Infection Control & Hospital Epidemiology (2024), **45**, 390–392
doi:10.1017/ice.2023.194

SHEA

Concise Communication

Inactivation and/or physical removal of *Candida auris* from floors by detergent cleaner, disinfectants, microfiber, and ultraviolet C light (UV-C)

William A. Rutala PhD, MPH[1,2], Austin C. Bolomey BS[3], Jennifer L. Cadnum BS[3] and Curtis J. Donskey MD[4,5]

[1]Statewide Program for Infection Control and Epidemiology, University of North Carolina School (UNC) of Medicine, Chapel Hill, North Carolina, [2]Division of Infectious Diseases, UNC School of Medicine, Chapel Hill, North Carolina, [3]Research Service, Louis Stokes Cleveland VA Medical Center, Cleveland, Ohio, [4]Geriatric Research, Education and Clinical Center, Louis Stokes Cleveland Veterans' Affairs Medical Center, Cleveland, Ohio and [5]Department of Medicine, Case Western Reserve University School of Medicine, Cleveland, Ohio

Abstract

Contaminated surfaces may be a source of transmission for the globally emerging pathogen, *Candida auris*. Because floors may be a source of *C. auris* contamination on hands, strategies for inactivating or removing *C. auris* from floors were investigated. A sporicidal disinfectant and UV-C were most effective in inactivating *C. auris* on floors.

(Received 28 May 2023; accepted 25 July 2023; electronically published 2 October 2023)

Candida auris is an emerging multidrug-resistant fungus that can cause invasive disease in critically ill patients with a mortality rate as high as 30%–60%.[1] Increasing numbers of infections have been identified since it was first identified in Japan in 2009. In the United States, *C. auris* was made nationally notifiable in 2018. Between 2016 and the present, there has been a steady increase in the number of cases in the United States (53 cases in 2016 and 1,471 cases in 2021) as well as the number of states and countries reporting clinical cases of *C. auris*. Currently, *C. auris* has been divided into 5 geographical clades.[1]

C. auris presents a serious global health threat for several reasons to include the following: causes serious infections with high mortality; antifungal treatment options are limited; increasing prevalence; biofilm formation; has caused multiple outbreaks in healthcare facilities; persists on environment surfaces for days to weeks; a person can be colonized (or infected) with *C. auris* and shed it into the environment; *C. auris* can be spread from person-to-person directly via touch or secondarily through contact with contaminated surfaces and medical equipment; and *C. auris* is not rapidly inactivated by some commonly used disinfectants (eg, quaternary ammonium compounds diluted in water).[1–3] Patients with comorbidities, patients with immunosuppressive conditions, and patients on ventilators are more likely to develop *C. auris* infection.[1]

Floors are contaminated with *Candida* spp,[4] and there is indirect evidence supporting the potential for transfer of pathogens from floors to patients.[5] Deshpande et al[6] showed that surfaces such as blood-pressure cuffs and call buttons were often in contact with the floor and in contact with those objects frequently resulted in transfer of pathogens to hands. One potential intervention to address floor contamination is the use of ultraviolet-C light (UV-C) and disinfectants with or without microfiber because microfiber may be more effective in removing microorganisms from environmental surfaces.[7] This study was undertaken using current floor cleaning and disinfection methods to assess whether these strategies minimize the environmental spread of *C. auris*.

Author for correspondence: William A. Rutala, PhD, MPH, CIC, Division of Infectious Diseases, UNC School of Medicine, Bioinformatics Building, CB#7030, 130 Mason Farm Road, Chapel Hill, NC 27514-7030. Email: brutala@med.unc.edu

Cite this article: Rutala WA, Bolomey AC, Cadnum JL, Donskey CJ. Inactivation and/or physical removal of *Candida auris* from floors by detergent cleaner, disinfectants, microfiber, and ultraviolet C light (UV-C). *Infect Control Hosp Epidemiol* 2024. 45: 390–392, doi: 10.1017/ice.2023.194

Methods

Disinfectants and C. auris *clade used in this study*

We investigated the efficacy of different cleaning and disinfection methods against *C. auris*. We evaluated 1 detergent cleaner (Prominence Heavy Duty Floor Cleaner, Diversey, Charlotte, NC) and 2 disinfectants. We evaluated 1 disinfectant with nonsporicidal claims [Virex II 256 One Step Disinfectant Cleaner (a quaternary ammonium compound), Diversey] and 1 disinfectant with a sporicidal claim [Spore Defense, Clorox, CA (0.25% sodium hypochlorite)]. The Virex II 256 did not have a *Clostridioides difficile* spore claim or a *C. auris* claim, whereas the Spore Defense had a 5-minute *C. difficile* spore claim and a 3-minute *C. auris* claim. *C. auris* (CDC AR no. 0385, clade 4) was obtained from the CDC Antibiotic Resistance Isolate Bank.

Test-surface inoculation and disinfection

We inoculated three 30×30-cm (12×12-inch) floor tiles with 10^5 to 10^6 colony-forming units (CFU) of *C. auris* in phosphate-buffered saline with 5% fetal calf serum. The 100 µL inoculum was spread to cover an entire tile using an L-shaped plastic spreader. To compare the microfiber (Hygen, Rubbermaid) and cotton mop (VanDuck 100% Cotton Mop Pads), the microfiber and cotton-mop pads were immersed in the test product (ie, water, detergent,

Table 1. Inactivation and/or Removal of *C. auris* From Floors by UV-C and Microfiber or Cloth Mops With Water, Detergent

Variable	Type of Mop	Log Reduction on Tile 1 (SEM)	Transfer to Tile 2 (SEM)	Transfer to Tile 3 (SEM)
Prominence detergent	Microfiber	3.69 ± 0.15	0.00 ± 0.00	0.16 ± 0.00
	Cotton	3.69 ± 0.16	0.50 ± 0.33	0.00 ± 0.00
Virex II 256	Microfiber	3.26 ± 0.28	0.16 ± 0.16	0.26 ± 0.14
	Cotton	3.69 ± 0.18	0.00 ± 0.00	0.00 ± 0.00
Spore Defense	Microfiber	>3.85 ± 0.00 (ND)	0.00 ± 0.00	0.00 ± 0.00
	Cotton	3.69 ± 0.20	0.00 ± 0.00	0.00 ± 0.00
Water	Microfiber	3.51 ± 0.33	0.34 ± 0.22	0.09 ± 0.09
	Cotton	2.45 ± 0.74	0.50 ± 0.33	1.00 ± 0.33
UV	N/A	>3.85 ± 0.00 (ND)	N/A	N/A

Note. SEM, standard error of the mean; N/A, not applicable; ND, none detected.

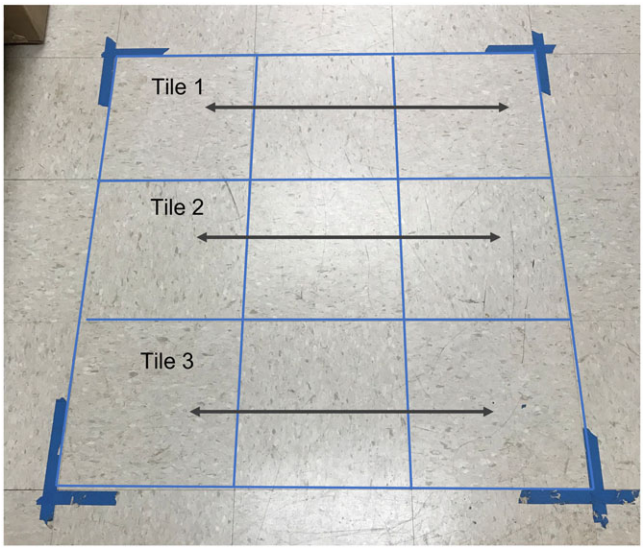

Figure 1. Picture of 30×30-cm (12×12-inch) floor tiles used for inoculation with *Candida auris* and wiping with microfiber and cotton cloth mops. Three 30×30-cm (12×12-inch) tiles were inoculated (shown as 1–3) and wiped from left to right and back 3 times.

disinfectant), and the excess fluid was wrung out. The tiles were wiped 3 times (from left to right and back) first covering the *C. auris* inoculated tiles and then the 2 adjacent tiles (Fig. 1). The purpose of wiping the 2 adjacent tiles was to assess the potential for transfer of *C. auris* to uninoculated tiles. Each of the tile surfaces were sampled using rayon swabs (BBL CultureSwabs; Becton, Dickinson, and Company, Franklin Lakes, NJ) premoistened with Dey-Engley neutralizer. The swabs were spun in a vortexer in 200 µL PBS with 0.5% polysorbate 80. Dilutions were plated on Sabouraud dextrose agar, and the plates were incubated for 72 hours at 37°C. The experiments were repeated 3 times. The recovery of *C. auris* from control (ie, untreated) tiles was ~4-log.

For UV-C light treatment (UVDI, Santa Clarita, CA), a 10-minute exposure was used with the device positioned 91cm (3 feet) from and perpendicular to the inoculated tile.

Results

The sporicidal disinfectant with microfiber and UV-C reduced *C. auris* on the floor to undetectable levels (Table 1) and did not allow transfer to adjacent tiles. Microfiber with water, detergent and the 2 disinfectants reduced *C. auris* by >3-$\log_{10}$ or 99.9% on tile 1. Cotton mop pads with the 2 disinfectants and the detergent reduced *C. auris* by >3-$\log_{10}$ on tile 1, but cotton mop pads with water did not. Microfiber and/or cotton mops transferred *C. auris* to uninoculated tiles when used with water, the detergent, and the quaternary ammonium compound, but no transfer to uninoculated tiles occurred with the sporicidal disinfectant.

Discussion

C. auris is inactivated by many disinfectants, but it is not rapidly inactivated by a commonly used floor disinfectant (ie, a quaternary ammonium compound diluted in water).[2,3] Because floors may be a source of pathogen contamination on hands,[6] and quaternary-ammonium compounds are not rapidly effective against *C. auris*, we investigated other strategies for inactivating or removing *C. auris* on floors.

Our data suggest that the most effective method to eliminate *C. auris* from floors is UV-C and a sporicidal disinfectant. Sporicidal disinfectants have been shown to inactivate *C. auris* and provide an option to eliminate *C. auris* from floors.[2,3] Another possible option, which was not tested, is nonsporicidal disinfectants that are registered against *C. auris* (ie, List P).[8]

Water, detergent, and a nonsporicidal disinfectant (with no *C. auris* claim) cross-contaminated uncontaminated surfaces from an inoculated tile. This procedure demonstrated that when *C. auris* was not inactivated by the floor "treatment" procedure, the mop (cotton or microfiber) will physically move the *C. auris* from a contaminated to clean surface because *C. auris* remained viable and the potential for hand contamination was not eliminated.[2,3,9]

A 10-minute UV-C exposure was very effective in eliminating *C auris* on the floor. In an earlier publication, longer UV-C treatment cycles (eg, 20 minutes) were necessary to achieve a 3 $\log_{10}$ reduction in *C. auris* at 152.4 cm (5 feet).[10] In the current study, the UV-C device was in closer proximity to the inoculated tiles (91 cm) and the inoculum was less concentrated because it was spread over an entire tile versus a 10–40-mm–diameter steel disk.[10]

Our study had several limitations. Only one detergent, quaternary ammonium disinfectant, and sporicidal disinfectant were tested, and only 3 repetitions were performed. Although the microfiber mop with Virex II transferred *C. auris*, no transfer was detected with the cotton mop and Virex II. Therefore, we cannot exclude the possibility that cotton mop with Virex II would be as effective as the cotton mop with Spore Defense. Evaluations of UV-

https://doi.org/10.1017/ice.2023.194 Published online by Cambridge University Press

C in clinical settings are needed because it is not known whether the laboratory results for UV-C are applicable to real-world settings. Finally, the detergent Prominence may contain octyl phenol ethoxylate, which could have some antimicrobial activity.

In summary, several publications have offered indirect evidence that contaminated floors may contribute to transmission of pathogens.[5,6] Although additional evidence may be required before substantial interventions in cleaning and disinfection are justified,[5] prudent practices to minimize transmission of *C. auris* from floors in endemic or epidemic settings include the use of disinfectants [US EPA List P (*C. auris* claim) and List K (sporicidal)] and technologies (eg, UV-C) known to be effective in killing *C. auris*.

Acknowledgments.

Financial support. No financial support was provided relevant to this article.

Competing interests. Dr. Rutala is a consultant to PDI and Kinnos. Dr. Donskey has received research grants from Clorox, Pfizer, and EcoLab.

References

1. Weber DJ, Rutala WA, Sickbert-Bennett EE. Emerging infectious diseases, focus on infection prevention, environmental survival and germicide susceptibility: SARS-CoV-2, Mpox, and *Candida auris*. *Am J Infect Control* 2019;47S:A29–A38.
2. Rutala WA, Kanamori K, Gergen MF, Sickbert-Bennett EE, Weber DJ. Susceptibility of *Candida auris* and *Candida albicans* to 21 germicides used in healthcare facilities. *Infect Control Hosp Epidemiol* 2019;40: 380–382.
3. Cadnum JL, Shaikh AA, Piedrahita CT, *et al.* Effectiveness of disinfectants against *Candida auris* and other *Candida* species. *Infect Control Hosp Epidemiol* 2017;38:1240–1243.
4. Kumar J, Eilertson B, Cadnum JL, *et al.* Environmental contamination with *Candida* species in multiple hospitals including a tertiary-care hospital with a *Candida auris* outbreak. *Pathog Immun* 2019;4:260–270.
5. Donskey CJ. Update on potential interventions to reduce the risk for transmission of healthcare associated pathogens from floors and sinks. *Am J Infect Control*. In press.
6. Deshpande A, Cadnum JL, Fertelli D, *et al.* Are hospital floors an underappreciated reservoir for transmission of healthcare-associated pathogens? *Am J Infect Control* 2017;45:336–338.
7. Rutala WA, Gergen MF, Weber DJ. Microbiologic evaluation of microfiber mops for surface disinfection. *Am J Infect Control* 2007;35:569–573.
8. List P: antimicrobial products registered with EPA for claims against *Candida auris*. Environmental Protection Agency website. https://www.epa.gov/pesticide-registration/list-p-antimicrobial-products-registered-epa-claims-against-candida-auris. Accessed September 13, 2023.
9. Cadnum JL, Hurless KN, Kundrapu S, Donskey CJ. Transfer of *Clostridium difficile* spores by nonsporicidal wipes and improperly used hypochlorite wipes: practice + product = perfection. *Infect Control Hosp Epidemiol* 2013;34:441–442.
10. Cadnum JL, Shaikh AA, Piedrahita CT, Jencson AL, Larkin EL, Ghannoum MA, Donskey CJ. Relative resistance of the emerging fungal pathogen *Candida auris* and other *Candida* species to killing by ultraviolet light. *Infect Control Hosp Epidemiol* 2018;39:94–96.

https://doi.org/10.1017/ice.2023.194 Published online by Cambridge University Press