ENVIRONMENTAL CONTAMINATION WITH SARS-COV-2 IN NURSING HOMES

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Key Points:

- COVID-19 patients shed virus into their surrounding environment frequently and persistently.
- Independent patients are more likely to contaminate their immediate environment.
- Contamination of common areas within and near COVID-19 units occurred infrequently.

Why does this matter?

While detection of SARS-CoV-2 viral RNA does not indicate infectiousness, this detection can be used to determine where in the nursing home setting virus is most likely to be present. Infection control policies should thoughtfully incorporate environmental cleaning, education, and diligent use of PPE by frontline staff.

ABSTRACT

Background: SARS-CoV-2 outbreaks in nursing homes (NHs) have been devastating and have led to the creation of COVID-19 units within NHs to care for affected patients. Frequency and persistence of SARS-CoV-2 environmental contamination in these units has not been studied.

Methods: A prospective cohort study was conducted between October 2020 and January 2021 in four Michigan NHs. Swabs from high-touch surfaces in COVID-19 infected-patient rooms were obtained at enrollment and follow-up. Demographic and clinical data were collected from clinical records. Primary outcome of interest was the probability of SARS-CoV-2 RNA detection from specific environmental surfaces in COVID-19 patient rooms. We used multivariable logistic regression to assess patient risk factors for SARS-CoV-2 contamination. Pairwise Phi coefficients were calculated to measure correlation of site-specific environmental detection upon enrollment and during follow-up.

Results: One hundred four patients with COVID-19 were enrolled (61.5% >80 yrs; 67.3% female; 89.4% non-Hispanic white; 51% short-stay) and followed for 241 visits. The study population had significant disabilities in activities of daily living (ADL; 81.7% dependent in four or more ADLs) and comorbidities, including dementia (55.8%), diabetes (40.4%), and heart failure (32.7%). Over the 3-month study period, 2087 swab specimens were collected (1896 COVID-19 patient rooms, 191 common areas). SARS-CoV-2 positivity was 28.4% (538/1896 swabs) on patient room surfaces and 3.7% (7/191 swabs) on common area surfaces. Nearly 90% (93/104) of patients had SARS-CoV-2 contamination in their room at least once. Environmental contamination upon enrollment correlated with contamination of the same site during follow-up. Functional independence increased the odds of proximate contamination.

Conclusions: Environmental detection of viral RNA from surfaces in the rooms of COVID-19 patients is nearly universal *and* persistent; more investigation is needed to determine the implications of this for infectiousness. Patients with greater independence are more likely than fully dependent patients to contaminate their immediate environment.

Keywords: SARS-CoV-2; COVID-19; nursing homes

Introduction

The coronavirus disease 2019 (COVID-19) pandemic has disproportionately affected patients in nursing homes (NHs) and long-term care facilities,[1,2] accounting for 5% of all cases and 32% of all COVID-19 deaths nationwide.[3,4] NHs have responded by rapidly creating COVID-19 units, thus caring for their patients within the NHs and reducing hospital transfers. Advancing our understanding of environmental contamination with the causative virus of COVID-19, SARS-CoV-2, within these units deserves further investigation.

Researchers have found that within acute care hospitals, SARS-CoV-2 is transmitted more readily to surfaces in COVID-19 patient rooms than to surfaces in common areas[5-8]; however, the role of environmental contamination on transmission, the stability of the virus in the environment, factors that affect virus survival or persistence on inanimate surfaces, and patient characteristics affecting environmental contamination remain understudied.[5,9-11] Evidence from NHs are lacking. Compared to hospitals, NHs are designed as more congregate living spaces, which house patients more vulnerable to infection. Moreover, the very disabilities that confine patients to the NH and require physical assistance from others also preclude his or her ability to fully isolate for the entire duration of COVID-19 illness.

In this prospective cohort study, we characterize the epidemiology of SARS-CoV-2 virus across the patient care blueprint of COVID-19 units within 4 NHs, from inside COVID-19 patients' rooms to common use areas. Our main objectives were to: 1) characterize the extent of contamination of patient room surfaces and NH common areas with SARS-CoV-2 viral RNA; 2) ascertain whether this contamination was persistent over time; and 3) evaluate the impact of functional status, disease severity, and comorbidity on environmental contamination.

Methods

Study Population and Design

This study was conducted between October 2020 and January 2021 in COVID-19 units within 4 NHs in Southeast Michigan. Any patient diagnosed with recent (≤14 days) COVID-19 infection was enrolled in this prospective cohort study to evaluate environmental contamination. Trained research clinicians collected swab specimens from specific room surfaces of patients infected with COVID-19 within the past 14 days. Swab specimens were collected a total of three times over the course of one week, with visits occurring 1 to 4 days apart. Likewise, once per week, swab specimens were collected from specific common area surfaces at all participating facilities. The study was approved by the University of Michigan Institutional Review Board and Human Research Activation Committee (to ensure safety during the COVID-19 pandemic), including a waiver of informed consent to collect environmental samples and deidentified clinical data.

Infection Control Policies at Study Sites

All four NHs had comprehensive infection prevention programs, including a COVID-19 response team consisting of several leadership and frontline staff. Characteristics of participating NH COVID-19 units, as well as policies for personal protective equipment (PPE) use, audit frequencies, and environmental cleaning procedures, are included in **Supplemental Table S1.**

Swab Specimen Collection and Transport

To assess COVID-19 patient room contamination with SARS-CoV-2 viral RNA, swab specimens were collected from the following high-touch, representative environmental surfaces at each study visit: bed controls, call button, bedside tabletop, TV remote, privacy curtain,

windowsill, toilet seat, doorknob, and air vent (if within reach). The common area specimens collected weekly included the following, in or nearest to the facility's designated COVID-19 unit: sitting area tabletop, sitting area chair or arm rest, dining room tabletop, nurses' station table top, nurses' station computer keyboard, and elevator buttons. For all flat surfaces, an area of approximately 5x20 cm was swabbed. For smaller objects, the entire surface was swabbed. Flocked swabs (Copan 502CS01 or Puritan 25-3306U) were used and placed into 3ml viral transport media (Labscoop VR2020) following collection.[12,13] All environmental specimens were placed on ice and transported within two hours of collection to a BSL-2 University of Michigan research laboratory. Samples were aliquoted into two 1.5 mL vials and stored at -80 °C until testing.

Clinical Data Collection

Research personnel reviewed COVID-19 patient medical records to collect demographic and clinical data. Baseline demographic data were obtained from patient's admission documentation, Minimum Data Set (MDS) assessments, or NH provider notes, and included: age; sex; race; ethnicity; short- or long-stay patient designation (≤90 days, short-stay; >90 days, long-stay); admitting and discharge locations; advanced directives; MDS Brief Interview for Mental Status (BIMS) score,[14] a performance-based cognitive screener for NH patients; Charlson comorbidity score[15]; and independence in activities of daily living (ADL) score (i.e., bathing, dressing, toileting, transferring, continence, and feeding).[16,17] ADL independence was further defined categorically as: dependent in all 6 activities; independent in 1 or 2 activities; and independent in 3 or more activities. Clinical data was collected for any of the following events from 30 days prior to the study start through the end of the study period: hospitalization, antibiotic and

antiviral use, device use, and presence of an open wound. COVID-19 data collected included: COVID-19 test collection and results in the past 30 days; vital signs on the date of first positive COVID-19 test; vital signs at study discharge; and signs and symptoms present at the onset of COVID-19 infection. Signs and symptoms included the following (per CDC guidelines[18]) documented in the two weeks following the first COVID-19 positive test: fever or chills; cough; shortness of breath or difficulty breathing; fatigue; muscle or body aches; headache; new loss of taste or smell; sore throat; congestion or runny nose; nausea or vomiting; diarrhea; hypoxia (blood O2<95%); hypotension (blood pressure <90/60); tachypnea (abnormally rapid breathing or respiration>24); tachycardia (pulse>120); poor appetite/poor oral intake; change in mental status; and worsening functional status. All COVID-19 data was abstracted directly from the NH provider notes and/or the hospital provider notes (if the patient was at the hospital in the two weeks following COVID-19 diagnosis). If a symptom was not documented, it was recorded as "absent." At least two trained research clinicians reviewed every patient chart to ensure completeness.

Laboratory Methods

RNA was extracted using the KingFisher automated extraction and purification system, where 200 µL of a thawed specimen aliquot was extracted and then eluted into 50 µL of an elution buffer, following instructions within the EUA protocol for TaqPath COVID-19 SARS-CoV-2 Combo Kit (ThermoFisher).[19] For samples collected between 11/4/2020 to 11/18/2020, RNA was extracted using a QIAamp Viral RNA Mini Kit (Qiagen 52906) as an alternative method, where 140 µL of the original specimen was extracted and eluted into 100 µL of water.

Extracted specimens were tested for the presence of SARS-CoV-2 RNA using the CDC 2019-nCoV real-Time RT-PCR EUA Protocol.[13] Samples with amplification for both targets (N1 and N2) with Ct value < 40 were considered positive, and samples with no signal for either target were called negative. When fluorescence was detected for only one of two targets, RNA was re-extracted from the originally thawed aliquot and tested using the TaqPath COVID-19 Combo Kit for confirmation.[19] For the TaqPath COVID-19 Combo Kit assay, specimens were considered positive if two of the three targets—S gene, N gene, ORF1ab gene—amplified with Ct <= 37. Specimens with partial amplification for both the CDC-based and TaqPath-based assays were classified as positive in analyses, as further described in **Supplemental Figure S1.**

Sample Size

Our sample included 4 NHs with an average bed size of 125 beds (range, 40 to 215) (**Supplemental Table S1**). Power calculations were based on the predicted probabilities of SARS-CoV-2 viral RNA detection. Based on limited existing research from NH settings and using functional disability as our primary risk factor, we predicted 50% of all patient rooms would have one or more environmental site contaminated before cleaning. We based our sample size on the conservative assumption that the odds of colonization among those with functional disability would be 1.65 times higher than among patients without disability. Thus, a sample size of 100 was needed to detect this pre-specified difference between groups with 80% power and alpha=0.05.

Statistical Analysis

Since short-stay populations differ significantly from long-stay populations in their length of stay, cognition, and function, we were interested in understanding and curating risk factors for each. We compared baseline characteristics between short-stay and long-stay patients using Fisher's exact test to assess significance in categorical descriptors and Wilcoxon Rank Sum to evaluate significance between continuous descriptors. The main outcome of interest was the presence of SARS-CoV-2 viral RNA on environmental objects in the rooms of COVID-19 positive NH patients. To accomplish aim 1, we present SARS-CoV-2 positivity at a swab-, visit-, and patient-level, and further consider proximate contamination (defined as SARS-CoV-2 detected at any site *within* three feet of the patient bed) vs distant contamination (SARS-CoV-2 detected *greater* than 3 feet from the patient bed) at enrollment, within the patient room only (common area swabs excluded). At least three proximate cultures (median 4 cultures, IQR: 3-4) and at least two distant cultures (median 4 cultures, IQR: 4-5) were collected during each visit.

To accomplish aim 2, we examined the site-specific prevalence of SARS-CoV-2 isolated from environmental surfaces in the rooms of infected patients on enrollment and during follow-up. In this analysis, persistence was defined as contamination at one or more room sites at enrollment and at least one follow-up visit (visit 2 or 3). To test for persistence of contamination at each specific type of environmental site, we used the Phi coefficient, a measure of association between two binary variables, to assess for correlation between contamination (vs non-contamination) at baseline versus follow-up.[20]

To accomplish aim 3, we used logistic regression models with random effect, a type of generalized mixed effect model, to consider *all visits* in evaluating the association between functional independence (predictor) and SARS-CoV-2 transmission to the patient environment (primary outcomes of proximate, distant, and any contamination), adjusting for comorbidities,

demographics, and disease severity. Data were analyzed using Stata 15 (College Station, TX: StataCorp LLC).

Results

Patient Characteristics

A total of 104 patients at the four NHs were screened within 14 days of their first positive COVID-19 test and enrolled in the study between October 2020 and January 2021 (100% of COVID-19 patients screened were enrolled). Baseline demographics of the patients are in **Table 1**. More than half (62%) of the study population was 80 years of age or older; 67% were female; 89% non-Hispanic white. Patients had a median Charlson comorbidity score of 2. More than three-quarters (82%) were dependent in four or more ADLs. In the 30 days preceding the study period, 24% had been hospitalized; 15% had an indwelling device; 13% had an open wound; and 5% had antiviral use. The discharge location for patients following study completion (as of February 2021) included: 35% still residing at the NH; 31% discharged to the community; 20% to acute-care hospital; 14% deceased; 1% transferred to another NH.

Of the 104 patients, 51 were long-stay patients (in the NH for more than 90 days) and 53 were short-stay (90 days or less). Dementia was more prevalent among long-stay compared to short-stay patients (72.6% vs 39.6%, $p=0.001$). In the 30 days prior to study enrollment, short-stay patients were more likely to have been hospitalized (44.2% compared to 3.9% among long-stay patients, $p<0.001$); to have received antibiotics (47.2% compared to 11.8%, $p<0.001$); and to have had an indwelling device (26.2% compared to 5.9%, $p=0.008$).

SARS-CoV-2 Contamination in Patient Rooms and Common Areas

A total of 2087 swab specimens were collected: 1896 from the rooms of 104 COVID-19 patients (with 241 visits), and 191 from NH common areas in and around the COVID-19 unit. In total, positivity rates included 28.4% of 1896 swabs, 79.7% of 241 visits (with at least one positive

environmental site), and 89.4% of 104 patients (with at least one positive environmental site). **Figure 1** shows the patient-, visit-, and swab-level distribution across all four units.

On enrollment (an average of 6.33 days after first positive test, SD: 4.3, range 0-16), at least one proximate site (located within 3 ft of patient's bed) was contaminated in 55.8% of patient rooms and at least one distant site (>3 ft) was contaminated in 62.5% of patient rooms. Of 55 rooms with a TV remote, 24 (43.6%) were contaminated on enrollment. Of all 104 rooms, 40 (38.5%) call buttons, 25 (24.0%) bedside tables, and 24 (23.1%) bed controls were contaminated (**Figure 2**). Among distant sites, 38.8% (40/103) of windowsills, 27.1% (23/85) of air vents, 16.7% (17/102) of toilet seats, 8.7% (9/104) of doorknobs, and 5.5% (3/55) of privacy curtains were contaminated. Common areas were infrequently contaminated; sitting area chairs were the most frequently contaminated with SARS-CoV-2 detected on 4/33 (12.1%) visits. Dining room tables (6.3%, 2/32) and sitting area tables (3.0%, 1/33) were also contaminated; elevator buttons and nurse station tables and keyboards were not contaminated at any point.

Persistence of SARS-CoV-2 Contamination

Eighty-eight (84.6%) patients had at least one follow-up visit allowing for evaluation of persistence. TV remotes were most likely to be contaminated, with 68.1% (32 of 47 patients with follow-up and a remote in the room) contaminated at any point in the study. TV remote contamination was most persistent, often detected on both enrollment and during follow-up (34%; 16/47). Windowsills were persistently contaminated in a third (29/88) of rooms and contaminated at any point in 59.1% (52/88); call buttons were persistently contaminated in 28.4% (25/88) of rooms and contaminated at any point in 58.0% (51/88) (**Figure 3)**.

Pairwise correlation between environmental sites on enrollment and during follow-up is shown in **Supplemental Figure S2**. All sites show very strong (Phi coefficient>0.25) internal correlation between contamination on enrollment and during follow-up. Additionally, pairwise correlations of contamination among all proximate sites (bed controls, call buttons, bedside tabletops, and TV remotes) from enrollment to follow-up range from strong (0.1673 Phi coefficient of correlation between enrollment call button contamination and follow-up TV remote contamination; N=52 rooms) to very strong (Phi=0.4996 correlation between table top contamination on enrollment and follow-up TV remote contamination; N=52 rooms).

Risk Factors for SARS-CoV-2 Room Contamination

After adjusting for time from first positive test to enrollment, patient characteristics, and disease severity, increased functional independence was found to be significantly associated with greater odds of proximate contamination (**Table 2**). Compared to the reference group of fully dependent patients (dependent in all six assessed ADLs), those who were independent in 1-2 ADLs (odds ratio [OR], 5.74; 95% confidence interval [CI], 1.49-22.21) and those who were independent in at least 3 ADLs (OR, 8.63; 95% CI, 1.45-51.43) are significantly more likely to have proximate room contamination. Higher Charlson comorbidity score was significantly associated with proximate contamination (OR, 1.59; 95% CI, 1.10-2.30) as well as with overall room contamination (OR, 1.48; 95% CI, 1.02-2.16). Longer time (>3 days) from first COVID-19 positive test to study enrollment was associated with 75% less contamination in the proximate area (OR, 0.25; 95% CI, 0.07-0.86). Functional independence and other covariates were not found to be significantly associated with distant contamination nor overall contamination.

Discussion

Our study shows that SARS-CoV-2 frequently contaminates high-touch surfaces within patient rooms in NH COVID-19 units. In contrast, it is reassuring that the frequency of contamination in non-patient care areas of these units is very low. These results inform the extent and patterns of environmental contamination within these units and will inform effective cleaning practices in order to provide safe care of COVID-19 patients within these units.

Studies of environmental contamination from intensive care units (ICUs), emergency departments, and hospital isolation wards show the prevalence of SARS-CoV-2 in the environment is variable and ranges from 0-70% of samples.[21-42] Ong et al.[22] tested 10 surfaces in 20 patient rooms within a single ICU and found 14 (70%) had at least one positive site, with an overall contamination rate of 14% (28/200 samples). The most contaminated objects were the bedrail and floor (30%), followed by the air outlet vent (25%), and infusion pumps (20%). Within the NH setting, a small study from Canada examined air samples and no-touch surfaces of 31 COVID-19 positive patients' rooms from 7 long-term care facilities.[43] No SARS-CoV-2 was detected in any air samples, but 20 of 62 swabs (32%) from 16 of 31 rooms were positive for SARS-CoV-2 RNA by RT-qPCR.[43]

Our study shows that environmental contamination with SARS-CoV-2 within COVID-19 units in NHs is ubiquitous and persistent. The persistence of COVID-19 has not been studied in NHs and other settings. Santarpia et al.[6] obtained several surface samples from the rooms of 13 COVID-19 infected patients from two hospitals and nine National Quarantine Unit isolation rooms, finding: 81.0% of toilet seat samples to be positive for SARS-CoV-2 RNA; 77.8% of cell phones; 72.7% of window ledges; 70.8% of bedside tables and bedrails; and 55.6% of TV remote controls. Wan et al.[23] also conducted environmental culturing of similar sites in COVID-19

infected patient rooms, finding the electrocardiograph (ECG) fingertip piece to be the most contaminated object (72.7% positive rate), and deeming the bedrail to be the "sentinel" site—the most correlated with additional sites being also positive (10 times). In a study from Yang et al.[24] the toilet seat was the most contaminated site (30%), and no differences between samples of symptomatic vs. asymptomatic patients were found. These studies all underscore that COVID-19 patients frequently contaminate their environment with SARS-CoV-2 and within NHs this contamination is persistent, suggesting continuous shedding.

Prior studies in the acute-care setting showed that contamination of general ward areas outside patient rooms is consistently low (not exceeding 3%).[8,25,26] This may have implications on guidance for visitors and visitation policies in NHs. Prior studies have not shown any specific predictors of environmental contamination.[27,28] We found that functional disability was not associated with increased odds of environmental contamination; on the contrary, after adjusting for clinical risk factors, increased patient independence was significantly associated with greater odds of environmental transmission within 3 feet of the patient bed.

While the CDC notes that the risk of transmission via environmental contamination of SARS-CoV-2 is generally low,[44] there are several factors which may increase this risk that are especially relevant in a NH setting. NHs may have very high prevalence rates during outbreaks (28.4% of environmental cultures observed in our study); mask wearing and hand hygiene may be inconsistent among NH patients with active infection; and the acuity of infections among NH patients may lead to increased viral shedding over what may be seen in the broader community.[45] For this reason, effective infection prevention and cleaning in NHs remain a priority during times of SARS-CoV-2 circulation, particularly since wearing masks for prolonged periods of time may not be feasible for this population.[46]

Our study has several limitations. While we show that the NH patient room environment is frequently contaminated with SARS-CoV-2, we do not have evidence of whether the virus detected is viable or able to be transmitted to others. Ben-Shmuel et al.[29] showed in lab-controlled conditions, SARS-CoV-2 lost its infectivity completely by day 4 at ambient temperature, though the virus likely persists much longer in the environment (Zhou et al.[47] found it in the environment 28 days after patient discharge). While transmissibility of virus from contaminated objects is still unknown, we conclude that thorough disinfection in COVID-19 units is vital. One other limitation of our study is that COVID-19 signs and symptoms were collected based on chart documentation in the two weeks following a positive COVID-19 test. Clinical documentation at each site varied. However, our rates of signs and symptoms were quite high for many patients (**Supplemental Table S2**), suggesting comprehensive charting at all four sites. Our study has several strengths. We were able to conduct in-depth environmental study in these settings in the midst of an outbreak and when research staff were not allowed access, by rapidly training and engaging our frontline clinicians. It is also one of the first studies to investigate patient-level risk factors impacting environmental contamination of SARS-CoV-2 in these settings.

Our data indicate significant environmental contamination in rooms where NH patients infected with COVID-19 are housed and cared for. NH infection control policies and procedures should consider the environment as a potential medium of transmission, with a need for strict adherence to environmental cleaning, developing technology-based environmental cleaning solutions and diligent use of PPE by frontline staff.

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Table 1. Clinical and Demographic Characteristics of the Study Population including Short- and Long-stay Patients

Characteristic	Total Population (N=104)	Short-stay patients (N=53)	Long-stay patients (N=51)	p-value
Age				
45-69	12 (11.5)	9 (17.0)	3 (5.9)	0.116[a]
70-79	28 (26.9)	17 (32.1)	11 (21.6)	
80-89	36 (34.6)	16 (30.2)	20 (39.2)	
Age >89	28 (26.9)	11 (20.8)	17 (33.3)	
Sex				
Male	34 (32.7)	21 (39.6)	13 (25.5)	0.147[a]
Female	70 (67.3)	32 (60.4)	38 (74.5)	
Race				
Non-Hispanic white	93 (89.4)	50 (94.3)	43 (84.3)	0.119[a]
Non-white or Unknown	11 (10.6)	3 (5.7)	8 (15.7)	
BIMS score, mean (SD)[b]	10.6 (4.8)	10.2 (4.8)	11.2 (4.8)	0.280[c]
Activities of Daily Living[d]				
Dependent in all 6 ADLs	29 (27.9)	8 (15.1)	21 (41.2)	0.012[a]
Independent in 1-2 ADLs	56 (53.4)	34 (64.2)	22 (43.1)	
Independent in ≥ 3 ADLs	19 (18.3)	11 (20.8)	8 (15.7)	
Charlson Comorbidity Index score, median (IQR)	2 (1 – 3.5)	2 (1 – 4)	2 (1- 3)	0.756[c]
Comorbidities				
Dementia	58 (55.8)	21 (39.6)	37 (72.6)	0.001[a]
Diabetes	42 (40.4)	24 (45.3)	18 (35.3)	0.324[a]
CHF	34 (32.7)	19 (35.9)	15 (29.4)	0.535[a]
COPD	18 (17.3)	10 (18.9)	8 (15.7)	0.797[a]
In 30D prior to study period:				
Hospitalization *N=103; 1 patient missing data*	25 (24.3)	23/52 (44.2)	2/51 (3.9)	<0.001[a]
Antibiotic Use	31 (29.8)	25 (47.2)	6 (11.8)	<0.001[a]
Antiviral Use	5 (4.8)	5 (9.4)	0 (-)	0.057[a]
Indwelling Device *N=93; 11 patients missing data*	14 (15.1)	11/42 (26.2)	3/51 (5.9)	0.008[a]
Open Wound *N=94; 10 patients missing data*	12 (12.8)	7/44 (15.9)	5/50 (10.0)	0.538[a]
Days from first positive test to enrollment, mean (SD)	6.3 (4.3)	4.2 (3.9)	8.5 (3.7)	<0.001[c]
Discharge status:				
Still resides at facility	36 (34.6)	3 (5.7)	33 (64.7)	<0.001[a]
Community	32 (30.8)	32 (60.4)	0 (-)	

Acute-care hospital	21 (20.2)	12 (22.6)	9 (17.7)	
Deceased	14 (13.5)	5 (9.4)	9 (17.7)	
Another NH	1 (1.0)	1 (1.9)	0 (-)	
Room contamination on enrollment				
SARS-CoV-2 detected ≤3 feet from patient bed	58 (55.8)	34 (64.2)	24 (47.1)	0.114[a]
SARS-CoV-2 detected > 3 feet from patient bed	65 (62.5)	32 (60.4)	33 (64.7)	0.689[a]

[a] Significance evaluated using Fisher's exact test

[b] BIMS score evaluates cognitive impairment on a scale of 0-15: 0-7 indicates severe cognitive impairment; 8-12 indicates moderate impairment; 13-15 indicates intact cognitive response. The BIMS score was not collected for 27 (26.2%) study participants (5 short-stay, 22 long-stay) due to non-verbal or severe impairment.

[c] Significance evaluated using Wilcoxon rank-sum test

[d] Activities considered to assess independence: toileting, feeding, dressing, transferring, continence, bathing

Table 2. Risk Factors for SARS-CoV-2 Contamination in Patient Room

Mixed-Effect Multivariable Logistic Regression; 104 Patients, 241 observations (average 2.3 per patient)

Risk Factor	Adjusted Odds Ratios (95% Confidence Interval)		
	Contamination Outcome		
	Proximate (within 3 feet of bed) *141 events*	Distant (at least 3 feet from bed) *150 events*	Any (any site in patient room) *192 events*
Study timeline			
Enrolled >3 days from diagnosis	0.25 (0.07, 0.86)**	0.94 (0.34, 2.63)	0.66 (0.20, 2.16)
Patient characteristics			
Age ≥ 80	0.63 (0.20, 1.95)	0.98 (0.37, 2.59)	0.58 (0.18, 1.84)
Sex (male)	0.96 (0.29, 3.16)	0.51 (0.18, 1.44)	0.31 (0.09, 1.04)*
Charlson Comorbidity score	1.59 (1.10, 2.30)**	1.25 (0.92, 1.69)	1.48 (1.02, 2.16)**
Functional Independence			
Dependent in all 6 ADLs	*reference group*	*reference group*	*reference group*
Independent in 1-2 ADLs	5.74 (1.49, 22.21)**	1.50 (0.49, 4.55)	1.58 (0.46, 5.41)
Independent in ≥ 3 ADLs	8.63 (1.45, 51.43)**	1.45 (0.35, 6.06)	2.40 (0.44, 13.00)
Disease Severity			
Required supplemental oxygen	0.94 (0.31, 2.79)	0.73 (0.28, 1.88)	0.47 (0.15, 1.40)

Abbreviations: ADLs, Activities of Daily Living

* indicates p-value < 0.10

** indicates p-value < 0.05

Figure Legends

Figure 1. SARS-CoV-2 on Swab Specimens Collected – Patient-level, Visit-level, and Swab-level

Among all patients enrolled (n=104), the percent of patients with at least one environmental surface positive for SARS-CoV-2 on at least one visit ranged from 66.7% to 92.6% across the four participating nursing home (NH) facilities. Among all visits conducted (n=241), the percent of visits with at least one environmental surface positive for SARS-CoV-2 ranged from 60.0% to 87.0% across the four NHs. Among all swab specimens collected from COVID-19 patient room surfaces (n=1896), positivity ranged from 15.3% to 42.8% across the four NHs.

Figure 2. Contamination of Environmental Surfaces at Study Enrollment

On enrollment, environmental sites proximate to the patient bed (within 3 feet) were contaminated at rates ranging from 23.1% (bed controls) to 43.6% (TV remotes). Contamination rates of distant sites (greater than 3 feet from the patient bed) on enrollment ranged 5.5% (curtains) to 38.8% (windows). SARS-CoV-2 was detected on 3 of 6 common area sites sampled, at rates ranging from 3.0% (sitting area table) to 12.1% (sitting area chair).

Figure 3. Environmental Contamination during Baseline and Follow-up Visits

Among 88 patient rooms with at least 1 follow-up visit, persistence of contamination at each environmental sampling site is assessed. In 47 rooms with TV remotes, SARS-CoV-2 was detected at any point (on enrollment and/or during follow-up) in 68.1%; the virus was detected on enrollment and during follow-up (persistently) in 34.0%. Windowsills and call buttons were sampled all 88 rooms, with the virus detected at any point in 59.1% and 58.0%, respectively.

SARS-CoV-2 was detected persistently in 33.0% of windowsills and 28.4% of call buttons. All other sites were contaminated in less than 50% of rooms and persistently so in less than 25%.

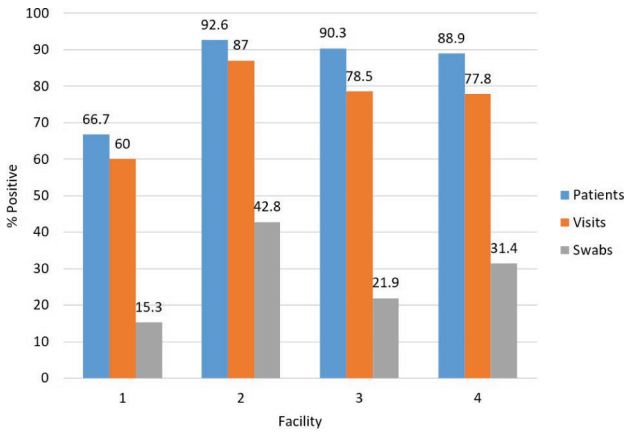
Supplemental Materials

Supplemental Table S1. Facility Characteristics and Infection Prevention and Control Policies

Supplemental Table S2. Study Population COVID-19 Signs and Symptoms, per Medical Chart Documentation.

Supplemental Figure S1. PCR Results Algorithm for CDC and Multiplex Assays. Samples with amplification for both targets (N1 and N2) with Ct value <40 were considered positive, and samples with no signal for either target were called negative. Specimens were considered positive if two of the three targets—S gene, N gene, ORF lab gene—amplified with Ct <=37.

Supplemental Figure S2. Pairwise Correlation of Environmental Contamination on Enrollment and during Follow-up. Phi Coefficient (measure of pairwise correlation) indicated in each pairwise square. N observations for each pair indicated in bottom right corner of each pairwise square. Strength of pairwise correlations indicated by colors, per figure legend.



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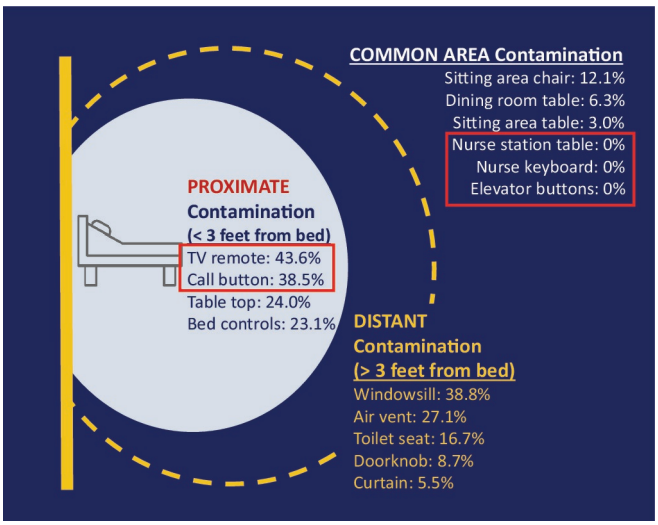

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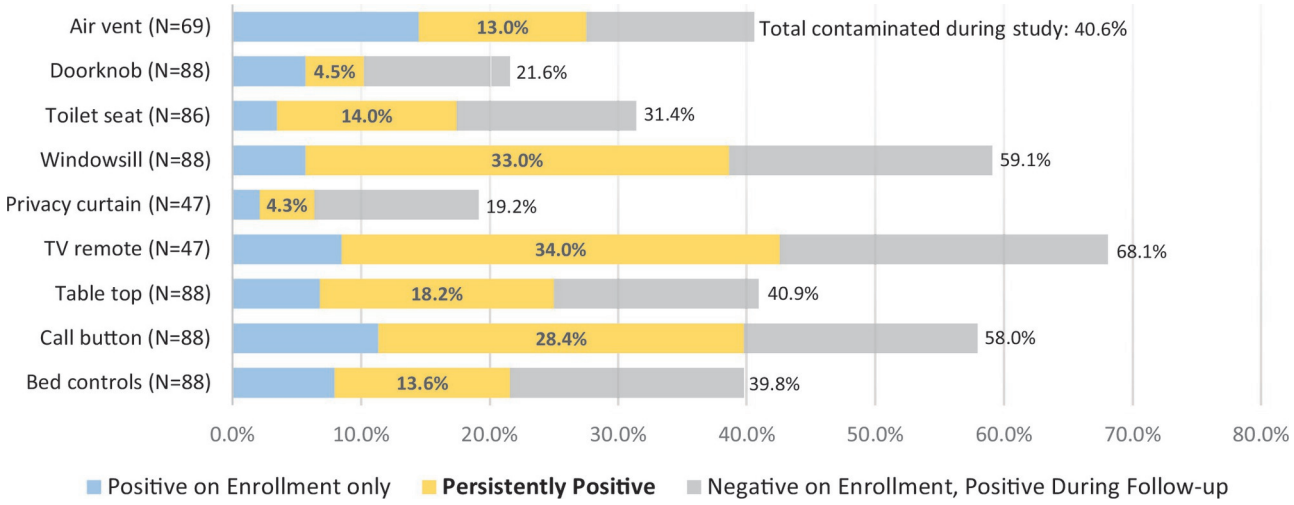

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