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Candida and candidiasis in Portugal: Past situation, current trends and future challenges

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ABSTRACT

Candida infections are among the most common fungal diseases globally, with candidemia posing a serious threat in hospitalized and immunocompromised patients. In Portugal, though *Candida albicans* is the predominant species identified, other species such as *Candida parapsilosis* and *Nakaseomyces glabratus* (formerly *Candida glabrata*) are increasingly detected, particularly in intensive care units and patients with invasive devices. Emerging multidrug-resistant strains, notably *Candidozyma auris* (formerly *Candida auris*), have raised significant concern, with the first Portuguese cases reported recently. Surveillance studies suggest that antifungal resistance rates are generally low, though fluconazole resistance in *C. parapsilosis* is a concern, since ERG11 mutations were recently detected in several isolates. Echinocandins are recommended as first-line therapy, yet availability is uneven across healthcare centers. Beyond candidemia, superficial infections like vulvovaginal candidiasis and onychomycosis remain highly frequent. Active research in Portugal on *Candida* biology, virulence, and novel therapies, have been conducting for different research groups. Strengthening surveillance, rapid diagnostics, molecular identification, and infection control measures, alongside mandatory notification of *C. auris*, are critical for effective management. Integrated strategies under a "One Health" framework are essential to mitigate morbidity, mortality, and resistance trends associated with *Candida* infections.

Candida y candidiasis en Portugal: situación pasada, tendencias actuales y desafíos futuros

Palabras clave:
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RESUMEN

Las infecciones por *Candida* se encuentran entre las enfermedades fúngicas más comunes a nivel mundial, siendo la candidemia una amenaza grave en pacientes hospitalizados e inmunocomprometidos. En Portugal, aunque *Candida albicans* es la especie predominante, se detectan cada vez más otras especiesdel género, como *Candida parapsilosis* y *Nakaseomyces glabratus* (antes *Candida glabrata*), especialmente en unidades de cuidados intensivos y en pacientes con dispositivos invasivos. Las cepas multirresistentes emergentes, en particular *Candidozyma auris* (antes *Candida auris*), han generado gran preocupación, con los primeros casos portugueses reportados recientemente. Los estudios de vigilancia indican tasas generalmente bajas de resistencia a los antifúngicos, aunque la resistencia al fluconazol en *C. parapsilosis* es motivo de preocupación, dado que se han detectado mutaciones en el gen *ERG11* en varios aislamientos. Se recomienda el uso de equinocandinas como terapia de primera línea, aunque su disponibilidad es desigual entre los centros sanitarios. Más allá de la candidemia, las infecciones superficiales como la

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candidiasis vulvovaginal y la onicomicosis siguen siendo muy frecuentes. En Portugal, diversos grupos de investigación desarrollan estudios sobre biología, virulencia y nuevas terapias contra *Candida*. Fortalecer la vigilancia, el diagnóstico rápido, la identificación molecular y las medidas de control, junto con la notificación obligatoria de *C. auris*, es fundamental para una gestión eficaz. Estrategias integradas bajo el marco "One Health" son esenciales para mitigar la morbilidad, mortalidad y tendencias de resistencia asociadas a las infecciones por *Candida*.

Candidemia remains a major cause of morbidity and mortality worldwide, posing significant challenges to healthcare systems. In Portugal, recent data reveal evolving epidemiological patterns and antifungal resistance trends that warrant closer attention. This article explores these developments and offers a critical perspective on their implications for public health and clinical practice in Portuguese settings.

Epidemiological insights on candidemia

Candida infections are among the most frequent causes of fungal infections worldwide,[15] with candidemia representing a serious nosocomial infection associated with high morbidity and mortality, especially among the immunocompromised and those exposed to invasive medical procedures. Early epidemiological estimates suggested an incidence of candidemia of approximately 2.19 cases per 100,000 population in Portugal, equating to roughly 231 cases annually.[45] Recent data from 16 Portuguese medical centers show that invasive fungal diseases are perceived as low-to-very low incidence, with *Candida* species identified as the most frequent pathogen.[22] In all candidemia surveillance programs performed around the world, *Candida albicans* was the most frequent species found, but non-*C. albicans* species and multidrug-resistant strains are increasingly reported.[37] This has been attributed to evolving patient populations (older, immunocompromised, more invasive procedures), antifungal selection pressures, and improved diagnostic methods.[49] In Portuguese settings, *C. albicans* was historically the predominant species, while other species such as *Candida parapsilosis* emerged in intensive care units and among patients with invasive devices, as oncological patients. In fact, in the last decades, *C. parapsilosis* has been described as the second most frequent species found in blood cultures, both in general and specific populations, with a prevalence of around 20–25% .[12,19,28,34,44] In recent years, several studies have reported an increasing prevalence of *Nakaseomyces glabratus* (previously known as *Candida glabrata*), as mentioned in a retrospective study conducted at Centro Hospitalar Universitário de São João,[38] between 2016 and 2017, where 117 episodes of candidemia were diagnosed, or in a 5-year retrospective study (2015–2019) at the Cova da Beira University Hospital Center.[46] In both cases, *N. glabratus* was the etiological agent isolated in 22% of cases.

The increasing prevalence of *C. parapsilosis* and *N. glabratus* may be attributed to species-specific characteristics: *C. parapsilosis* has the capacity to form biofilms and persist on surfaces for extended periods, while *N. glabratus* has intrinsic reduced susceptibility to fluconazole and genuine fluconazole resistance observed in varying rates,[50] an antifungal agent that is widely used in prophylaxis regimens.

Recent surveillance studies indicate growing concern over the emergence of multidrug-resistant species,[27,39] with emphasis on the growing prevalence of *Candidozyma auris* (previously known as *Candida auris*).[17] In 2023, the first case of *C. auris* (Clade III) was reported in Portugal. The patient had been transferred from Angola to an ICU in a Lisbon hospital for liver transplantation after a SARS-CoV-2 infection.[24] In this case, it was not possible to determine if *C. auris* was an agent of infection or colonization. Miranda et al. reported cases of *C. auris* (Clade I) candidemia occurred in the same year, comprising eight epidemiologically linked isolates from colonized and infected patients admitted to a major hospital in northern Portugal.[29]

Candida antifungal susceptibility profile and therapeutic approach

According to the recently published 2025 ECMM/ISHAM/ASM global *Candida* guideline, echinocandins are strongly recommended as first-line treatment of candidemia.[9] The paper enrolling data from 16 Portuguese medical centers states that antifungal therapy is widely available, yet only 85% of sites stock echinocandins.[22]

Candida susceptibility to antifungals in Portugal has been investigated in some multicentric studies and in surveillance reports, showing that antifungal resistance rates among most *Candida* species is low. Nationwide surveillance in 2011–2012[19] collected 97 *C. albicans* isolates from patients with candidemia across 10 hospitals. Resistance to fluconazole, voriconazole, and posaconazole was 2%, 4%, and 11%, respectively. Echinocandin resistance ranged from 8% for anidulafungin to 15% for micafungin, with all isolates remaining susceptible to amphotericin B. Cross-resistance among azoles was observed in eight isolates. The most recent multicenter analysis (2020–2022)[31] evaluated 185 isolates from ICU patients and reported very low azole resistance (0.8% for fluconazole; 1.6% for voriconazole), including two isolates resistant to both antifungals. Anidulafungin resistance was slightly higher (3.8%), and amphotericin B resistance was not detected. In recent years, fluconazole resistance in *C. parapsilosis* has been emerging in different countries, being subject of significant interest and concern.[13] Hospital transmission appears to be a major factor in spreading resistant strains, as the emergence of resistance is not solely attributable to the selective pressure resulting from the use of antifungals.[16] In the previously mentioned multicentric study performed in 2011–2012,[19] 4% of fluconazole resistance was found among the 55 *C. parapsilosis* isolates tested. In a prospective ICU colonization study (2020–2022),[31] two out of 89 *C. parapsilosis* isolates were resistant to fluconazole, which corresponds to ∼2.2% resistance rate.

A very recent study analyzed 145 *C. parapsilosis* isolates collected from different biological and environmental products in Portugal in 2003–2007 and 2017–2024: eight fluconazole-resistant isolates (8.5% frequency) from the latter period were found, which contrasts with the absence of fluconazole-resistant isolates collected before 2007.[33] The dominant mechanism is a mutation in ERG11, the Y132F substitution, which markedly reduces fluconazole susceptibility.

A prospective multicenter ICU study (three ICUs in Portugal) collected *Candida* isolates from 675 patients and tested them against fluconazole, voriconazole, amphotericin B, and anidulafungin. The overall rate of resistance to fluconazole was 2.7%, with three out of 133 *C. albicans*, two out of 89 *C. parapsilosis* and two out of 24 *N. glabratus* isolates identified as resistant. Only one *C. albicans* iso-

late was resistant to voriconazole, while three isolates from three species (*C. albicans*, *C. tropicalis*, and *C. parapsilosis*) were resistant to anidulafungin.[31]

The first documented case of *C. auris* isolated in Portugal showed that this isolate had resistance to fluconazole, itraconazole and voriconazole.[24] In contrast, cases of *C. auris* candidemia reported in 2025 showed that all isolates were resistant to fluconazole, amphotericin B, and echinocandins.[29]

Superficial *Candida* infections

Not only candidemia encompasses clinically relevant *Candida* infections in our country, but superficial infections also have an important role as well. In an 11-year retrospective study on vulvovaginal candidiasis (VVC) at the Centro Hospitalar Universitário Cova da Beira, covering 2011–2021,[35] the prevalence of *Candida* in symptomatic women was ~20.5%, while asymptomatic colonization was ~16.1%. In that cohort, *C. albicans* was predominant (90.5% in symptomatic, 68.8% in colonized women), followed by *N. glabratus* (8.1%) and *C. parapsilosis* (3.4%) as the next most frequent non-*C. albicans* species. In a study focusing on VVC published in Portugal in 2022 that included 470 symptomatic and asymptomatic women,[20] the incidence of VVC among women with vulvovaginitis was 74.4%. Furthermore, 63.7% of asymptomatic women were colonized with *Candida* species. In the study, *C. albicans* was the most common species identified (59%), followed by *N. glabratus* (27%). Eight distinct species were identified among the isolated *Candida*, with a similar distribution among colonized and infected participants. Of note, various isolates, especially of the most common species, showed low susceptibility towards fluconazole. Importantly, women with history of recurrent vaginal infections, those who use over-the-counter antifungals, oral contraceptive pills and non-cotton underwear were found to be at significantly higher risk of developing VVC frequently.[20] In Portugal, recurrent vaginal candidiasis (rVVC) remains highly prevalent and recurrent in women of reproductive age. This clinical condition is defined as experiencing at least four distinct episodes of vaginal candidiasis within a 12-month period. Epidemiological estimates suggested an incidence of approximately 2854 cases per 100,000 females.[45] Hence, accurate species identification, susceptibility testing and changes in specific behaviors may improve therapeutic outcomes and decrease recurrence episodes.

Regarding nail infections, and according to a multicentric study performed by the Portuguese Society of Dermatology and Venerology, comprising the years 2014–2016, from the 2375 fungal agents isolated, 13% were yeasts, being *C. albicans* and *C. parapsilosis* the most frequently isolated species, with 38.5% and 22% frequency, respectively.[41]

Research and development *versus* gaps and challenges

In addition to clinical investigations, several Portuguese groups have been engaged in diverse research areas related to *Candida*, from fundamental biology to applied innovation targeting a better knowledge of the pathogen itself, strategies for prevention of *Candida* colonization and/or infection and therapeutic approaches. Their work encompasses, for example, studies on biofilm structure,[1,26,47] genomics,[4,10,31,42] identification of new virulence factors,[6,14,18,23,30,47] pathogenesis,[2,25] application and development of new compounds with antifungal properties on *Candida*,[7,8,21,32,40] and new therapeutical strategies,[11,36] among others. The increasing number of groups working on *Candida* enhances its importance as pathogen and emphasizes how the Portuguese scientific community is committed in reducing, directly or indirectly, the mortality and morbidity associated to *Candida* infections. However, Portugal still has limited national data sets on candidiasis incidence, species-specific trends and resistance profiles, highlighting the urgent need for surveillance even for containment measures in healthcare settings. The non-mandatory notification of fungal infections and heterogeneous reporting hamper comprehensive epidemiology of this fungal agent. More data is needed to map species shifts, emerging resistance, and outcomes, particularly considering the changes in patient demographics and healthcare practices.

As advised by the Portuguese Association of Medical Mycology (ASPOMM), surveillance, prevention and innovation need to be integrated in a robust strategy, to build a comprehensive and sustainable response to fungal infections.[43] Hence, from my perspective, the future management of *Candida* infections in Portugal will depend on the implementation of integrated strategies, as: (1) Rapid diagnostic methods and species identification using rapid tests with high sensitivity and specificity; (2) Molecular identification of the etiological agent by sequencing, especially from deep infections; (3) Enhanced and continuous surveillance with more frequent use of whole-genome sequencing for species identification, resistance profiling and detection of virulence traits; (4) Empirical therapy guided by local susceptibility data to both minimize resistance selection and provide timely antifungal therapy; (5) Interdisciplinary collaboration, addressing environmental and healthcare-related fungal threats, given the “One Health” context of these infections; (6) Implementation of robust infection control protocols, essential to improve patient outcomes and prevent outbreaks; (7) Mandatory notification of *C. auris*, given its potential to cause antifungal resistant outbreaks.

Recognizing *Candida* infection as a dynamic and evolving challenge, and strengthening surveillance and research, accordingly, may contribute to improved patient care and the development of evidence-based health policies and more effective healthcare planning.

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Conflict of interest

The author declares no conflict of interest. Q3

Uncited references Q4

3,5,48.

References

1. Alves AMCV, Lopes BO, Leite ACRM, Cruz GS, Brito ÉHS, Lima LF, et al. Characterization of oral *Candida* spp. biofilms in children and adults carriers from Eastern Europe and South America. Antibiotics (Basel). 2023;12:797, http://dx.doi.org/10.3390/antibiotics12050797.
2. Alves R, Barata-Antunes C, Casal M, Brown AJP, Van Dijck P, Paiva S. Adapting to survive: how *Candida* overcomes host-imposed constraints during human colonization. PLoS Pathog. 2020;16, http://dx.doi.org/10.1371/journal.ppat.1008478, e1008478.
3. Alves R, Sousa-Silva M, Vieira D, Soares P, Chebaro Y, Lorenz MC, et al. Carboxylic acid transporters in *Candida* pathogenesis. mBio. 2020;11, http://dx.doi.org/10.1128/mBio.00156-20, e00156-20.
4. Bezerra AR, Oliveira C, Correia I, Guimarães AR, Sousa G, Carvalho MJ, et al. The role of non-standard translation in *Candida albicans* pathogenesis. FEMS Yeast Res. 2021;21, http://dx.doi.org/10.1093/femsyr/foab032, foab032.
5. Blázquez-Muñoz MT, Costa-Barbosa A, Alvarado M, Mendonça A, Benkhellat S, Vilanova M, et al. Loss of CHT3 in *Candida albicans* wild-type strains increases surface-exposed chitin and affects host–pathogen interaction. Front Cell Infect Microbiol. 2025;15, http://dx.doi.org/10.3389/fcimb.2025.1654710, 1654710.

6. Branco J, Miranda IM, Rodrigues AG. *Candida parapsilosis* virulence and antifungal resistance mechanisms: a comprehensive review of key determinants. J Fungi (Basel). 2023;9:80, http://dx.doi.org/10.3390/jof9010080.
7. Cardoso JMS, Guerreiro SI, Lourenço A, Alves MM, Montemor MF, Mira NP, et al. Ag(I) camphorimine complexes with antimicrobial activity towards clinically important bacteria and species of the *Candida* genus. PLoS One. 2017;12, http://dx.doi.org/10.1371/journal.pone.0177355, e0177355.
8. Cerqueira F, Medeiros R, Lopes I, Campos C, Ferraz MP, Silva F, et al. A Cyclam Salt as an antifungal agent: interference with *Candida* spp. and *Cryptococcus neoformans* mechanisms of virulence. Antibiotics (Basel). 2024;13:222, http://dx.doi.org/10.3390/antibiotics13030222.
9. Cornely OA, Sprute R, Bassetti M, Chen SC, Groll AH, Kurzai O, et al. Global guideline for the diagnosis and management of candidiasis: an initiative of the ECMM in cooperation with ISHAM and ASM. Lancet Infect Dis. 2025;25:e280–93, http://dx.doi.org/10.1016/S1473-3099(24)00749-7 [Epub 13 February 2025. Erratum in: Lancet Infect Dis. 2025 Apr;25(4):e203. doi: 10.1016/S1473-3099(25)00154-9. Erratum in: Lancet Infect Dis. 2025 May;25(5):e261. doi: 10.1016/S1473-3099(25)00252-X. Erratum in: Lancet Infect Dis. 2025 Dec;25(12):e684. doi: 10.1016/S1473-3099(25)00657-7].
10. Correia I, Oliveira C, Reis A, Guimarães AR, Aveiro S, Domingues P, et al. A proteogenomic pipeline for the analysis of protein biosynthesis errors in the human pathogen *Candida albicans*. Mol Cell Proteomics. 2024;23:100818, http://dx.doi.org/10.1016/j.mcpro.2024.100818.
11. Costa-Barbosa A, Pacheco MI, Gomes AC, Collins T, Vilanova M, Pais C, et al. Preclinical evaluation of a divalent liposomal vaccine to control invasive candidiasis. NPJ Vaccines. 2025;10:124, http://dx.doi.org/10.1038/s41541-025-01183-0.
12. Costa-de-Oliveira S, Pina-Vaz C, Mendonça D, Gonçalves Rodrigues A. A first Portuguese epidemiological survey of fungaemia in a university hospital. Eur J Clin Microbiol Infect Dis. 2008;27:365–74, http://dx.doi.org/10.1007/s10096-007-0448-4.
13. Daneshnia F, de Almeida Júnior JN, Ilkit M, Lombardi L, Perry AM, Gao M, et al. Worldwide emergence of fluconazole-resistant *Candida parapsilosis*: current framework and future research roadmap. Lancet Microbe. 2023;4:e470–80, http://dx.doi.org/10.1016/S2666-5247(23)00067-8.
14. Delgado-Silva Y, Vaz C, Carvalho-Pereira J, Carneiro C, Nogueira E, Correia A, et al. Participation of *Candida albicans* transcription factor RLM1 in cell wall biogenesis and virulence. PLoS One. 2014;9, http://dx.doi.org/10.1371/journal.pone.0086270, e86270.
15. Denning DW. Global incidence and mortality of severe fungal disease. Lancet Infect Dis. 2024;24:e428–38, http://dx.doi.org/10.1016/S1473-3099(23)00692-8.
16. Escribano P, Guinea J. Fluconazole-resistant *Candida parapsilosis*: a new emerging threat in the fungi arena. Front Fungal Biol. 2022;3, http://dx.doi.org/10.3389/ffunb.2022.1010782, 1010782.
17. European Centre for Disease Prevention and Control. Survey on the epidemiological situation, laboratory capacity and preparedness for *Candidozyma (Candida) auris*, 2024. ECDC; 2025.
18. Faria-Gonçalves P, Rolo J, Gaspar C, Palmeira-de-Oliveira R, Martinez-de-Oliveira J, Palmeira-de-Oliveira A. Virulence factors as promoters of chronic vulvovaginal candidosis: a review. Mycopathologia. 2021;186:755–73, http://dx.doi.org/10.1007/s11046-021-00592-8.
19. Faria-Ramos I, Neves-Maia J, Ricardo E, Santos-Antunes J, Silva AT, Costa-de-Oliveira S, et al. Species distribution and in vitro antifungal susceptibility profiles of yeast isolates from invasive infections during a Portuguese multicenter survey. Eur J Clin Microbiol Infect Dis. 2014;33:2241–7, http://dx.doi.org/10.1007/s10096-014-2194-8.
20. Fernandes Â, Azevedo N, Valente A, Dias M, Gomes A, Nogueira-Silva C, et al. Vulvovaginal candidiasis and asymptomatic vaginal colonization in Portugal: epidemiology, risk factors and antifungal pattern. Med Mycol. 2022;60, myac029.
21. Fernandes Â, Azevedo N, Valente A, Dias M, Gomes A, Nogueira-Silva C, et al. Vulvovaginal candidiasis and asymptomatic vaginal colonization in Portugal: epidemiology, risk factors and antifungal pattern. Med Mycol. 2022;60, http://dx.doi.org/10.1093/mmy/myac029, myac029.
22. Fernandes R, Sabino R, Cunha C, Cornely OA, Carvalho A, Salmanton-García J. PT group for IFI management capacity multicentric study on the clinical mycology capacity and access to antifungal treatment in Portugal. Mycopathologia. 2024;189:15, http://dx.doi.org/10.1007/s11046-024-00830-9.
23. Grainha TRR, Jorge PADS, Pérez-Pérez M, Pérez Rodríguez G, Pereira MOBO, Lourenço AMG. Exploring anti-quorum sensing and anti-virulence based strategies to fight *Candida albicans* infections: an in silico approach. FEMS Yeast Res. 2018;18, http://dx.doi.org/10.1093/femsyr/foy022.
24. Henriques J, Mixão V, Cabrita J, Duarte TI, Sequeira T, Cardoso S, et al. *Candida auris* in intensive care setting: the first case reported in Portugal. J Fungi (Basel). 2023;9:837, http://dx.doi.org/10.3390/jof9080837.
25. Henriques M, Silva S. *Candida albicans* virulence factors and its pathogenicity. Microorganisms. 2021;9:704, http://dx.doi.org/10.3390/microorganisms9040704.
26. Huc A, Azevedo AS, Andrade JC, Rodrigues CF. Interspecies interactions of single- and mixed-species biofilms of *Candida albicans* and *Aggregatibacter actinomycetemcomitans*. Biomedicines. 2025;13, http://dx.doi.org/10.3390/biomedicines13081890, 1890.
27. Ksiezopolska E, Gabaldón T. Evolutionary emergence of drug resistance in *Candida* opportunistic pathogens. Genes (Basel). 2018;9:461, http://dx.doi.org/10.3390/genes9090461.
28. Lopes MM, Barros R, Peres I, Serelha M, Neto MT, Cabrita J, et al. Surveillance of nosocomial fungal infections in a Portuguese paediatric hospital: incidence and risk factors. J Mycol Med. 2006;16:212–9, http://dx.doi.org/10.1016/j.mycmed.2006.08.004.
29. Miranda IM, Gonçalves MFM, Pinheiro D, Hilário S, Paiva JA, Guimarães JT, et al. First report of *Candida auris* candidemia in Portugal: genomic characterisation and antifungal resistance-associated genes analysis. J Fungi (Basel). 2025;11:716, http://dx.doi.org/10.3390/jof11100716.
30. Moreira A, Silva S, Botelho C, Sampaio P, Pais C, Henriques M. *Candida bracarensis*: evaluation of virulence factors and its tolerance to amphotericin b and fluconazole. Mycopathologia. 2015;180:305–15, http://dx.doi.org/10.1007/s11046-015-9925-y.
31. Moura G, Miranda I, Cheesman C, Tuite MF, Santos MA. Stop codon decoding in *Candida albicans*: from non-standard back to standard. Yeast. 2002;19:727–33, http://dx.doi.org/10.1002/yea.874;
Nascimento T, Inácio J, Guerreiro D, Diaz P, Patrício P, Proença L, et al. Susceptibility patterns of *Candida* species collected from intensive care units in Portugal: a prospective study in 2020–2022. Infect Prev Pract. 2024;6, http://dx.doi.org/10.1016/j.infpip.2024.100403, 100403.
32. Pacheco MI, Guimarães B, Pereira-Silva P, Costa-Barbosa A, Gonçalves MST, Sousa MJ, et al. Combining fluconazole with benzo[a]phenoxazine derivatives as a promising strategy against fluconazole-resistant *Candida* species. Molecules. 2024;29, http://dx.doi.org/10.3390/molecules29215197, 5197.
33. Papuc AM, Veríssimo C, Simões H, Toscano C, Gomes JP, Mixão V, et al. Phenotypic and genomic characterization of azole resistance in Portuguese *Candida parapsilosis* isolates. Front Fungal Biol. 2025;6, http://dx.doi.org/10.3389/ffunb.2025.1713961, 1713961.
34. Paulo C, Mourão C, Veiga PM, Marques JM, Rocha G, Alves AF, et al. Retrospective analysis of clinical yeast isolates in a hospital in the centre of Portugal: spectrum and revision of the identification procedures. Med Mycol. 2009;47:836–44, http://dx.doi.org/10.3109/13693780802709081.
35. PereiraMIR [Master thesis] A prevalência de *Candida* spp no Centro Hospitalar da Cova da Beira; 2023.
36. Pinheiro MJF, Costa JP, Marques F, Mira NP, Carvalho MFNN, Alves MM. Bioactive coatings with ag-camphorimine complexes to prevent surface colonization by the pathogenic yeast *Candida albicans*. Antibiotics (Basel). 2021;10:638, http://dx.doi.org/10.3390/antibiotics10060638.
37. Pinho S, Miranda IM, Costa-de-Oliveira S. Global epidemiology of invasive infections by uncommon *Candida* species: a systematic review. J Fungi (Basel). 2024;10:558, http://dx.doi.org/10.3390/jof10080558.
38. Pinto-Magalhães S, Martins A, Lacerda S, Filipe R, Prista-Leão B, Pinheiro D, et al. Candidemia in a Portuguese tertiary care hospital: analysis of a 2-year period. J Mycol Med. 2019;29:320–4, http://dx.doi.org/10.1016/j.mycmed.2019.08.002.
39. Pristov KE, Ghannoum MA. Resistance of *Candida* to azoles and echinocandins worldwide. Clin Microbiol Infect. 2019;25:792–8, http://dx.doi.org/10.1016/j.cmi.2019.03.028.
40. Rajão A, Silva JPN, Almeida-Nunes DL, Rompante P, Rodrigues CF, Andrade JC. *Limosilactobacillus reuteri* AJCR4: a potential probiotic in the fight against oral *Candida* spp. biofilms. Int J Mol Sci. 2025;26:638, http://dx.doi.org/10.3390/ijms26020638.
41. Rato M, Costin A, Furtado C, Sousa C, Toscano C, Veríssimo C. Epidemiology of superficial fungal infections in Portugal: 3-year review (2014–2016). J Port Soc Dermatol Venereol. 2018;76:269–78, http://dx.doi.org/10.29021/spdv.76.3.910.
42. Rodrigues L, Miranda IM, Andrade GM, Mota M, Cortes L, Rodrigues AG, et al. Blunted dynamics of adenosine A2A receptors is associated with increased susceptibility to *Candida albicans* infection in the elderly. Oncotarget. 2016;7:62862–72, http://dx.doi.org/10.18632/oncotarget.11760.
43. Sabino R, Antunes F, Araujo R, Bezerra AR, Brandão J, Carneiro C, et al. Addressing critical fungal pathogens under a One Health perspective: key insights from the Portuguese Association of Medical Mycology. Mycopathologia. 2025;190:73, http://dx.doi.org/10.1007/s11046-025-00981-3.
44. Sabino R, Veríssimo C, Brandão J, Alves C, Parada H, Rosado L, et al. Epidemiology of candidemia in oncology patients: a 6-year survey in a Portuguese central hospital. Med Mycol. 2010;48:346–54, http://dx.doi.org/10.1080/13693780903161216.
45. Sabino R, Verissímo C, Brandão J, Martins C, Alves D, Pais C, et al. Serious fungal infections in Portugal. Eur J Clin Microbiol Infect Dis. 2017;36:1345–52, http://dx.doi.org/10.1007/s10096-017-2930-y [Epub 10 February 2017; PMID: 28188492].
46. Santos RPS [Master thesis] Colonizações e infeções por Candida spp. em situações multifatoriais – estudo retrospetivo a 5 anos no Centro Hospitalar Universitário Cova da Beira; 2020.
47. Silva S, Negri M, Henriques M, Oliveira R, Williams DW, Azeredo J. Adherence and biofilm formation of non-*Candida albicans Candida* species. Trends Microbiol. 2011;19:241–7, http://dx.doi.org/10.1016/j.tim.2011.02.003.
48. Silva S, Negri M, Henriques M, Oliveira R, Williams DW, Azeredo J. *Candida glabrata*, *Candida parapsilosis* and *Candida tropicalis*: biology, epidemiology,

pathogenicity and antifungal resistance. FEMS Microbiol Rev. 2012;36:288–305, http://dx.doi.org/10.1111/j.1574-6976.2011.00278.x.
49. Soriano A, Honore PM, Puerta-Alcalde P, Garcia-Vidal C, Pagotto A, Gonçalves-Bradley DC, et al. Invasive candidiasis: current clinical challenges and unmet needs in adult populations. J Antimicrob Chemother. 2023;78:1569–85, http://dx.doi.org/10.1093/jac/dkad139.
50. Wolfgruber S, Sedik S, Klingspor L, Tortorano A, Gow NAR, Lagrou K, et al. Insights from three pan-European multicentre studies on invasive *Candida* infections and outlook to ECMM *Candida* IV. Mycopathologia. 2024;189:70, http://dx.doi.org/10.1007/s11046-024-00871-0.