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BRIEF REPORT

Microbial Assessment of Health Care–Associated Pathogens on Various Environmental Sites in Patient Rooms After Terminal Room Disinfection

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We examined the microbial burden on hospital room environmental sites after standard (quaternary ammonium [Quat]) or enhanced disinfection (quat/ultraviolet light [UV-C], bleach, or bleach/UV-C). An enhanced terminal room disinfection reduced the microbial burden of epidemiologically important pathogens on high-touch surfaces in patient rooms, especially sites around the bed, better than standard room disinfection.

Keywords. disinfection; environment; health care–associated pathogens; microbial burden; ultraviolet light.

Hospital room environmental surfaces are often contaminated with health care–associated pathogens and multidrug-resistant organisms (MDROs) despite terminal hospital room cleaning [1]. The World Health Organization (WHO) recommends 5 moments for hand hygiene, but compliance with hand hygiene among health care personnel after touching patient surroundings is often low [2]. A patient admitted to a hospital room previously occupied by a patient colonized or infected with an MDRO has an increased risk of acquiring the pathogen [3]. Contaminated health care environments have been shown to have an important role in transmission of pathogens, and therefore thoroughness of daily and terminal cleaning/disinfection needs to be improved [4]. There is increasing evidence that no-touch technologies for decontamination of patient rooms (eg, ultraviolet light [UV-C] devices and hydrogen peroxide systems) are an effective method to enhance terminal room cleaning/disinfection, reduce MDROs on environmental surfaces, and reduce health care–associated infections [1, 5, 6].

Although there is no epidemiologic/operational definition of high-touch surfaces, efforts to improve environmental hygiene in health care facilities have been focused on these surfaces. Previous studies have described that there was no significant difference in microbial contamination in terms of aerobic colony counts on high-, medium-, and low-touch surfaces classified by the frequency of touch after terminal cleaning at a single center [7, 8]. However, the contamination levels of specific types of environmental surfaces with MDROs after terminal cleaning have yet to be elucidated fully. In this study, we investigated the microbial burden of aerobes and epidemiologically important pathogens (EIPs) on hospital room environmental sites after standard or enhanced terminal room disinfection in a large clinical study.

METHODS

Microbial data from the Benefits of Enhanced Terminal Room Disinfection Study were utilized [5]. All patient rooms were randomly assigned to standard disinfection (quaternary ammonium [Quat]) or an enhanced disinfection (quat/UV-C, bleach, or bleach/UV-C).

Environmental sampling was performed following terminal room decontamination using Rodac plates (25 cm^2/plate) from 8 of 10 hospital room sites, including patient rooms (bed rail, over-bed table, supply/medicine cart, chair, side counter, linen hamper lid, sink) and bathrooms (toilet seat, shower floor, bathroom floor) as described previously [6]. The bed rail and over-bed table were classified as high-touch sites, and all other sites sampled were classified as medium/low-touch sites based on previous study results in general medical/surgical floors [7]. Five Rodac plates (~125 cm^2) per site were sampled for aerobic counts and anaerobic counts, respectively. The number of colony-forming units (CFUs) of aerobes and 4 target EIPs, including multidrug-resistant *Acinetobacter* (MDRA), methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), and *Clostridioides difficile*, was counted. For anaerobic counts, the number of CFUs of *C. difficile* only on each Rodac plate was determined.

The number of Rodac plates with >300 CFUs of aerobes was 137 (3.7% of 3680 plates), and >300 CFUs were calculated as 300 CFUs. Five plates were unable to be interpreted because moisture on the plate made the colonies run together; these were excluded from analysis. A total of 3675 samples from 736

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environmental sites in all 92 patient rooms (21 standard rooms and 71 enhanced rooms) at 3 study hospitals were analyzed.

The CFUs of aerobes and EIPs were compared by environmental site between standard and enhanced terminal room disinfection. Using JMP 13 (Statistical Analysis System, Cary, NC, USA), statistical analyses were performed using the 2-tailed Fisher test for categorical variables and the Wilcoxon test for continuous variables. A P value ≤.05 was considered statistically significant. Linear regression was used to examine whether there was a correlation between CFUs of aerobes and EIPs.

Patient Consent Statement

The study was approved by the Duke University Health System Institutional Review Board and was registered on ClinicalTrials.gov as NCT01803100. Informed consent was obtained from study subjects.

RESULTS

Overall, the frequency of all environmental sites positive for EIP was 11.4% (84/736) in all rooms, 21.4% (36/168) in standard rooms, and 8.5% (48/568) in enhanced rooms ($P < .0001$ between standard and enhanced rooms) (Figure 1). Environmental sites, other than the toilet seat, in standard rooms were more likely to be contaminated with EIPs than in enhanced rooms (5/21 vs 2/70, $P = .0066$, for over-bed table; 7/21 vs 5/70, $P = .0051$, for bed rail; and $P > .05$ for other sites). The mean number of CFUs of EIPs per site (CFU/125 cm^2) was 2.4 in all rooms, 7.6 in standard rooms, and 0.9 in enhanced rooms ($P < .0001$ between standard and enhanced rooms) (Table 1). For each EIP pathogen, the mean number of CFUs of MDRA, VRE, MRSA, and *C. difficile* per site was 0.3, 1.3, 0.4, and 0.4 in all rooms (1.1, 4.9, 1.1, and 0.5 in standard rooms vs 0, 0.2, 0.2, and 0.4 in enhanced rooms; $P < .0001$ for MDRA, $P = .002$ for VRE, $P > .05$ for MRSA, and $P > .05$ for *C. difficile*). Any specific environmental site in standard rooms tended to have higher mean counts than in enhanced rooms ($P = .0013$ for over-bed table, $P = .0015$ for bed rail, $P = .025$ for side counter, $P < .0001$ for high-touch sites, $P = .0027$ for medium/low-touch sites, and $P < .0001$ for sites in patient rooms).

The mean number of CFUs of aerobes per site (CFU/125 cm^2) was 193.6 in all rooms, 200.8 in standard rooms, and 191.5 in enhanced rooms (Table 1). There were no statistically significant differences for mean CFUs of total aerobic counts per site between standard and enhanced rooms. There was no relationship between CFUs of aerobes and EIPs (the square of the correlation coefficient, $R^2 = .0079$).

DISCUSSION

Our microbial analysis from a large clinical disinfection study demonstrated that enhanced terminal room disinfection, including use of a UV-C device, reduced the microbial burden of health care–associated pathogens, especially MDRA and VRE, on environmental sites better than standard room disinfection. Environmental disinfection of touchable surfaces after standard terminal room cleaning using quaternary ammonium needs to be improved. Enhanced terminal room decontamination reduced the microbial burden of EIPs on high-touch surfaces in patient rooms, especially sites around the bed (ie, over-bed table, bed rail).

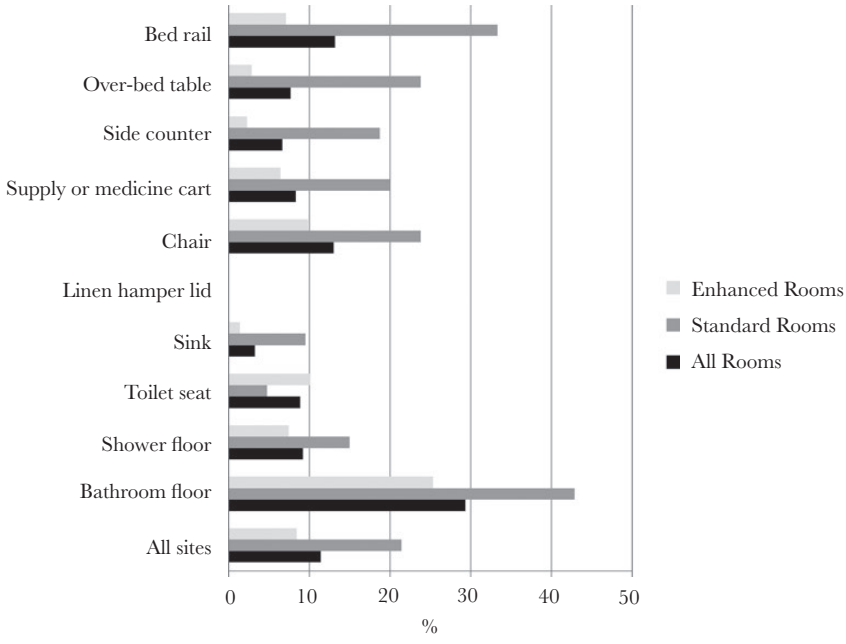

Figure 1. Frequency of environmental sites positive for epidemiologically important pathogens after terminal room disinfection.

Table 1. Microbial Burden of Epidemiologically Important Pathogens and Aerobes by Environmental Site After Standard or Enhanced Terminal Room Disinfection

	All Rooms			Standard Rooms			Enhanced Rooms			*P* Value (Standard vs Enhanced)	
Site	No. of Sites Assessed	Mean CFU/125 cm^2 of EIP (SD)	Mean CFU/125 cm^2 of Aerobes (SD)	No. of Sites Assessed	Mean CFU/125 cm^2 of EIP (SD)	Mean CFU/125 cm^2 of Aerobes (SD)	No. of Sites Assessed	Mean CFU/125 cm^2 of EIP (SD)	Mean CFU/125 cm^2 of Aerobes (SD)	Mean CFU/125 cm^2 of EIP	Mean CFU/125 cm^2 of Aerobes
Bed rail	91	3.4 (15.5)	129.4 (196.8)	21	12.8 (30.6)	142.9 (167.3)	70	0.5 (2.2)	125.3 (205.7)	.0015	NS
Over-bed table	91	0.8 (4.2)	143.2 (233.3)	21	3.2 (8.5)	101.2 (128.5)	70	0.1 (0.4)	155.8 (256)	.0013	NS
Side counter	60	0.3 (1.5)	160.6 (240.8)	16	1 (2.7)	156.3 (157.2)	44	0 (0.3)	162.2 (266.3)	.025	NS
Supply or medicine cart	36	0.2 (0.8)	94.5 (131.5)	5	0.4 (0.9)	160.4 (281.1)	31	0.2 (0.7)	83.9 (93.8)	NS	NS
Chair	92	1.1 (4.7)	162 (219.8)	21	2.4 (6.2)	155.1 (152.2)	71	0.7 (4.1)	164 (237)	NS	NS
Linen hamper lid	5	0 (0)	327.4 (506.2)	1	0	1208.0	4	0 (0)	107.3 (135.9)	NS	NS
Sink	92	0.1 (0.9)	118.5 (206.7)	21	0.4 (1.7)	82.5 (103.9)	71	0 (0.2)	129.2 (227.9)	NS	NS
Toilet seat	90	1.3 (6.9)	212.8 (284.5)	21	1.9 (8.5)	157.4 (188.4)	69	1.1 (6.3)	229.7 (307)	NS	NS
Shower floor	87	0.5 (3)	325.6 (382.4)	20	1.6 (6)	376.3 (384.8)	67	0.2 (0.7)	310.4 (383.3)	NS	NS
Bathroom floor	92	11.8 (61.4)	323.4 (375.4)	21	37.7 (125)	394 (411.2)	71	4.2 (13.4)	302.5 (364.7)	NS	NS
Sites in patient rooms	467	1.1 (7.5)	139.8 (217.7)	106	3.9 (14.9)	138.0 (182.8)	361	0.3 (2.1)	140.3 (227.2)	<.0001	NS
Sites in bathrooms	269	4.6 (36.4)	287.1 (352.8)	62	13.9 (73.9)	308.1 (353.7)	207	1.9 (8.8)	280.8 (353.1)	NS	NS
High-touch sites	182	2.1 (11.4)	136.3 (215.4)	42	8.0 (22.7)	122.0 (148.9)	140	0.3 (1.6)	140.6 (231.9)	<.0001	NS
Medium/low-touch sites	554	2.5 (25.5)	212.5 (300.6)	126	7.5 (52.1)	227.0 (296.9)	428	1.0 (6.4)	208.2 (301.9)	.0027	NS
All sites	736	2.4 (22.8)	193.6 (283.7)	168	7.6 (46.4)	200.8 (271.1)	568	0.9 (5.6)	191.5 (287.5)	<.0001	NS
All sites for MRSA	736	0.4 (5)	_	168	1.1 (9.7)	_	568	0.2 (2.1)	_	NS	_
All sites for VRE	736	1.3 (21.5)	_	168	4.9 (44.8)	_	568	0.2 (1.7)	_	.002	_
All sites for MDRA	736	0.3 (4)	_	168	1.1 (8.2)	_	568	0 (0.5)	_	<.0001	_
All sites for *Clostridioides difficile*	736	0.4 (4)	_	168	0.5 (3.7)	_	568	0.4 (4.1)	_	NS	_

Abbreviations: CFU, colony-forming units; EIP, epidemiologically important pathogen (including MRSA, VRE, MDRA, and *C. difficile*); MDRA, multidrug-resistant *Acinetobacter*; MRSA, methicillin-resistant *Staphylococcus aureus*; NS, not significant; VRE, vancomycin-resistant *Enterococcus*.

In this study, the overall microbial burden (mean ~194 CFU/125 cm^2 of aerobes) was lower compared with a previous multicenter bioburden study result (ie, mean 353 CFU/100 cm^2) [9], which could be explained in part by high compliance of cleaning/disinfection at our study hospitals, use of enhanced terminal disinfection methods, and difference in sampling methods (Rodac plates vs sponge wipes). In addition, the microbial burden was not significantly different between standard and enhanced rooms. A possible explanation is that aerobic pathogens live and reproduce in the environment and may recontaminate the surfaces after disinfection [10].

Study limitations included that a limited number of surface samples (ie, 5 Rodac plates per site assessed), inability to determine all levels of microbial growth (ie, plates with >300 CFUs), and the small sample size of a few sites (ie, supply/medicine cart, linen hamper lid) may have affected our study results in terms of aerobic counts between standard and enhanced rooms.

Any type of environmental site in our study could be contaminated with EIPs even if enhanced terminal room disinfection was conducted. Our previous study revealed that a 94% decrease in room contamination with EIPs was associated with a 35% decrease in subsequent patient colonization and/or infection [6]. With increasing scientific evidence on contamination of the health care environment and efficacy of UV-C room decontamination against health care–associated pathogens and reduction of infections [1, 5, 11], further strategies for improving daily and terminal cleaning (eg, thoroughness of cleaning, appropriate use of disinfectants), use of products with residual disinfecting activity (ie, ≥24 hours), and developing new no-touch methods (eg, continuous room decontamination technology) of disinfection on all touchable inanimate surfaces in patient rooms are needed.

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Potential conflicts of interest. Drs. Rutala and Weber are consultants to Professional Disposables International (PDI). All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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