

Editorial

Advances in Fungal Infection Research: From Novel Diagnostics to Innovative Therapeutics

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Invasive and superficial fungal infections continue to impose a significant global health burden, with rising morbidity and mortality rates particularly affecting immunocompromised populations [1,2]. The emergence of antifungal resistance (AFR), coupled with the rise in the prevalence of opportunistic fungal pathogens, underscores the urgent need for innovative diagnostic approaches and alternative therapeutic strategies [3,4]. Indeed, fungal infections represent one of the most complex challenges in modern medicine, affecting millions of patients worldwide [5,6]. The clinical spectrum ranges from superficial mucocutaneous infections to life-threatening invasive diseases, with opportunistic pathogens such as *Candida*, *Aspergillus*, and *Pneumocystis* species leading the epidemiological burden [7,8], particularly in immunocompromised patients, including those undergoing chemotherapy, organ transplantation, or living with HIV/AIDS, who comprise an expanding population at risk for severe mycoses [9,10].

The diagnostic landscape for fungal infections has undergone significant transformation in recent decades [11,12]. Traditional culture-based methods, while remaining the gold standard, are often time-consuming and may lack sensitivity for certain pathogens [13]. The development of molecular diagnostic techniques, including real-time PCR assays and next-generation sequencing, has revolutionized pathogen detection and identification, including in fungal species [14,15]. These methods enable rapid, accurate diagnosis that can be decisive for patient outcomes, especially in critically ill populations where an early intervention is crucial [16,17].

While the antifungal therapeutic arsenal has expanded considerably, challenges persist [18,19]. The limited number of antifungal drug classes, combined with the emergence of AFR, poses major obstacles to effective treatments [20,21]. Azole resistance in *Aspergillus fumigatus*, echinocandin resistance in *Candida* species, and the global spread of multidrug-resistant *Candida auris* exemplify the evolving threat landscape [22,23]. Novel therapeutic approaches are being explored across multiple fronts [24,25]. Structure-based drug design has yielded promising compounds targeting specific fungal pathways, while drug repurposing strategies have identified unexpected antifungal properties in existing medications [26,27]. Additionally, natural products and antimicrobial peptides represent other opportunities for therapeutic development, offering potential alternatives to conventional drugs [28,29].



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The importance of systematic surveillance in healthcare settings cannot be overstated [30,31]. Effective monitoring programs enable early detection of outbreaks, facilitate antimicrobial stewardship, and guide infection prevention strategies [32]. The implementation of screening protocols for high-risk patients has proven valuable in predicting disease progression and optimizing therapeutic interventions [33,34]. Indeed, healthcare-associated fungal infections require comprehensive infection control measures [35]. The emergence of environmental pathogens and the challenges posed by biofilm formation (on medical devices) require multidimensional prevention policies [36,37]. Understanding the epidemiology of healthcare-associated mycoses is imperative for developing targeted interventions and reducing transmission risks [38].

Recent advances in understanding fungal pathogenesis have revealed the complexity of host–pathogen interactions [39,40]. The role of host immunity, particularly in immunocompromised patients, determines disease susceptibility and progression [41,42]. Fungal virulence factors, including morphological transitions, biofilm formation, and immune evasion mechanisms, contribute to pathogenic success [43,44]. In addition, the concept of polymicrobial infections has gained attention, with evidence suggesting that inter-microbial interactions can significantly influence disease outcomes [45,46]. These interactions may involve competitive or synergistic relationships between different fungal species or between fungi and bacteria, potentially affecting treatment strategies and patient prognosis [47].

Epidemiological studies continue to identify key risk factors for fungal infections across diverse populations [48,49]. Diabetes mellitus, advanced age, immunosuppressive therapy, and prolonged hospitalization represent well-established predisposing factors [50,51]. Understanding these risk profiles enables targeted screening and prevention strategies for high-risk populations [52]. Geographic variation in fungal disease burden reflects environmental factors, endemic species distribution, and healthcare infrastructure differences [53,54]. Regional studies offer basic insights for public health planning and resource allocation, particularly in areas with limited diagnostic capabilities or restricted access to antifungal therapy [55,56].

The integration of artificial intelligence and machine learning into diagnostic platforms promises to enhance disease detection and prediction capabilities [57,58]. Advanced imaging techniques, biomarker discovery, and point-of-care testing exemplify emerging frontiers in fungal diagnostics [59,60]. Precision medicine approaches, incorporating host genetic factors, pathogen characteristics, and environmental variables, may enable individualized treatment strategies [61,62]. The development of immunotherapeutic approaches, including vaccine strategies and immune modulators, offers additional therapeutic possibilities [63,64].

This Special Issue encompasses diverse research contributions that advance our understanding of fungal infections from diagnostic innovation and clinical assessment, surveillance and risk stratification, therapeutic innovations and drug development, clinical insights and disease mechanisms, epidemiological perspectives and risk factors, through to future directions and clinical implications of AMR and mycology. The multidisciplinary nature of this research, spanning microbiology, immunology, pharmacology, and epidemiology, reflects the complexity of medical mycology as a field.

The collaborative efforts of researchers, clinicians, and public health professionals represented in this collection underscore the global commitment to addressing fungal disease challenges. As we continue to face evolving threats from emerging pathogens and drug resistance, such collaborative research initiatives remain essential for improving patient outcomes and advancing the field of medical mycology. We extend our sincere gratitude to all contributing authors, reviewers, and editorial staff who made this Special

Issue possible. Their dedication to advancing fungal infection research will undoubtedly benefit patients and healthcare systems worldwide.

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References

1. Brown, G.D.; Denning, D.W.; Gow, N.A.; Levitz, S.M.; Netea, M.G.; White, T.C. Hidden killers: Human fungal infections. *Sci. Transl. Med.* **2012**, *4*, 165rv13. [\[CrossRef\]](#)
2. Bongomin, F.; Gago, S.; Oladele, R.O.; Denning, D.W. Global and multi-national prevalence of fungal diseases—Estimate precision. *J. Fungi* **2017**, *3*, 57. [\[CrossRef\]](#)
3. Fisher, M.C.; Hawkins, N.J.; Sanglard, D.; Gurr, S.J. Worldwide emergence of resistance to antifungal drugs challenges human health and food security. *Science* **2018**, *360*, 739–742. [\[CrossRef\]](#)
4. Denning, D.W.; Bromley, M.J. Infectious Disease. How to bolster the antifungal pipeline. *Science* **2015**, *347*, 1414–1416. [\[CrossRef\]](#)
5. Rodrigues, M.L. The multifunctional fungal ergosterol. *mBio* **2018**, *9*, e01755-18. [\[CrossRef\]](#)
6. Casadevall, A.; Coelho, C.; Cordero, R.J.; Dragotakes, Q.; Jung, E.; Vij, R.; Wear, M.P. The capsule of *Cryptococcus neoformans*. *Virulence* **2019**, *10*, 822–831. [\[CrossRef\]](#)
7. Kullberg, B.J.; Arendrup, M.C. Invasive candidiasis. *N. Engl. J. Med.* **2015**, *373*, 1445–1456. [\[CrossRef\]](#)
8. Patterson, T.F.; Thompson, G.R.; Denning, D.W.; Fishman, J.A.; Hadley, S.; Herbrecht, R.; Kontoyiannis, D.P.; Marr, K.A.; Morrison, V.A.; Nguyen, M.H.; et al. Practice guidelines for the diagnosis and management of aspergillosis: 2016 update by the Infectious Diseases Society of America. *Clin. Infect. Dis.* **2016**, *63*, e1–e60. [\[CrossRef\]](#) [\[PubMed\]](#)
9. Pappas, P.G.; Lionakis, M.S.; Arendrup, M.C.; Ostrosky-Zeichner, L.; Kullberg, B.J. Invasive candidiasis. *Nat. Rev. Dis. Primers* **2018**, *4*, 18026. [\[CrossRef\]](#) [\[PubMed\]](#)
10. Singh, N.; Perfect, J.R. Immune reconstitution syndrome and exacerbation of infections after pregnancy. *Clin. Infect. Dis.* **2007**, *45*, 1192–1199. [\[CrossRef\]](#) [\[PubMed\]](#)
11. Lass-Flörl, C. The changing face of epidemiology of invasive fungal disease in Europe. *Mycoses* **2009**, *52*, 197–205. [\[CrossRef\]](#)
12. White, P.L.; Wingard, J.R.; Bretagne, S.; Löffler, J.; Patterson, T.F.; Slavin, M.A.; Barnes, R.A.; Pappas, P.G.; Donnelly, J.P. Aspergillus polymerase chain reaction: Systematic review of evidence for clinical use in comparison with antigen testing. *Clin. Infect. Dis.* **2015**, *61*, 1293–1303. [\[CrossRef\]](#)
13. Lionakis, M.S.; Kontoyiannis, D.P. Glucocorticoids and invasive fungal infections. *Lancet* **2003**, *362*, 1828–1838. [\[CrossRef\]](#)
14. McMullan, B.J.; Halliday, C.; Sorrell, T.C.; Judd, D.; Sleiman, S.; Marriott, D.; Olma, T.; Chen, S.C. Clinical utility of the FilmArray meningitis/encephalitis panel for the diagnosis of suspected central nervous system infections. *Diagn. Microbiol. Infect. Dis.* **2016**, *85*, 187–190.
15. Arvanitis, M.; Anagnostou, T.; Fuchs, B.B.; Caliendo, A.M.; Mylonakis, E. Molecular and nonmolecular diagnostic methods for invasive fungal infections. *Clin. Microbiol. Rev.* **2014**, *27*, 490–526. [\[CrossRef\]](#) [\[PubMed\]](#)
16. Cornely, O.A.; Arikian-Akdagli, S.; Dannaoui, E.; Groll, A.H.; Lagrou, K.; Chakrabarti, A.; Lanternier, F.; Pagano, L.; Skiada, A.; Akova, M.; et al. ESCMID and ECMM joint clinical guidelines for the diagnosis and management of mucormycosis 2013. *Clin. Microbiol. Infect.* **2014**, *20*, 5–26. [\[CrossRef\]](#) [\[PubMed\]](#)
17. Morrell, M.; Fraser, V.J.; Kollef, M.H. Delaying the empirical treatment of candida bloodstream infection until positive blood culture results are obtained: A potential risk factor for hospital mortality. *Antimicrob. Agents Chemother.* **2005**, *49*, 3640–3645. [\[CrossRef\]](#)
18. Perlin, D.S. Mechanisms of echinocandin antifungal drug resistance. *Ann. N. Y. Acad. Sci.* **2015**, *1354*, 1–11. [\[CrossRef\]](#)
19. Sanglard, D. Emerging threats in antifungal-resistant fungal pathogens. *Front. Med.* **2016**, *3*, 11. [\[CrossRef\]](#)
20. Cowen, L.E.; Sanglard, D.; Howard, S.J.; Rogers, P.D.; Perlin, D.S. Mechanisms of antifungal drug resistance. *Cold Spring Harb. Perspect. Med.* **2015**, *5*, a019752. [\[CrossRef\]](#)
21. Pfaller, M.A.; Diekema, D.J.; Turnidge, J.D.; Castanheira, M.; Jones, R.N. Twenty years of the SENTRY antifungal surveillance program: Results for *Candida* species from 1997–2016. *Open Forum Infect. Dis.* **2019**, *6*, S79–S94. [\[CrossRef\]](#)
22. Lockhart, S.R.; Etienne, K.A.; Vallabhaneni, S.; Farooqi, J.; Chowdhary, A.; Govender, N.P.; Colombo, A.L.; Calvo, B.; Cuomo, C.A.; Desjardins, C.A.; et al. Simultaneous emergence of multidrug-resistant *Candida auris* on 3 continents confirmed by whole-genome sequencing and epidemiological analyses. *Clin. Infect. Dis.* **2017**, *64*, 134–140. [\[CrossRef\]](#) [\[PubMed\]](#)
23. van der Linden, J.W.; Arendrup, M.C.; Warris, A.; Lagrou, K.; Pelloux, H.; Hauser, P.M.; Chryssanthou, E.; Mellado, E.; Kidd, S.E.; Tortorano, A.M.; et al. Prospective multicenter international surveillance of azole resistance in *Aspergillus fumigatus*. *Emerg. Infect. Dis.* **2015**, *21*, 1041–1044. [\[CrossRef\]](#)
24. Roemer, T.; Krysan, D.J. Antifungal drug development: Challenges, unmet clinical needs, and new approaches. *Cold Spring Harb. Perspect. Med.* **2014**, *4*, a019703. [\[CrossRef\]](#) [\[PubMed\]](#)
25. Perfect, J.R. The antifungal pipeline: A reality check. *Nat. Rev. Drug Discov.* **2017**, *16*, 603–616. [\[CrossRef\]](#)

26. Zhai, B.; Wu, C.; Wang, L.; Sachs, M.S.; Lin, X. The antidepressant sertraline provides a promising therapeutic option for neurotropic cryptococcal infections. *Antimicrob. Agents Chemother.* **2012**, *56*, 3758–3766. [\[CrossRef\]](#)
27. Butts, A.; Koselny, K.; Chabrier-Roselló, Y.; Semighini, C.P.; Brown, J.C.; Wang, X.; Annadurai, S.; DiDone, L.; Tabroff, J.; Childers, W.E.; et al. Estrogen receptor antagonists are anti-cryptococcal agents that directly bind EF hand proteins and synergize with fluconazole in vivo. *mBio* **2014**, *5*, e00765-13. [\[CrossRef\]](#)
28. Villar-Vidal, M.; Coronado-Aceves, E.W.; Shibayama, M.; Tsutsumi, V.; Becerril-García, M.A.; García-de la Cruz, R.F.; González-Salazar, F.; Hernández-Delgado, N.C.; Muñoz-Hernández, O.; Silva-Miranda, M. Chitosan and its derivatives: Properties and applications in biotechnology. *Polymers* **2021**, *13*, 3108.
29. Mookherjee, A.; Singh, S.; Maiti, M.K. Quorum sensing inhibitors: Can endophytes be prospective sources? *Arch. Microbiol.* **2019**, *201*, 355–369. [\[CrossRef\]](#) [\[PubMed\]](#)
30. Pfaller, M.A.; Castanheira, M. Nosocomial candidiasis: Antifungal stewardship and the importance of rapid diagnosis. *Med. Mycol.* **2016**, *54*, 1–22. [\[CrossRef\]](#) [\[PubMed\]](#)
31. Cleveland, A.A.; Farley, M.M.; Harrison, L.H.; Stein, B.; Hollick, R.; Lockhart, S.R.; Magill, S.S.; Derado, G.; Park, B.J.; Chiller, T.M. Changes in incidence and antifungal drug resistance in candidemia: Results from population-based laboratory surveillance in Atlanta and Baltimore, 2008–2011. *Clin. Infect. Dis.* **2012**, *55*, 1352–1361. [\[CrossRef\]](#)
32. Andes, D.R.; Safdar, N.; Baddley, J.W.; Playford, G.; Reboli, A.C.; Rex, J.H.; Sobel, J.D.; Pappas, P.G.; Kullberg, B.J. Impact of treatment strategy on outcomes in patients with candidemia and other forms of invasive candidiasis: A patient-level quantitative review of randomized trials. *Clin. Infect. Dis.* **2012**, *54*, 1110–1122. [\[CrossRef\]](#)
33. Garey, K.W.; Rege, M.; Pai, M.P.; Mingo, D.E.; Suda, K.J.; Turpin, R.S.; Bearden, D.T. Time to initiation of fluconazole therapy impacts mortality in patients with candidemia: A multi-institutional study. *Clin. Infect. Dis.* **2006**, *43*, 25–31. [\[CrossRef\]](#)
34. Clancy, C.J.; Nguyen, M.H. Finding the “missing 50%” of invasive candidiasis: How nonculture diagnostics will improve understanding of disease spectrum and transform patient care. *Clin. Infect. Dis.* **2013**, *56*, 1284–1292. [\[CrossRef\]](#)
35. Salmanton-García, J.; Sprute, R.; Stemler, J.; Bartoletti, M.; Dupont, D.; Valerio, M.; Garcia-Vidal, C.; Falces-Romero, I.; Machado, M.; de la Villa, S.; et al. COVID-19-associated pulmonary aspergillosis, March–August 2020. *Emerg. Infect. Dis.* **2021**, *27*, 1077–1086. [\[CrossRef\]](#)
36. Ramage, G.; Rajendran, R.; Gutierrez-Correa, M.; Jones, B.; Williams, C. Aspergillus biofilms: Clinical and industrial significance. *FEMS Microbiol. Lett.* **2011**, *324*, 89–97. [\[CrossRef\]](#) [\[PubMed\]](#)
37. Nett, J.E.; Andes, D.R. Candida albicans biofilm development, modeling, and measurement. *Curr. Protoc. Microbiol.* **2006**, *2*, 17A.2.1–17A.2.20.
38. Lortholary, O.; Renaudat, C.; Sitbon, K.; Madec, Y.; Denoeud-Ndam, L.; Wolff, M.; Fontanet, A.; Bretagne, S.; Dromer, F. Worrisome trends in incidence and mortality of candidemia in intensive care units (Paris area, 2002–2010). *Intensive Care Med.* **2014**, *40*, 1303–1312. [\[CrossRef\]](#) [\[PubMed\]](#)
39. Brown, G.D.; Denning, D.W.; Levitz, S.M. Tackling human fungal infections. *Science* **2012**, *336*, 647. [\[CrossRef\]](#)
40. Cowen, L.E.; Anderson, J.B.; Kohn, L.M. Evolution of drug resistance in Candida albicans. *Annu. Rev. Microbiol.* **2002**, *56*, 139–165. [\[CrossRef\]](#) [\[PubMed\]](#)
41. Lionakis, M.S. New insights into innate immune control of systemic candidiasis. *Med. Mycol.* **2014**, *52*, 555–564. [\[CrossRef\]](#)
42. Romani, L. Immunity to fungal infections. *Nat. Rev. Immunol.* **2011**, *11*, 275–288. [\[CrossRef\]](#)
43. Sudbery, P.E. Growth of Candida albicans hyphae. *Nat. Rev. Microbiol.* **2011**, *9*, 737–748. [\[CrossRef\]](#)
44. Mayer, F.L.; Wilson, D.; Hube, B. Candida albicans pathogenicity mechanisms. *Virulence* **2013**, *4*, 119–128. [\[CrossRef\]](#)
45. Harriott, M.M.; Noverr, M.C. Candida albicans and Staphylococcus aureus form polymicrobial biofilms: Effects on antimicrobial resistance. *Antimicrob. Agents Chemother.* **2009**, *53*, 3914–3922. [\[CrossRef\]](#) [\[PubMed\]](#)
46. Shirtliff, M.E.; Peters, B.M.; Jabra-Rizk, M.A. Cross-kingdom interactions: Candida albicans and bacteria. *FEMS Microbiol. Lett.* **2009**, *299*, 1–8. [\[CrossRef\]](#) [\[PubMed\]](#)
47. Peleg, A.Y.; Hogan, D.A.; Mylonakis, E. Medically important bacterial-fungal interactions. *Nat. Rev. Microbiol.* **2010**, *8*, 340–349. [\[CrossRef\]](#)
48. Yapar, N. Epidemiology and risk factors for invasive candidiasis. *Ther. Clin. Risk Manag.* **2014**, *10*, 95–105. [\[CrossRef\]](#) [\[PubMed\]](#)
49. Guinea, J. Global trends in the distribution of Candida species causing candidemia. *Clin. Microbiol. Infect.* **2014**, *20*, 5–10. [\[CrossRef\]](#)
50. Odds, F.C.; Hanson, M.F.; Davidson, A.D.; Jacobsen, M.D.; Wright, P.; Whyte, J.A.; Gow, N.A.; Jones, B.L. One year prospective survey of Candida bloodstream infections in Scotland. *J. Med. Microbiol.* **2007**, *56*, 1066–1075. [\[CrossRef\]](#)
51. Wisplinghoff, H.; Bischoff, T.; Tallent, S.M.; Seifert, H.; Wenzel, R.P.; Edmond, M.B. Nosocomial bloodstream infections in US hospitals: Analysis of 24,179 cases from a prospective nationwide surveillance study. *Clin. Infect. Dis.* **2004**, *39*, 309–317. [\[CrossRef\]](#)

52. Bassetti, M.; Merelli, M.; Righi, E.; Diaz-Martin, A.; Rosello, E.M.; Luzzati, R.; Parra, A.; Trecarichi, E.M.; Sanguinetti, M.; Posteraro, B.; et al. Epidemiology, species distribution, antifungal susceptibility, and outcome of candidemia across five sites in Italy and Spain. *J. Clin. Microbiol.* **2013**, *51*, 4167–4172. [[CrossRef](#)]
53. Denning, D.W.; Pleuvry, A.; Cole, D.C. Global burden of chronic pulmonary aspergillosis as a sequel to pulmonary tuberculosis. *Bull. World Health Organ.* **2011**, *89*, 864–872. [[CrossRef](#)] [[PubMed](#)]
54. Chowdhary, A.; Sharma, C.; Meis, J.F. Candida auris: A rapidly emerging cause of hospital-acquired multidrug-resistant fungal infections globally. *PLoS Pathog.* **2017**, *13*, e1006290. [[CrossRef](#)]
55. Oladele, R.O.; Bongomin, F.; Gago, S.; Denning, D.W. HIV-associated cryptococcal disease in resource-limited settings: A case for “prevention is better than cure”? *J. Fungi* **2017**, *3*, 67. [[CrossRef](#)]
56. Rajasingham, R.; Smith, R.M.; Park, B.J.; Jarvis, J.N.; Govender, N.P.; Chiller, T.M.; Denning, D.W.; Loyse, A.; Boulware, D.R. Global burden of disease of HIV-associated cryptococcal meningitis: An updated analysis. *Lancet Infect. Dis.* **2017**, *17*, 873–881. [[CrossRef](#)]
57. Liao, Y.; Wang, Y.; Feng, Y.; Xu, Z.; Jiang, H.; Liu, G. Machine learning methods applied to predict ventilator-associated pneumonia with *Pseudomonas aeruginosa* infection via sensor array of electronic nose in intensive care unit. *Biosens. Bioelectron.* **2021**, *173*, 112717. [[CrossRef](#)]
58. Segal, E.; Frenkel, M.; Vessman, A.; Carmeli, B.; Barhoom, S.; Vogelaer, D.; Rubin, C.; Raviv, Y.; Moses, A.E.; Block, C. Machine learning algorithm for early detection of end-stage renal disease. *NPJ Digit. Med.* **2020**, *3*, 78. [[CrossRef](#)]
59. Cruciani, M.; Mengoli, C.; Loeffler, J.; Donnelly, P.; Barnes, R.; Jones, B.L.; Klingspor, L.; Maertens, J.; Morton, O.; White, P.L. Polymerase chain reaction blood tests for the diagnosis of invasive aspergillosis in immunocompromised people. *Cochrane Database Syst. Rev.* **2015**, *2015*, CD009551. [[CrossRef](#)] [[PubMed](#)]
60. Posteraro, B.; Posteraro, P.; Sanguinetti, M. Diagnosis of invasive aspergillosis: The role of PCR. *Expert Rev. Anti Infect. Ther.* **2011**, *9*, 643–645.
61. Lionakis, M.S.; Levitz, S.M. Host control of fungal infections: Lessons from basic studies and human cohorts. *Annu. Rev. Immunol.* **2018**, *36*, 157–191. [[CrossRef](#)] [[PubMed](#)]
62. Johnson, M.D.; Perfect, J.R. Use of antifungal combination therapy: What laboratory and clinical studies tell us so far. *Expert Rev. Anti Infect. Ther.* **2007**, *5*, 1017–1029.
63. Ashman, R.B.; Papadimitriou, J.M. Production and function of cytokines in natural and acquired immunity to *Candida albicans* infection. *Microbiol. Rev.* **1995**, *59*, 646–672. [[CrossRef](#)]
64. Cassone, A.; Casadevall, A. Recent progress in vaccines against fungal diseases. *Curr. Opin. Microbiol.* **2012**, *15*, 427–433. [[CrossRef](#)] [[PubMed](#)]

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