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OVERVIEW OF THE MAIN FUNGAL INFECTIONS IN HUMANS

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ABSTRACT

Human fungal infections (mycoses) represent a rapidly growing public health concern worldwide. Although many fungi exist as environmental saprophytes or harmless commensals, a substantial number of species can cause disease ranging from superficial skin infections to severe invasive disease with high mortality. The global rise in immunocompromised patient populations, combined with increasing antifungal resistance, contributes to the expanding burden of fungal disease. This review summarizes the major categories of human mycoses, key etiological agents, clinical manifestations, diagnostic challenges, and current therapeutic strategies. Recent advances in diagnostics, antifungal development, and molecular epidemiology are discussed, with emphasis on emerging pathogens and evolving resistance profiles [1,2,6,7].

KEYWORDS

Human Mycoses, Fungal Infections, Invasive Fungal Disease, Dermatophytosis, Candidiasis, Aspergillosis, Antifungal Resistance, Emerging Fungal Pathogens, Subcutaneous Mycoses, Endemic Mycoses

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Introduction

Fungal pathogens are responsible for more than a billion infections annually, with millions of cases progressing to moderate or severe disease. Despite this, fungal diseases receive significantly less attention compared to bacterial or viral infections. The increasing prevalence of malignancies, organ transplantation, HIV infection, critical illness, and immunomodulatory therapies has created a growing population susceptible to invasive fungal disease (IFD). Environmental changes, including rising temperatures and urbanization, have also expanded the geographic range of several pathogenic fungi [1,2,3].

Human mycoses are traditionally classified according to tissue depth: superficial (cutaneous), subcutaneous, and systemic (invasive). Each category encompasses distinct organisms, clinical features, and management strategies [2,8].

1. Superficial and Cutaneous Mycoses

Superficial and cutaneous fungal infections are the most common globally and typically involve keratinized tissues.

Dermatophytoses

Dermatophytes such as *Trichophyton*, *Microsporum*, and *Epidermophyton* species cause infections of the skin, nails, and hair. These infections manifest as well-demarcated, erythematous, scaling plaques and may become chronic if untreated. *Trichophyton rubrum* remains the predominant agent worldwide [2,3,5].

Yeast Infections

Yeasts, particularly *Candida albicans*, cause mucocutaneous candidiasis affecting the oral cavity, genital mucosa, intertriginous areas, and nails. Overgrowth is typically associated with moisture, dysbiosis, antibiotic use, pregnancy, or immune dysfunction [1,6].

Malassezia-Associated Conditions

Malassezia species are responsible for pityriasis versicolor and seborrheic dermatitis. These organisms thrive in lipid-rich environments, contributing to superficial but recurrent disease [2,5].

2. Subcutaneous Mycoses

Subcutaneous infections arise after traumatic implantation of fungal elements into deeper tissues.

Sporotrichosis

Caused by *Sporothrix schenckii*, this infection presents as nodular lesions that spread along lymphatic channels. Zoonotic transmission, especially from cats, has become increasingly recognized in some regions.

Chromoblastomycosis and Mycetoma

Chronic infections caused by dematiaceous fungi result in warty or tumorous lesions that may lead to fibrosis or lymphatic obstruction. Mycetoma, a progressive, granulomatous disease of the soft tissues and bone, is an important cause of disability in tropical regions.

3. Systemic and Invasive Fungal Diseases

Systemic or invasive fungal infections pose the most serious clinical threat, with high morbidity and mortality [2,3,4].

Invasive Candidiasis

Invasive disease caused by *Candida* species includes candidemia and deep-organ infection. Non-albicans species such as *Candida glabrata* and *Candida auris* are of increasing concern due to rising antifungal resistance. Outbreaks of multidrug-resistant *C. auris* have been reported in hospitals worldwide [1,3].

Invasive Aspergillosis

Aspergillus fumigatus is the leading cause of invasive aspergillosis. Infection typically affects patients with neutropenia, hematologic malignancies, or those receiving stem cell transplants. Azole resistance in *A. fumigatus* is an expanding global issue linked both to agricultural fungicide use and azole use in medical therapy [4,5,6,7].

Mucormycosis

Members of the order Mucorales cause rapidly progressive infections, particularly in patients with diabetes, trauma, or profound immunosuppression. The disease is characterized by angioinvasion and tissue necrosis [3,4].

Endemic (Dimorphic) Mycoses

Dimorphic fungi such as *Histoplasma capsulatum*, *Coccidioides* spp., and *Blastomyces dermatitidis* cause pulmonary and systemic disease following inhalation of spores. Although geographically restricted, climate change has expanded their endemic range [8,9].

Diagnosis

Diagnosis of fungal infections remains challenging due to nonspecific symptoms and slow culture growth. Current approaches include:

- Direct microscopy and histopathology
- Culture-based methods, still considered the gold standard but limited by long turnaround times
- Serological assays, such as galactomannan and β -D-glucan testing
- Molecular diagnostics, including PCR and next-generation sequencing
- Mass spectrometry (MALDI-TOF) for rapid species identification

Advances in point-of-care diagnostics and host biomarker detection offer promising avenues but require further validation [3,4,6].

Treatment and Antifungal Resistance

Four main antifungal classes are currently used: azoles, polyenes, echinocandins, and nucleic acid analogs.

Azoles (fluconazole, itraconazole, voriconazole, posaconazole) inhibit ergosterol synthesis and are widely used. Resistance is increasing, especially among *Candida* and *Aspergillus* species.

Echinocandins (caspofungin, micafungin, anidulafungin) are first-line agents for invasive candidiasis.

Amphotericin B, a polyene, remains essential for severe infections including mucormycosis and cryptococcosis.

Flucytosine is primarily used in combination therapy, especially for cryptococcal meningitis.

New antifungal agents (such as rezafungin and fosmanogepix) are in advanced clinical development and may help address resistance concerns [6,7,10].

Conclusions

Fungal infections constitute an increasingly important global health issue. While superficial infections remain widespread and often benign, invasive fungal diseases continue to carry unacceptably high mortality, particularly among immunocompromised patients. Improvements in diagnostics, surveillance, rational antifungal therapy, and investment in research are essential to reduce the burden of human mycoses [1,2,6,7].

Author's contribution:

Conceptualization: Klaudia Arciszewska, Aleksandra Padkowska; Methodology: Klaudia Arciszewska, Jakub Maciej Pieniążek; Software: Jakub Maciej Pieniążek, Paweł Arkadiusz Malmur; Check: Klaudia Arciszewska, Aleksandra Padkowska; Formal analysis: Klaudia Arciszewska, Mateusz Dobosz; Investigation: Klaudia Arciszewska, Julia Kajszczyk, Aleksandra Rak; Resources: Paweł Arkadiusz Malmur; Data curation: Kinga Rogowska-Borettini; Writing – rough preparation: Klaudia Arciszewska; Writing – review and editing: Aleksandra Padkowska, Aleksandra Romanowska, Aleksandra Rak; Visualization: Klaudia Arciszewska; Supervision: Aleksandra Padkowska; Project administration: Kinga Rogowska-Borettini; Validation: Weronika Biaduń-Mućko, Aleksandra Rak.

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