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Comparison of disinfection using pre-soaked wipes and automatic UV-C radiation without prior cleaning

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Abstract

Background: The use of automatic UV-C disinfection devices has increased in recent years to improve cleaning performance in hospitals. Since laboratory tests allow no direct conclusions about effectiveness in a hospital, we established a field test for efficacy assessment of UV-C in comparison to manual disinfection under realistic conditions.
Methods: Frequent sampling of surfaces with close contact to high risk patients were taken before and after disinfection using swab technique to obtain representative data samples for disinfected and non-disinfected surfaces. Subsequently, the log reduction values (LRV) and the proportion of disinfection success were evaluated for UV-C radiation and full compliant manual disinfection using alcohol based wipes.
Results: Mean contamination was reduced from 23.3 to 1.98 cfu/cm² (LRV 0.9) and 29.7 to 0.26 cfu/cm² (LRV 1.2) for UV-C and manual disinfection, respectively. UV-C disinfection achieved 75.5 % successful disinfected surfaces, whereas manual disinfection showed 97.2 %.
Conclusions: Full compliant manual disinfection showed slightly greater LRV and disinfection success than automatic UV-C disinfection. In comparison to manual disinfection success in reality, operator-independent UV-C disinfection still enables the potential to improve disinfection performance in addition to manual disinfection.

Materials and Methods

Fig.1 Photo of Examination room (A) and standardized sample areas at examination chairs (B)

Examination rooms (23.60 m²) with four examination chairs were used for experiments (fig.1A). Environmental samples were taken from each examination chair at six standardized areas (fig.1B). For quantitative culture surfaces were swabbed using SRK FLOQSwabs (906C, Copan Italia, Brescia, Italy). To ensure sampling of standardized areas (100 cm²) on the left and right armrest, in the middle of the headboard and on the seat, sterile square sampling templates (Copan Italia, Brescia, Italy) were used. In the case of the patient call (71.5 cm²) and the examination chair control panel (71.2 cm²), only the front side was sampled. To determine total viable colony count (cfu/cm²) of surfaces, 200 µL of transport medium or an appropriate 10-fold dilution for untreated surfaces were plated on Columbia agar with 5 % Sheep Blood (bioMérieux, Marcy l'Etoile, France). In addition, 200 mL each were spread out on Mannitol Salt Agar (Thermo Scientific, Schwerte, Germany), Slanetz and Bartley (Thermo Scientific), MaC Conkey (Thermo Scientific) and Sabouraud-Dextrose-Agar (Thermo Scientific) culture plates. The plates were incubated for 48 h at 37 °C under aerobic conditions. Morphologically conspicuous colonies were identified using MALDI-TOF mass spectrometry and the MALDI Biotyper® database (Bruker, Bremen, Germany). Antimicrobial susceptibility testing of *Staphylococcus aureus* and *Enterococcus faecium* was performed using VITEK 2 (bioMérieux).
UV-C disinfection (UVCD) was performed using the UVD robot model C (UVD Robots, Odense, Denmark; fig.3). For UVCD process, the UVD robot (average emittance 2,500 µW/cm²) was started at the window end of the room. After finishing the required 3-min warm-up phase and the additional 20 s of disinfection at first disinfection position (fig.2, Desi1), the robot drove a straight route with seven additional stops for 50 s each (fig.2). This irradiation time was based on results of previous studies with the same UV-C robot [1, 2].
Manual disinfection (MD) was carried out with alcoholic ready-to-use disinfectant wipes (Bacillol® AF Tissues, Paul Hartmann AG, Germany), observing the exposure time of 5 min specified by the manufacturer to achieve bactericidal efficacy. Each examination chair was disinfected using four wipes. The first for the armrests, the second and third for the headboard and seat, respectively, and the last for the control panel and the patient call button.
In each experiment (UVCD: n=6, MD: n=3), two examination chairs were sampled before and two after the disinfection procedure per room. The effectiveness of the disinfection was assessed using two different evaluation criteria, the total colony counts and the detection of relevant pathogens. Successful disinfection was defined as total colony count of <1 cfu/cm² and lack of potential pathogens. Subsequently, logarithmic reduction values (LRVs) were calculated by subtracting the $\log_{10}$ value of mean total colony count per room and position before and after disinfection. If the calculated mean value per cm² was less than 1, $\log_{10}$ of 1 was used to calculate LRVs, analogues to DIN EN 17272:2020. Finally, the LRVs of UVCD and MD were compared. Therefore, pairwise comparison using *t*-test was performed with statistical software R (version 4.2.2) and R studio (version 2022.12.0) and activated package *rstatix*. As described in DIN EN 14885:2023, differences were defined as significant if *P*-value was less than 0.05.

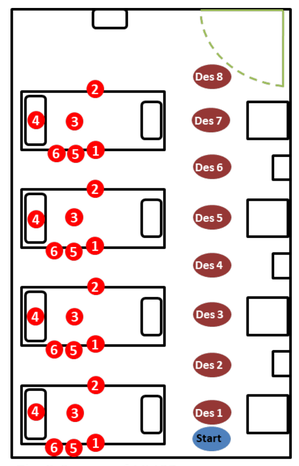

Fig.2 Setup of UVCD process

Fig.3 UVD robot model C; UVD Robots, Odense, Denmark

Results

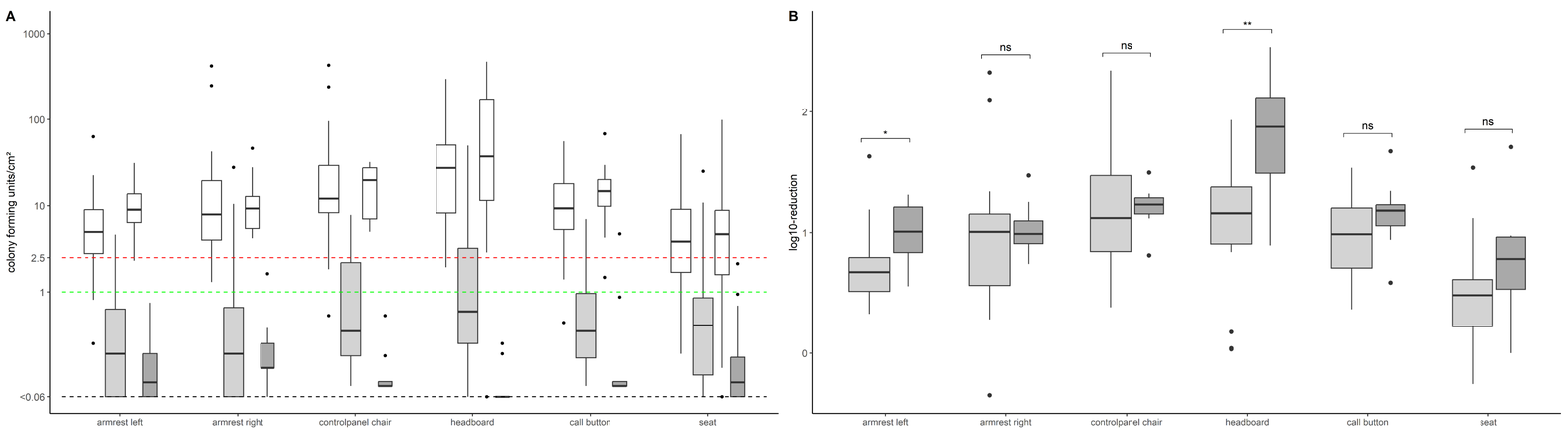

Fig.4 Colony counts before and post UVCD and MD (**A**) and log reduction values (**B**). White boxplots represent colony-forming units (cfu)/cm² (**A**) before UVCD and MD per position. Light grey and grey filled boxplots display cfu/cm² post UVCD and MD, respectively. The width of boxplots depends on the number of values (UVCD n=36, MD n=18). Detection limit, limit for successful disinfection and limit for insufficient disinfection are represented by black, green and red dashed lines. Log reduction values (**B**) of UVCD are displayed by light grey and MD by grey filled boxplots. Results of the *t*-test comparisons per position are represented by significances above brackets (ns = not significant, * $P < 0.05$, ** $P < 0.01$).

Table 1 Evaluation of successful disinfection

Disinfection	Disinfection success	Proportion	Percentage
UVCD	successful disinfection (≤ 1 cfu/cm² and no HAI pathogen)	163/216	75.5 %
	acceptable residual contamination (> 1 – 2.5 cfu/cm² and no HAI pathogen)	17/216	7.9 %
	insufficient disinfection (> 2.5 KBE/cm² and/or HAI pathogen)	36/216	16.6 %
MD	successful disinfection (≤ 1 cfu/cm² and no HAI pathogen)	104/106	98.1 %
	acceptable residual contamination (> 1 – 2.5 cfu/cm² and no HAI pathogen)	1/106	0.9 %
	insufficient disinfection (> 2.5 KBE/cm² and/or HAI pathogen)	1/106	0.9 %

Table 2 Detection of *Staphylococcus aureus* and *Enterococcus faecium* before and post disinfection

	E. faecium	VRE	*S. aureus*	MRSA
before UVCD	5/216	0/5	18/216	7/18
before MD	6/106	4/6	14/106	0/14
after UVCD	1/216	0/1	2/216	1/2
after MD	0/106	0/0	0/106	0/0

Conclusion

- Full compliant manual disinfection showed slightly higher LRVs and disinfection success than automatic UV-C disinfection in a field test setting
- Despite the use of UV-C doses effective in laboratory experiments, no complete inactivation of relevant pathogens could be achieved in the field test.
- The mechanical removal of contamination is an essential contribution to the success of disinfection.
- Successful, operator-independent UV-C disinfection still has the potential to improve disinfection performance in addition to manual disinfection.

Literature

1. Knobling B, Franke G, Belmar Campos C, Büttner H, Christner M, Klupp EM, Maurer PM, Knobloch JK. Tolerance of clinical vancomycin-resistant *Enterococcus faecium* isolates against UV-C light from a mobile source. Antimicrob Resist Infect Control 2023;12(1):63.
2. Knobling B, Franke G, Carlsen L, Belmar Campos C, Büttner H, Klupp EM, Maurer PM, Knobloch JK. Phenotypic variation in clinical *S. aureus* isolates did not affect disinfection efficacy using short-term UV-C radiation. Microorganisms 2023;11:1332.