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# Survival of Candida auris in the environment and the development of resistance to disinfection

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**Abstract**

Introduction:

The increasing number of cases of *Candida auris* across continents since its emergence in 2009, continue to raise an alarm and the significance of *C. auris* as a pathogen. The fungus has been found mainly in critical care patients causing nosocomial infections, hospital outbreaks and high rate of mortality. This pathogen has indicated the ability to survive for long periods outside of their host which facilitate the transmission from healthcare workers to patients. In the hospital environment many different types of surface materials are used which can become contaminated. Many disinfectants with different efficacies are used to decontaminate these surfaces. Therefore, it is important to study the survival of *C. auris* on these surfaces in different conditions and the effect of disinfectants.

**Aim:**

The aim of this study was to investigate the survival of *C. auris* on various environmental surfaces under different conditions and a possible development of resistance to repeated use of disinfectants.

**Methods:**

Known size of glass, fabric, plastic, wood and steel blocks were fabricated and artificially contaminated with planktonic 3 strains of *C. auris* and one strain of *C. albicans*. One set was kept wet and one dry for 3 weeks, and at intervals, *C. auris* counts were performed using a dilution and culture technique. Similarly, biofilms were grown and counts were performed. The resulted counts were compared to the initial counts using a student t-test. In the disinfectant study, 4 commonly used disinfectants such as sodium dichloroisocyanurate (NADCC), benzalkonium chloride (BC), 70% ethyl alcohol (Eth) and hydrogen peroxide (HP) were selected and minimum inhibitory concentrations (MIC) were determined using a broth microdilution technique. Time-kill assays were performed using MIC, ½ and ¼ MIC dilutions. *C. auris* was pulsed daily with 10 minute exposure for 15 days and MIC was repeated. In addition, ergosterol quantities and *ERG11* gene expression were measured for the exposed and unexposed *C. auris* cells. Finally, whole-genome sequencing was performed on the exposed and unexposed cells of *C. auris* and mutations were identified.

**Results:**

The survival results showed that *C. auris* survived on all the surfaces for more than 3 weeks with either increase or reduction in the viable cells. Planktonic cells survived the most on wood and steel with 390 and 148% increase, and least on glass with 93% reduction in the counts. Survival was significantly better in the wet condition ($p$ <0.001) compared to the dry condition. In the biofilm form *C. auris* flourished on all the surfaces with an increase of up to 575% regardless of wet and dry conditions. *C. albicans* behaved similarly on all the surfaces and conditions.

In the time-kill study, at recommended concentration NADCC and BC killed 100% of *C. auris* within 30 seconds whereas Eth required one minute and HP was found to be very weak requiring 5 minutes to kill 100% of *C. auris*. When *C. auris* was pulsed for 10 minutes daily with disinfectants for 15 days, it was found that for NADCC and BC the MIC increased in the exposed cells compared to the unexposed cells. NADCC and HP exposed cells had increased level of ergosterol and both induced a significant level of *ERG11* gene expression. Genome sequencing results showed that BC treated Cau4888 was found to have more genetic variations than NaDCC treated *C. auris*. Most of the changes/variations were made upstream of the genes, possibly the promoter regions. Even though some of the mutated genes were identified, most are unannotated genes.

**Conclusions:**

In wet and dry conditions, planktonic and biofilm form of *C. auris* can survive on many different types of surfaces for more than 3 weeks. It is important to use an effective disinfectant at a recommended concentration. Repeated exposure to sublethal concentrations may develop resistance to the disinfectant in this organism. This highlights the importance of immediate cleaning and disinfection of surfaces after exposure to *C. auris* to minimize transmission.