carried out after the discharge of a laboratory-confirmed COVID-19 case; and (3) the nurses' station of each of the wards with COVID-19 patients. Sites of swabs were chosen as frequently touched areas by either the patient or staff as appropriate (Table I).

Timing of surface swab samples was determined by passage of time from most recent clean. COVID-19 patient rooms were cleaned once per day and nurses' station areas twice. For swabs of these areas, a minimum time of 4 h was allowed to elapse before samples were taken. Swabs of empty terminally cleaned and disinfected patient rooms were taken before the admission of a new patient. For cleaning of patient and ward

Table I
Sites of swabs/air samples and results

Sample location	Grand total	Detected	Not detected
COVID-19 patient's room			
Bed rail	6	4	2
Bedside table	6	3	3
Call bell	4	1	3
Patient chair-arm	4	1	3
Remote for bed	2	2	0
Toilet door handle	4	0	4
Total	26	11	15
Nurses' station COVID-19 cohort ward			
Desk	10	0	10
Keyboard	10	0	10
Telephone	10	1	9
Total	30	1	29
Patient room post-terminal clean			
Bed rail	5	0	5
Bedside table	5	0	5
Call bell	5	1	4
Patient chair-arm	5	0	5
Toilet door handle	5	0	5
Total	25	1	24
Air sample – control			
Control	1	0	1
Total	1	0	1
Air sample – COVID-19 patient room			
Inside patient room	2	0	2
Inside patient room – multi-bed bay	3	0	3
Near patient	3	0	3
Total	8	0	8
Air sample – COVID-19 cohort ward			
Anteroom	1	0	1
Corridor	5	0	5
Nurse station	2	0	2
Total	8	0	8
Grand total	98	13	85

areas, a chlorine dioxide agent was used (Tristel FUSE®). For a terminal clean after discharge of a COVID-19 patient, chlorine dioxide cleaning was followed by UVC decontamination using the SteriPro® UVC disinfection robot.

Air sampling was performed in single patient rooms housing COVID-19 patients both intubated and non-intubated, in multi-bed bays accommodating COVID-19 patients on respiratory treatments deemed likely to generate aerosols, e.g., non-invasive ventilation, and in the general corridor outside the rooms of COVID-19 patients (Table I).

Surface and air samples were analysed for the presence of SARS-CoV-2 RNA by molecular testing using the Cepheid Xpert Xpress SARS-CoV-2 assay (Cepheid AB, Solna, Sweden) under Emergency Use Authorization. The Xpert test platform integrates specimen processing, nucleic acid extraction, reverse transcriptase polymerase chain reaction amplification of SARS-CoV-2 RNA, and amplicon detection in a single cartridge. The assay amplifies two nucleic acid targets, namely N2 (nucleocapsid) and E (envelope) wherein N2 is more specific for SARS-CoV-2.

Results and discussion

Eighty-one surface swab samples were retrieved for the purposes of the study, 26 from within COVID-19 patient rooms, 25 from COVID-19 patient rooms after discharge and following completion of terminal cleaning and disinfection with additional UVC decontamination and 30 from nurses' stations.

Testing of the patient room indicated that the patient easily contaminated the area, with almost half of the tests detecting SARS-CoV-2 (11/26, 42.3%). These areas may have been contaminated by coughing, as they were all in close proximity to the patient's bed or chair, or by spread from the patient's contaminated hands. The remote control for the bed in two rooms was the most frequently positive site (2/2, 100%). These were located in rooms in the ICU, where the remote is an area frequently handled by staff members while caring for the patient. The bed side rail was the second most frequent (4/6, 66.7%), another area touched frequently by both patient and staff. The handle of the en suite bathroom door was not found to be contaminated in any of four en suite rooms tested. This may be due to the fact that it was located more than 2 m from the patient or that the patient was too unwell to mobilize to use the bathroom.

There was just one positive test among the samples taken from cleaned rooms. One call bell was found to be contaminated but was also noted to be in disrepair and unlikely to be easily cleaned. In addition, its placement in the room was beyond the reach of the UVC. Replacement and alternative location was immediately recommended. Subsequently all wards were instructed to review equipment condition and cleaning protocols. One telephone at a nurses' station tested positive for SARS-CoV-2 whereas all desk and computer keyboard samples returned negative results. This might suggest that contamination arose due to the respiratory droplets of an infected staff member rather than transfer of patient virus from the contaminated patient room.

The total number of air samples taken was 16, eight from patient rooms, eight from corridors of COVID-19 wards. One control sample of VTM was reserved as a negative control sample for laboratory testing. None of the air samples taken yielded positive results. While this might reassure us that the virus was not airborne, the absence of a positive control such as a positive result even in near patient testing prevents us from drawing any firm conclusions as we could not validate our sampling method.

In conclusion, the hospital environment has long been identified as a source of transmission of other infections within hospitals [9]. Placing patients in accommodation isolated from those without infection, hand hygiene, wearing of appropriate personal protective equipment and thorough environmental cleaning and disinfection have all been recognized as important interventions to prevent and control the spread of infections in hospital. It follows that the same measures be put in place to prevent the spread of COVID-19. This study demonstrates that these measures effectively prevented spread of SARS-CoV-2 from contaminated patient rooms to general ward areas. This will inform future management of COVID-19 in the event of resurgence as well as other emerging infectious diseases.

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Conflict of interest statement
None declared.

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