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An overview of *Candida auris* in Iraq: the silent killer

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ABSTRACT. *Candida auris* is an emerging pathogen known for its high mortality compared to other fungal diseases in healthcare units. Since its initial description in Japan in 2009, *C. auris* has been reported worldwide, including in Middle Eastern countries. Iraq, one of the Middle Eastern countries, does not seem to have adequately addressed *C. auris* as a serious emergent pathogen in the healthcare units, especially since numerous healthcare facilities in the Middle Eastern region have reported *C. auris* infections. Additionally, this pathogen poses unique challenges in the area due to its ability to resist multiple antifungal agents, causing serious invasive infections with high mortality rates. Efforts to control *C. auris* in Middle Eastern countries have primarily focused on infection surveillance, implementing infection prevention and control measures, and developing regional guidelines for diagnosis and management. However, the challenges associated with its detection, including misidentification and a lack of standardized diagnostic methods, have complicated these efforts. Understanding the epidemiology and molecular characteristics of *C. auris* in the Middle East is crucial for effective management and control. In conclusion, the combination of its multidrug resistance, high mortality rate, and the challenges of detecting and treating *C. auris* requires immediate attention and the implementation of comprehensive surveillance and prevention strategies, especially in Iraq. Despite concerted efforts by health agencies and national authorities, Iraq lacks a comprehensive surveillance system and a clear strategy to combat this pathogen effectively, making this fungus a significant threat to Iraq's healthcare systems.

Keywords: emerging fungus; *Candida auris*; Middle East; multidrug-resistant fungus; invasive fungal infections.

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Introduction

The *Candida* species cause most fungal infections in humans (Bongomin & Fayemiwo, 2021), and *C. albicans* is the most common isolate in clinical samples worldwide (Tahmasebi et al., 2023; Silva et al., 2023; Notarte et al., 2023; Erami et al., 2023), recently, *Candida* non-albicans isolates, as *C. krusei*, *C. parapsilosis*, *C. tropicalis*, *and C. glabrata*, have significantly increased in clinical specimens (Deorukhkar et al., 2014); and researchers have begun to pay close attention to them because they produce an array of enzymes and metabolites, serve as probiotics, and being used in food, pharmaceuticals, and detergents industries (Silva et al., 2009; Deorukhkar et al., 2014; Ramdin, Chibabhai, Saggers, Bandini, & Ballot, 2023; Vargas-Espíndola et al., 2023; Notarte et al., 2023) and one of the most important species of these isolates is *Candida auris*, which has had considerable attention in the last decade (Sticchi et al., 2023).

Approximately 200 *Candida* species exist, but few cause infections in humans when their immune systems are compromised or debilitated (Spampinato & Leonardi, 2013). As a commensal pathogen, *C. albicans* inhabits the gastrointestinal tract, the genitourinary tract, the oral cavity, and the conjunctiva, among many other locations. However, it causes infection when the host becomes debilitated or immunocompromised. These infections can be superficial, affect the skin or mucous membrane, invade the bloodstream and disseminate to internal organs (Spampinato & Leonardi, 2013). Other *Candida* species found in healthy individuals include *C. parapsilosis*, *C. glabrata*, *C. tropicalis*, and *C. krusei*. All five mentioned species cause more than 90% of invasive candidiasis (Turner & Butler, 2014). Several species within the *Candida* genus are now recognized as having sexual or parasexual characteristics in addition to asexual form(Alby & Bennett, 2010; Reedy, Floyd, & Heitman, 2009). Some diploid asexual *Candida* species undergo a parasexual cycle, which involves mating between diploid cells of opposite mating types and loss of chromosomes (Turner & Butler, 2014).

Candida auris is a new species in the *Candida* genus. It was reported in 2009 as a case of ear infection in Japan and has since been reported in several countries (Satoh et al., 2009). Based on the Centers for Disease Control and Prevention data, *C. auris* is reported in more than 40 countries on all continents except Antarctica (Geremia, Brugnaro, Solinas, Scarparo, & Panese, 2023; Crea et al., 2019; Plachouras et al., 2020; Sharma & Chakrabarti, 2020; Shariq, Rasheed, Alghsham, & Abdulmonem, 2023), including the United States, United Kingdom, India, South Africa, Asia, and Australia(Rhodes & Fisher, 2019; Szekely et al., 2019; Du et al., 2020; Černáková, Roudbary, Brás, Tafaj, & Rodrigues, 2021), and the number of cases is still rising worldwide (Du et al., 2020). Nowadays, in the healthcare field, *C. auris* has caused significant concern due to its ability to cause high mortality rates in invasive infections, resistance to multiple antifungal agents, and ability to persist in healthcare environments, in addition to the increasing number of recorded infections cases with this fungus (Geremia et al., 2023).

Candida auris is distinct from other *Candida* species in its genetic makeup, virulence, and antifungal resistance profile. In particular, the genetic similarity index of *C. auris* from different *Candida* species ranges from 82% in *C. lusitaniae* to 39% in *C. rugosa*, while the similarity index for *C. albicans* is 43% (Jeffery-Smith et al., 2018). Regarding virulence, *C. auris* is more aggressive and antifungal resistant than all other *Candida* species. (Du et al., 2020; Hernando-Ortiz et al., 2021; Bravo Ruiz & Lorenz, 2021; Gao et al., 2021). Some recent studies reported high mortality rates associated with *C. auris* infections, ranging from 30% to 59% (Lockhart et al., 2017; Osei Sekyere, 2018). It is thought that it is due to the difficulty in treating the infections and the underlying comorbidities of the affected patients. *C. auris* resists several antifungal agents, including echinocandins and polyenes, commonly used to treat fungal infections worldwide and in Iraq (Gao et al., 2021; Bravo Ruiz & Lorenz, 2021). This multidrug-resistant profile of this fungus has led to treatment challenges and increased mortality rates in infected patients. Therefore, *C. auris* infections are considered serious in hospitalized patients, particularly those with debilitated immune systems. In addition to spreading easily, this fungus can survive for long periods on surfaces in healthcare settings. Therefore, healthcare facilities need proper strategies and infection control measures to prevent it from spreading (Geremia et al., 2023).

The emergence of *C. auris* as a global health threat has prompted increased surveillance and research efforts to better understand this fungal pathogen's epidemiology, transmission, and treatment (Sticchi et al., 2023; Bravo Ruiz & Lorenz, 2021). Several outbreaks of *C. auris* infections have been reported worldwide, and there are concerns that *C. auris* may become endemic in some regions, like some antibiotic-resistant bacteria (Du et al., 2020; Jeffery-Smith et al., 2018; Barber et al., 2023).

In Iraq, there is no available data on *C. auris* infections, no systematic studies have been conducted, and no clear strategy for dealing with this disease exists (Ahmad & Alfouzan, 2021). This study reviews the available databases about this pathogen in Iraq to fill this gap.

Material and methods

Literature and reports from international databases, including Medline [http://pubmed.gov/], Scopus [https://www.scopus.com/], Global Health-CINAHL [https://www.ebsco.com/products/research-databases/cinahl-complete], CDC [data.CDC.gov], and the official Iraqi virtual library [ivsl.org/ivsl?func=feedback&language=ar], were examined to find the requested information about *C. auris*. The search was limited to confirmed data and publications in English and Arabic, and unconfirmed case reports and any other cases that did not follow a standard procedure in detection and reporting were excluded. The articles were reviewed for epidemiology and information about *C. auris*, particularly in Iraq; furthermore, personal contacts with nationwide colleagues were performed for any documented data to be included in this article.

The global prevalence of *Candida auris* infections

Deferent Clinical settings, including hospitals, intensive care units, and community facilities, have reported *C. auris* infections (Ahmad & Alfouzan, 2021). The exact transmission mode is not fully understood, but contact with contaminated surfaces or equipment is believed to transmit and persist *C. auris* to patients and healthcare workers. Additionally, *C. auris* can colonize healthy individuals' skin and mucous membranes, possibly contributing to its spread.

Candida auris outbreaks have been reported in many countries across most continents. However, the outbreaks' intensity varies from country to country. (Figure 1) (Chen et al., 2020). Globally, five genetically distinct clades of *C. auris* were detected (Clades I, II, III, IV, and V). In contrast, most outbreaks were reported by Clades I, III, and IV, and research proves that there is an association between these genetic clades and their geographic distribution throughout the world (Lockhart et al., 2017; Chow et al., 2020; Muñoz et al., 2021; Ahmad & Asadzadeh, 2023).

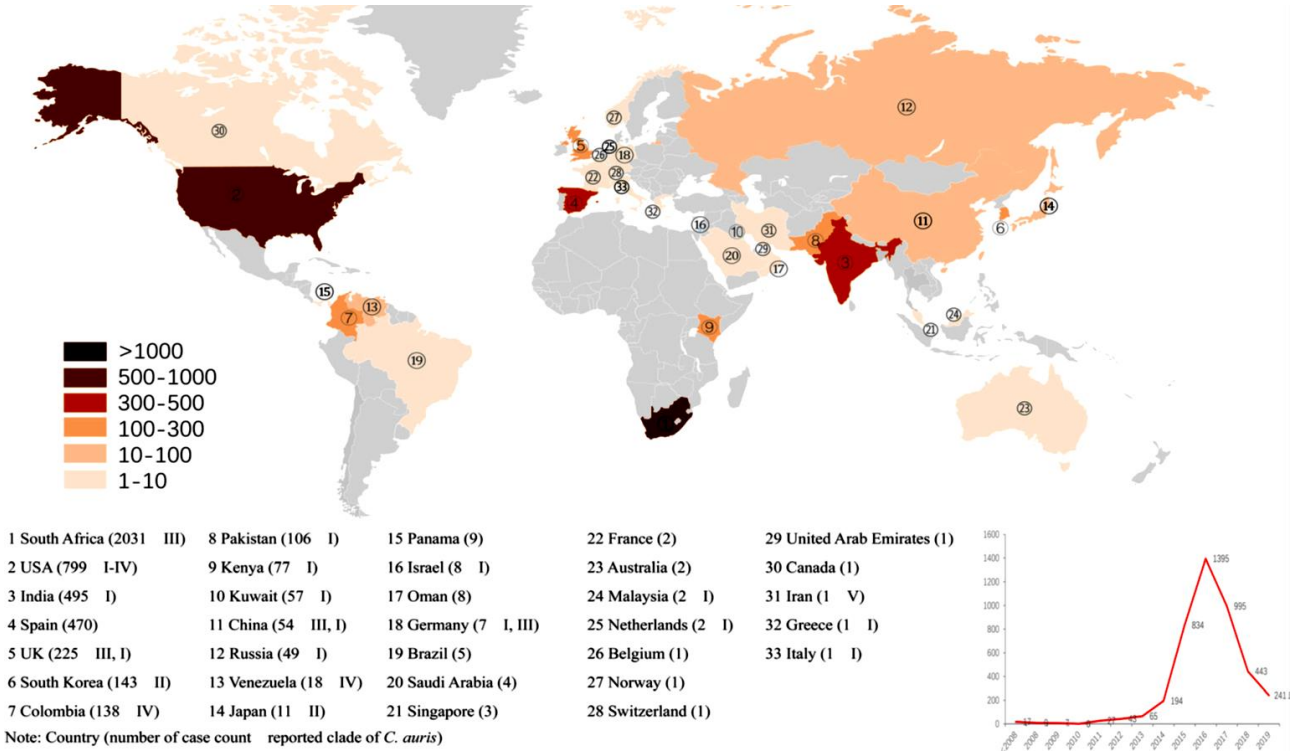

Figure 1. Globally reported *Candida auris* infection (2009-2020) along with an epidemic curve showing the number of *C. auris* cases yearly. (Chen et al., 2020)

One of the key factors contributing to the global prevalence of infections caused by this fungus is its ability to colonize and persist in healthcare facilities (Sabino, Veríssimo, Pereira, & Antunes, 2020). *C. auris* has been found to survive on various surfaces, including hospital equipment and medical devices, for an extended period; this persistence allows the pathogen to spread easily from one person to another in healthcare units, making it challenging to control (Ahmad & Asadzadeh, 2023; Sabino et al., 2020). Furthermore, the global prevalence of *C. auris* infections is influenced by challenges in detecting and identifying this fungus. It can be easily misidentified or undetected by traditional laboratory methods (Ahmad & Asadzadeh, 2023; Kim et al., 2009; Lee et al., 2011). All this has made *C. auris* infections a cause for global concern among healthcare professionals and researchers.

Prevalence of *Candida auris* infections in Middle Eastern countries

The prevalence of *C. auris* infections in the Middle East has become a growing concern due to the high mortality rate associated with the pathogen (Mohsin et al., 2020). A systematic analysis of the origin of infected cases was complicated because most Middle Eastern countries lacked epidemiological surveys and documentation systems. For the few cases with available data, the Middle Eastern countries (Kuwait, Jordan, Saudi Arabia, Oman, Qatar, and the United Arab Emirates) were mentioned (Table 1). Of note, there was also one cross-border transfer within the European Union/European Economic Area (EU/EEA) of an Iraqi patient's nationality with a *C. auris* infection (Steinmann, Schrauzer, Kirchhoff, Meis, & Rath, 2021). Surprisingly, no documented instances of *C. auris* infection have been found in other Middle Eastern and North African (MENA) countries, including Iraq and Jordan (Osei Sekyere, 2018; Osman et al., 2020).

Discussion

In recent years, *Candida auris* has emerged as an emerging multidrug-resistant fungus that poses a serious threat to public health with high mortality rates, particularly in healthcare facilities (Alvarado et al., 2021; Abastabar et al., 2019). In light of its global importance and the lack of data regarding this fungus in Iraq, where it has yet to be documented, coupled with its widespread prevalence in most Middle Eastern countries, investigating this microorganism in Iraq is a crucial undertaking that necessitates prompt attention due to its direct implications for the health of those afflicted.

Table 1. Registration date of *Candida auris* infection cases in Middle Eastern countries.

Country	Year	Reference
Kuwait	2014	(Emara et al., 2015)
Oman	2017	(Al-Siyabi et al., 2017)
UAE	2018	(Alatoom et al., 2018)
Saudi Arabia	2018	(Abdalhamid, Almaghrabi, Althawadi, & Omrani, 2018)
Qatar	2018	(Shaukat et al., 2021)
Iran	2018	(Chow et al., 2019)
Israel	2014	(Ben-Ami et al., 2017)
Turkey	2021	(Kurt et al., 2021)

Conclusion

While there have not been reports of *C. auris* infection in Iraq, this fungus may be present in healthcare facilities in the country. Healthcare workers and authorities should remain vigilant and take proactive measures to prevent and control *C. auris* infections. In general, preventing and controlling *C. auris* infections requires a multifaceted approach, including strict adherence to infection control measures, antibiotic stewardship, and healthcare, and education and training of staff are also important (Ahmad & Asadzadeh, 2023) in addition to an effective surveillance system for tracking *C. auris* infections, especially since the fungus' exact mode of transmission and pathogenesis is unclear. However, increased surveillance and research efforts are needed to contain its spread, develop effective treatment strategies, and improve proactive epidemiological surveillance and detection measures to control and screen for *C. auris* infection in Iraq.

References

Abastabar, M., Haghani, I., Ahangarkani, F., Rezai, M. S., Taghizadeh Armaki, M., Roodgari, S., ... Badali, H. (2019). *Candida auris* otomycosis in Iran and review of recent literature. *Mycoses*, *62*(2), 101-105. DOI: https://doi.org/10.1111/myc.12886

Abdalhamid, B., Almaghrabi, R., Althawadi, S., & Omrani, A. (2018). First report of *Candida auris* infections from Saudi Arabia. *Journal of Infection and Public Health*, *11*(4), 598-599. DOI: https://doi.org/10.1016/j.jiph.2018.05.010

Ahmad, S., & Alfouzan, W. (2021). Antifungal susceptibility, and infection control measures to combat the spread of infections in healthcare facilities. *Microorganisms*, *9*(4), 1-25. DOI: https://doi.org/10.3390/microorganisms9040807

Ahmad, S., & Asadzadeh, M. (2023). Strategies to prevent transmission of *Candida auris* in healthcare settings. *Current Fungal Infection Reports*, *17*(1), 36-48. DOI: https://doi.org/10.1007/s12281-023-00451-7

Al-Siyabi, T., Al Busaidi, I., Balkhair, A., Al-Muharrmi, Z., Al-Salti, M., & Al'Adawi, B. (2017). First report of *Candida auris* in Oman: Clinical and microbiological description of five candidemia cases. *Journal of Infection*, *75*(4), 373-376. DOI: https://doi.org/10.1016/j.jinf.2017.05.016

Alatoom, A., Sartawi, M., Lawlor, K., AbdelWareth, L., Thomsen, J., Nusair, A., & Mirza, I. (2018). Persistent candidemia despite appropriate fungal therapy: First case of *Candida auris* from the United Arab Emirates. *International Journal of Infectious Diseases*, *70*, 36-37. DOI: https://doi.org/10.1016/j.ijid.2018.02.005

Alby, K., & Bennett, R. J. (2010). Sexual reproduction in the *Candida* clade: cryptic cycles, diverse mechanisms, and alternative functions. *Cellular and Molecular Life Sciences*, *67*(19), 3275-3285. DOI: https://doi.org/10.1007/S00018-010-0421-8

Alvarado, M., Bartolomé Álvarez, J., Lockhart, S. R., Valentín, E., Ruiz-Gaitán, A. C., Eraso, E., & Groot, P. W. J. (2021). Identification of *Candida auris* and related species by multiplex PCR based on unique GPI protein-encoding genes. *Mycoses*, *64*(2), 194-202. DOI: https://doi.org/10.1111/myc.13204

Barber, C., Crank, K., Papp, K., Innes, G. K., Schmitz, B. W., Chavez, J., ... Gerrity, D. (2023). Community-scale wastewater surveillance of *Candida auris* during an ongoing outbreak in Southern Nevada. *Environmental Science and Technology*, *57*(4), 1755-1763. DOI: https://doi.org/10.1021/acs.est.2c07763

Ben-Ami, R., Berman, J., Novikov, A., Bash, E., Shachor-Meyouhas, Y., Zakin, S., ... Finn, T. (2017). Multidrug-resistant *Candida haemulonii* and *C. auris* , Tel Aviv, Israel. *Emerging Infectious Diseases*, *23*(2), 195-203. DOI: https://doi.org/10.3201/eid2302.161486

Bongomin, F., & Fayemiwo, S. A. (2021). Epidemiology of fungal diseases in Africa: A review of diagnostic drivers. *Current Medical Mycology*, *7*(1), 63-70. DOI: https://doi.org/10.18502/CMM.7.1.6246

Bravo Ruiz, G., & Lorenz, A. (2021). What do we know about the biology of the emerging fungal pathogen of humans *Candida auris*? *Microbiological Research*, *242*, 1-13. DOI: https://doi.org/10.1016/j.micres.2020.126621

Černáková, L., Roudbary, M., Brás, S., Tafaj, S., & Rodrigues, C. F. (2021). *Candida auris*: A quick review on identification, current treatments, and challenges. *International Journal of Molecular Sciences*, *22*(9), 1-16. DOI: https://doi.org/10.3390/ijms22094470

Chen, J., Tian, S., Han, X., Chu, Y., Wang, Q., Zhou, B., & Shang, H. (2020). Is the superbug fungus really so scary? A systematic review and meta-analysis of global epidemiology and mortality of *Candida auris*. *BMC Infectious Diseases*, *20*(1), 1-10. DOI: https://doi.org/10.1186/s12879-020-05543-0

Chow, N. A., Groot, T., Badali, H., Abastabar, M., Chiller, T. M., & Meis, J. F. (2019). Potential fifth clade of *Candida auris*, Iran, 2018. *Emerging Infectious Diseases*, *25*(9), 1780-1781. DOI: https://doi.org/10.3201/eid2509.190686

Chow, N. A., Muñoz, J. F., Gade, L., Berkow, E. L., Li, X., Welsh, R. M., ... Cuomo, C. A. (2020). Tracing the evolutionary history and global expansion of *Candida auris* using population genomic analyses. *MBio*, *11*(2), 1-34. DOI: https://doi.org/10.1128/mBio.03364-19

Crea, F., Codda, G., Orsi, A., Battaglini, A., Giacobbe, D. R., Delfino, E., ... Marchese, A. (2019). Isolation of *Candida auris* from invasive and noninvasive samples of a patient suffering from vascular disease, Italy, July 2019. *Eurosurveillance*, *24*(37), 1-4. DOI: https://doi.org/10.2807/1560-7917.ES.2019.24.37.1900549

Deorukhkar, S. C., Saini, S., & Mathew, S. (2014). Non-albicans *Candida* infection: An emerging threat. *Interdisciplinary Perspectives on Infectious Diseases*, *2014*, 1-7. DOI: https://doi.org/10.1155/2014/615958

Du, H., Bing, J., Hu, T., Ennis, C. L., Nobile, C. J., & Huang, G. (2020). *Candida auris*: Epidemiology, biology, antifungal resistance, and virulence. *PLOS Pathogens*, *16*(10), 1-18. DOI: https://doi.org/10.1371/journal.ppat.1008921

Emara, M., Ahmad, S., Khan, Z., Joseph, L., Al-Obaid, I., Purohit, P., & Bafna, R. (2015). *Candida auris* candidemia in Kuwait, 2014. *Emerging Infectious Diseases*, *21*(6), 1091-1092. DOI: https://doi.org/10.3201/eid2106.150270

Erami, M., Aboutalebian, S., Hezaveh, S. J. H., Ghazvini, R. D., Momen-Heravi, M., Jafari, Y., ... Mirhendi, H. (2023). Microbial and clinical epidemiology of invasive fungal rhinosinusitis in hospitalized COVID-19 patients, the divergent causative agents. *Medical Mycology*, *61*(3), 1-8. DOI: https://doi.org/10.1093/mmy/myad020

Gao, J., Chow, E. W. L., Wang, H., Xu, X., Cai, C., Song, Y., ... Wang, Y. (2021). LncRNA DINOR is a virulence factor and global regulator of stress responses in *Candida auris*. *Nature Microbiology*, *6*(7), 842-851. DOI: https://doi.org/10.1038/s41564-021-00915-x

Geremia, N., Brugnaro, P., Solinas, M., Scarparo, C., & Panese, S. (2023). *Candida auris* as an emergent public health problem: A current update on European outbreaks and cases. *Healthcare*, *11*(3), 1-12. DOI: https://doi.org/10.3390/healthcare11030425

Hernando-Ortiz, A., Mateo, E., Perez-Rodriguez, A., Groot, P. W. J., Quindós, G., & Eraso, E. (2021). Virulence of *Candida auris* from different clinical origins in *Caenorhabditis elegans* and *Galleria mellonella* host models. *Virulence*, *12*(1), 1063-1075. DOI: https://doi.org/10.1080/21505594.2021.1908765

Jeffery-Smith, A., Taori, S. K., Schelenz, S., Jeffery, K., Johnson, E. M., Borman, A., ... Brown, C. S. (2018). *Candida auris*: A review of the literature. *Clinical Microbiology Reviews*, *31*(1), e00029-17. DOI: https://doi.org/10.1128/CMR.00029-17

Kim, M.-N., Shin, J. H., Sung, H., Lee, K., Kim, E.-C., Ryoo, N., ... Ryang, D. W. (2009). *Candida haemulonii* and closely related species at 5 university hospitals in Korea: identification, antifungal susceptibility, and clinical features. *Clinical Infectious Diseases*, *48*(6), 57-61. DOI: https://doi.org/10.1086/597108

Kurt, A. F., Kuskucu, M. A., Balkan, I.. I., Baris, A., Yazgan, Z., Serife Oz, A., ... Aygun, G. (2021). *Candida auris* fungemia and a local spread taken under control with infection control measures: First report from Turkey. *Indian Journal of Medical Microbiology*, *39*(2), 228-230. DOI: https://doi.org/10.1016/j.ijmmb.2021.03.007

Lee, W. G., Shin, J. H., Uh, Y., Kang, M. G., Kim, S. H., Park, K. H., & Jang, H.-C. (2011). First three reported cases of nosocomial fungemia caused by *Candida auris*. *Journal of Clinical Microbiology*, *49*(9), 3139-3142. DOI: https://doi.org/10.1128/JCM.00319-11

Lockhart, S. R., Etienne, K. A., Vallabhaneni, S., Farooqi, J., Chowdhary, A., Govender, N. P., ... Litvintseva, A. P. (2017). Simultaneous emergence of multidrug-resistant *Candida auris* on 3 continents confirmed by whole-genome sequencing and epidemiological analyses. *Clinical Infectious Diseases*, *64*(2), 134-140. DOI: https://doi.org/10.1093/cid/ciw691

Mohsin, J., Weerakoon, S., Ahmed, S., Puts, Y., Al Balushi, Z., Meis, J. F., & Al-Hatmi, A. M. S. (2020). A Cluster of *Candida auris* blood stream infections in a tertiary care hospital in Oman from 2016 to 2019. *Antibiotics*, *9*(10), 1-11. DOI: https://doi.org/10.3390/antibiotics9100638

Muñoz, J. F., Welsh, R. M., Shea, T., Batra, D., Gade, L., Howard, D., ... Cuomo, C. A. (2021). Clade-specific chromosomal rearrangements and loss of subtelomeric adhesins in *Candida auris*. *Genetics*, *218*(1), 1-14. DOI: https://doi.org/10.1093/genetics/iyab029

Osei Sekyere, J. (2018). *Candida auris*: A systematic review and meta-analysis of current updates on an emerging multidrug-resistant pathogen. *MicrobiologyOpen*, *7*(4), 1-29. DOI: https://doi.org/10.1002/mbo3.578

Osman, M., Al Bikai, A., Rafei, R., Mallat, H., Dabboussi, F., & Hamze, M. (2020). Update on invasive fungal infections in the Middle Eastern and North African region. *Brazilian Journal of Microbiology* , *51*(4), 1771-1789. DOI: https://doi.org/10.1007/s42770-020-00325-x

Plachouras, D., Lötsch, F., Kohlenberg, A., Monnet, D. L., Lass-Flörl, C., Muchl, R., ... Brown, C. (2020). *Candida auris*: Epidemiological situation, laboratory capacity and preparedness in the European Union and European economic area, January 2018 to May 2019. *Eurosurveillance*, *25*(12), 1-6. DOI: https://doi.org/10.2807/1560-7917.ES.2020.25.12.2000240

Notarte, K. I., Pastrana, A., Ver, A. M., Velasco, J. V. L., Gellaco, M. M. L. D., & Pecundo, M. (2023). Mycosis in the Philippines: Epidemiology, clinical presentation, diagnostics and interventions. In *Mycology in the Tropics* (p. 213-233). New York, NY: Elsevier. DOI: https://doi.org/10.1016/B978-0-323-99489-7.00005-6

Ramdin, T. D., Chibabhai, V., Saggers, R. T., Bandini, R. M., & Ballot, D. E. (2023). Epidemiology, risk factors and outcomes associated with candidaemia in very low birth weight infants at a tertiary South African Hospital over a 7-year period (2013–2019). *Clinical Epidemiology and Global Health*, *20*, 1-5. DOI: https://doi.org/10.1016/j.cegh.2023.101247

Reedy, J. L., Floyd, A. M., & Heitman, J. (2009). Mechanistic plasticity of sexual reproduction and meiosis in the *Candida* pathogenic species complex. *Current Biology*, *19*(11), 891-899. DOI: https://doi.org/10.1016/J.CUB.2009.04.058

Rhodes, J., & Fisher, M. C. (2019). Global epidemiology of emerging *Candida auris*. *Current Opinion in Microbiology*, *52*, 84-89. DOI: https://doi.org/10.1016/j.mib.2019.05.008

Sabino, R., Veríssimo, C., Pereira, Á. A., & Antunes, F. (2020). *Candida auris*, an agent of hospital-associated outbreaks: which challenging issues do we need to have in mind? *Microorganisms*, *8*(2), 1-19. DOI: https://doi.org/10.3390/microorganisms8020181

Satoh, K., Makimura, K., Hasumi, Y., Nishiyama, Y., Uchida, K., & Yamaguchi, H. (2009). *Candida auris* sp. nov., a novel ascomycetous yeast isolated from the external ear canal of an inpatient in a Japanese hospital. *Microbiology and Immunology*, *53*(1), 41-44. DOI: https://doi.org/10.1111/j.1348-0421.2008.00083.x

Shariq, A., Rasheed, Z., Alghsham, R. S., & Abdulmonem, W. Al. (2023). *Candida auris*: An emerging fungus that presents a serious global health threat. *International Journal of Health Sciences*, *17*(2), 1-2.

Sharma, M., & Chakrabarti, A. (2020). On the origin of *Candida auris*: Ancestor, environmental stresses, and antiseptics. *MBio*, *11*(6), 1-7. DOI: https://doi.org/10.1128/mbio.02102-20

Shaukat, A., Al Ansari, N., Al Wali, W., Karic, E., El Madhoun, I., Mitwally, H., ... Alutra-Visan, F. (2021). Experience of treating *Candida auris* cases at a general hospital in the state of Qatar. *IDCases*, *23*, 1-4. DOI: https://doi.org/10.1016/j.idcr.2020.e01007

Silva, S., Henriques, M., Martins, A., Oliveira, R., Williams, D., & Azeredo, J. (2009). Biofilms of non-*Candida albicans Candida* species: quantification, structure and matrix composition. *Medical Mycology*, *47*(7), 681-689. DOI: https://doi.org/10.3109/13693780802549594

Silva, C. M., Carvalho, A. M. R., Macêdo, D. P. C., Jucá, M. B., Amorim, R. J. M., & Neves, R. P. (2023). Candidemia in Brazilian neonatal intensive care units: risk factors, epidemiology, and antifungal resistance. *Brazilian Journal of Microbiology*, *54*(2), 817-825. DOI: https://doi.org/10.1007/s42770-023-00943-1

Spampinato, C., & Leonardi, D. (2013). *Candida* infections, causes, targets, and resistance mechanisms: Traditional and alternative antifungal agents. *BioMed Research International*, *2013*, 1-13. DOI: https://doi.org/10.1155/2013/204237

Steinmann, J., Schrauzer, T., Kirchhoff, L., Meis, J. F., & Rath, P.-M. (2021). Two *Candida auris* cases in Germany with no recent contact to foreign healthcare-epidemiological and microbiological investigations. *Journal of Fungi*, *7*(5), 1-6. DOI: https://doi.org/10.3390/jof7050380

Sticchi, C., Raso, R., Ferrara, L., Vecchi, E., Ferrero, L., Filippi, D., ... Sabbatucci, M. (2023). Increasing number of cases due to *Candida auris* in North Italy, July 2019-December 2022. *Journal of Clinical Medicine*, *12*(5), 1-11. DOI: https://doi.org/10.3390/jcm12051912

Szekely, A., Borman, A. M., & Johnson, E. M. (2019). *Candida auris* isolates of the Southern Asian and South African lineages exhibit different phenotypic and antifungal susceptibility profiles *in vitro*. *Journal of Clinical Microbiology*, *57*(5), 1-29. DOI: https://doi.org/10.1128/JCM.02055-18

Tahmasebi, E., Keshvad, A., Alam, M., Abbasi, K., Rahimi, S., Nouri, F., ... Fernandes, G. V. O. (2023). Current infections of the orofacial region: Treatment, diagnosis, and epidemiology. *Life*, *13*(2), 1-23. DOI: https://doi.org/10.3390/life13020269

Turner, S. A., & Butler, G. (2014). The *Candida* pathogenic species complex. *Cold Spring Harbor Perspectives in Medicine*, *4*(9), 1-18. DOI: https://doi.org/10.1101/cshperspect.a019778

Vargas-Espíndola, L. A., Cuervo-Maldonado, S. I., Enciso-Olivera, J. L., Gómez-Rincón, J. C., Jiménez-Cetina, L., Sánchez-Pedraza, R., ... Murillo-Sarmiento, B. A. (2023). Fungemia in hospitalized adult patients with hematological malignancies: epidemiology and risk factors. *Journal of Fungi*, *9*(4), 1-14. DOI: https://doi.org/10.3390/jof9040400