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Brief Report

SARS-CoV-2 RNA persists on surfaces following terminal disinfection of COVID-19 hospital isolation rooms

Helen L. Zhang MD [a,*], Brendan J. Kelly MD, MSCE [a,b], Michael Z. David MD, PhD [a,b], Ebbing Lautenbach MD, MPH, MSCE [a,b], Elizabeth Huang BS [a], Selamawit Bekele BA [a], Pam Tolomeo MPH [a], Emily Reesey MS [a], Sean Loughrey MS [b], David Pegues MD [a,c], Matthew J. Ziegler MD, MSCE [a,b,c], for the CDC Prevention Epicenters Program

[a] Division of Infectious Diseases, Department of Medicine, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA
[b] Department of Biostatistics, Epidemiology and Informatics, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA
[c] Department of Health Care Epidemiology, Infection Prevention and Control, University of Pennsylvania Health System, Philadelphia, PA

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A B S T R A C T

We evaluated the effect of terminal cleaning on SARS-CoV-2 RNA contamination of COVID-19 isolation rooms in an acute care hospital. SARS-CoV-2 RNA was detected on 32.1% of room surfaces after cleaning; the odds of contamination increased with month. The prevalence of elevated high-touch surface contamination was lower in terminally cleaned rooms than patient-occupied rooms.

While uncommon under rigorous infection control measures, nosocomial SARS-CoV-2 infection has been reported among hospitalized patients.[1,2] SARS-CoV-2 transmission occurs primarily via respiratory droplets and aerosols but may also occur secondarily via fomites, given virus stability on certain surfaces.[3] This emphasizes the importance of effective surface decontamination in health care settings. However, there are limited data on SARS-CoV-2 surface contamination following terminal cleaning and how this might serve as a measure of cleaning effectiveness. We evaluated SARS-CoV-2 RNA levels on surfaces of terminally cleaned Coronavirus Disease 2019 (COVID-19) patient rooms in an acute care hospital.

MATERIALS AND METHODS

Setting: The study was conducted September 15, 2020 through December 21, 2020 at the Hospital of the University of Pennsylvania, an 807-bed academic medical center in Philadelphia, PA. The terminal disinfection protocol for COVID-19 patient rooms is described in Supplementary Methods.

Specimen collection and processing: Surfaces were sampled using 20 cm^2 single-use templates and sterile flocked swabs (FLOQSwab, COPAN Diagnostics, Murrieta, CA) following terminal disinfection of rooms of patients with polymerase chain reaction (PCR)-confirmed SARS-CoV-2 infection. RNA extraction and quantitative real-time PCR to detect the SARS-CoV-2 N1 region were performed; as part of a parallel study, surface samples during patient occupancy were also obtained (Supplementary Methods).[4]

Statistical analysis. Data were analyzed using Stata/IC 16.1 (College Station, TX). Comparisons were performed using Fisher's exact test for categorical variables and Wilcoxon rank-sum test or Kruskall-Wallis test for continuous variables. Mixed effects binomial models with a random effect of surface type and logit link were used to evaluate the association between hospital unit and odds of contamination, and the association between month and odds of contamination. Mixed effects binomial models with random effects of surface type and room and logit link were used to evaluate the association

* Address correspondence to Helen L. Zhang, MD, 3400 Spruce St, 3 Silverstein Ste. E, Philadelphia, PA 19104, USA.
E-mail address: helen.zhang1@pennmedicine.upenn.edu (H.L. Zhang).
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Table 1
SARS-CoV-2 RNA contamination of COVID-19 patient isolation rooms following terminal cleaning.

Surface type	Elevation	Touch frequency	No. of specimens with detectable SARS-CoV-2 RNA (%)	Median (range) SARS-CoV-2 RNA viral load, copies/specimen
Bed rail	Elevated	High	4/50 (8.0%)	218.8 (40.9 – 478.6)
Computer mouse	Elevated	High	15/50 (30.0%)	117.9 (31.0 – 1,073.8)
Computer keyboard	Elevated	High	13/50 (26.0%)	62.4 (30.0 – 1,828.2)
Inner doorknob	Elevated	High	21/51 (41.2%)	92.5 (33.6 – 30,646.8)
Toilet	Elevated	High	5/51 (9.8%)	182.4 (35.8 – 303.4)
Sink	Elevated	Low	6/50 (12.0%)	1,915.3 (33.7 – 645,246.9)
Wall, near patient bed	Elevated	Low	5/50 (10.0%)	169.8 (56.5 – 695.2)
Wall, bathroom	Elevated	Low	4/50 (8.0%)	52.7 (36.0 – 342.2)
Wall, near room exit	Elevated	Low	2/50 (4.0%)	274.2 (43.8 – 504.7)
Floor, near patient bed	Floor	Low	39/50 (78.0%)	264.7 (41.4 – 123,236.9)
Floor, bathroom	Floor	Low	44/50 (88.0%)	221.5 (47.9 – 14,381.4)
Floor, near room exit	Floor	Low	35/50 (70.0%)	483.2 (35.9 – 93,755.5)

between terminal cleaning and odds of contamination in paired samples. An alpha of 0.05 was used, and two-tailed *P*-values are reported.

RESULTS

Fifty-one patient rooms in three non-intensive care units were evaluated. Forty-eight (94.1%) were sampled following and 3 (5.9%) before ultraviolet germicidal irradiation (UVGI).

SARS-CoV-2 RNA was detected on 193 per 602 (32.1%) surfaces after terminal cleaning, including 118 per 150 (78.7%) floor surfaces, 58 per 252 (23.0%) elevated high-touch surfaces, and 17 per 200 (8.5%) elevated low-touch surfaces ($P < .001$, Table 1). Among surfaces with detectable SARS-CoV-2 RNA, median (interquartile range [IQR]) viral load was 193.1 (90.0 – 612.8) copies per specimen among all surfaces, 288.1 (131.0 – 793.9) copies perr specimen among floor surfaces, 92.7 (53.9 – 182.4) copies per specimen among elevated high-touch surfaces, and 169.8 (56.4 – 504.7) copies per specimen among elevated low-touch surfaces ($P < .001$). Hospital unit was associated with odds of surface contamination ($P < .001$), with higher odds of SARS-CoV-2 RNA detection on Unit 2 (odds ratio [OR] = 2.1, 95% confidence interval [CI] 1.1 to 3.7, $P = .015$) and Unit 3 (OR = 4.1, 95% CI 2.3 to 7.3, $P < .001$) compared to Unit 1. Odds of surface contamination increased over the study period (OR = 1.8 per 1 month increase, 95% CI 1.4 to 2.2, $P < .001$).

Compared to COVID-19 rooms during patient occupancy, terminally cleaned rooms had a lower prevalence of SARS-CoV-2 RNA contamination among elevated high-touch surfaces (58/252 [23.0%] vs 272/830 [32.8%], $P = .003$) but a similar prevalence among elevated low-touch surfaces (17/200 [8.5%] vs 77/664 [11.6%], $P = .25$) and floors (118/150 [78.7%] vs 395/502 [78.7%], $P > .99$). Among contaminated surfaces, median viral load was lower in terminally cleaned rooms compared to patient-occupied rooms among elevated high-touch surfaces (median [IQR] = 92.7 [53.9 – 182.4] vs 253.6 [98.3 – 825.3] copies per specimen, $P < .001$) and floor surfaces (median [IQR] = 288.1 [131.0 – 793.9] vs 486.6 [170.6 – 1419.7] copies per specimen, $P = .021$), but this difference was not significant among elevated low-touch surfaces (median [IQR] = 169.8 [56.4 – 504.7] vs 298.6 [114.9 – 1153.2] copies per specimen, $P = .11$).

Among 12 COVID-19 patient rooms that underwent paired sampling during patient occupancy and after terminal cleaning, variable patterns of SARS-CoV-2 RNA surface contamination were observed pre- and post-terminal cleaning (Table 2). Overall, there was a trend towards decreased odds of contamination after terminal cleaning among elevated surfaces (OR = 0.4, 95% CI = 0.2 to 1.1, $P = .065$) but not floor surfaces (OR 0.9, 95% CI 0.3 to 2.3, $P = .79$).

DISCUSSION

While terminal disinfection was associated with lower SARS-CoV-2 RNA contamination of elevated high-touch surfaces compared to patient-occupied rooms, SARS-CoV-2 RNA remained detectable on a majority of floor surfaces and a substantial minority of elevated surfaces. Our findings diverge from those of two other studies, one of which reported no SARS-CoV-2 RNA detection on COVID-19 intensive care unit (ICU) room surfaces following terminal disinfection using an aldehyde-based cleaning agent and the other reporting a substantial reduction in SARS-CoV-2 RNA detection (38.9% pre-disinfection to 0%

Table 2
SARS-CoV-2 RNA surface detection in COVID-19 patient isolation rooms during patient occupancy (pre-terminal disinfection) and post-terminal disinfection.

	No. with detectable SARS-CoV-2 RNA/Total no. surfaces; median viral load of contaminated surfaces (copies/specimen)					
	High-touch elevated surfaces		Low-touch elevated surfaces		Floor surfaces	
Room	During occupancy	Post-terminal disinfection	During occupancy	Post-terminal disinfection	During occupancy	Post-terminal disinfection
1	0/5; n/a	0/5; n/a	0/4; n/a	0/4; n/a	3/3; 635.3	0/3; n/a
2	1/5; 307.3	0/5; n/a	0/4; n/a	0/4; n/a	2/3; 1,445.9	3/3; 54.6
3	1/5; 110.3	0/4; n/a	0/4; n/a	0/4; n/a	3/3; 232.5	3/3; 624.7
4	0/5; n/a	0/5; n/a	0/4; n/a	0/4; n/a	2/3; 335.0	3/3; 74.2
5	1/5; 1,319.3	0/5; n/a	0/4; n/a	0/4; n/a	1/3; 2,199.5	0/3; n/a
6	1/5; 258.9	0/5; n/a	1/4; 124.7	0/4; n/a	2/3; 453.3	2/3; 217.2
7	4/5; 88.8	3/4; 248.5	1/4; 193.3	0/4; n/a	3/3; 2,326.1	3/3; 22,126.6
8	2/5; 48.7	3/5; 75.0	1/4; 669.9	No data	3/3; 735.1	No data
9	0/5; n/a	2/5; 150.2	0/4; n/a	0/4; n/a	3/3; 237.5	3/3; 428.0
10	0/5; n/a	1/5; 92.9	2/4; 149.4	0/4; n/a	3/3; 764.5	3/3; 2,337.7
11	3/5; 57.3	0/5; n/a	1/4; 63.5	0/4; n/a	3/3; 177.2	2/3; 162.1
12	4/5; 283.6	4/5; 124.3	1/4; 48,960.9	0/4; n/a	3/3; 3,781.3	2/3; 1,002.9

to 5.6% post-disinfection) on ICU room surfaces following ultraviolet light-emitting diode irradiation and terminal cleaning.[5, 6]

SARS-CoV-2 RNA contamination of terminally cleaned rooms was noted to increase with month despite stable disinfection protocols and adequate disinfectant supply, raising the question of whether disinfection quality decreased in the setting of increased cleaning burden and worker fatigue. Alternatively, this observation could have been due to higher cumulative contamination over time. Differences in RNA detection were also observed between hospital units, possibly indicative of variable disinfection quality.

The high prevalence of SARS-CoV-2 RNA contamination on terminally cleaned floors is of uncertain significance. Recent data suggest that hospital floors serve as an underappreciated source of pathogen dissemination via footwear, portable equipment, or contact with high-touch objects.[7, 8] The role of floor decontamination in SARS-CoV-2 infection prevention warrants further investigation. Additionally, a high median viral load was observed among sinks, which are known to serve as reservoirs for other health care-associated pathogens.[9] The significance of this finding is also unclear.

This study has limitations. Paired pre-cleaning samples were only available for 12 per 51 of the rooms sampled after terminal cleaning. Additionally, the detection of SARS-CoV-2 RNA does not differentiate between viable virus and nonviable viral particles, so our findings do not provide evidence that viable virus persists on terminally cleaned surfaces or that SARS-CoV-2 transmission can occur via contact with these surfaces.

CONCLUSIONS

SARS-CoV-2 RNA contamination was highly prevalent on patient room surfaces following terminal cleaning. Further study is needed to evaluate the presence of viable virus and potential for fomite transmission.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.ajic.2022.01.014.

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