Infection Control & Hospital Epidemiology (2019), **40**, 380–382
doi:10.1017/ice.2019.1

SHEA
The Society for Healthcare Epidemiology of America

Research Brief

Susceptibility of *Candida auris* and *Candida albicans* to 21 germicides used in healthcare facilities

William A. Rutala PhD, MPH[1], Hajime Kanamori MD, PhD, MPH[1,2,3], Maria F. Gergen MT (ASCP)[2], Emily E. Sickbert-Bennett PhD[1,2] and David J. Weber MD, MPH[1,2]

[1]Division of Infectious Diseases, University of North Carolina School of Medicine, Chapel Hill, North Carolina, United States, [2]Department of Hospital Epidemiology, University of North Carolina Health Care, Chapel Hill, North Carolina, United States and [3]Department of Infection Control and Laboratory Diagnostics, Internal Medicine, Tohoku University Graduate School of Medicine, Sendai, Japan

(Received 26 July 2018; accepted 6 October 2018)

Candida auris is an emerging fungal pathogen that is often resistant to major classes of antifungal drugs. It is considered a serious global health threat because it can cause severe infections with frequent mortality in more than a dozen countries. It can survive on healthcare environmental surfaces for at least 7 days and can cause outbreaks in healthcare facilities. Clearly, infection prevention strategies, such as surface disinfection, will be essential to controlling *Candida* transmission. Unfortunately, data on the activity of antiseptics and disinfectants used in healthcare to inactivate this pathogen are limited.[1–5] In this study, we investigated 12 different disinfectants (ie, 8 low- and intermediate-level disinfectants in 2 dilutions of sodium hypochlorite and 5 high-level disinfectants/chemical sterilants) and 9 antiseptics commonly used in healthcare facilities for their antimicrobial activity against *C. auris* and *C. albicans*.

We used the disc-based quantitative carrier testing to evaluate the germicidal activity of multiple antiseptics and disinfectants against the emerging pathogen *C. auris*.[6,7] We considered the carrier test to mimic disinfectant application on an inanimate surface in a clinical environment better than a suspension test commonly reported by manufacturers and the published literature. The *C. auris* isolate used was Antibiotic Resistance Bank no. 0385 from the Centers for Disease Control and Prevention. Based on tentative minimum inhibitory concentration (MIC) breakpoints,[8] this isolate was resistant to fluconazole and was susceptible to anidulafungin, micafungin, caspofungin, and amphotericin B. To determine whether *C. auris* susceptibility to germicides was similar to that of other *Candida* species, we also tested *C. albicans* (ATCC strain no. 60193). In brief, 10 µL inoculum containing ~10^4 with 5% fetal calf serum of *C. auris* or *C. albicans* was placed onto each stainless steel disc (1 cm diameter) and dried in a vacuum desiccator for 2 hours. After drying, each carrier was placed in a plastic vial with the inoculated side up. The dried inoculum was entirely covered by 50 µL of the test germicide for 1 minute at room temperature (~20°C), Then 9.95 mL eluent with neutralizer (Dey/Engley neutralizing broth) was added into each carrier holder to dilute and neutralize the germicide. Serial dilutions of the eluates were filtered to evaluate the fungal viability and to achieve countable numbers. The membrane filters of appropriate serial dilutions were placed on sheep blood agar plates and incubated for 24–48 hours at 37°C, and the fungal were then counted. We performed 3 replicates for each organism and germicide. Also, 3 carrier controls were prepared during each experiment in the manner described above but without germicide exposure. Compared to mean carrier control counts, the $\log_{10}$ reduction of the test organism for each germicide was calculated.[9]

The efficacy of germicides with active ingredient, product name, manufacturer, and classification against *C. auris* and *C. albicans* are provided in Table 1. Under the challenging test conditions (ie, 5% FCS and 1 minute exposure time), 12 of 22 tested disinfectants and antiseptics (55%) demonstrated at least a 3-$\log_{10}$ reduction, and 16 (73%) demonstrated at least a 2-$\log_{10}$ reduction for *C. auris*. Also, 14 of these 22 (64%) demonstrated at least a 3-$\log_{10}$ reduction, and 17 (77%) demonstrated at least a 2-$\log_{10}$ reduction for *C. albicans*. Of the 9 antiseptics, 7 (78%) did not demonstrate a 3-$\log_{10}$ reduction against *C. auris*; these included 10% povidone-iodine, 0.5% triclosan, 1% chloroxylenol, 1% chlorhexidine gluconate (CHG) with 61% ethyl alcohol, 2% CHG, 4% CHG, and 3% hydrogen peroxide. Of 13 tested disinfectants (low-level disinfectants and high-level disinfectants), 10 (77%) demonstrated at least a 3-$\log_{10}$ reduction at 1 minute, with 3 exceptions: (1) a 1:50 dilution of 5.25% sodium hypochlorite (~1,245 ppm chlorine; Chlorine Test Kit, Model CN-21P, Hach, Loveland, CO); (2) a diluted, water-based quaternary ammonium compound (QAC); and (3) a 0.55% ortho-phthalaldehyde. In general, the $\log_{10}$ reductions for *C. auris* and *C. albicans* were similar: 12 of 13 (92%) within a 1 $\log_{10}$ difference) for the 13 tested disinfectants. But 4 of 9 (44%) of the antiseptics had a >1 $\log_{10}$ difference in susceptibility.

There is no standard level of germicidal efficacy for environmental surfaces, but most of the disinfectants tested that demonstrated at least a 3-$\log_{10}$ reduction are likely to be clinically effective against *C. auris* when used appropriately. Some of the Environmental Protection Agency (EPA)–registered disinfectants used in this study have an EPA registration claim longer than the 1 minute used in this study. All of the FDA-cleared high-level disinfectants have a

Author for correspondence: William A. Rutala, Email: brutala@med.unc.edu

PREVIOUS PRESENTATION. This work was presented in part as a poster (no. 483) at IDWeek 2017 on October 5, 2017, in San Diego, California.

Cite this article: Rutala WA, *et al*. (2019). Susceptibility of *Candida auris* and *Candida albicans* to 21 germicides used in healthcare facilities. *Infection Control & Hospital Epidemiology*, 40: 380–382, https://doi.org/10.1017/ice.2019.1

Table 1. Germicidal Activity Against *Candida auris* and *Candida albicans* Using a Quantitative Carrier Test Method

Germicide name	Manufacturer, Location	Active Ingredient	Formulation Tested	Classification	*C. auris*[a]	*C. albicans*[a]
Purell Advanced instant hand sanitizer	GOJO, Akron, OH	70% ethanol	Undiluted	Antiseptic	4.0	2.5
Betadine solution	Purdue Products, Stamford, CT	10% povidone–iodine/1% iodine	Undiluted	Antiseptic	2.5	2.3
Medicated Soft 'N Sure	Steris, St. Louis, MO	0.5% triclosan	Undiluted	Antiseptic/Handwash	1.4	1.7
Soft Care Defend	Diversey, Charlotte, NC	1% chloroxylenol	Undiluted	Antiseptic/Handwash	2.8	3.9
Avagard	3M, St Paul, MN	1% chlorhexidine gluconate solution, 61% ethyl alcohol	Undiluted	Antiseptic/Surgical hand scrub	2.0	1.9
Scrub-Stat 2%	Ecolab, St Paul, MN	2% chlorhexidine gluconate solution	Undiluted	Antiseptic/Surgical hand scrub/handwash	1.6	2.8
Scrub-Stat 4%	Ecolab, St Paul, MN	4% chlorhexidine gluconate solution	Undiluted	Antiseptic/Surgical hand scrub/handwash	1.9	3.5
Isopropyl rubbing alcohol 70% USP	Medichoice, Mechanicsville, VA	70% isopropyl alcohol	Undiluted	Antiseptic/Disinfectant	3.8	4.1
Solution of hydrogen peroxide 3% USP	Medichoice, Mechanicsville, VA	3% hydrogen peroxide	Undiluted	Antiseptic	1.4	1.8
Austin's A-1 bleach 1:10	James Austin Co, Mars, PA	5.25% sodium hypochlorite (~6,100–6,700 ppm)	1:10 dilution	Disinfectant	4.1	4.0
Austin's A-1 bleach 1:50	James Austin Co, Mars, PA	5.25% sodium hypochlorite (~1,245 ppm)	1:50 dilution	Disinfectant	1.6	1.5
Vesphene IIse	Steris, St Louis, MO	9.09% o-phenylphenol, 7.66% p-tertiary amylphenol	1:128 dilution	Disinfectant	4.1	3.6
Hydrogen peroxide cleaner disinfectant	Clorox, Oakland, CA	1.4% hydrogen peroxide	Undiluted	Disinfectant	4.1	4.1
Lysol disinfectant spray	Reckitt Benckiser, Parsippany, NJ	58% ethanol, 0.1% QAC[b]	Undiluted	Disinfectant	3.8	4.1
A-456 II disinfectant cleaner	Ecolab, St Paul, MN	21.7% QAC[c]	1:256 dilution	Disinfectant	1.7	1.5
Super Sani-Cloth wipe	PDI, Orangeburg, NY	55% isopropyl alcohol, 0.5% QAC[d]	Undiluted[f]	Disinfectant	3.9	4.1
Prime Sani-Cloth wipe	PDI, Orangeburg, NY	28.7% isopropyl alcohol, 27.3% ethyl alcohol, 0.61% QAC[e]	Undiluted[f]	Disinfectant	4.1	4.1
S40 sterilant concentrate S4000	Steris, Mentor, OH	35% peracetic acid	0.20%	High-level disinfectant/ Chemical sterilant	4.1	4.1
Cidex-OPA	Advanced Steril Prod, Irvine, CA	0.55% ortho-phthalaldehyde	Undiluted	High-level disinfectant	2.3	3.8
Cidex	Advanced Steril Prod, Irvine, CA	2.4% glutaraldehyde	Undiluted	High-level disinfectant/ Chemical sterilant	4.1	4.1
Oxycide	Ecolab, St Paul, MN	27.5% hydrogen peroxide, 5.8% peroxyacetic acid	1:43 dilution	High-level disinfectant/ Chemical sterilant	4.1	4.1
Revital-Ox Resert	Steris, Mentor, OH	2% accelerated hydrogen peroxide	Undiluted	High-level disinfectant	4.1	4.1

Note. QAC, quaternary ammonium compound.
[a]Values are shown in mean $\log_{10}$ reductions under a test condition of 10^4 test organisms with 5% fetal calf serum and 1 minute contact time.
[b]QAC: alkyl (C_{14} 50%, C_{12} 40%, C_{16} 10%) dimethyl benzyl ammonium saccharinate 0.1%.
[c]QAC: octyl decyl dimethyl ammonium chloride 6.51%; dioctyl dimethyl ammonium chloride 2.604%; didecyl dimethyl ammonium chlorid 3.906%; alkyl (50% C_{14}, 40% C_{12}, 10% C_{16}) dimethyl benzyl ammonium chloride 8.68%
[d]QAC: n-alkyl (C_{12} 68%, C_{14} 32%) dimethyl ethylbenzyl ammonium chlorides 0.25%; n-Alkyl (C_{14} 60%, C_{16} 30%, C_{12} 5%, C_{18} 5%) dimethyl benzyl ammonium chlorides 0.25%.
[e]QAC: didecyl dimethyl ammonium chloride 0.61%.
[f]Extract from cloth.

registration claim >1 minute (eg, 8–45 minutes). In summary, with the exception of a water-based QAC and a 1:50 dilution of sodium hypochlorite, our data demonstrate that most disinfectants (10 of 13, 77%) used in healthcare facilities are effective (>3-$\log_{10}$ reduction) against *C. auris*. Importantly, water-based QACs, which are commonly used for surface disinfectants, had limited activity and therefore should not be used for disinfection of environmental surfaces or noncritical patient equipment in rooms housing patients with *C. auris*.[10] In contrast, 7 of 9 antiseptics (78%) did not achieve a 3-$\log_{10}$ reduction of *C. auris* in 1 minute.

Because *C. auris* can persist on surfaces in healthcare environments, cleaning and disinfecting the patient care environment (daily and discharge/terminal cleaning) with effective products is essential. The CDC has recommended the use of EPA-registered

hospital-grade disinfectants effective against *Clostridium difficile* spores (primarily chlorine-based products).[8] Our data demonstrate that several other commonly used surface disinfectants (ie, a phenolic, 1.4% improved hydrogen peroxide, and alcohol-quaternary ammonium compounds) are as effective against *C. auris* as chlorine-based products. Other infection prevention strategies to minimize the contribution of the environment to *C. auris* transmission are "no-touch" room decontamination technologies[10] and improved thoroughness of cleaning/disinfecting environmental surfaces using thoroughness indicators (eg, fluorescent markers). Further studies are needed to evaluate other test surfaces (eg, polymer) and to identify infection prevention strategies that prevent contaminated surfaces from being a source of acquisition by patients of this globally emerging pathogen.

Acknowledgements. None.

Financial support. This study was supported by UNC Health Care.

Conflicts of interest. Dr Rutala is a consultant for PDI and Advanced Sterilization Products. Dr Weber is a consultant for PDI. The other authors report no conflicts of interest relevant to this article.

References

1. Vallabhaneni S, Kallen A, Tsay S, *et al.* Investigation of the first seven reported cases of *Candida auris*, a globally emerging invasive, multidrug-resistant fungus—United States, May 2013–August 2016. *Morb Mortal Wkly Rep* 2016;65:1234–1237.
2. Schelenz S, Hagen F, Rhodes JL, *et al.* First hospital outbreak of the globally emerging *Candida auris* in a European hospital. *Antimicrob Resist Infect Control* 2016;5:35.
3. Biswal M, Rudramurthy SM, Jain N, *et al.* Controlling a possible outbreak of *Candida auris* infection: lessons learnt from multiple interventions. *J Hosp Infect* 2017;97:363–370.
4. Cadnum JC, Shaikh AA, Piedrahita CT, *et al.* Effectiveness of disinfectants against *Candida auris* and other *Candida* species. *Infect Control Hosp Epidemiol* 2017;38:1240–3.
5. Piedrahita CT, Cadnum JC, Jencson AL, Shaikh AA, Ghannoum MA, Donskey CJ. Environmental surfaces in healthcare facilities are a potential source for transmission of *Candida auris* and other *Candida* species. *Infect Control Hosp Epidemiol* 2017;38:1107–1109.
6. Sattar SA, Springthorpe VS, Adegbunrin O, Zafer AA, Busa M. A disc-based quantitative carrier test method to assess the virucidal activity of chemical germicides. *J Virol Methods* 2003;112:3–12.
7. Rutala WA, Peacock JE, Gergen MF, Sobsey MD, Weber DJ. Efficacy of hospital germicides against adenovirus 8, a common cause of epidemic keratoconjunctivitis in health care facilities. *Antimicrob Agents Chemother* 2006;50:1419–1424.
8. Recommendations for infection prevention and control for *Candida auris*. Centers for Disease Control and Prevention website. https://www.cdc.gov/fungal/candida-auris/c-auris-infection-control.html. Updated 2018. Accessed September 26, 2018.
9. Kanamori H, Rutala WA, Weber DJ, Gergen MF, Sickbert-Bennett EE, Weber DJ. Germicidal activity against carbapenem/colistin resistant *Enterobacteriaceae* using a quantitative carrier test method. *Antimicrob Agents Chemother* 2018;62:e00318–18. doi: 10.1128/AAC.00318-18.
10. Cadnum JL, Shaikh AA, Piedrahita CT, *et al.* 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.