ANNALS OF THE UNIVERSITY OF CRAIOVA

Series: ✓*Biology*
✓*Horticulture*
✓*Food products processing technology*
✓*Environmental engineering*

Vol. XXX (LXVI) - 2025

PATHOGENIC FUNGI: TAXONOMY, VIRULENCE, AND CLINICAL SIGNIFICANCE

Ciupeanu Daniela[1]*, Copilescu Danilea-Maria[2]
[1] University of Craiova, Faculty of Horticulture
[2] University of Craiova, Faculty of Horticulture, Biology student
* *Corresponding author. E-mail:* ciupeanudaniela@gmail.com

Keywords*: Pathogenic fungi; Mycoses; Candida albicans; Aspergillus fumigatus; Antifungal resistance*

ABSTRACT

Pathogenic fungi are increasingly important in clinical and public health, with species like Candida albicans, Aspergillus fumigatus, Cryptococcus neoformans, and dermatophytes causing disease. They range from superficial infections of skin and nails to severe systemic illness in immunocompromised patients. Their virulence relies on biofilm formation, enzyme production, and thermal dimorphism. Advances in diagnostics and antifungal testing have improved treatment, yet resistance to azoles and echinocandins is rising. Prevention depends on host immunity, careful antifungal use, and environmental monitoring. Continued research is essential to reduce their impact.

INTRODUCTION

Fungi are eukaryotic microorganisms characterized by complex cellular organization and remarkable ecological diversity. Most species live as saprophytes or symbionts, contributing to nutrient cycling and ecological balance. However, a limited yet clinically significant subset has evolved to become pathogenic to humans, exploiting weaknesses in host defenses. These opportunistic pathogens primarily cause disease when the immune system is compromised (Pfaller & Diekema 2007).

Clinically relevant species encompass several morphological groups: yeasts such as Candida albicans, filamentous molds like Aspergillus fumigatus, dimorphic fungi (Histoplasma capsulatum, Blastomyces dermatitidis), and encapsulated yeasts such as Cryptococcus neoformans. Their ability to thrive in hostile host environments arises from multiple virulence determinants, including biofilm formation, secretion of hydrolytic enzymes, and dimorphic switching, all of which enhance tissue invasion and persistence (Calderone & Fonzi 2001, Mayer et al. 2013).

The global burden of fungal diseases has gained growing recognition in recent decades. Superficial infections affect over one billion individuals annually, while invasive fungal infections are responsible for more than 1.5 million deaths each year—figures that rival the mortality of tuberculosis and malaria (Brown et al. 2012). The highest risk groups include immunocompromised patients such as those with HIV/AIDS, hematologic malignancies, or post-transplant immunosuppression (Perfect 2017).

Across Europe and worldwide, surveillance data demonstrate a steady increase in systemic fungal infections, particularly candidemia and aspergillosis, compounded by the alarming emergence of antifungal resistance (Kullberg &

Arendrup 2015, Pristov & Ghannoum 2019). These epidemiological trends underscore the necessity for robust diagnostic systems, antifungal stewardship, and continuous epidemiological monitoring.

At a regional level, in Romania and the broader Eastern European context, information on the prevalence and resistance of pathogenic fungi remains limited. This underscores the importance of academic and clinical investigations dedicated to fungal pathogens. The present paper therefore synthesizes current knowledge on pathogenic fungi, highlighting their clinical importance, resistance mechanisms, and the challenges they pose to modern healthcare systems.

MATERIAL AND METHODS

This study was designed as a narrative synthesis aimed at integrating the current body of academic and clinical knowledge concerning pathogenic fungi, their taxonomy, virulence mechanisms, and clinical relevance.

Data sources. Relevant literature was identified through major scientific databases including PubMed, Scopus, and Web of Science, using specific keywords such as pathogenic fungi, mycoses, Candida, Aspergillus, Cryptococcus, and antifungal resistance. The search encompassed review papers, clinical studies, surveillance reports, and experimental investigations published between 2000 and 2024.

Inclusion criteria. Selected studies addressed topics such as fungal taxonomy, morphology, mechanisms of pathogenicity, epidemiology, diagnostic approaches, antifungal resistance, and treatment strategies. Both experimental laboratory studies and clinical case series were included to ensure a balanced representation of research perspectives.

Exclusion criteria. Publications were excluded if they lacked primary data, were written in non-English languages without accessible abstracts, or focused on non-human fungal species.

Data extraction and synthesis. From the eligible literature, relevant findings were extracted and analyzed narratively. The synthesis focused on five main dimensions:

(i) taxonomy and morphological characteristics of fungi;

(ii) mechanisms of pathogenicity;

(iii) clinical presentation of superficial and invasive mycoses;

(iv) antifungal resistance profiles; and

(v) strategies for diagnosis, prevention, and treatment.

This methodological framework allowed for an integrative and comparative overview of the field, linking fundamental mycological concepts with clinical applicability. By combining data from multiple research domains, the study provides a comprehensive context for understanding the evolution, epidemiology, and medical impact of pathogenic fungi.

RESULTS AND DISCUSSIONS

Local findings. In the present study, pathogenic fungi were identified from clinical and environmental samples collected during the observation period. The genera Candida and Aspergillus were the most frequently isolated, confirming their dominance in both superficial and systemic infections. Less frequent but clinically relevant isolates included Cryptococcus and several dermatophytes (Trichophyton, Microsporum). The distribution observed in our analysis reflects global epidemiological patterns, with Candida species accounting for approximately half of all recorded infections, followed by Aspergillus. These findings emphasize the

importance of local surveillance to complement international data and to adapt therapeutic and preventive strategies accordingly (Fig. 1).

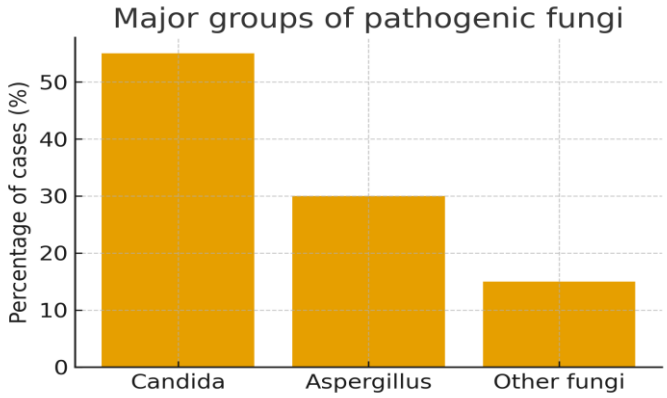

Figure 1. Major groups of pathogenic fungi

Diversity of pathogenic fungi. Although thousands of fungal species have been described, only about a hundred are known to cause disease in humans. Among them, the most clinically important belong to the genera Candida, Aspergillus, Cryptococcus, Histoplasma, Blastomyces, and the dermatophytes (Trichophyton, Microsporum, Epidermophyton). Candida albicans remains the leading cause of opportunistic fungal infections, while Candida auris has recently emerged as a multidrug-resistant species of global concern (Pfaller & Diekema 2007; Jeffery-Smith et al. 2018). Figure 2 illustrates the relative frequency of major genera implicated in human fungal infections, emphasizing the predominance of Candida and Aspergillus.

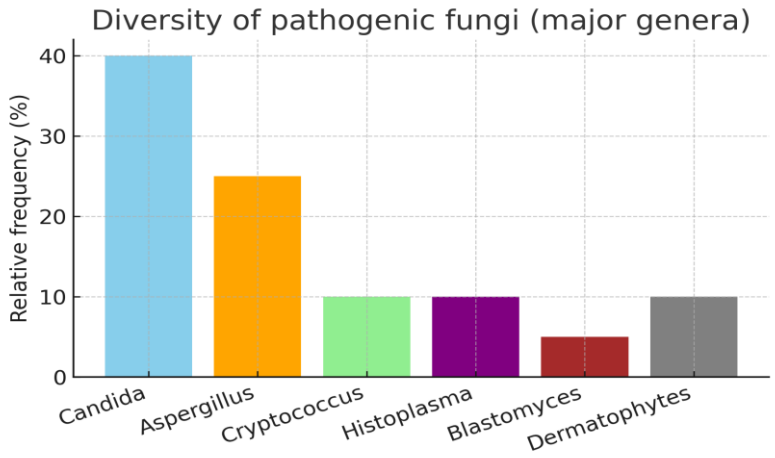

Figure 2. Diversity of pathogenic fungi (major genera)

Virulence factors. The success of pathogenic fungi in colonizing and persisting within host tissues depends on several specialized virulence mechanisms. *Candida albicans* demonstrates remarkable adaptability through yeast–hyphae dimorphism,

biofilm formation on mucosal surfaces and medical devices, and the secretion of hydrolytic enzymes such as proteases and lipases (Calderone & Fonzi 2001, Mayer et al. 2013). *Aspergillus fumigatus* employs a different arsenal—its small, airborne conidia allow deep inhalation into the lungs, while thermotolerance and gliotoxin production enhance its ability to invade immunocompromised hosts (Latgé & Chamilos 2020). The relative contribution of these mechanisms is depicted in Figure 3.

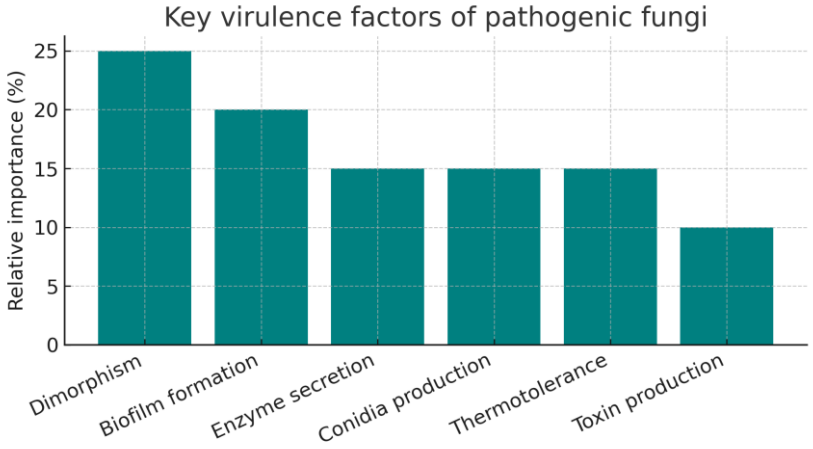

Figure 3. Key virulence factors of pathogenic fungi

Clinical spectrum. Superficial mycoses such as dermatophytoses and mucosal candidiasis affect over a billion people worldwide and, although usually chronic, are seldom life-threatening (Brown et al. 2012). In contrast, invasive fungal infections—candidemia, aspergillosis, cryptococcosis, histoplasmosis—carry high mortality rates, particularly in patients with hematologic malignancies, HIV/AIDS, or those who have undergone organ transplantation (Perfect 2017).

Antifungal resistance. Resistance to major drug classes has become a pressing clinical problem. Aspergillus fumigatus increasingly exhibits azole resistance, largely due to environmental fungicide exposure, while Candida species show both echinocandin and multidrug resistance (Pristov & Ghannoum 2019). The emergence of Candida auris, resistant to multiple agents and linked to hospital outbreaks, underscores the need for continuous epidemiological surveillance (Jeffery-Smith et al. 2018).

Epidemiological trends. European and global studies consistently report a growing burden of invasive fungal infections. Candida dominates intensive care settings, Aspergillus prevails among transplant and hematology patients, and Cryptococcus remains a leading cause of death among individuals with HIV/AIDS in low- and middle-income countries (Kullberg & Arendrup 2015; Rajasingham et al. 2017).

Implications for healthcare. The data highlight the urgent need for:

- Early diagnosis using molecular methods and antigen detection.
- Antifungal stewardship to optimize drug use and delay resistance.
- Infection-prevention measures, especially in high-risk wards.
- Global and local surveillance programs to monitor incidence and emerging pathogens.

Together, these strategies can mitigate the impact of pathogenic fungi and improve outcomes for vulnerable populations.

CONCLUSIONS

Pathogenic fungi represent a limited but clinically significant group of organisms, with a spectrum ranging from superficial infections to life-threatening systemic mycoses.

Opportunistic fungi such as *Candida albicans*, *Aspergillus fumigatus*, and *Cryptococcus neoformans* dominate clinical practice, while emerging species like *Candida auris* highlight the evolving epidemiological landscape.

Virulence factors including biofilm formation, dimorphism, and enzyme production enhance persistence and resistance to therapy.

Antifungal resistance is an increasing global concern, threatening the efficacy of azoles and echinocandins, and demanding strong antifungal stewardship.

Continuous surveillance, rapid diagnostics, and preventive strategies are essential to reduce morbidity and mortality associated with fungal infections.

REFERENCES

Brown G. D., Denning D. W., Gow N. A. R., Levitz S. M., Netea M. G., White T. C. 2012. Hidden killers: human fungal infections. Science Translational Medicine, 4(165), 165rv13. American Association for the Advancement of Science.

Calderone R. A., Fonzi W. A. 2001. Virulence factors of Candida albicans. Trends in Microbiology, 9(7), 327–335. Elsevier.

Jeffery-Smith A., Taori S. K., Schelenz S., Jeffery K., Johnson E. M., Borman A., Candida auris Incident Management Team. 2018. Candida auris: a review of the literature. Clinical Microbiology Reviews, 31(1), e00029-17. American Society for Microbiology.

Kullberg B. J., Arendrup M. C. 2015. Invasive candidiasis. New England Journal of Medicine, 373(15), 1445–1456. Massachusetts Medical Society.

Latgé J. P., Chamilos G. 2020. Aspergillus fumigatus and aspergillosis in 2019. Clinical Microbiology Reviews, 33(1), e00140-18. American Society for Microbiology.

Mayer F. L., Wilson D., Hube B. 2013. Candida albicans pathogenicity mechanisms. Virulence, 4(2), 119–128. Taylor & Francis.

Perfect J. R. 2017. The antifungal pipeline: a reality check. Nature Reviews Drug Discovery, 16(9), 603–616. Springer Nature.

Pfaller M. A., Diekema D. J. 2007. Epidemiology of invasive candidiasis: a persistent public health problem. Clinical Microbiology Reviews, 20(1), 133–163. American Society for Microbiology.

Pristov K. E., Ghannoum M. A. 2019. Resistance of pathogenic fungi to antifungal drugs: current state and future outlook. Journal of Clinical Investigation, 129(4), 1437–1445. American Society for Clinical Investigation.

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. 2017. Global burden of disease of HIV-associated cryptococcal meningitis: an updated analysis. The Lancet Infectious Diseases, 17(8), 873–881. Elsevier.

Zhou Y., Wang J., Guo Y., et al. 2023. Proportions of Pseudomonas aeruginosa and antimicrobial-resistant P. aeruginosa in surgical site infections: a systematic review and meta-analysis. Open Forum Infectious Diseases, 11(2), ofad647. Oxford University Press.