CONCISE COMMUNICATION

Environmental Surfaces in Healthcare Facilities are a Potential Source for Transmission of *Candida auris* and Other *Candida* Species

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Contaminated surfaces have been implicated as a potential route for dissemination of the emerging multidrug-resistant fungal pathogen *Candida auris*. In laboratory testing, *C. auris* and other *Candida* species persisted for 7 days on moist or dry surfaces. *Candida* species were recovered frequently from the hospital environment, particularly from moist surfaces.

Infect Control Hosp Epidemiol 2017;38:1107–1109

Candida auris is a globally emerging pathogen that is often resistant to multiple antifungal agents.[1–4] In several studies, *C. auris* has been recovered from environmental surfaces in healthcare facilities, suggesting that contaminated surfaces may be an important source of acquisition.[1–3] However, it is not clear whether *C. auris* has a greater propensity to survive on surfaces than other *Candida* species. Although relatively little information is available on the extent of *Candida* contamination of surfaces in healthcare facilities, several *Candida* species can survive for prolonged periods on surfaces,[6] and some studies have demonstrated recovery of *Candida* species other than *C. auris* from surfaces in hospitals.[7] Here, we compared the survival rates of *Candida auris* with other *Candida* species on surfaces, and we conducted a culture survey to determine the frequency of contamination of hospital environmental surfaces with *Candida* species.

METHODS

The study protocol was approved by the institutional review board of the Louis Stokes Veterans Affairs Medical Center. We examined survival of 8 *C. auris* strains and 3 strains each of *C. albicans*, *C. glabrata*, and *C. parapsilosis* on dry and moist surfaces for up to 7 days. The 8 strains of *C. auris* have been described previously: MRL 31102 and 31103 and CBS# 10913, 12372, 12373, 12772, 12776, and 12777.[4] The *C. albicans* strains were American Type Culture Collection strains (ATCC) SC5314, MBL32249, and MBL 32708. The *C. glabrata* strains were ATCC MBL31820, 34870, and 9542. The *C. parapsilosis* strains were clinical isolates. The moist surfaces were 10-mm-diameter sections of moist nonnutrient agar inside a Petri dish sealed with parafilm to prevent desiccation. The dry surfaces were 10-mm-diameter, circular, nonporous steel disks. In preliminary experiments, the survival rates of *C. auris* were similar on multiple different dry surfaces, including steel disks, ceramic or plastic laminate tiles, and sections of privacy curtain material (data not shown).

The surfaces were inoculated with 10^6 colony-forming units (CFU) of washed *Candida* species from an overnight culture suspended in 10 µL of phosphate-buffered saline (PBS). The inoculum was allowed to air dry. At 2 hours and at 1, 2, and 7 days, the inoculated surfaces were sampled by transferring to plastic tubes containing 1 mL of PBS and vortexing for 2 minutes. Quantitative cultures were performed by plating serially diluted specimens on Sabouraud dextrose agar (Becton Dickinson, Sparks, MD) that were incubated at 37°C for 72 hours to determine the presence and concentration of *Candida* species. The percent recovery at each time point was calculated in comparison to the CFU recovered immediately after inoculation. The experiments were performed in triplicate.

In the hospital, we used BBL CultureSwabs (Becton Dickinson, Cockeysville, MD) to sample moist surfaces (ie, sinks and shower drains) and dry surfaces in patient rooms; for dry surfaces the swabs were premoistened with sterile PBS. For large surfaces, 5 × 10-cm areas were sampled; for small objects, the entire surface area was sampled. For dry surfaces, 1 swab was used to sample multiple sites inside the patient room (bed rails, bedside tables, call buttons, and telephones) and 1 swab was used to sample sites in the bathroom (toilet seats and toilet hand rails). The swabs were vortexed for 1 minute in sterile PBS, and serially diluted aliquots were plated on Sabouraud dextrose agar. Colonies consistent with *Candida* species were subjected to identification using API 20C AUX for yeast identification (BioMerieux, Lombard, IL) and the Bruker Biotyper matrix-assisted laser desorption/ionization time-of-flight (MALDI-TOF) system (Bruker, Billerica, MA) including a research-use-only library containing *C. auris*.[8] For comparison, aliquots from the swab samples were plated on selective media for methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), and fluoroquinolone-resistant gram-negative bacilli.[9] For selection of fluoroquinolone-resistant gram-negative bacilli, MacConkey plates containing 1 µg/mL of ciprofloxacin were used.

A quasibinomial logit model was used to compare survival of the different *Candida* species on inoculated surfaces at 1 and 7 days. The Fisher exact test with adjusted *P* values for post hoc pairwise comparisons was used to compare percentages of positive hospital environmental cultures for *Candida* species versus the bacterial pathogens. Data were analyzed using R version 3.2.2 software (R Foundation for Statistical Computing, Vienna, Austria).

https://doi.org/10.1017/ice.2017.127 Published online by Cambridge University Press

RESULTS

As shown in Figure 1, on dry steel disks the percent recovery of each of the *Candida* species in comparison to the initial inoculum decreased over time. However, for each strain tested, organisms remained detectable after 7 days. Recovery rates of *C. auris* at days 1 and 7 were significantly greater than recovery rate of *C. albicans* but significantly less than the recovery rate of *C. parapsilosis* ($P < .05$). In addition, recovery rates of each of the 8 strains of *C. auris* were similar. On moist nonnutrient agar, no significant decrease in the recovery rate of the *Candida* species was observed.

Figure 2 shows the frequencies of recovery of *Candida* species and the bacterial pathogens from hospital surfaces. There were no significant differences in the percent recovery of *Candida* species versus the other pathogens from dry surfaces ($P \geq .05$). However, *Candida* species were recovered significantly more often than the other pathogens from moist surfaces ($P < .01$). The *Candida* species that recovered included 7 *C. glabrata* strains, 7 *C. parapsilosis* strains, 1 *C. tropicalis* strain, 1 *C. albicans* strain, 1 *C. metapsilosis* strain, and 1 *C. lusitaniae* strain.

DISCUSSION

Overall, 8 strains of *C. auris* survived on moist or dry surfaces for 7 days. *Candida auris* exhibited a greater propensity to survive on surfaces than *C. albicans*, but not *C. parapsilosis* or *C. glabrata*. In comparison to common bacterial pathogens, *Candida* species were recovered with similar frequencies from dry surfaces and were recovered significantly more often from moist areas such as sinks. These results provide support for the hypothesis that contaminated surfaces could be an important source for transmission of *Candida auris*.[1–3]

The CDC recommends thorough daily and terminal disinfection of room surfaces and shared medical equipment in rooms of patients with *C. auris* infection.[5] Although many disinfectants have an Environmental Protection Agency registration against *Candida* species, it is recommended that a disinfectant effective against *C. difficile* spores be used.[5] Further data are needed regarding the efficacy of different disinfectants against *C. auris*. Given that we frequently recovered *Candida* species from moist surfaces, the potential for spread of *C. auris* from moist sites, such as sinks that have been implicated in dissemination of multidrug-resistant gram-negative bacilli, should also be clarified.[10]

The high recovery rate of non-*albicans Candida* species from hospital surfaces suggests that the environment might be an underappreciated reservoir for spread of *Candida* species other than *C. auris*. Non-*albicans Candida* species, including *C. lusitaniae*, *C. parapsilosis*, and *C. glabrata*, have been recovered from the hospital environment.[7,8] Further studies are warranted to investigate the role of contaminated surfaces in transmission of *Candida* species.

Our study has some limitations. We only studied 3 to 8 strains of each *Candida* species. However, survival rates on surfaces were similar for different strains. We studied survival on surfaces in a laboratory setting, and we studied only 2 types of surfaces. As noted previously, preliminary experiments demonstrated that the survival rates of *C. auris* were similar on multiple types of dry surfaces. We only studied survival on surfaces for 7 days. Further studies are needed to evaluate longer time periods and to identify other factors that may impact survival. Finally, we did not compare the survival rates of the *Candida* species to those of bacterial pathogens.

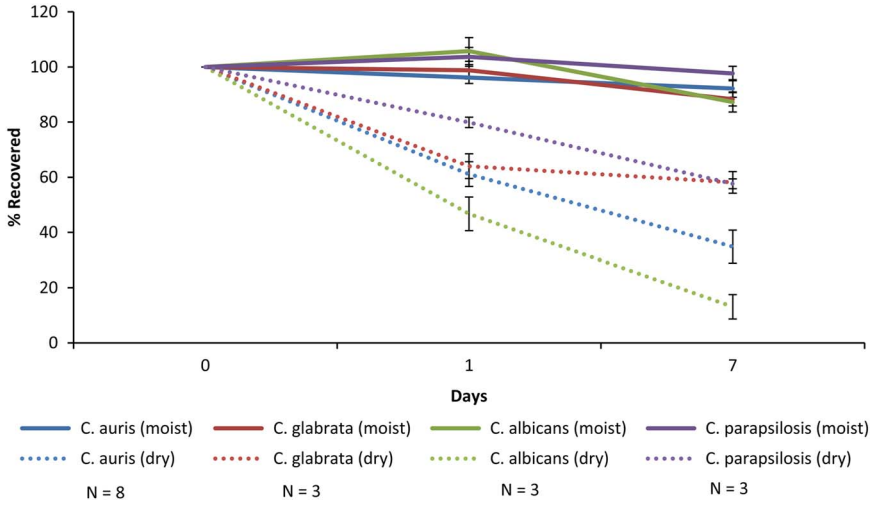

FIGURE 1. Survival of 8 strains of *Candida auris*, 3 strains of *C. glabrata*, 3 strains of *C. parapsilosis*, and 3 strains of *C. albicans* on dry steel disks and on moist nonnutrient agar. The surfaces were inoculated with 10^6 colony-forming units (CFU) of the *Candida* species and quantitative cultures were performed at 2 hours and at 1, 2, 4, and 7 days after inoculation. The percent recovery at each time point was calculated in comparison to the CFU recovered immediately after inoculation. The experiments were performed in triplicate.

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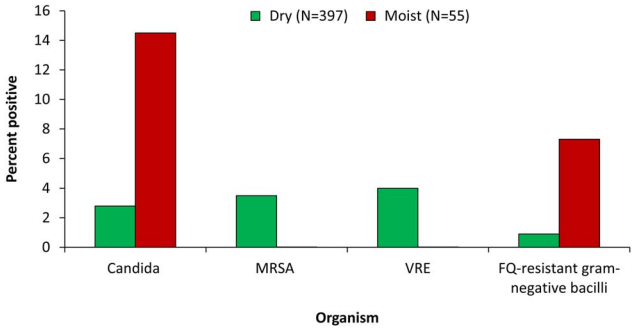

FIGURE 2. Rate of recovery of *Candida* species, methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), and carbapenem-resistant gram-negative bacilli from dry and moist hospital surfaces.

ACKNOWLEDGMENTS

Financial support: This work was supported by the Department of Veterans Affairs.

Potential conflicts of interest: C.J.D. has received research grants from Merck, GOJO, STERIS, and EcoLab, and he serves on an advisory board for 3M. All other authors report no conflicts of interest relevant to this article.

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Received April 13, 2017; accepted May 25, 2017; electronically published July 11, 2017

 0899-823X/2017/3809-0016. DOI: 10.1017/ice.2017.127

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