

## Concise Communication

# Efficacy of 23 commonly used liquid disinfectants against *Candida auris* isolates from the 4 major clades

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### Abstract

We tested the effectiveness of 23 disinfectants used in healthcare facilities against isolates from the 4 major clades of *Candida auris*. Sporidical disinfectants were consistently effective, whereas quaternary-ammonium disinfectants had limited activity. Quaternary-ammonium–alcohol and hydrogen-peroxide–based disinfectants varied in effectiveness against *C. auris*.

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*Candida auris* is a globally emerging fungal pathogen that has caused outbreaks in healthcare settings.<sup>1</sup> In the United States, *C. auris* cases have increased dramatically in recent years, with documented spread to 28 states and Washington, DC, by the end of 2022.<sup>2</sup> Contaminated surfaces and reusable medical equipment have been implicated in transmission.<sup>1,2</sup> Therefore, the Centers for Disease Control and Prevention (CDC) recommends thorough cleaning and disinfection of surfaces and shared equipment using disinfectants effective against *C. auris*.<sup>1</sup> One concern regarding *C. auris* is that some commonly used disinfectants, particularly quaternary-ammonium products, may have limited efficacy.<sup>3–5</sup>

In 2017, the Environmental Protection Agency (EPA) published recommended methods for evaluating the efficacy of antimicrobial products against *Candida auris* on hard, nonporous surfaces with Antibiotic Resistance Bank (AR) no. 0381 (clade II) as the test strain.<sup>6</sup> In 2021, the EPA published updated testing guidance that included the recommendation that *C. auris* AR-0385 (a drug-resistant clade IV strain) be used.<sup>7</sup> This change in test organism was based in part on evidence that *C. auris* isolates from clades III and/or IV might have reduced susceptibility to low concentrations of sodium hypochlorite and ultraviolet-C (UV-C) light in comparison to the clade II isolate initially recommended for standard testing.<sup>5,8</sup> Products demonstrating efficacy against AR-0385 may claim effectiveness against *C. auris* and drug-resistant *C. auris*, whereas products demonstrating efficacy only against AR-0381 will only be able to maintain a claim of effectiveness against *C. auris*.<sup>9</sup> List P provides a listing of antimicrobial products registered with the EPA for claims against *Candida auris*. Given the rapid spread of *C. auris* in the United States, including clades III and IV,<sup>2</sup> data regarding the effectiveness of a wide range of disinfectants used in healthcare settings are needed. In the current study, we tested the effectiveness of 23

disinfectant products used in healthcare facilities against isolates from the 4 major clades of *C. auris*.

### Methods

#### Test organisms

The *C. auris* test strains included isolates from 4 phylogenetic clades, including AR-0381 (clade II; East Asia origin), AR-0389 (clade I; South Asia origin), AR-0383 (clade III; Africa origin), and AR-0385 (clade IV; South America origin). *Candida albicans* American Type Culture Collection (ATCC) strain 10231 was tested for comparison.

#### Disinfectants tested

The disinfectants that were tested were chosen based on the results of a 2019 survey of a convenience sample of 57 healthcare facilities from 30 states (authors' unpublished data). All disinfectant brands used in the facilities were tested. All facilities reported use of sporidical disinfectants in rooms of patients with *Clostridioides difficile* infection (CDI): 53 facilities used chlorine-based disinfectants and 4 used peracetic-acid–based disinfectants. In rooms of non-CDI patients, 28 facilities (49%) primarily used quaternary-ammonium disinfectants, 17 (30%) used improved hydrogen-peroxide disinfectants, 7 (12%) used chlorine-based disinfectants, and 5 (9%) used phenolic disinfectants. Table 1 shows the characteristics of the 23 disinfectants included in testing, including the active ingredients and recommended contact times for *C. auris* or *Candida albicans*.

#### Efficacy of the disinfectants against *C. auris*

EPA MLB SOP MB-35-03 was used to test the efficacy of the 23 disinfectants against the test organisms.<sup>7</sup> A 3-part soil load containing bovine serum albumin, yeast extract, and mucin was used.<sup>7</sup> For wipe products, the liquid disinfectant was expressed from the saturated wipes for testing.<sup>7</sup> Contact times were based on the manufacturer's recommendations. Cultures were performed by

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**Table 1.** Characteristics of the 23 Disinfectants Tested Against *Candida auris* and *Candida albicans*

Disinfectant Category and Brand	Active Components	Contact Time (C. <i>auris</i> or alternative organism) <sup>a</sup>	Sporicidal Claim <sup>b</sup>	<i>Candida auris</i> Claim (Alternative Organism) <sup>c</sup>
<b>Chlorine-based disinfectants</b>				
Clorox Healthcare bleach germicidal cleaner	Sodium hypochlorite 0.65%	3 min	Yes	Yes
Clorox germicidal bleach wipe	Sodium hypochlorite 0.65%	3 min	Yes	Yes
Clorox Dispatch Hospital cleaner disinfectant	Sodium Hypochlorite 0.65%	3 min	Yes	Yes
PDI Sani-Cloth bleach germicidal disposable wipe	Sodium hypochlorite 0.63%	4 min	Yes	Yes
Artemis BioSolutions Defender disinfectant	Sodium dichloroisocyanurate (NaDCC) (4306 parts per million free chlorine)	4 min	Yes	No ( <i>Clostridioides difficile</i> )
<b>Peracetic-acid-based disinfectant</b>				
EcoLab OxyCide daily disinfectant	Peracetic acid 1200 parts per million, hydrogen peroxide <1%, acetic acid	3 min	Yes	Yes
<b>Improved hydrogen peroxide</b>				
Clorox Healthcare hydrogen-peroxide cleaner disinfectant	Hydrogen peroxide 1.4%	3 min <sup>d</sup>	No	Yes
Diversey Oxivir TB	Hydrogen peroxide 0.5%	5 min	No	Yes
Diversey Alpha HP multisurface cleaner	Hydrogen peroxide .07%	10 min	No	No (bacterial claim)
PDI Sani-Hypercide	Hydrogen peroxide 4.0% <sup>d</sup>	1 min	Yes	Yes
<b>Quaternary-ammonium compound</b>				
Diversey Virex II 256	Didecyl dimethyl ammonium chloride 8.7%, n-Alkyl dimethyl benzyl ammonium chloride 8.2%	10 min	No	No ( <i>Candida albicans</i> )
Diversey Virex Plus	Octyl decyl dimethyl ammonium chloride 6.7%, Dioctyl dimethyl ammonium chloride 2.7%, Didecyl dimethyl ammonium chloride 4.0%, Alkyl (C14, 50%; C12, 40%; C16, 10%) dimethyl benzyl ammonium chloride 8.9%	3 min	No	Yes ( <i>Candida albicans</i> )
Kinzua Shield foam	n-Alkyl (60% C <sub>14</sub> , 30% C <sub>16</sub> , 5% C <sub>12</sub> , 5% C <sub>18</sub> ) dimethyl benzyl ammonium chloride 0.1%, n-Alkyl (68% C <sub>12</sub> , 32% C <sub>14</sub> ) dimethyl ethylbenzyl ammonium chloride 0.1%	10 min	No	No (Trichophyton)
Diversey Crew Non-Acid Disinfectant Cleaner	Alkyl (50% C <sub>14</sub> , 40% C <sub>12</sub> , 10% C <sub>16</sub> ) dimethyl benzyl ammonium chloride .03%, Octyl decyl dimethyl ammonium chloride .03%, dodecyl dimethyl ammonium chloride .01%, Doctyl dimethyl ammonium chloride .01%	10 min	No	No (Trichophyton)
Kinzua TB	n-Alkyl (60% C <sub>14</sub> , 30% C <sub>16</sub> , 5% C <sub>12</sub> , 5% C <sub>18</sub> ) dimethyl benzyl ammonium chloride 0.1%, n-Alkyl (68% C <sub>12</sub> , 32% C <sub>14</sub> ) dimethyl ethylbenzyl ammonium chloride 0.1%	10 min	No	No (Trichophyton)
Kinzua Shield Ultra	Didecyl dimethyl ammonium chloride 0.04%, Alkyl (50% C <sub>14</sub> , 40% C <sub>12</sub> , 10% C <sub>16</sub> ) Dimethyl benzyl ammonium chloride 0.03%	10 min	No	No (Trichophyton)
Diversey Crew NA SC	Alkyl (50% C <sub>14</sub> , 40% C <sub>12</sub> , 10% C <sub>16</sub> ) dimethyl benzyl ammonium chloride .03%, Octyl decyl dimethyl ammonium chloride .03%, dodecyl dimethyl ammonium chloride .01%, Doctyl dimethyl ammonium chloride .01%	10 min	No	No (Trichophyton)
Diversey Crew Restroom Floor & Surface SC	Alkyl (50% C <sub>14</sub> , 40% C <sub>12</sub> , 10% C <sub>16</sub> ) dimethyl benzyl ammonium chloride .03%, Octyl decyl dimethyl ammonium chloride .03%, dodecyl dimethyl ammonium chloride .01%, Doctyl dimethyl ammonium chloride .01%	10 min	No	No (bacterial claim)
<b>Quaternary ammonium plus alcohol</b>				
PDI Sani-Cloth Germicidal Wipes	n-Alkyl (68% C <sub>12</sub> , 32% C <sub>14</sub> ) dimethyl ethylbenzyl ammonium chlorides .25%, n-Alkyl (60% C <sub>14</sub> , 30% C <sub>16</sub> , 5% C <sub>12</sub> , 5% C <sub>18</sub> ) dimethyl benzyl ammonium chlorides .25%, Isopropyl alcohol 55%	2 min	No	Yes

(Continued)

Table 1. (Continued)

Disinfectant Category and Brand	Active Components	Contact Time ( <i>C. auris</i> or alternative organism) <sup>a</sup>	Sporicidal Claim <sup>b</sup>	<i>Candida auris</i> Claim (Alternative Organism) <sup>c</sup>
Kinzua KE 15 Citrus Surface Disinfectant	n-Alkyl (60% C <sub>14</sub> , 30% C <sub>16</sub> , 5% C <sub>12</sub> , 5% C <sub>18</sub> ) dimethyl benzyl ammonium chloride 0.1%, n-Alkyl (68% C <sub>12</sub> , 32% C <sub>14</sub> ) dimethyl ethylbenzyl ammonium chloride 0.1%	10 min	No	No (Trichophyton)
Metrex CaviWipes	Di-isobutylphenoxyethoxyethyl dimethyl benzyl ammonium chloride .28%, Isopropanol 17.2%	3 min	No	No (Trichophyton)
Metrex CaviCide spray	Di-isobutylphenoxyethoxyethyl dimethyl benzyl ammonium chloride .28%, Isopropanol 17.2%	3 min	No	No (Trichophyton)
<b>Phenolic acid</b>				
Wexford Labs Wexcide 128	Orthophenylphenol 3.4%, ortho benzyl para chlorophenol 3.0%	10 min	No	No (Trichophyton)

<sup>a</sup>Contact time for disinfectants based on manufacturers' recommendations for *Candida auris*, or if no claim against *C. auris* the contact time for an alternative organism was used.

<sup>b</sup>Environmental Protection Agency-registered claim against *Clostridioides difficile* spores.

<sup>c</sup>Environmental Protection Agency-registered claim against *Candida auris* and alternative organisms used for contact time if no *C. auris* claim.

<sup>d</sup>Hydrogen-peroxide disinfectant that has sporicidal activity due to generation of low concentrations of peracetic acid during use (5-min *C. difficile* claim).

plating specimens on Sabouraud dextrose agar (Becton Dickinson, Sparks, MD) and incubating them at 37°C for 72 hours. Log<sub>10</sub> reductions were calculated by subtracting viable organisms recovered from treated versus untreated control carriers. The tests were performed in triplicate. Disinfectants were classified as effective if a >5 log<sub>10</sub> reduction in *C. auris* was achieved after the contact time recommended by the manufacturer.<sup>6,7</sup>

## Results

Table 2 shows the mean log<sub>10</sub> reductions achieved by the 23 disinfectants against the 4 *C. auris* strains and *C. albicans*. Overall, 5 chlorine-based disinfectants and the peracetic-acid-based disinfectant consistently reduced all the *C. auris* strains and *C. albicans* by >5 log<sub>10</sub>. Also, 3 (75%) hydrogen-peroxide-based disinfectants reduced all the test strains by >5 log<sub>10</sub>. However, a fourth hydrogen-peroxide-based disinfectant (Alpha HP) with a relatively low hydrogen-peroxide concentration of 0.06% did not achieve a >5 log<sub>10</sub> reduction of any of the test strains. Of the 4 quaternary-ammonium-alcohol disinfectants (Super Sani Cloth and Kinzua KE 15), 2 (50%) consistently reduced all the test organisms by >5 log<sub>10</sub>. One quaternary-ammonium-alcohol disinfectant (CaviCide) reduced the clade II isolate by >5 log<sub>10</sub> but did not reduce the clade I, III, or IV isolates by >5 log<sub>10</sub>.

None of the quaternary-ammonium-based products achieved a >5 log<sub>10</sub> reduction in the clade IV AR-0385 isolate. However, 1 quaternary-ammonium disinfectant (Kinzua TB) did achieve a >5 log<sub>10</sub> reduction in the clade II AR-0381 isolate. A phenolic-acid-based disinfectant did not achieve a >5 log<sub>10</sub> reduction of any of the test strains.

## Discussion

Our results are consistent with previous evidence demonstrating that sporicidal disinfectants are effective against *C. auris*, whereas quaternary-ammonium disinfectants have limited activity.<sup>3-5</sup> None of the 8 quaternary-ammonium disinfectants tested achieved the >5 log<sub>10</sub> reduction in *C. auris* AR-0385

required for a claim against drug-resistant *C. auris*. The limited efficacy of quaternary-ammonium disinfectants is important given the widespread use of these products in healthcare facilities in the context of the rapid spread of *C. auris*. The fact that many patients with *C. auris* are colonized and only detected through screening increases the likelihood that unrecognized cases may enter facilities where cleaning and disinfection practices may not be sufficient to limit spread.

Our results highlight the fact that different products within categories of disinfectants may vary in effectiveness against *C. auris*. Two quaternary-ammonium-alcohol disinfectants achieved a >5 log<sub>10</sub> reduction in *C. auris* AR-0385 and the other test organisms, suggesting that the addition of alcohol to quaternary-ammonium disinfectants may enhance activity against *C. auris*. However, testing of individual quaternary-ammonium-alcohol products is required because 2 other products in this category (CaviWipes and CaviCide Spray) did not achieve a >5 log<sub>10</sub> reduction in *C. auris* AR-0385, although CaviCide Spray did achieve a >5 log<sub>10</sub> reduction in *C. auris* AR-0381. Notably, recent formulations of these products (Cavicide 1 and CaviWipes 1) with increased concentrations of the quaternary-ammonium compound and alcohol are listed on EPA List P as effective against *C. auris* with a 1-minute claim. Similarly, 3 hydrogen-peroxide-based disinfectants were effective against all the test strains and are on List P, but a fourth product with a relatively low hydrogen-peroxide concentration of 0.06% (Alpha HP) did not achieve a >5 log<sub>10</sub> reduction of any of the test strains and is not on List P.

Our study had several limitations. Only 1 isolate from each of the 4 predominant clades was tested. Additional studies are needed with more strains. We only studied chlorine-based disinfectants with ≥4,306 parts per million free chlorine. Chlorine-based products with lower free chlorine are sometimes used and may be less effective against *C. auris*.<sup>4,5,10</sup> We only completed laboratory assessments of the products. Real-world studies are needed. Finally, for wipes we tested the efficacy of liquid expressed from the towelette. This procedure may have led to the underestimation of reductions achieved by wipes, which also reduce pathogens by physical removal.

**Table 2.** Mean (SE) Log<sub>10</sub> Reductions in *Candida auris* and *Candida albicans* for the 23 Tested Disinfectants

Product	Clade II	Clade I	Clade IV	Clade III	<i>Candida albicans</i> <sup>a</sup>
<b>Chlorine-based disinfectants</b>					
Clorox Healthcare bleach germicidal cleaner	5.72 (0.00)	5.87 (0.00)	≥6.00 (0.00)	≥6.00 (0.00)	5.10 (0.00)
Clorox germicidal bleach wipe	5.72 (0.00)	5.49 (0.00)	5.75 (0.00)	≥6.00 (0.00)	5.25 (0.00)
Clorox Dispatch Hospital cleaner disinfectant	5.72 (0.00)	5.25 (0.00)	5.35 (0.00)	5.72 (0.00)	5.67 (0.00)
PDI Sani-Cloth bleach germicidal disposable wipe	5.98 (0.00)	5.91 (0.00)	≥6.00 (0.00)	≥6.00 (0.00)	5.67 (0.00)
Artemis BioSolutions Defender disinfectant	6.00 (0.00)	5.20 (0.00)	5.4 (0.00)	5.4 (0.00)	6.00 (0.00)
<b>Peracetic acid-based disinfectant</b>					
EcoLab OxyCide daily disinfectant	5.3 (0.22)	5.30 (0.00)	5.42 (0.00)	5.46 (0.00)	5.9 (0.04)
<b>Improved hydrogen peroxide</b>					
Clorox Healthcare hydrogen-peroxide cleaner disinfectant	5.22 (0.00)	5.89 (0.00)	5.10 (0.00)	5.01 (0.00)	5.10 (0.00)
Diversey Oxivir TB	5.34 (0.00)	5.89 (0.00)	5.10 (0.00)	5.01 (0.00)	5.10 (0.00)
Diversey Alpha HP multisurface cleaner	4.02 (0.29)	1.48 (0.23)	0.00 (0.09)	0.17 (0.24)	0.96 (0.24)
PDI Sani-Hypercide	≥6.00 (0.00)	5.89 (0.00)	5.10 (0.00)	5.01 (0.00)	5.67 (0.00)
<b>Quaternary-ammonium compound</b>					
Diversey Virex II 256	2.50 (0.20)	0.13 (0.10)	0.10 (0.11)	0.00 (0.03)	0.33 (0.05)
Diversey Virex Plus	2.50 (0.26)	0.06 (0.59)	0.00 (0.11)	0.00 (0.17)	0.00 (0.12)
Kinzua Shield Foam	3.56 (0.17)	3.89 (0.36)	1.62 (0.42)	1.98 (0.04)	4.22 (0.31)
Diversey Crew nonacid disinfectant	1.17 (0.24)	0.16 (0.06)	0.00 (0.18)	0.41 (0.16)	0.88 (0.15)
Kinzua TB	5.22 (0.00)	5.26 (0.23)	1.93 (0.49)	3.78 (0.31)	4.39 (0.72)
Kinzua Shield Ultra	0.40 (0.34)	0.91 (0.24)	0.00 (0.20)	1.33 (0.16)	0.00 (0.16)
Diversey Crew NA SC	0.79 (0.14)	0.66 (0.03)	0.00 (0.29)	0.71 (0.17)	0.53 (0.27)
Diversey Crew Restroom Floor & Surface SC	1.35 (0.15)	4.50 (0.29)	2.15 (0.23)	3.25 (0.19)	4.74 (0.22)
<b>Quaternary-ammonium plus alcohol</b>					
PDI Sani-Cloth germicidal wipes	5.30 (0.00)	5.74 (0.00)	≥6.00 (0.00)	≥6.00 (0.00)	5.66 (0.00)
Kinzua KE 15 Citrus surface disinfectant	5.30 (0.00)	5.87 (0.00)	≥6.00 (0.00)	≥6.00 (0.00)	5.10 (0.00)
Metrex CaviWipes <sup>b</sup>	3.55 (0.32)	2.98 (0.06)	1.95 (0.24)	1.84 (0.02)	4.75 (0.27)
Metrex CaviCide spray <sup>b</sup>	5.63 (0.14)	4.06 (0.28)	3.04 (0.56)	2.10 (0.14)	5.25 (0.00)
<b>Phenolic acid disinfectant</b>					
Wexford Labs Wexcide 128	3.60 (0.80)	2.16 (0.43)	0.60 (0.29)	1.6 (0.43)	2.8 (0.00)

Note. *C. auris* Clade II, Antibiotic Resistance Bank (AR) 0381; clade I, AR-0389; clade III, AR-0383, and clade IV, AR-0385.

<sup>a</sup>*Candida albicans* American Type Culture Collection strain 10231.

<sup>b</sup>Recent formulations of these products (CaviWipes 1 and Cavicide 1) with increased concentrations of the quaternary-ammonium compound and alcohol are listed on EPA List P as effective against *C. auris* with a 1-min claim.

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