Journal of Communicable Diseases
Volume 57, Issue 2 - 2025, Pg. No. 192-201
Peer Reviewed & Open Access Journal

Review Article

The Enigma of *Candida auris*: A Review on Transmission, Outbreaks, and Infection Control

Sathyakamala Ravichandran[1], Mohankumar Appadurai[2], Priyadarshini Shanmugam[3]

[1]Senior Resident, Department of Microbiology, Pt Madan Mohan Malaviya Hospital, Malviya Nagar, New Delhi, India
[2]Research Scholar, [3]Professor & Head, Department of Microbiology, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education (CARE), Kelambakkam, Tamil Nadu, India
DOI: https://doi.org/10.24321/0019.5138.202555

I N F O

Corresponding Author:
Priyadarshini Shanmugam, Department of Microbiology, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education (CARE), Kelambakkam, Tamil Nadu, India
E-mail Id:
priyadarshini0018@gmail.com
Orcid Id:
https://orcid.org/0000-0003-4382-562X
How to cite this article:
Ravichandran S, Appadurai M, Shanmugam P. The Enigma of Candida auris: A Review on Transmission, Outbreaks, and Infection Control. J Commun Dis. 2025;57(2):192-201.

Date of Submission: 2025-01-24
Date of Acceptance: 2025-04-12

A B S T R A C T

Candida auris (*C. auris*) is a species of pathogenic yeast that has emerged as a global health threat in recent years. It was first identified in 2009 in Japan but has since been reported in more than 40 countries worldwide, with an increasing number of cases and outbreaks. Infections caused by *Candida auris* are linked to significant mortality rates, particularly in vulnerable populations, such as immunocompromised patients and those in healthcare settings. It's concerning as it's resistant to multiple classes of antifungal drugs, complicating treatment. The exact modes of transmission of *Candida auris* are still not entirely understood, but it can spread through contact with contaminated surfaces, healthcare workers, or other patients. Control measures, such as strict adherence to infection control practices, including hand hygiene, environmental cleaning, and appropriate use of antifungal agents, are essential to control and prevent outbreaks. There is a need for continued surveillance and research to understand the epidemiology, pathogenesis, and optimal treatment of *Candida auris* infections and to develop new strategies for preventing and controlling its spread. The emergence of *Candida auris* as a multidrug-resistant fungal pathogen has posed significant challenges to healthcare systems worldwide. This review describes a comprehensive analysis of the epidemiology, pathogenesis, and diagnostic challenges associated with *C. auris* infections. Furthermore, it explores the mechanisms of antifungal resistance exhibited by this pathogen and discusses current treatment options and infection control measures. Finally, the study outlines future directions for research and intervention strategies to mitigate the spread and impact of *C. auris* outbreaks.

Keywords: *Candida auris*, Bloodstream Infections, Hand Hygiene, Phenotypic Variability

Introduction

Candida auris is a rare but dangerous fungal pathogen that has become increasingly prevalent in healthcare settings worldwide in recent years.[1] Initially discovered in 2009 in Japan, *C. auris* has since been identified in over 40 countries on six continents, causing outbreaks and fatalities in hospitals, long-term care facilities, and other healthcare settings.[2] The fungus is often resistant to multiple antifungal drugs, making it difficult to treat, and it has a high mortality rate. *C. auris* infections can present in various ways, including urinary tract infections, bloodstream infections, wound infections, and ear infections. Patients with *C. auris* infections may experience fever, chills, and fatigue, as well as symptoms specific to the site of infection. In some cases, patients may be asymptomatic carriers of the fungus, making it difficult to identify and control outbreaks.[3] Despite efforts to contain its spread, the adaptability and resilience of *C. auris* continue to pose formidable challenges to healthcare systems worldwide. This review addresses the diagnostic challenges associated with identifying *C. auris* infections, particularly in resource-limited settings where laboratory infrastructure may be inadequate. Additionally, it delves into the underlying mechanisms of antifungal resistance exhibited by this pathogen, shedding light on potential targets for future drug development. Current treatment options, including antifungal agents and combination therapies, are evaluated considering their efficacy and limitations. Furthermore, infection control measures, like strict adherence to environmental decontamination, hand hygiene protocol, and patient isolation strategies, are discussed to mitigate the transmission risk within healthcare settings. The synthesis of these insights aims to inform clinical practice and guide public health efforts in combating *C. auris* spread and minimising its impact on vulnerable patient populations.

Materials and Methods

A thorough search was carried out in major global databases like Scopus, Web of Science, Medline (PubMed), and EMBASE to collect all relevant articles offering up-to-date information on *Candida auris*, including its epidemiology, pathogenesis, diagnostic challenges, resistance mechanisms, treatment options, infection control measures, and its future directions. We focused on studies published between 2009 and 2024, limiting the language to English. The search included keywords such as "*Candida auris*", "bloodstream infections", "hand hygiene", and "phenotypic variability".

Epidemiology

C. auris has been isolated from various anatomical sites of individuals across numerous nations spanning six continents. Incidence and colonisation are predominantly observed among critically ill patients, impacting both paediatric and adult demographics. Reports of patients harbouring *C. auris* now span the globe, encompassing regions such as India, Kuwait, South Korea, Pakistan, Oman, Israel, South Africa, the United States, Europe, Canada, Norway, Spain, and Germany.[4] Infections attributable to *Candida auris* present formidable treatment challenges, with mortality rates ranging from 30% to 60% in various investigations. Contributing to the risk of *C. auris* infection are factors such as recent hospitalisation, prior exposure to broad-spectrum antibiotics, and immunocompromised states. While predominantly a nosocomial pathogen, *C. auris* has also manifested in community-acquired infections, broadening its impact beyond healthcare facilities. Transmission within healthcare settings is facilitated by person-to-person contact, while its persistence on environmental surfaces further complicates containment efforts. Identifying *C. auris* in clinical settings poses a significant challenge, necessitating specialised laboratory testing for accurate diagnosis.[5]

Pathogenesis

Candida auris can cause serious infections in humans, particularly in immunocompromised individuals or those patients with underlying medical conditions. The pathogenesis of *C. auris* involves a complex interplay between the host immune system, the microbe, and environmental factors.[6] The first step in infection by *C. auris* is colonisation of the skin or mucous membranes. *C. auris* can form biofilms on surfaces, which can help it adhere to the skin or other surfaces.[7] Once it has colonised the skin, it can invade deeper tissues and cause infection. The ability to colonise and to invade tissues is partially due to its ability to switch between different morphological forms, that is, between yeast-like and hyphal forms, which enables effective tissue penetration.[8] Once *C. auris* has colonised a host, it can lead to a variety of infections, including urinary tract infections, bloodstream infections, and wound infections.[9] The virulence of *C. auris* is due to a variety of factors, including the secretion of hydrolytic enzymes such as lipases and proteases, which can damage host tissues and aid in the invasion of the organism. *C. auris* also can form biofilms, which can protect it from the host immune system and antimicrobial agents.[10] The immune response to *C. auris* is complex and multifaceted. In general, the host immune system responds to *C. auris* by activating both immune responses (innate and adaptive).[11] The activation of immune cells like macrophages and neutrophils is a key part of the innate immune response, which can phagocytose and kill the yeast. The activation of B cells and T cells, which produce antibodies to target the yeast, is a crucial aspect of the adaptive immune response.[12] However, *C. auris* has several mechanisms by which it can evade the host immune response. For example, *C. auris* can produce a capsule that can help it avoid phagocytosis

ISSN: 0019-5138
DOI: https://doi.org/

by immune cells.[13] Environmental factors can also play a role in the pathogenesis of *C. auris*. *C. auris* is resistant to many commonly used antifungal agents, which can make it difficult to treat infections. Additionally, *C. auris* can survive in hospital environments for extended periods, which can lead to outbreaks of infections.[14] Its ability to persist in the environment is due, in part, to its ability to form biofilms on surfaces.[14,15]

Diagnostic Challenges

Over the last decade, *C. auris*, a multi-drug-resistant yeast, has surfaced as a significant worldwide health concern. It poses a serious risk to public health, especially among hospitalised individuals with preexisting conditions, leading to severe infections and alarmingly high death rates.[16] The diagnostic challenges of *C. auris* arise from its variability in both phenotype and genotype, coupled with the absence of reliable diagnostic tools. Difficulty in differentiating it from other *Candida species* further complicates accurate identification. Addressing these challenges necessitates improved methodologies tailored to the unique characteristics of *C. auris*.[17]

Phenotypic Variability

Candida auris has a wide range of phenotypic characteristics, which vary depending on the growth medium, temperature, and other environmental factors.[18] This variability makes it difficult to identify the organism using traditional microbiological methods, such as culture and biochemical tests.[19] Additionally, *C. auris* is often misidentified by automated systems such as VITEK as other Candida species, such as *Candida famata*, *Candida sake*, and *Candida haemulonii*, which can lead to inappropriate treatment.[19,20]

Genotypic Variability

Candida auris exhibits genetic diversity, characterised by various clades and subclades, impacting its susceptibility to antifungal drugs and virulence.[21] Nevertheless, existing molecular typing methods lack standardisation, and there is no consensus on the optimal approach for identifying distinct clades and subclades of *C. auris*. This highlights the urgent need for standardised protocols to enhance the accurate characterisation and management of this pathogen.[22,23]

Lack of Reliable Diagnostic Tools

The current gold standard for diagnosing *C. auris* is culture-based identification using chromogenic agar. However, this method is time-consuming and requires expertise.[24]

Moreover, chromogenic agar has limited sensitivity and specificity, particularly for detecting atypical strains of *C. auris*.[24,25] Additionally, serological tests and antigen detection tests have been developed for the diagnosis of *C. auris*, but their accuracy is still under evaluation.[26]

Differentiating from other Candida Species

C. auris exhibits phenotypic and genotypic similarities to other Candida species like *Candida haemulonii*, *Candida famata*, and *Candida sake*, leading to frequent misidentification and posing challenges for accurate diagnosis.[19] Additionally, the potential for co-colonisation with other *Candida species* further complicates the diagnostic process and subsequent treatment decisions, highlighting the need for enhanced diagnostic methodologies to differentiate and manage these infections effectively.[19,27]

Resistance Mechanisms of C.auris

An emerging fungal pathogen is *Candida auris*, particularly in hospitals, where it poses a threat to immunocompromised patients. Its resistance to common antifungal drugs complicates treatment significantly, often requiring alternative therapies. The development of multidrug resistance further limits the options for treatment and increases the risk of treatment failure. Effective containment measures and surveillance are crucial to mitigate its impact on patient outcomes and healthcare systems.[28]

A key mechanism of resistance in *Candida auris* involves mutations in genes responsible for encoding the target proteins of antifungal drugs.[29] Mutations in the ERG11 gene of *Candida auris*, which encodes lanosterol 14-alpha-demethylase, play a pivotal role in antifungal resistance. These genetic alterations lead to significant structural changes in the target protein, hampering the binding affinity of azole antifungal drugs.[30] Consequently, the efficacy of these drugs is compromised, rendering traditional treatment approaches less effective against this pathogen. Understanding the molecular mechanisms of these mutations is crucial for the novel therapeutic strategies' development to combat this challenging pathogen.[31,32]

Another significant mechanism of resistance in *Candida auris* involves the overexpression of efflux pumps, integral membrane proteins responsible for expelling antifungal drugs from the cell. *Candida auris* has been observed to upregulate multiple efflux pumps, including CDR1, CDR2, and MDR1, which actively pump out various antifungal agents, thereby conferring resistance to these drugs.[33] This heightened efflux activity diminishes the intracellular concentration of antifungal agents, reducing their effectiveness against *Candida auris* infections. Understanding and targeting these efflux mechanisms are crucial for developing effective therapeutic strategies against this resilient pathogen.[34]

In addition to mutations and efflux pumps, *Candida auris* can also develop resistance through changes in the cell wall structure.[33] The cell wall is an important component of the fungal cell, and it maintains the shape and integrity of the cell. Changes in the cell wall structure can make it

ISSN: 0019-5138
DOI: https://doi.org/

more difficult for antifungal drugs to penetrate the cell and reach their target.[35,36] *Candida auris* has been found to have thicker cell walls compared to other Candida species, which may contribute to its resistance to antifungal drugs.[36]

Finally, *Candida auris* can also acquire resistance through horizontal gene transfer by several mechanisms, including plasmids, transposons, and integrons. Through horizontal gene transfer, *Candida auris* can acquire genes that encode resistance to antifungal drugs, allowing it to become resistant to drugs that it may not have been able to resist before.[37,38]

Treatment Options

The treatment of *Candida auris* infections can be challenging due to its resistance to multiple antifungal drugs. However, several treatment options are available, and the choice of therapy depends on various factors such as the severity of the infection, patient characteristics, and drug susceptibility testing.[39-42]

Antifungal therapy is the primary treatment for *Candida auris* infections, and the drugs commonly used include echinocandins, azoles, and polyenes.[41-44]

- **Echinocandins:** they are a class of antifungal drugs that inhibit the β-glucan synthesis in the cell wall of fungus, which is essential for its structural integrity. They are the first-line agents for the treatment of *Candida auris* infections. 3 main echinocandins, micafungin, caspofungin, and anidulafungin, are currently being used for clinical treatment.[45]
- **Azoles:** Azoles are another antifungal class of drugs that target the cell membrane of fungi by inhibiting ergosterol synthesis. They are available in both oral and intravenous forms and are generally well tolerated. Azoles such as fluconazole, voriconazole and isavuconazole are used for the treatment of *Candida auris* infections.[45,46]
- **Polyenes:** Polyenes, such as amphotericin B, are antifungal drugs that bind to ergosterol, a component of the fungal cell membrane, and form pores, leading to cell death. They are generally reserved for severe infections due to their toxicity and are often used in combination with other antifungal agents.[46]

Drug resistance is a significant concern in the treatment of *Candida auris* infections. The fungus can develop resistance to antifungal drugs through several mechanisms, such as mutations in drug target genes, overexpression of efflux pumps, and alterations in the cell wall. Therefore, drug susceptibility testing is essential to guide the choice of antifungal therapy.[47-49]

Combination therapy with multiple antifungal agents may be necessary in some cases, particularly in severe infections or in patients with compromised immune systems. Combination therapy may increase the effectiveness of treatment and reduce the development of drug resistance.[50,51] non-pharmacological measures such as infection control and prevention measures are also essential in the management of *Candida auris* infections. These measures include rigorous hand hygiene, environmental cleaning and disinfection, and isolation precautions for infected patients.[52-54] Early diagnosis and prompt initiation of appropriate therapy are crucial in improving patient outcomes and reducing the spread of the fungus.[54]

Infection Control Measures

Candida auris can survive on environmental surfaces for long periods, making it difficult to control. Some important considerations are:

- **Surveillance:** Hospitals should have a system in place for detecting the presence of *C. auris*. All patients should be screened for the fungus, especially those who have been hospitalised in countries where the fungus is endemic.[55,56]
- **Isolation:** Patients who tested positive should be isolated in a private room with negative pressure. Wear appropriate personal protective equipment (PPE) for those healthcare workers entering the room.
- **Hand hygiene:** To control this spread, maintaining hand hygiene is essential. Healthcare workers should use soap to wash their hands and water or use alcohol-based hand sanitisers while caring for patients with *C. auris* (both before and after). They should also avoid wearing jewellery or watches and keep their nails short and clean.
- **Environmental cleaning:** Environmental cleaning is crucial to control this spread. All surfaces in the patient's room should be cleaned and disinfected regularly with an appropriate disinfectant. This includes bedrails, bedside tables, and medical equipment. Healthcare workers should wear gloves and other appropriate PPE when cleaning the room.[57]
- **Cohorting strategy:** This strategy is used to group patients with the same infection together. Patients with *C. auris* should be cohorted to prevent the spread of the fungus to other patients.
- **Antifungal stewardship:** Antifungal stewardship is the responsible use of antifungal drugs to prevent the development of resistance. Hospitals should have a program in place to monitor the use of antifungal drugs and ensure that they are used appropriately.[58]
- **Education and training:** This is critical in preventing the spread of *C. auris*. Healthcare workers should be educated on the risks associated with *C. auris* and how to prevent its spread. They should also receive training on the appropriate use of PPE and how to clean and disinfect patient rooms.

ISSN: 0019-5138
DOI: https://doi.org/

- **Communication is essential to control the spread of *C. auris*:** Hospitals should have a system in place for communicating the presence of *C. auris* to other facilities of healthcare workers to prevent the spread of the fungus.[59]
- **Screening and decolonisation of patients who have been exposed to *C. auris*:** This is an effective strategy in preventing the spread of the fungus. Patients who have been exposed should be screened for the fungus, and those who test positive should be decolonised.
- **Patient education:** This is critical in preventing the *C. auris* spread, and they should be educated on the risk factors associated with the pathogen and how to prevent its spread. They should also be encouraged to speak up if they see healthcare workers not following infection control measures.[60,61]

Surveillance, isolation, hand hygiene, environmental cleaning, cohorting, antifungal stewardship, education and training, communication, screening and decolonisation, and patient and family education are all essential in controlling the spread of *C. auris*. Healthcare facilities should have a comprehensive programme in place to prevent the spread of this potentially deadly fungus.

Future Directions

As a relatively new pathogen, much is unknown about the future directions of *Candida auris*. However, based on current research and trends, we can make some predictions about what may lie ahead.[62-64]

Increased Incidence and Geographic Spread

Candida auris has already shown a remarkable ability to spread geographically, and it is likely to do so in the future.[65] The fungus has been reported in more than 40 countries, and it has caused outbreaks in multiple regions. As it spreads, the incidence of *Candida auris* infections is likely to increase.[66,67] Healthcare facilities that have experienced outbreaks in the past are at higher risk of future outbreaks, and new regions may also experience outbreaks as the fungus continues to spread.[68]

Further Evolution and Adaptation

Like many microbes, *Candida auris* has the potential to evolve and adapt over time. This may involve the acquisition of new resistance mechanisms or the development of new virulence factors that allow the fungus to colonise and infect its hosts better. Some researchers have suggested that *Candida auris* may be able to switch from a commensal organism (one that lives harmlessly on the skin or in the gut) to a pathogen more easily than other Candida species, which could contribute to its virulence.[69-71]

Emergence of New Clones

Candida auris is not a single organism but rather a group of closely related strains. New strains of the fungus may emerge over time, each with its unique characteristics. Some researchers have already identified distinct clusters of *Candida auris* strains with different geographic and temporal origins, suggesting that the fungus is evolving along different trajectories in different parts of the world. This may have implications for diagnosis and treatment, as different strains may vary in their response to antifungal therapy.[72-74]

Impact on Vulnerable Populations

Candida auris infections are often associated with vulnerable populations, including those with weakened immune systems and those in long-term care facilities. As the incidence of these infections increases, these populations may be at even greater risk. Additionally, some researchers have suggested that *Candida auris* may be more virulent than other Candida species, which could increase the severity of infections in vulnerable populations.[74]

Need for New Treatment Modalities

The multidrug-resistant nature of *Candida auris* has made it difficult to treat with existing antifungal drugs. As the fungus continues to evolve and adapt, it may become even more resistant to current antifungals. This emphasises the crucial need for the development of newer antifungal agents effective against *Candida auris* and multidrug-resistant fungi.[75]

Improved Surveillance and Control Measures

Given its potential for rapid spread and ability to cause outbreaks, surveillance and control measures are very critical in preventing its spread. This involves enhanced screening of patients in healthcare facilities, improved infection control practices, and the development of new diagnostic tools that can quickly identify *Candida auris*.[76] Additionally, researchers may need to investigate the environmental reservoirs of the fungus to understand its spread and identify ways to prevent its transmission.[77]

While much is still unknown about the future directions of this fungus, it is likely to continue to spread geographically, evolve and adapt over time, impact vulnerable populations, and drive the need for new treatments, improved surveillance, and control measures. As researchers and public health officials continue to study *Candida auris*, it will be critical to stay vigilant and proactive in efforts to contain its spread and mitigate its impact.[78,79,80]

Conclusion

In conclusion, *Candida auris* has emerged as a significant global public health concern, with reported cases spanning over 40 countries and escalating numbers. This fungus is implicated in outbreaks within healthcare facilities, correlating with elevated mortality rates. Its ability to resist multiple classes of antifungal drugs, facilitated by

ISSN: 0019-5138
DOI: https://doi.org/

the formation of protective biofilms and prolonged surface survival, presents formidable challenges for treatment and infection management. The lack of standardised laboratory methods for identifying *Candida auris* complicates timely diagnosis and treatment initiation, potentially leading to misidentification and underestimation of its prevalence. Additionally, limited availability and increasing resistance to effective antifungal medications exacerbate treatment complexities. A comprehensive approach to prevention and control necessitates stringent infection control measures, surveillance efforts, and dedicated research endeavours. Enhanced understanding of *Candida auris* epidemiology, biology, and resistance mechanisms, alongside the development of innovative treatment and diagnostic modalities, is imperative.

In summary, addressing the evolving threat of *Candida auris* demands a collaborative and multidisciplinary response. Vigilant surveillance, ongoing research initiatives, and implementation of effective prevention and control strategies are paramount in mitigating its impact on global public health.

Conflict of Interest: None

Source of Funding: None

Author's Contribution: The study was conceptualized by SR and PS Methodology, formal analysis, and investigation were carried out by SR and PS The original draft of the manuscript was prepared by SR Review and editing were conducted by MA and PS Overall supervision was provided by PS.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process: None

References

1. Thatchanamoorthy N, Rukumani Devi V, Chandramathi S, Tay ST. *Candida auris*: A mini review on epidemiology in healthcare facilities in Asia. Journal of Fungi. 2022 Oct 26;8(11):1126. [Google Scholar] [Pubmed]
2. Chowdhary A, Sharma C, Meis JF. *Candida auris*: a rapidly emerging cause of hospital-acquired multidrug-resistant fungal infections globally. PLOS pathogens. 2017 May 18;13(5):e1006290. [Google Scholar] [Pubmed]
3. Kordalewska M, Zhao Y, Lockhart SR, Chowdhary A, Berrio I, Perlin DS. Rapid and accurate molecular identification of the emerging multidrug-resistant pathogen *Candida auris*. Journal of clinical microbiology. 2017 Aug;55(8):2445-52. [Google Scholar] [Pubmed]
4. Jeffery-Smith A, Taori SK, Schelenz S, Jeffery K, Johnson EM, Borman A, *Candida auris* Incident Management Team, Manuel R, Brown CS. *Candida auris*: a review of the literature. Clinical microbiology reviews. 2018 Jan;31(1):10-128. [Google Scholar] [Pubmed]
5. Papon N, Courdavault V, Clastre M, Bennett RJ. Emerging and emerged pathogenic Candida species: beyond the Candida albicans paradigm. PLoS pathogens. 2013 Sep 26;9(9):e1003550. [Google Scholar] [Pubmed]
6. Lee WG, Shin JH, Uh Y, Kang MG, Kim SH, Park KH, Jang HC. First three reported cases of nosocomial fungemia caused by *Candida auris*. Journal of clinical microbiology. 2011 Sep;49(9):3139-42. [Google Scholar] [Pubmed]
7. Newton PJ, Harris C, Morris J, Denning DW. Impact of liposomal amphotericin B therapy on chronic pulmonary aspergillosis. Journal of Infection. 2016 Nov 1;73(5):485-95. [Google Scholar] [Pubmed]
8. Satoh K, Makimura K, Hasumi Y, Nishiyama Y, Uchida K, Yamaguchi H. *Candida auris* sp. nov., a novel ascomycetous yeast isolated from the external ear canal of an inpatient in a Japanese hospital. Microbiology and immunology. 2009 Jan;53(1):41-4. [Google Scholar] [Pubmed]
9. Schelenz S, Hagen F, Rhodes JL, Abdolrasouli A, Chowdhary A, Hall A, Ryan L, Shackleton J, Trimlett R, Meis JF, Armstrong-James D. First hospital outbreak of the globally emerging *Candida auris* in a European hospital. Antimicrobial Resistance & Infection Control. 2016 Dec;5:1-7. [Google Scholar] [Pubmed]
10. Chow NA, Gade L, Tsay SV, Forsberg K, Greenko JA, Southwick KL, Barrett PM, Kerins JL, Lockhart SR, Chiller TM, Litvintseva AP. Multiple introductions and subsequent transmission of multidrug-resistant *Candida auris* in the USA: a molecular epidemiological survey. The Lancet Infectious Diseases. 2018 Dec 1;18(12):1377-84. [Google Scholar] [Pubmed]
11. Du H, Bing J, Hu T, Ennis CL, Nobile CJ, Huang G. *Candida auris*: Epidemiology, biology, antifungal resistance, and virulence. PLoS pathogens. 2020 Oct 22;16(10):e1008921. [Google Scholar] [Pubmed]
12. Lee J, Kim W, Choi YJ, Lee S, Park H, Kim SH, et al. The type VI secretion system of Pseudomonas aeruginosa targets a toxin to bacteria. PLoS Pathog. 2020 Sep;16(9):e1008921. doi:10.1371/journal.ppat.1008921.
13. Lyman M, Forsberg K, Sexton DJ, Chow NA, Lockhart SR, Jackson BR, Chiller T. Worsening spread of *Candida auris* in the United States, 2019 to 2021. Annals of internal medicine. 2023 Apr;176(4):489-95. [Google Scholar] [Pubmed]
14. Chowdhary A, Prakash A, Sharma C, Kordalewska M, Kumar A, Sarma S, Tarai B, Singh A, Upadhyaya G, Upadhyay S, Yadav P. A multicentre study of antifungal susceptibility patterns among 350 *Candida auris* isolates (2009–17) in India: role of the ERG11 and FKS1 genes in azole and echinocandin resistance. Journal of Antimicrobial Chemotherapy. 2018 Apr 1;73(4):891-9. [Google Scholar] [Pubmed]

15. Rhodes J, Abdolrasouli A, Farrer RA, Cuomo CA, Aanensen DM, Armstrong-James D, Fisher MC, Schelenz S. Genomic epidemiology of the UK outbreak of the emerging human fungal pathogen *Candida auris*. Emerging microbes & infections. 2018 Dec 1;7(1):1-2. [Google Scholar] [Pubmed]
16. Schelenz S, Hagen F, Rhodes JL, Abdolrasouli A, Chowdhary A, Hall A, Ryan L, Shackleton J, Trimlett R, Meis JF, Armstrong-James D. First hospital outbreak of the globally emerging *Candida auris* in a European hospital. Antimicrobial Resistance & Infection Control. 2016 Dec;5:1-7. [Google Scholar] [Pubmed]
17. Zhu Y, O'Brien B, Leach L, Clarke A, Bates M, Adams E, Ostrowsky B, Quinn M, Dufort E, Southwick K, Erazo R. Laboratory analysis of an outbreak of *Candida auris* in New York from 2016 to 2018: impact and lessons learned. Journal of clinical microbiology. 2020 Mar 25;58(4):10-128. [Google Scholar] [Pubmed]
18. Larkin E, Hager C, Chandra J, Mukherjee PK, Retuerto M, Salem I, Long L, Isham N, Kovanda L, Borroto-Esoda K, Wring S. 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. Antimicrobial agents and chemotherapy. 2017 May;61(5):10-128. [Google Scholar] [Pubmed]
19. Sherry L, Ramage G, Kean R, Borman A, Johnson EM, Richardson MD, Rautemaa-Richardson R. Biofilm-forming capability of highly virulent, multidrug-resistant *Candida auris*. Emerging infectious diseases. 2017 Feb;23(2):328. [Google Scholar] [Pubmed]
20. Chow NA, Muñoz JF, Gade L, Berkow EL, Li X, Welsh RM, Forsberg K, Lockhart SR, Adam R, Alanio A, Alastruey-Izquierdo A. Tracing the evolutionary history and global expansion of *Candida auris* using population genomic analyses. MBio. 2020 Apr 28;11(2):10-128. [Google Scholar] [Pubmed]
21. Ravichandran S, Shanmugam P, Thayikkannu AB. Phenotypic and Genotypic Characterization of *Candida auris*, an Emerging Pathogen Isolated from Blood. Blood. 2022;54(4):54-61. [Google Scholar]
22. Escandón P, Chow NA, Caceres DH, Gade L, Berkow EL, Armstrong P, Rivera S, Misas E, Duarte C, Moulton-Meissner H, Welsh RM. Molecular epidemiology of *Candida auris* in Colombia reveals a highly related, countrywide colonization with regional patterns in amphotericin B resistance. Clinical Infectious Diseases. 2019 Jan 1;68(1):15-21. [Google Scholar] [Pubmed]
23. Kean R, Brown J, Gulmez D, Ware A, Ramage G. *Candida auris*: a decade of understanding of an enigmatic pathogenic yeast. Journal of fungi. 2020 Feb 26;6(1):30. [Google Scholar] [Pubmed]
24. Al-Reesi A, Al-Reesi H. Diabetic ketoacidosis among COVID-19 patients admitted to suhar hospital, Oman: clinical characteristics and outcomes. J Diabetes Metab. 2021 Mar 16;12(5):866. [Google Scholar]
25. Lockhart SR, Berkow EL, Chow N, Welsh RM. *Candida auris* for the clinical microbiology laboratory: not your grandfather's Candida species. Clinical microbiology newsletter. 2017 Jul 1;39(13):99-103. [Google Scholar] [Pubmed]
26. Bergeron G, Bloch D, Murray K, Kratz M, Parton H, Ackelsberg J, Antwi M, Del Rosso P, Dorsinville M, Kubinson H, Lash M. *Candida auris* colonization after discharge to a community setting: New York City, 2017–2019. InOpen forum infectious diseases 2021 Jan (Vol. 8, No. 1, p. ofaa620). US: Oxford University Press. [Google Scholar] [Pubmed]
27. Horton MV, Holt AM, Nett JE. Mechanisms of pathogenicity for the emerging fungus *Candida auris*. PLoS Pathogens. 2023 Dec 21;19(12):e1011843. [Google Scholar] [Pubmed]
28. Jeffery-Smith A, Taori SK, Schelenz S, Jeffery K, Johnson EM, Borman A, *Candida auris* Incident Management Team, Manuel R, Brown CS. *Candida auris*: a review of the literature. Clinical microbiology reviews. 2018 Jan;31(1):10-128. [Google Scholar] [Pubmed]
29. Kidd SE, Chen SC, Meyer W, Halliday CL. A new age in molecular diagnostics for invasive fungal disease: are we ready?. Frontiers in microbiology. 2020 Jan 14;10:2903. [Google Scholar] [Pubmed]
30. Pham D, Sivalingam V, Tang HM, Montgomery JM, Chen SC, Halliday CL. Molecular diagnostics for invasive fungal diseases: Current and future approaches. Journal of Fungi. 2024 Jun 26;10(7):447. [Google Scholar] [Pubmed]
31. Cortegiani A, Misseri G, Fasciana T, Giammanco A, Giarratano A, Chowdhary A. Epidemiology, clinical characteristics, resistance, and treatment of infections by *Candida auris*. Journal of intensive care. 2018 Dec;6:1-3. [Google Scholar] [Pubmed]
32. Du H, Bing J, Hu T, Ennis CL, Nobile CJ, Huang G. *Candida auris*: Epidemiology, biology, antifungal resistance, and virulence. PLoS pathogens. 2020 Oct 22;16(10):e1008921. [Google Scholar] [Pubmed]
33. Horton MV, Holt AM, Nett JE. Mechanisms of pathogenicity for the emerging fungus *Candida auris*. PLoS Pathogens. 2023 Dec 21;19(12):e1011843. [Google Scholar] [Pubmed]
34. Kwon YJ, Shin JH, Byun SA, Choi MJ, Won EJ, Lee D, Lee SY, Chun S, Lee JH, Choi HJ, Kee SJ. *Candida auris* clinical isolates from South Korea: identification, antifungal susceptibility, and genotyping. Journal of clinical microbiology. 2019 Apr;57(4):10-128. [Google Scholar] [Pubmed]

ISSN: 0019-5138
DOI: https://doi.org/

35. Larkin E, Hager C, Chandra J, Mukherjee PK, Retuerto M, Salem I, Long L, Isham N, Kovanda L, Borroto-Esoda K, Wring S. 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. Antimicrobial agents and chemotherapy. 2017 May;61(5):10-128. [Google Scholar] [Pubmed]
36. Prakash A, Sharma C, Singh A, Singh PK, Kumar A, Hagen F, Govender NP, Colombo AL, Meis JF, Chowdhary A. Evidence of genotypic diversity among *Candida auris* isolates by multilocus sequence typing, matrix-assisted laser desorption ionization time-of-flight mass spectrometry and amplified fragment length polymorphism. Clinical Microbiology and Infection. 2016 Mar 1;22(3):277-e1. [Google Scholar] [Pubmed]
37. Lone SA, Ahmad A. *Candida auris*—the growing menace to global health. Mycoses. 2019 Aug;62(8):620-37. [Google Scholar] [Pubmed]
38. Pappas PG, Kauffman CA, Andes DR, Clancy CJ, Marr KA, Ostrosky-Zeichner L, Reboli AC, Schuster MG, Vazquez JA, Walsh TJ, Zaoutis TE. Clinical practice guideline for the management of candidiasis: 2016 update by the Infectious Diseases Society of America. Clinical infectious diseases. 2016 Feb 15;62(4):e1-50. [Google Scholar] [Pubmed]
39. Pappas PG, Kauffman CA, Andes DR, Clancy CJ, Marr KA, Ostrosky-Zeichner L, Reboli AC, Schuster MG, Vazquez JA, Walsh TJ, Zaoutis TE. Clinical practice guideline for the management of candidiasis: 2016 update by the Infectious Diseases Society of America. Clinical infectious diseases. 2016 Feb 15;62(4):e1-50. [Google Scholar] [Pubmed]
40. Fakhim H, Chowdhary A, Prakash A, Vaezi A, Dannaoui E, Meis JF, Badali H. In vitro interactions of echinocandins with triazoles against multidrug-resistant *Candida auris*. Antimicrobial agents and chemotherapy. 2017 Nov;61(11):10-128. [Google Scholar] [Pubmed]
41. Kofla G, Ruhnke M. Pharmacology and metabolism of anidulafungin, caspofungin and micafungin in the treatment of invasive candidosis-review of the literature. European journal of medical research. 2011 Apr 28;16(4):159. [Google Scholar] [Pubmed]
42. Fisher JF, Sobel JD, Kauffman CA, Newman CA. Candida urinary tract infections—treatment. Clinical infectious diseases. 2011 May 15;52(suppl_6):S457-66. [Google Scholar] [Pubmed]
43. Berkow EL, Angulo D, Lockhart SR. In vitro activity of a novel glucan synthase inhibitor, SCY-078, against clinical isolates of *Candida auris*. Antimicrobial agents and chemotherapy. 2017 Jul;61(7):10-128. [Google Scholar] [Pubmed]
44. Britz E, Govender NP. Global emergence of a multidrug resistant fungal pathogen, *Candida auris*. Southern African Journal of Infectious Diseases. 2016 Jan 1;31(3):3-4. [Google Scholar]
45. Schelenz S, Barnes RA, Barton RC, Cleverley JR, Lucas SB, Kibbler CC, Denning DW. British Society for Medical Mycology best practice recommendations for the diagnosis of serious fungal diseases. The Lancet Infectious Diseases. 2015 Apr 1;15(4):461-74. [Google Scholar] [Pubmed]
46. Shackleton J, Schelenz S, Rochon M, Hall A, Ryan L, Cervera-Jackson R. The impact of environmental decontamination in a *Candida auris* outbreak. J Hosp Infect. 2016;94(Suppl 1):S24-134. [Google Scholar]
47. Rudramurthy SM, Chakrabarti A, Paul RA, Sood P, Kaur H, Capoor MR, Kindo AJ, Marak RS, Arora A, Sardana R, Das S. *Candida auris* candidaemia in Indian ICUs: analysis of risk factors. Journal of Antimicrobial Chemotherapy. 2017 Jun 1;72(6):1794-801. [Google Scholar] [Pubmed]
48. Jaggavarapu S, Burd EM, Weiss DS. Micafungin and amphotericin B synergy against *Candida auris*. The Lancet Microbe. 2020 Dec 1;1(8):e314-5. [Google Scholar] [Pubmed]
49. Zhu YC, Barat SA, Borroto-Esoda K, Angulo D, Chaturvedi S, Chaturvedi V. Pan-resistant *Candida auris* isolates from the outbreak in New York are susceptible to ibrexafungerp (a glucan synthase inhibitor). [Google Scholar] [Pubmed]
50. Billamboz M, Fatima Z, Hameed S, Jawhara S. Promising drug candidates and new strategies for fighting against the emerging superbug *Candida auris*. Microorganisms. 2021 Mar 18;9(3):634. [Google Scholar] [Pubmed]
51. Eldesouky HE, Salama EA, Lanman NA, Hazbun TR, Seleem MN. Potent synergistic interactions between lopinavir and azole antifungal drugs against emerging multidrug-resistant *Candida auris*. Antimicrobial agents and chemotherapy. 2020 Dec 16;65(1):10-128. [Google Scholar] [Pubmed]
52. De Oliveira HC, Monteiro MC, Rossi SA, Pemán J, Ruiz-Gaitán A, Mendes-Giannini MJ, Mellado E, Zaragoza O. Identification of off-patent compounds that present antifungal activity against the emerging fungal pathogen *Candida auris*. Frontiers in cellular and infection microbiology. 2019 Apr 2;9:83. [Google Scholar] [Pubmed]
53. Eldesouky HE, Lanman NA, Hazbun TR, Seleem MN. Aprepitant, an antiemetic agent, interferes with metal ion homeostasis of *Candida auris* and displays potent synergistic interactions with azole drugs. Virulence.

ISSN: 0019-5138
DOI: https://doi.org/

2020 Dec 31;11(1):1466-81. [Google Scholar] [Pubmed]
54. Walraven CJ, Lee SA. Antifungal lock therapy. Antimicrobial agents and chemotherapy. 2013 Jan;57(1):1-8. [Google Scholar] [Pubmed]
55. Černáková L, Roudbary M, Brás S, Tafaj S, Rodrigues CF. *Candida auris*: a quick review on identification, current treatments, and challenges. International Journal of Molecular Sciences. 2021 Apr 25;22(9):4470. [Google Scholar] [Pubmed]
56. Rudramurthy SM, Colley T, Abdolrasouli A, Ashman J, Dhaliwal M, Kaur H, Armstrong-James D, Strong P, Rapeport G, Schelenz S, Ito K. In vitro antifungal activity of a novel topical triazole PC945 against emerging yeast *Candida auris*. Journal of Antimicrobial Chemotherapy. 2019 Oct 1;74(10):2943-9. [Google Scholar] [Pubmed]
57. Wiederhold NP, Najvar LK, Jaramillo R, Olivo M, Patterson H, Connell A, Fukuda Y, Mitsuyama J, Catano G, Patterson TF. The novel arylamidine T-2307 demonstrates in vitro and in vivo activity against *Candida auris*. Antimicrobial agents and chemotherapy. 2020 Feb 21;64(3):10-128. [Google Scholar] [Pubmed]
58. Iyer KR, Whitesell L, Porco Jr JA, Henkel T, Brown LE, Robbins N, Cowen LE. Translation inhibition by rocaglates activates a species-specific cell death program in the emerging fungal pathogen *Candida auris*. MBio. 2020 Apr 28;11(2):10-128. [Google Scholar] [Pubmed]
59. Tan J, Liu Z, Sun Y, Yang L, Gao L. Inhibitory effects of photodynamic inactivation on planktonic cells and biofilms of *Candida auris*. Mycopathologia. 2019 Aug 15;184:525-31. [Google Scholar] [Pubmed]
60. de Groot T, Chowdhary A, Meis JF, Voss A. Killing of *Candida auris* by UV-C: Importance of exposure time and distance. Mycoses. 2019 May;62(5):408-12. [Google Scholar] [Pubmed]
61. Dutta S, Rahman MH, Hossain KS, Haq JA. Detection of *Candida auris* and its antifungal susceptibility: first report from Bangladesh. IMC Journal of Medical Science. 2019;13(2):18-22. [Google Scholar]
62. Ben-Ami R, Berman J, Novikov A, Bash E, Shachor-Meyouhas Y, Zakin S, Maor Y, Tarabia J, Schechner V, Adler A, Finn T. Multidrug-resistant candida haemulonii and *C. Auris*, tel aviv, Israel. Emerging infectious diseases. 2017 Feb;23(2):195. [Google Scholar] [Pubmed]
63. Emara M, Ahmad S, Khan Z, Joseph L, Al-Obaid IM, Purohit P, Bafna R. *Candida auris* candidemia in Kuwait, 2014. Emerging infectious diseases. 2015 Jun;21(6):1091. [Google Scholar] [Pubmed]
64. Al-Siyabi T, Al Busaidi I, Balkhair A, Al-Muharrmi Z, Al-Salti M, Al'Adawi B. First report of *Candida auris* in Oman: Clinical and microbiological description of five candidemia cases. Journal of Infection. 2017 Oct 1;75(4):373-6. [Google Scholar] [Pubmed]
65. Mohsin J, Hagen F, Al-Balushi ZA, de Hoog GS, Chowdhary A, Meis JF, Al-Hatmi AM. The first cases of *Candida auris* candidaemia in Oman. Mycoses. 2017 Sep;60(9):569-75. [Google Scholar] [Pubmed]
66. Abastabar M, Haghani I, Ahangarkani F, Rezai MS, Taghizadeh Armaki M, Roodgari S, Kiakojuri K, Al-Hatmi AM, Meis JF, Badali H. *Candida auris* otomycosis in Iran and review of recent literature. Mycoses. 2019 Feb;62(2):101-5. [Google Scholar] [Pubmed]
67. Alatoom A, Sartawi M, Lawlor K, AbdelWareth L, Thomsen J, Nusair A, Mirza I. Persistent candidemia despite appropriate fungal therapy: First case of *Candida auris* from the United Arab Emirates. International Journal of Infectious Diseases. 2018 May 1;70:36-7. [Google Scholar] [Pubmed]
68. Allaw F, Kara Zahreddine N, Ibrahim A, Tannous J, Taleb H, Bizri AR, Dbaibo G, Kanj SS. First *Candida auris* outbreak during a COVID-19 pandemic in a tertiary-care center in Lebanon. Pathogens. 2021 Feb 3;10(2):157. [Google Scholar] [Pubmed]
69. Mohd Tap R, Lim TC, Kamarudin NA, Ginsapu SJ, Abd Razak MF, Ahmad N, Amran F. A fatal case of *Candida auris* and Candida tropicalis candidemia in neutropenic patient. Mycopathologia. 2018 Jun;183:559-64. [Google Scholar] [Pubmed]
70. Tan YE, Tan AL. Arrival of Fungus in Singapore: Report of the First 3 Cases. Annals of the Academy of Medicine, Singapore. 2018 Jul 1;47(7):260-2. [Google Scholar] [Pubmed]
71. Tan YE, Teo JQ, Rahman NB, Ng OT, Kalisvar M, Tan AL, Koh TH, Ong RT. *Candida auris* in Singapore: Genomic epidemiology, antifungal drug resistance, and identification using the updated 8.01 VITEK® 2 system. International journal of antimicrobial agents. 2019 Dec 1;54(6):709-15. [Google Scholar] [Pubmed]
72. Sears D, Schwartz BS. *Candida auris*: An emerging multidrug-resistant pathogen. International Journal of Infectious Diseases. 2017 Oct 1;63:95-8. [Google Scholar] [Pubmed]
73. Clancy CJ, Nguyen MH. Emergence of *Candida auris*: an international call to arms. Clinical Infectious Diseases. 2017 Jan 15;64(2):141-3. [Google Scholar] [Pubmed]
74. Chakrabarti A, Singh S. Multidrug-resistant *Candida auris*: an epidemiological review. Expert review of anti-infective therapy. 2020 Jun 2;18(6):551-62. [Google Scholar] [Pubmed]
75. Assress HA, Nyoni H, Mamba BB, Msagati TA. Occurrence and risk assessment of azole antifungal drugs in water and wastewater. Ecotoxicology and Environmental Safety. 2020 Jan 15;187:109868. [Google

ISSN: 0019-5138
DOI: https://doi.org/

Scholar] [Pubmed]
76. Vitiello A, Ferrara F, Boccellino M, Ponzo A, Cimmino C, Comberiati E, Zovi A, Clemente S, Sabbatucci M. Antifungal drug resistance: an emergent health threat. Biomedicines. 2023 Mar 31;11(4):1063. [Google Scholar] [Pubmed]
77. Desoubeaux G, Coste AT, Imbert C, Hennequin C. Overview about *Candida auris*: what's up 12 years after its first description?. Journal of Medical Mycology. 2022 May 1;32(2):101248. [Google Scholar] [Pubmed]
78. Jung J, Kim MJ, Kim JY, Lee JY, Kwak SH, Hong MJ, Chong YP, Lee SO, Choi SH, Kim YS, Woo JH. *Candida auris* colonization or infection of the ear: A single-center study in South Korea from 2016 to 2018. Medical Mycology. 2020 Jan 1;58(1):124-7. [Google Scholar] [Pubmed]
79. Pal M, Tariku F, Upadhyay D, Paula CR, Patil B. *Candida auris*: an emerging life-threatening fungal pathogen of global public health concern. J Bacteriol Mycol. 2024;12(2):40-3. [Google Scholar]
80. Lee WG, Shin JH, Uh Y, Kang MG, Kim SH, Park KH, Jang HC. First three reported cases of nosocomial fungemia caused by *Candida auris*. Journal of clinical microbiology. 2011 Sep;49(9):3139-42. [Google Scholar] [Pubmed]

ISSN: 0019-5138
DOI: https://doi.org/