

Candida auris in skilled nursing facilities

Philip S. Yune, Jared Coe, Mana Rao  and Michael Y. Lin

Abstract: *Candida auris* is a fungal organism resistant to several classes of antifungals. Since its identification in 2009, it has gained worldwide attention in healthcare for its virulence and resistance to commonly used antifungal therapeutics. Although its origin and mechanisms of transmission are not fully elucidated, it is widely recognized as a high priority healthcare-associated pathogen. Infection control efforts in skilled nursing facilities have been very challenging due to the tendency of *C. auris* to persist in the environment and colonize residents. In this narrative review, we discuss the epidemiology and infection prevention of *C. auris* in skilled nursing facilities. We also identify challenges in the diagnosis and management of both symptomatic infections and asymptomatic colonization.

Keywords: *Candida auris*, skilled nursing facility

Received: 3 April 2023; revised manuscript accepted: 8 July 2023.

Introduction, brief history, and microbiology

Candida auris is a fungal organism that presents significant challenges to healthcare systems around the world. For patients, systemic infection from this organism can result in poor health outcomes. For clinicians, treatment and infection control can be challenging. With high mortality rates associated with invasive *C. auris* infections, infection prevention efforts in skilled nursing facilities and other healthcare facilities are crucial to preventing further morbidity and mortality.¹

C. auris was first identified in Japan in 2009 from a patient's ear drainage, although a subsequent study determined that the organism had been unknowingly isolated in 1996 from a patient's blood culture samples in South Korea.^{2,3} Since 2009, multiple clades have been detected in different parts of the world in a short period of time. The first United States *C. auris* cases occurred between May 2013 and August 2016 among seven patients from Illinois, Maryland, New Jersey, and New York. *C. auris* was isolated from blood, urine, and ear cultures. Of the seven cases, five isolates were mistakenly identified as *C. haemulonii*, and five of seven *C. auris* isolates were resistant to fluconazole. None of these isolates were pan resistant.⁴ *C. auris* may be mistakenly identified as other yeast species including other

Candida species, *Saccharomyces*, and *Rhodotorula*.⁵ The number of patients colonized with *C. auris* has increased significantly worldwide in the past few years. Increasing case counts pose a significant concern in modern healthcare because of the characteristics of *C. auris* and its burden to healthcare systems, including high all-cause mortality, difficulty of isolation and detection, multidrug resistance, and its pattern of transmission.⁶

The exact origin of *C. auris* and why this organism appeared in different parts of the world virtually simultaneously still remains unknown.⁷ *C. auris* genome analysis has revealed genome assembly size ranging from 12.1 to 12.7 Mb⁸ with approximately 6500–8500 protein coding sequences that encode proteins responsible for its virulence.⁹ Whole-genome sequencing of *C. auris* has previously identified four major clades based on the location in which the first isolates were found: South Asian (Clade I), East Asian (Clade II), South African (Clade III), and South American (Clade IV).^{10,11} More recently, *C. auris* isolates from Iran have been recognized to be separated by only 100 single-nucleotide polymorphisms (SNPs) from each other, while they differ from other clades by more than 200,000 SNPs, suggesting that these isolates represent a potential new clade (Clade V).^{11–15} In the United States,

Ther Adv Infect Dis

2023, Vol. 10: 1–13

DOI: 10.1177/

20499361231189958

© The Author(s), 2023.

Article reuse guidelines:
sagepub.com/journals-
permissions

Correspondence to:

Mana Rao

Archcare, New York,
NY, USA Essen Medical
Associates, Bronx, 205
Lexington Ave, 3rd Floor,
New York, NY 10016, USA
manarao@gmail.com

Philip S. Yune

Division of Infectious
Disease, Department of
Medicine, Donald and
Barbara Zucker School
of Medicine at Hofstra/
Northwell, Manhasset,
NY, USA

Division of Infectious
Diseases, Department
of Medicine, Montefiore
Medical Center, Albert
Einstein College of
Medicine, Bronx, NY, USA

Jared Coe

Division of Infectious
Diseases, Department
of Medicine, Montefiore
Medical Center, Albert
Einstein College of
Medicine, Bronx, NY, USA

Michael Y. Lin

Division of Infectious
Diseases, Department of
Internal Medicine, Rush
University Medical Center,
Chicago, IL, USA

clades I, II, III, and IV have been isolated, with clades I and IV being most common.^{16,17} Phylogenetic analysis of different clades of *C. auris* is important as resistance pattern varies by clade type, and it provides valuable insight into its transmission dynamics.^{16,18} For example, clades I and III have been shown to exhibit distinct phenotypic and antimicrobial susceptibility patterns in vitro. Clade I isolates are able to form pseudohyphae unlike clade III. Also, although a majority of *C. auris* isolates are resistant to fluconazole, the minimum inhibitory concentrations for fluconazole and voriconazole have been higher in clade III compared with clade I.¹⁹ Clade II appears to have no mutation in the *ERG11* gene, which is responsible for encoding the target of azoles, resulting in higher susceptibility to azoles compared to other clades.^{20,21}

C. auris has multiple virulence factors, such as proteinase and phospholipase, that enable the organism to cause invasive disease (e.g., bloodstream infections) similar to other *Candida* species.²² In addition, *C. auris* can form biofilms which enhance its ability to inhabit human skin and act as a barrier to antifungal treatment.^{23,24} The genetic and molecular mechanisms of *C. auris* that confer resistance to the major classes of antifungal drugs (i.e., azoles, echinocandins, and polyenes) remain incompletely understood. Mutations in the *ERG11* gene that encodes sterol-demethylase enzymes are frequently observed, conferring resistance to fluconazole. Furthermore, the presence of antimicrobial efflux pumps, such as major facilitator superfamily transporters or adenosine triphosphate binding cassette, can reduce susceptibility to azoles and amphotericin B.^{9,18,25,26}

C. auris is difficult to eradicate from surfaces using traditional antiseptic agents. It can colonize and cause invasive fungal infections in vulnerable patient populations with increased exposure to healthcare settings, particularly in individuals who reside in long-term care facilities and the chronically ill. In this review, we aim to address the current understanding of *C. auris* from the perspective of management in skilled nursing facilities. We will discuss the healthcare epidemiology, risk factors for transmission of *C. auris* and summarize guidance regarding surveillance, cleaning/disinfection, clinical features of invasive disease, diagnostics, and management amongst residents at skilled nursing facilities.

Healthcare epidemiology

Current state of C. auris epidemiology in skilled nursing facilities

C. auris infection is associated with high morbidity and mortality.^{1,10} A review of 4733 worldwide cases reported in 33 countries found that overall mortality was 39% associated with *C. auris* infection, and 45% with *C. auris* fungemia.²⁷ It is estimated that ~5%–10% of colonized patients with *C. auris* eventually develop invasive disease.^{28,29} It is important to study the epidemiology of *C. auris* colonization and transmission in patients in skilled nursing facilities because the development of systemic infection potentially can be prevented. Residents in skilled nursing facilities are especially vulnerable to *C. auris* infection and transmission owing to their clinical characteristics, including multiple hospitalizations, exposures to *C. auris* from healthcare settings, exposures to antimicrobial agents, frequent contact with healthcare providers, and resource challenges in infection control, which can translate into higher likelihood of invasive *C. auris* in this setting.^{28,30}

Risk factors

Risk factors for *C. auris* colonization still remain to be fully characterized. A case control study of residents in New York skilled nursing facilities identified the following risk factors for *C. auris* colonization: mechanical ventilation, receipt of carbapenem antibiotics in the preceding 90 days, having one or more acute care hospital visit in the prior 6 months, and receipt of systemic fluconazole in the prior 90 days.²⁸ Similar risk factors were observed in Chicago, Illinois, where the majority of individuals with *C. auris* colonization or infection had serious medical conditions requiring hands-on care and indwelling medical devices [e.g., intravenous (IV) devices, feeding tubes, tracheostomies], and previously resided in a long-term acute care hospital or ventilator capable skilled nursing facilities in the prior 3 months.³¹ A more recent report from a small community hospital located in Western New York illustrated a case in which *C. auris* was detected from urine after 50 days of hospitalization. There were no epidemiologic or geographic links to *C. auris* cases elsewhere; however, extensive use of antibiotics and prolonged endotracheal intubation were described prior to the isolation of *C. auris* in urine, suggesting a possible correlation

of antibiotic exposure with colonization or infection with *C. auris*.³² Robust antimicrobial stewardship programs at skilled nursing facilities or long-term care facilities are currently needed to optimize antibacterial and antifungal usage in a concerted effort toward *C. auris* prevention.

Pan-resistant *C. auris* isolates have been reported rarely, with sporadic, geographically disparate clusters lacking direct epidemiologic linkages.^{10,33,34} Pan-resistance of *C. auris* isolates may develop through antifungal pressure during treatment, as observed in New York where three pan-resistant *C. auris* cases involved patients who had received prior echinocandin treatment.³⁴ Once developed, pan-resistant *C. auris* strains can transmit from person to person in healthcare settings.

It is noteworthy that *C. auris* clusters have occurred on units caring for COVID-19 patients during the pandemic.³⁵ The relation between COVID-19 treatment and *C. auris* transmission likely was related to pandemic efforts to conserve personal protective equipment (PPE), such as allowing re-use or extended use of gowns between patients.³⁶ Such COVID-19-related *C. auris* outbreaks highlight the importance of following routine infection control measures to prevent transmission of pathogens.

Transmission

Skilled nursing facilities have a significant role in the regional transmission of *C. auris* within and between healthcare facilities. For instance, epidemiologic relationships were drawn among most cases upon reviewing 77 clinical cases of *C. auris* in healthcare facilities located in seven states of United States from June 2016 to May 2017.⁶ Three Illinois cases were related to one particular long-term care facility. Cases from New York and New Jersey had overlap between hospitals and long-term care facilities. Moreover, isolates from New York and New Jersey were grouped in clade I, and those from Illinois were grouped in clade IV, suggesting separate introductions of *C. auris* into the United States, with subsequent regional transmission.⁶

Contamination of the healthcare environment with *C. auris* is likely a major driver of transmission to skilled nursing facility residents. Careful surveillance of the healthcare environment in a Chicago skilled nursing facility caring for residents

with *C. auris* demonstrated frequent contamination of the environment (70/100 environmental samples from doorknobs, windowsills, and bed handrails).³⁷ Notably, the handrails of two beds occupied by noncolonized residents were contaminated with *C. auris*. Fungal shedding from the occupants was suggested to be a common cause of environmental contamination, with a positive relationship between residents' *C. auris* skin burden and environmental contamination. Similar findings were seen in a multi-regional study of six long-term care facilities and one acute care hospital, which showed that environmental *C. auris* contamination was common in rooms of colonized residents (29%–38%). When the study's investigators disinfected the room, recontamination of room surfaces occurred quickly (within 4–12h) and was associated with the number of patient body sites colonized with *C. auris*.³⁸

Lastly, shared medical equipment may be important vectors of transmission. During an outbreak of *C. auris* in an intensive care unit in the United Kingdom, multiple infection control measures were used including weekly screening, contact precautions, and enhanced environmental cleaning. Despite this bundle of infection control measures, the outbreak was not controlled. A case-control analysis found reusable axillary temperature probes that were shared among patients to be a risk factor for *C. auris* acquisition, and the outbreak was not controlled until the difficult-to-clean probes were removed from the unit.³⁹

Infection control

Surveillance

Surveillance plays a crucial role in guiding the public health response to *C. auris*. The World Health Organization (WHO) recognizes the limitation of data on the impact of *C. auris* in public health due to the general lack of effective surveillance across the globe.⁴⁰ Global Antimicrobial Resistance and Use Surveillance System (GLASS) was launched to standardize antimicrobial resistance surveillance in 2015.⁴¹ An early implementation protocol was developed to assist participating nations in developing national surveillance systems incorporating invasive *Candida* species.⁴² For instance, South Korea, one of the first countries to detect *C. auris* isolates, implemented Kor-GLASS in 2016.⁴³ From its nine sentinel hospitals,

one case of *C. auris* bloodstream infection was identified out of a total 766 candidemia cases in 2 years of observation.⁴⁴ A centralized, global surveillance database for *C. auris* using this system is not available at this time.

In the United States, *C. auris* has been a nationally notifiable condition since 2018, and individual states have reporting mandates.^{45,46} Clinical cases of *C. auris* reported by local and state health departments are published weekly by the National Notifiable Diseases Surveillance System (NNDSS).⁴⁷ However, because not all states of United States mandate reporting of *C. auris* cases, the NNDSS database of *C. auris* is incomplete. Figure 1 shows the number of clinical cases of *C. auris* in the United States by state in 2022. Note that some states, such as California, Florida, Illinois, New York, and Nevada, had high incidence of *C. auris* (101–500 reported cases per state in a 12 months period), whereas it was not reported in some states.⁴⁸ For the future, expansion of the current mandatory reporting protocol to all states of United States or establishing a nation-wide, centralized *C. auris* surveillance system, ideally with genomic sequencing data,

would be helpful for comprehensive surveillance and tracking of *C. auris*.

It is worthwhile to consider the ‘resistance iceberg’: for every known *C. auris*-colonized resident identified through clinical culture testing, there may be many more unknown *C. auris*-colonized residents.^{49,50} For example, in Chicago, the public health department performed a point prevalence survey of the ventilator unit of a skilled nursing facility after one resident was identified as *C. auris* colonized; an additional 28 residents were subsequently identified as colonized with *C. auris*.³¹ Active surveillance for *C. auris* among skilled nursing facility residents requires access to a laboratory that can test for the organism. In the United States, collaboration with local public health departments can facilitate access to regional public health laboratories in the Antibiotic Resistance Laboratory Network.⁵¹ Screening typically occurs *via* a composite swab from bilateral axillae and groin sites and may be targeted at skilled nursing facility residents at time of admission or as a part of an outbreak response (e.g., testing close contacts or testing an entire ward or facility).⁵²

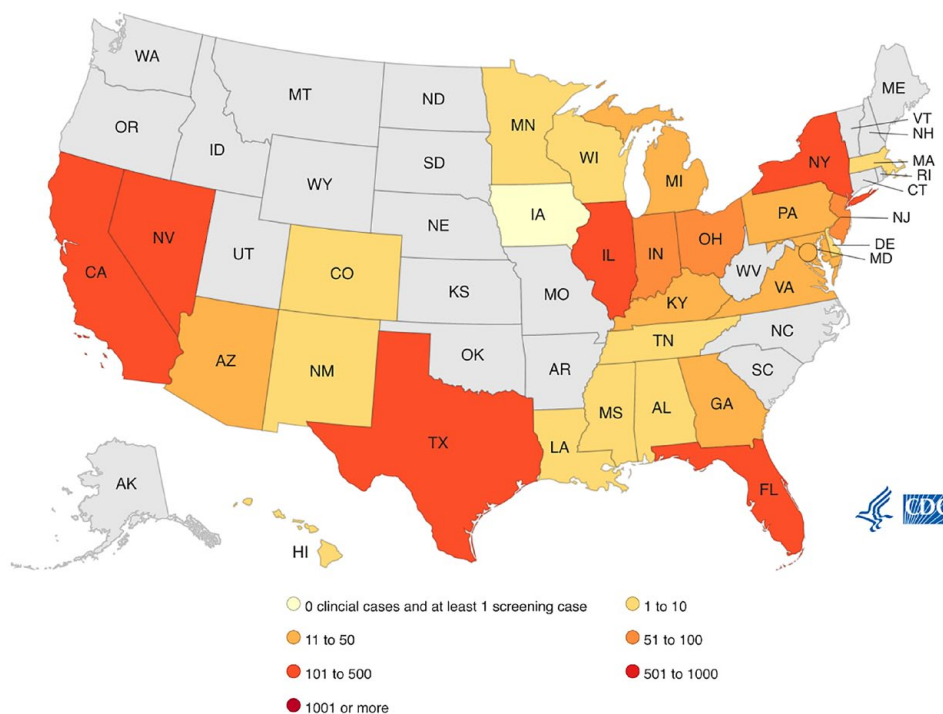


Figure 1. Reported clinical cases of *C. auris* by state in 2022.
 Source: Image courtesy of the US Centers for Disease Control and Prevention (CDC).⁴⁸

Cleaning and disinfection

The environmental control of *C. auris* is challenging, as illustrated by a study performed in four long-term care facilities and one acute care hospital.⁵³ The investigators performed targeted cleaning of high-touch surfaces in the patient room occupied by patients with confirmed multidrug-resistant organisms including *C. auris* and demonstrated recolonization of *C. auris* within 4 h of cleaning on the overbed table, handrail of the bed, and remote control. Of note, *C. auris* contamination of surfaces outside of resident rooms was much less common (1 of 120 swabs positive), suggesting that environmental contamination is primarily within patient rooms and can be contained within rooms if proper hand hygiene and gown/glove precautions are followed by staff upon exit of the room. Contamination of surfaces can be prolonged and varies by surface type; laboratory studies have shown that *C. auris* can survive at least a week on dry steel,⁵⁴ and at least 2 weeks on plastic surfaces.⁵⁵

Not all routine healthcare environmental disinfectants are active against *C. auris*, and some products with *C. albicans* or fungicidal claims may not be effective. In particular, quaternary ammonia compounds that are commonly used in the healthcare setting are not effective in controlling *C. auris*.^{56,57} Commercially available products with claims of

activity against *C. auris* are registered with the United States Environmental Protection Agency (EPA) ('List P'; see Table 1).⁵⁸ This list should be consulted when establishing local guidelines on selection of antimicrobial products and applying the product for the correct contact time. Infection control recommendations for residents in shared rooms include maintaining a minimum of three feet of separation, use of privacy curtains and high-quality environmental cleaning.⁵⁹ A negative result from environmental sampling for *C. auris* does not confirm absence of this organism and is not recommended by the US Center for Disease Control and Prevention (CDC) other than specific scenarios in which it could be useful such as investigation of an outbreak.

Implications on rehabilitation

Stringent cleaning, disinfection, and isolation requirements may significantly impact the capability to perform rehabilitation. Although literature is sparse on this subject, there have been reports of successful care in inpatient rehabilitation with patients with *C. auris*.^{60,61} In light of the risk of cross-contamination,^{6,39,62,63} physical therapy (PT) and occupational therapy (OT) were performed in the patient room. The report on inpatient rehabilitation experience in a large academic center located in New York, NY, illustrates a

Table 1. Antimicrobial products with claims to eradicate *C. auris*, registered with the EPA⁵⁸ (accessed March 28, 2023). Note that there are several commercial products with the same active ingredients. Contact time is per label instruction of each product, which may differ depending on the formulation type or the product.

Active ingredient	Type	Contact time (min)
Hydrogen peroxide and peracetic acid	Dilutable	1–3
Hydrogen peroxide, peracetic acid, and octanoic acid	Ready-to-use	4
Dodecylbenzenesulfonic acid	Ready-to-use or Wipe	1–1.25
Sodium hypochlorite	Ready-to-use or Wipe	1–3
Isopropyl alcohol and quaternary ammonium	Ready-to-use or Wipe	1–2
Hydrogen peroxide	Ready-to-use or Wipe	1–10
Quaternary ammoniums	Dilutable	10
Sodium dichloro-s-triazinetrione	Dilutable	2
Ethanol, isopropyl alcohol, and DDAC	Ready-to-use or Wipe	1
Hydrogen peroxide and peracetic acid	Dilutable	1–3

DDAC, Didecylmethylammonium chloride; EPA, Environmental Protection Agency.

patient who was hospitalized in a two-bed patient room. In the patient room, the second bed was removed to repurpose the space for private PT/OT sessions. Dedicated PT/OT equipment was used for the patient, which was also stored in the aforementioned space. Additional resources required for the prevention of in-facility spread of *C. auris*, including dedicated environmental service, staff education, private therapy sessions, and blocking a patient bed, can pose a significant burden to patient care.⁶⁰ The impact of *C. auris* on cost, efficacy, or infection prevention associated with rehabilitation in skilled nursing facilities is not well described. Strategies adopted by inpatient rehabilitation facilities for prevention of *C. auris* cross-transmission during PT and OT sessions could be adapted for skilled nursing facilities.^{60,61}

Transmission-based precautions

Because *C. auris* spreads from person to person via touch, transmission-based precautions such as Contact Precautions or Enhanced Barrier Precautions are strategies to control *C. auris* spread. The US CDC currently recommends isolation (Contact Precautions or Enhanced Barrier Precautions) in taking care of residents with *C. auris* for the duration of the residents stay at a long-term care facility.⁵⁹ Contact Precautions involve the use of gown and glove at the time of room entry for any type of in-room activity, and residents given dedicated equipment and placed in a private room (or cohorted in multi-bed rooms). Residents on Contact Precautions are restricted from leaving their rooms, except for medically necessary care, and are not allowed to participate in group activities.^{59,64} The use of Enhanced Barrier Precautions, in which gown and glove are used during high-contact activities such as dressing, bathing, wound care, or changing linens, is another option for *C. auris* control that is resident-centered and a more practical option in the skilled nursing facility setting because residents are not restricted exclusively to their rooms and can participate in group activities.⁶⁵

In addition to implementing isolation protocols, a multifaceted approach to adopt a combination of several interventions may be required to maximize effectiveness of infection control. On an individual level, each practitioner and staff member should

understand the implication of colonization and contamination by *C. auris* in patient care, practice correct use of transmission-based precautions and abide strongly by institutional infection control guidelines to limit nosocomial spread.

It is also important to understand the implications of resident isolation for other infectious diseases on the incidence of *C. auris*. An increase in *C. auris* cases in Orange County, California during 2020 and 2021 was reported among long-term acute care and skilled nursing facilities, and it was felt that these were attributable to alterations in infection control practices amid the COVID-19 pandemic such as crisis capacity strategies involving re-use or extended use of PPE, improper PPE use (double gloving), cohorting based on COVID-19 status alone, and inadequate environmental cleaning.⁶⁶

Visitors (including family members and personal aides) to the skilled nursing facility residents should abide by Contact Precautions or Enhanced Barrier Precautions at all times given the likelihood of them providing assistance with activities of daily living such as bathing or dressing. The risk of *C. auris* transmission to family members is generally believed to be low, with healthcare contact posing the highest risk of acquisition. Lastly, clear lines of communication must be in place while accepting patients or transferring residents with a *C. auris* diagnosis. This is vital to curb the chain of inter facility transmission (acute care facility to long-term care facility or vice versa, and long-term care facility to long-term care facility).

Diagnosis and treatment

Diagnosis

Use of traditional phenotypic methods for yeast identification, such as VITEK-2 YST, API 20C, BD Phoenix yeast identification system, and Microscan, can lead to misidentification of *C. auris* as erroneous species such as *C. haemulonii* or *C. parapsilosis*.⁵ There are now a variety of advanced testing platforms that can accurately identify *C. auris* from different sample types including matrix-assisted laser desorption/ionization time of flight and real-time-polymerase chain reaction.^{67,68} These newer diagnostics have sensitivities and specificities for *C. auris* reported to approach nearly 100%.⁶⁷ However, many community hospitals and laboratories are not

equipped with these advanced tests due to their high costs. In such settings, the use of differential and selective growth media has been described in the literature, which can be used in resource-limited settings before sending the specimen to a reference laboratory for confirmatory testing.⁶⁷ Differential media, which include CHROMagar Candida Plus and CandiSelect, allow for the growth of multiple fungal species with distinctive colony coloration. *C. auris* grows as white to cream colonies on CHROMagar Candida Plus supplemented with Pal's medium.⁶⁹ Selective media, such as Selective Auris Medium, are able to preferentially grow *C. auris* over other *Candida* species, with sensitivities and specificities reported to be 100%.⁷⁰ We encourage providers in skilled nursing facilities to contact their local laboratory to determine the available testing options for identifying *C. auris*. Furthermore, staff education on *C. auris* diagnostic techniques is critical at this point in time as the risk posed by this organism continues to escalate.⁷¹ Long-term care facilities in the United States are required by the Centers for Medicare & Medicaid Services to have a dedicated, on-site, trained infection preventionist (IP).⁷² IPs at long-term care facilities typically coordinate diagnostic testing and reporting with public health authorities per federal and state regulations.

Symptomatic disease and management

Due to the high mortality rates associated with invasive disease, early consideration of potential *C. auris* infection is important. Bloodstream infections, otomastoiditis, skin and wound infections, device and catheter infections, urinary tract infections, and central nervous system infections are well documented in the literature.^{3,73-77} Symptomatic disease due to *C. auris* can manifest with or without constitutional symptoms, and clinical signs can vary based on the affected organ system(s) and/or device(s). There is no distinctive feature of *C. auris* infection given its ability to infect various tissues.^{73,78,79} Given this, appropriate collection of fungal cultures from the affected site (blood, urine, ear discharge, etc.) is important to establish a definitive diagnosis. Isolation of *C. auris* at the site of symptoms (especially if this site is sterile), combined with clinical interpretation of a patient's signs and symptoms, helps with differentiation between symptomatic infection and asymptomatic colonization).⁷³ The US CDC

highly recommends an infectious disease consultation while managing *C. auris*.⁸⁰

In the United States, 85% of *C. auris* isolates are resistant to azoles, 33% to amphotericin B, and 1% to echinocandins.⁸¹ In vitro antifungal susceptibility to micafungin at low concentrations across multiple strains of *C. auris* has been demonstrated in literature.⁸² Thus, echinocandins (e.g., micafungin, caspofungin, or anidulafungin) are the empiric treatment of choice for invasive *C. auris* infections. For certain infections, liposomal amphotericin B is preferred, such as when *C. auris* is isolated from the cerebrospinal fluid and reliable concentrations of echinocandins cannot be attained in that space.⁸³

One of the difficulties that skilled nursing facilities face is the treatment of systemic infections due to *C. auris*. Echinocandins are only available in IV formulations due to large molecular weights causing poor oral bioavailabilities,⁸⁴ which may add burden to nursing staff in skilled nursing facilities related to the placement and management of IV access. From a practical perspective, development of a new generation of echinocandins with a less frequent dosing schedule (e.g., rezafungin with once weekly dosing schedule)^{85,86} is encouraging, as it may provide an easier means to manage *C. auris* infection in the skilled nursing facility setting.

New classes of antifungals are also in development. For instance, ibrexafungerp, a first-in-class triterpenoid antifungal, which works similarly to echinocandins by inhibiting (1 → 3)-β-D-glucan synthase, has demonstrated broad in vitro activity against many fungal species, including *C. auris*.⁸⁷ Efficacy and safety of oral ibrexafungerp for *C. auris* infections is currently being studied.⁸⁸ Another novel first-in-class antifungal, manogepix, has shown activity against invasive candidiasis including *C. auris* by inhibiting glycosylphosphatidylinositol-anchored protein synthesis.⁸⁹ A novel arylamide T-2307 has demonstrated in vitro and in vivo activity against *C. auris* by collapsing fungal mitochondrial membrane potential.⁹⁰ While there are novel treatment agents in the development pipeline, new antifungal agents take time to develop, and thus efforts to slow down the spread of *C. auris* remain high priority.

Asymptomatic colonization and management

Many *Candida* species are considered part of commensal organisms in the human gastrointestinal tract and other body sites such as skin and nails.^{91–93} Notably, *C. auris* appears to have a propensity to colonize on the skin.⁹¹ One study of nursing home residents investigated the relative sensitivity of screening one or more body sites for *C. auris* among nursing home residents in Chicago, where Clade IV is predominant.⁹⁴ Screening the nares alone resulted in the highest sensitivity (53%); the most-sensitive two-site combination was nares with palm/fingertips (76%), and a minimum of six body sites (nares, palm/fingertips, toe webs, perianal skin, inguinal crease, and axilla) was needed to identify all colonized residents, suggesting a wide degree of variation of body site colonization. In practice, the most commonly recommended approach to asymptomatic screening uses a composite swab of a resident's bilateral axillary and inguinal creases, sometimes with the addition of anterior nares.^{52,95} There is no consensus on decolonization protocol at this time. High-concentration chlorhexidine gluconate bathing ($\geq 625 \mu\text{g/mL}$) was shown to be effective in reducing the odds ratio of detecting *C. auris* on the skin.⁹⁴ In practice, even if chlorhexidine gluconate cannot completely eradicate *C. auris* from the skin, it may reduce skin burden and thereby prevent invasive disease. However, it is important to note that *C. auris* outbreaks have been observed in skilled nursing facilities routinely using chlorhexidine bathing.³¹

Conclusions

C. auris is a multidrug-resistant fungus that is a threat to healthcare settings worldwide.⁶ Invasive infection from *C. auris* is associated with high mortality for nursing home residents, with few available options for treatment.^{10,81} Skilled nursing facilities that care for residents requiring chronic mechanical ventilation or other highly dependent care are particularly vulnerable to *C. auris* outbreaks. As skilled nursing facilities evolve to care for a sicker resident population, *C. auris* will be an emerging threat that will demand higher attention to infection prevention and greater collaboration between healthcare facilities and public health.

Declarations

Ethics approval and consent to participate

Not applicable (review article).

Consent for publication

Not applicable (review article).

Author contributions

Philip S. Yune: Data curation; Writing – original draft; Writing – review & editing.

Jared Coe: Data curation; Writing – original draft; Writing – review & editing.

Mana Rao: Conceptualization; Data curation; Project administration; Resources; Supervision; Validation; Visualization; Writing – original draft; Writing – review & editing.

Michael Y. Lin: Conceptualization; Data curation; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Writing – original draft; Writing – review & editing.

Acknowledgements

None.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Competing interests

The authors declare that there is no conflict of interest.

Availability of data and materials

Not applicable.

ORCID iD

Mana Rao  <https://orcid.org/0000-0002-2516-2079>

References

1. Chowdhary A, Voss A and Meis JF. Multidrug-resistant *Candida auris*: 'new kid on the block' in hospital-associated infections? *J Hosp Infect* 2016; 94: 209–212.
2. Satoh K, Makimura K, Hasumi Y, *et al.* *Candida auris* sp. nov., a novel ascomycetous yeast isolated from the external ear canal of an inpatient in a Japanese hospital. *Microbiol Immunol* 2009; 53: 41–44.
3. Lee WG, Shin JH, Uh Y, *et al.* First three reported cases of nosocomial fungemia caused by *Candida auris*. *J Clin Microbiol* 2011; 49: 3139–3142.

4. 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. *MMWR Morb Mortal Wkly Rep* 2016; 65: 1234–1237.
5. The Center for Disease Control and Prevention. Identification of *Candida auris* [Internet], <https://www.cdc.gov/fungal/candida-auris/identification.html> (2022, accessed 28 March 2023).
6. Tsay S, Welsh RM, Adams EH, *et al.* Notes from the field: ongoing transmission of *Candida auris* in health care facilities - United States, June 2016–May 2017. *MMWR Morb Mortal Wkly Rep* 2017; 66: 514–515.
7. Sharma M and Chakrabarti A. On the origin of *Candida auris*: ancestor, environmental stresses, and antiseptics. *mBio* 2020; 11: e02102–e02120.
8. Muñoz JF, Gade L, Chow NA, *et al.* Genomic insights into multidrug-resistance, mating and virulence in *Candida auris* and related emerging species. *Nat Commun* 2018; 9: 5346.
9. Chatterjee S, Alampalli SV, Nageshan RK, *et al.* Draft genome of a commonly misdiagnosed multidrug resistant pathogen *Candida auris*. *BMC Genom* 2015; 16: 686.
10. Lockhart SR, Etienne KA, Vallabhaneni S, *et al.* Simultaneous emergence of multidrug-resistant *Candida auris* on 3 continents confirmed by whole-genome sequencing and epidemiological analyses. *Clin Infect Dis* 2017; 64: 134–140.
11. Du H, Bing J, Hu T, *et al.* *Candida auris*: Epidemiology, biology, antifungal resistance, and virulence. *PLoS Pathog* 2020; 16: e1008921.
12. Chow NA, de Groot T, Badali H, *et al.* Potential fifth clade of *Candida auris*, Iran, 2018. *Emerg Infect Dis* 2019; 25: 1780–1781.
13. Safari F, Madani M, Badali H, *et al.* A chronic autochthonous fifth clade case of *Candida auris* otomycosis in Iran. *Mycopathologia* 2022; 187: 121–127.
14. Abastabar M, Haghani I, Ahangarkani F, *et al.* *Candida auris* otomycosis in Iran and review of recent literature. *Mycoses* 2019; 62: 101–105.
15. Spruijtenburg B, Badali H, Abastabar M, *et al.* Confirmation of fifth *Candida auris* clade by whole genome sequencing. *Emerg Microbes Infect* 2022; 11: 2405–2411.
16. Chow NA, Muñoz JF, Gade L, *et al.* Tracing the evolutionary history and global expansion of *Candida auris* using population genomic analyses 2020; 11: e03364-19
17. Chow NA, Gade L, Tsay SV, *et al.* Multiple introductions and subsequent transmission of multidrug-resistant *Candida auris* in the USA: a molecular epidemiological survey. *Lancet Infect Dis* 2018; 18: 1377–1384.
18. Frias-De-León MG, Hernández-Castro R, Vite-Garín T, *et al.* Antifungal resistance in *Candida auris*: molecular determinants. *Antibiotics* 2020; 9: 568.
19. Szekeley A, Borman AM and Johnson EM. *Candida auris* isolates of the Southern Asian and South African lineages exhibit different phenotypic and antifungal susceptibility profiles *in vitro*. *J Clin Microbiol* 2019; 57: e02055-18.
20. Rhodes J and Fisher MC. Global epidemiology of emerging *Candida auris*. *Curr Opin Microbiol* 2019; 52: 84–89.
21. Rybak JM, Sharma C, Doorley LA, *et al.* Delineation of the direct contribution of *Candida auris* ERG11 mutations to clinical triazole resistance. *Microbiol Spectr* 2021; 9: e01585-21.
22. Larkin E, Hager C, Chandra J, *et al.* The emerging pathogen *Candida auris*: growth phenotype, virulence factors, activity of antifungals, and effect of SCY-078, a novel glucan synthesis inhibitor, on growth morphology and biofilm formation. *Antimicrob Agents Chemother* 2017; 61: e02396-16.
23. Fanning S and Mitchell AP. Fungal biofilms. *PLoS Pathog* 2012; 8: e1002585.
24. Rossato L and Colombo AL. *Candida auris*: what have we learned about its mechanisms of pathogenicity? *Front Microbiol* 2018; 9: 3081.
25. Chaabane F, Graf A, Jequier L, *et al.* Review on antifungal resistance mechanisms in the emerging pathogen *Candida auris*. *Front Microbiol* 2019; 10: 2788.
26. Sharma C, Kumar N, Pandey R, *et al.* Whole genome sequencing of emerging multidrug resistant *Candida auris* isolates in India demonstrates low genetic variation. *New Microbes New Infect* 2016; 13: 77–82.
27. Chen J, Tian S, Han X, *et al.* Is the superbug fungus really so scary? A systematic review and meta-analysis of global epidemiology and


- mortality of *Candida auris*. *BMC Infect Dis* 2020; 20: 827.
28. Rossow J, Ostrowsky B, Adams E, *et al*. Factors associated with *Candida auris* colonization and transmission in skilled nursing facilities with ventilator units, New York, 2016–2018. *Clin Infect Dis* 2021; 72: e753–e760.
 29. Southwick K, Adams EH, Greenko J, *et al*. 2039. New York State 2016–2018: progression from *Candida auris* colonization to bloodstream infection. *Open Forum Infect Dis* 2018; 5: S594–S595.
 30. Huang X, Welsh RM, Deming C, *et al*. Skin metagenomic sequence analysis of early *Candida auris* outbreaks in U.S. Nursing homes. *mSphere* 2021; 6: e00287–21.
 31. Pacilli M, Kerins JL, Clegg WJ, *et al*. Regional emergence of *Candida auris* in Chicago and lessons learned from intensive follow-up at 1 ventilator-capable skilled nursing facility. *Clin Infect Dis* 2020; 71: e718–e725.
 32. Mc Gann P, Lebreton F, Aggarwal A, *et al*. The emergence and persistence of *Candida auris* in Western New York with no epidemiologic links: a failure of stewardship? *Open Forum Infect Dis* 2023; 10: ofad123.
 33. Lyman M, Forsberg K, Reuben J, *et al*. Notes from the field: transmission of pan-resistant and echinocandin-resistant *Candida auris* in health care facilities - Texas and the District of Columbia, January–April 2021. *MMWR Morb Mortal Wkly Rep* 2021; 70: 1022–1023.
 34. Ostrowsky B, Greenko J, Adams E, *et al*. *Candida auris* isolates resistant to three classes of antifungal medications — New York, 2019. *MMWR Morb Mortal Wkly Rep* 2020; 69: 6–9.
 35. Vaseghi N, Sharifisooraki J, Khodadadi H, *et al*. Global prevalence and subgroup analyses of coronavirus disease (COVID-19) associated *Candida auris* infections (CACa): a systematic review and meta-analysis. *Mycoses* 2022; 65: 683–703.
 36. Prestel C, Anderson E, Forsberg K, *et al*. *Candida auris* outbreak in a COVID-19 Specialty Care Unit — Florida, July–August 2020. *MMWR Morb Mortal Wkly Rep* 2021; 70: 56–57.
 37. Sexton DJ, Bentz ML, Welsh RM, *et al*. Positive correlation between *Candida auris* skin-colonization burden and environmental contamination at a ventilator-capable skilled nursing facility in Chicago. *Clin Infect Dis* 2021; 73: 1142–1148.
 38. Sansom S, Gussin GM, Singh RD, *et al*. 88. Increasing bioburden of *Candida auris* body site colonization is associated with environmental contamination. *Open Forum Infect Dis* 2022; 9: ofac492.013.
 39. Eyre DW, Sheppard AE, Madder H, *et al*. A *Candida auris* outbreak and its control in an intensive care setting. *New Engl J Med* 2018; 379: 1322–1331.
 40. World Health Organization. GLASS-FUNGI: AMR surveillance of invasive fungal infection [Internet], <https://www.who.int/initiatives/glass/glass-modules-5> (2023, accessed 11 March 2023).
 41. World Health Organization. Global antimicrobial resistance and use surveillance system (GLASS) [Internet], <https://www.who.int/initiatives/glass> (2023, accessed 11 March 2023).
 42. World Health Organization. GLASS early implementation protocol for inclusion of *Candida* spp. [Internet], <https://www.who.int/publications/i/item/WHO-WSI-AMR-2019.4> (2019, accessed 11 March 2023).
 43. Korea Disease Control and Prevention Agency. Kor-GLASS [Internet], https://www.kdca.go.kr/nohas/common/monitoring/kor-glass.do?menuCt g=ctg03&menuId=menu01_2 (2022, accessed 11 March 2023).
 44. Won EJ, Choi MJ, Jeong SH, *et al*. Nationwide surveillance of antifungal resistance of *Candida* bloodstream isolates in South Korean hospitals: Two year report from Kor-glass. *J Fungi* 2022; 8: 996.
 45. The Center for Disease Control and Prevention. Reportable fungal diseases by state [Internet], <https://www.cdc.gov/fungal/fungal-disease-reporting-table.html> (2022, accessed 28 March 2023).
 46. The Center for Disease Control and Prevention. Surveillance for *Candida auris* [Internet], <https://www.cdc.gov/fungal/candida-auris/c-auris-surveillance.html> (2022, accessed 28 March 2023).
 47. The Center for Disease Control and Prevention. Nationally notifiable infectious diseases and conditions, United States: Weekly tables [Internet], https://wonder.cdc.gov/nndss/nndss_weekly_tables_menu.asp (2023, accessed 28 March 2023).
 48. The Center for Disease Control and Prevention. Tracking *Candida auris* [Internet], <https://www.cdc.gov/fungal/candida-auris/tracking-c-auris.html> (2022, accessed 28 March 2023).

49. Weinstein RA and Kabins SA. Strategies for prevention and control of multiple drug-resistant nosocomial infection. *Am J Med* 1981; 70: 449–454.
50. Cohen AL, Calfee D, Fridkin SK, *et al.* Recommendations for metrics for multidrug-resistant organisms in healthcare settings: SHEA/HICPAC position paper. *Infect Control Hosp Epidemiol* 2008; 29: 901–913.
51. The Center for Disease Control and Prevention. How to participate in CDC's AR lab network: Lab testing [Internet], <https://www.cdc.gov/drugresistance/ar-lab-networks/domestic/testing-details.html> (2021, accessed 28 March 2023).
52. The Center for Disease Control and Prevention. Screening for *Candida auris* colonization [Internet], <https://www.cdc.gov/fungal/candida-auris/c-auris-screening.html> (2020, accessed 28 March 2023).
53. Sansom SE, Gussin GM, Singh RD, *et al.* Erratum: multicenter evaluation of contamination of the healthcare environment near patients with *Candida auris* skin colonization - erratum. *Antimicrob Steward Healthc Epidemiol* 2022; 2: e166–e169.
54. Piedrahita CT, Cadnum JL, Jencson AL, *et al.* 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.
55. Welsh RM, Bentz ML, Shams A, *et al.* Survival, persistence, and isolation of the emerging multidrug-resistant pathogenic yeast *Candida auris* on a plastic health care surface. *J Clin Microbiol* 2017; 55: 2996–3005.
56. Rutala WA, Kanamori H, Gergen MF, *et al.* Susceptibility of *Candida auris* and *Candida albicans* to 21 germicides used in healthcare facilities. *Infect Control Hosp Epidemiol* 2019; 40: 380–382.
57. Sexton DJ, Welsh RM, Bentz ML, *et al.* Evaluation of nine surface disinfectants against *Candida auris* using a quantitative disk carrier method: EPA SOP-MB-35. *Infect Control Hosp Epidemiol* 2020; 41: 1219–1221.
58. The United States Environmental Protection Agency. List P: Antimicrobial products registered with EPA for claims against *Candida auris* [Internet], <https://www.epa.gov/pesticide-registration/list-p-antimicrobial-products-registered-epa-claims-against-candida-auris> (2023, accessed 28 March 2023).
59. The Center for Disease Control and Prevention. Infection prevention and control for *Candida auris* [Internet], <https://www.cdc.gov/fungal/candida-auris/c-auris-infection-control.html> (2023, accessed 28 March 2023).
60. Walits E, Patel G, Lavache S, *et al.* Management of *Candida auris* in an inpatient acute rehabilitation setting. *Am J Infect Control* 2020; 48: 222–223.
61. Reimer-McAtee M, Corsi G, Reed E, *et al.* Successful implementation of the CDC recommendations during the care of 2 patients with *Candida auris* in in-patient rehabilitation and intensive care settings. *Am J Infect Control* 2021; 49: 525–527.
62. Ruiz-Gaitán A, Moret AM, Tasiás-Pitarch M, *et al.* An outbreak due to *Candida auris* with prolonged colonisation and candidaemia in a tertiary care European hospital. *Mycoses* 2018; 61: 498–505.
63. Adams E, Quinn M, Tsay S, *et al.* *Candida auris* in healthcare facilities, New York, USA, 2013–2017. *Emerg Infect Dis* 2018; 24: 1816–1824.
64. Sathyapalan DT, Antony R, Nampoothiri V, *et al.* Evaluating the measures taken to contain a *Candida auris* outbreak in a tertiary care hospital in South India: an outbreak investigational study. *BMC Infect Dis* 2021; 21: 425.
65. The Center for Disease Control and Prevention. Implementation of personal protective equipment (PPE) use in nursing homes to prevent Spread of multidrug-resistant organisms (MDROs) [Internet], <https://www.cdc.gov/hai/containment/PPE-Nursing-Homes.html> (2023, accessed 28 March 2023).
66. Mitsunaga T, Holden D, Karmarkar E, *et al.* 169. The resurgence of *Candida auris* in California during the novel Coronavirus (COVID-19) pandemic, May 2020–May 2021. *Open Forum Infect Dis* 2021; 8: S101–S102.
67. Dennis EK, Chaturvedi S and Chaturvedi V. So many diagnostic tests, so little time: review and preview of *Candida auris* testing in clinical and public health laboratories. *Front Microbiol* 2021; 12: 757835.
68. Girard V, Mailler S, Chetry M, *et al.* Identification and typing of the emerging pathogen *Candida auris* by matrix-assisted laser desorption ionisation time of flight mass spectrometry. *Mycoses* 2016; 59: 535–538.

69. Kumar A, Sachu A, Mohan K, *et al.* Simple low cost differentiation of *Candida auris* from *Candida haemulonii* complex using CHROMagar *Candida* medium supplemented with Pal's medium. *Revista iberoamericana de micologia* 2017; 34: 109–111.
70. Das S, Singh S, Tawde Y, *et al.* A selective medium for isolation and detection of *Candida auris*, an emerging pathogen. *J Clin Microbiol* 2021; 59: e00326–NaN20.
71. The Center for Disease Control and Prevention. Increasing threat of spread of antimicrobial-resistant fungus in healthcare facilities [Internet], <https://www.cdc.gov/media/releases/2023/p0320-cauris.html> (2023, accessed 28 March 2023).
72. Centers for Medicare & Medicaid Services. Updated guidance for nursing home resident health and safety [Internet], <https://www.cms.gov/newsroom/fact-sheets/updated-guidance-nursing-home-resident-health-and-safety> (2022, accessed 28 March 2023).
73. Cortegiani A, Misseri G, Fasciana T, *et al.* Epidemiology, clinical characteristics, resistance, and treatment of infections by *Candida auris*. *J Intensive Care* 2018; 6: 69.
74. Choi HI, An J, Hwang JJ, *et al.* Otomastoiditis caused by *Candida auris*: case report and literature review. *Mycoses* 2017; 60: 488–492.
75. Anwar S, Glaser A, Acharya S, *et al.* *Candida auris*-an impending threat: a case report from home. *Am J Infect Control* 2020; 48: 1407–1408.
76. Singhal T, Kumar A, Borade P, *et al.* Successful treatment of *C. auris* shunt infection with intraventricular caspofungin. *Med Mycol Case Rep* 2018; 22: 35–37.
77. Mohsin J, Weerakoon S, Ahmed S, *et al.* A cluster of *Candida auris* blood stream infections in a tertiary care hospital in Oman from 2016 to 2019. *Antibiotics* 2020; 9: 638.
78. Ku TSN, Walraven CJ and Lee SA. *Candida auris*: disinfectants and implications for infection control. *Front Microbiol* 2018; 9: 726.
79. Lone SA and Ahmad A. *Candida auris*—the growing menace to global health. *Mycoses* 2019; 62: 620–637.
80. The Center for Disease Control and Prevention. Treatment and management of *C. auris* infections and colonization [Internet], <https://www.cdc.gov/fungal/candida-auris/c-auris-treatment.html> (2022, accessed 28 March 2023).
81. Forsberg K, Lyman M, Chaturvedi S, *et al.* 155. Public health action-based system for tracking and responding to U.S. *Candida* drug resistance: AR Lab Network, 2016–2019. *Open Forum Infect Dis* 2020; 7: S206–S207.
82. Lepak AJ, Zhao M, Berkow EL, *et al.* Pharmacodynamic optimization for treatment of invasive *Candida auris* infection. *Antimicrob Agents Chemother* 2017; 61: e00791-17.
83. Marx J, Welte R, Gasperetti T, *et al.* Anidulafungin and micafungin concentrations in cerebrospinal fluid and in cerebral cortex. *Antimicrob Agents Chemother* 2020; 64: e00275-20.
84. Kofla G and Ruhnke M. Pharmacology and metabolism of anidulafungin, caspofungin and micafungin in the treatment of invasive candidosis: review of the literature. *Eur J Med Res* 2011; 16: 159–166.
85. Ham YY, Lewis JS and Thompson Gr. Rezafungin: a novel antifungal for the treatment of invasive candidiasis. *Future Microbiol* 2021; 16: 27–36.
86. Mroczyńska M and Brillowska-Dąbrowska A. Review on current status of echinocandins use. *Antibiotics* 2020; 9: 227.
87. Ghannoum M, Arendrup MC, Chaturvedi VP, *et al.* Ibrexafungerp: a novel oral triterpenoid antifungal in development for the treatment of *Candida auris* infections. *Antibiotics* 2020; 9: 539.
88. The United States National Library of Medicine. Open-label study to evaluate the efficacy and safety of oral ibrexafungerp (SCY-078) in patients with candidiasis caused by *Candida auris* (CARES) [Internet], <https://clinicaltrials.gov/ct2/show/NCT03363841> (2017, accessed 28 March 2023).
89. Arendrup MC, Chowdhary A, Jørgensen KM, *et al.* Manogepix (APX001A) *in vitro* activity against *Candida auris*: Head-to-head comparison of EUCAST and CLSI MICs. *Antimicrob Agents Chemother* 2020; 64: e00656-20.
90. Wiederhold NP, Najvar LK, Jaramillo R, *et al.* The novel arylamidine T-2307 demonstrates *in vitro* and *in vivo* activity against *Candida auris*. *Antimicrob Agents Chemother* 2020; 64: e02198-19.
91. Forsberg K, Woodworth K, Walters M, *et al.* Erratum: *Candida auris*: the recent emergence of

- a multidrug-resistant fungal pathogen. *Med Mycol* 2019; 57: e7–e12.
92. Yang YL, Leaw SN, Wang AH, *et al.* Characterization of yeasts colonizing in healthy individuals. *Med Mycol* 2011; 49: 103–106.
93. Richardson MD and Warnock DW. *Fungal infection: diagnosis and management*. 4th ed. New York: John Wiley & Sons, 2012.
94. Proctor DM, Dangana T, Sexton DJ, *et al.* Integrated genomic, epidemiologic investigation of *Candida auris* skin colonization in a skilled nursing facility. *Nat Med* 2021; 27: 1401–1409.
95. Tsay S, Kallen A, Jackson BR, *et al.* Approach to the investigation and management of patients with *Candida auris*, an emerging multidrug-resistant yeast. *Clin Infect Dis* 2018; 66: 306–311.

Visit Sage journals online
[journals.sagepub.com/
home/tai](https://journals.sagepub.com/home/tai)

 Sage journals