

A study on fungal infections: From general types to Dermophytosis

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Article History	Abstract: Fungal infections are a significant global health concern, ranging from mild superficial infections to severe systemic diseases. This project explores the general types of fungal infections, highlighting their classification, causes, and common manifestations. A special focus is given to dermatophytosis, one of the most prevalent superficial fungal infections affecting skin, hair, and nails. The study discusses the etiology, epidemiology, clinical features, and treatment options for dermatophytosis, along with preventive measures to reduce its spread. By comparing different fungal infections and analyzing the local prevalence of dermatophytosis, this project aims to provide a comprehensive understanding of fungal diseases, their impact on human health, and the importance of early diagnosis and effective management.
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Introduction

Fungal infections are caused by fungi, a type of microorganism found in the environment, including soil, water, and even on the human body. These infections can affect the skin, nails, hair, and occasionally internal organs. Mild infections like athlete's foot or ringworm are common and usually treatable, while severe infections can occur in people with weakened immunity. [1]

The prevalence of fungal infections has been increasing globally due to factors such as widespread antibiotic use, immunosuppressive therapies, and lifestyle changes. Environmental factors like humidity, urbanization, and climate change also contribute to the spread of fungi in new regions. Fungi are highly adaptable and can survive in diverse conditions, which makes them a persistent challenge for healthcare systems. Understanding their biology, modes of transmission, and impact on human health is therefore essential for effective prevention, early diagnosis, and appropriate treatment strategies (Denning, 2024). (fungalinfectiontrust.org)

Importance of Studying Fungal Infections

Studying fungal infections is important because they affect a wide range of people, from healthy individuals to those with compromised immune systems. Skin infections like dermatophytosis, candidiasis, and nail infections may seem minor but can cause discomfort, itching, and social embarrassment, affecting the quality of life. On the other hand, systemic fungal infections can be severe and sometimes fatal, especially in patients undergoing chemotherapy, organ transplantation, or long-term antibiotic therapy.[2]

Understanding fungal infections helps healthcare professionals improve early diagnosis, select appropriate treatment options, and prevent complications. It also supports public health initiatives by raising awareness about hygiene practices, environmental precautions, and preventive measures. Moreover, studying fungal infections contributes to the development of new antifungal drugs and therapies, which are increasingly needed due

to drug resistance and the rising number of high-risk patients. By exploring both common and severe fungal infections, researchers and clinicians can ensure better management of these diseases and reduce their impact on society (Bongomin et al., 2021). (publish.knepublishing.com)

Objectives of the Study

The main objectives of this study are designed to provide a clear and structured understanding of fungal infections while keeping their real-life impact in mind. These objectives include:

- To provide a comprehensive understanding of fungal infections, including their causes, types, and clinical manifestations, helping students, healthcare professionals, and even curious readers appreciate how these infections affect people in everyday life.

- To focus specifically on dermatophytosis, one of the most common and noticeable fungal infections affecting the skin, hair, and nails, highlighting not just the medical aspect but also the discomfort and social impact it can cause.
- To explore diagnostic methods and laboratory investigations used for identifying fungal infections, bridging the gap between theory and practical application in hospitals and clinics.
- To review treatment options, including topical and systemic antifungal therapies, their effectiveness, and potential limitations, emphasizing the importance of proper management so that patients can recover comfortably and quickly.
- By achieving these objectives, this study aims not only to provide scientific knowledge but also to make the information relatable and practical. The goal is to ensure that readers understand the significance of fungal infections, recognize their impact on real people, and appreciate the importance of prevention, diagnosis, and treatment in a way that is meaningful and applicable. [3]

Overview of Fungal Infections

Fungal infections are caused by a diverse group of microorganisms called fungi. These organisms are eukaryotic, meaning their cells have a defined nucleus, and they exist in a wide range of environments, including soil, water, air, and on living organisms. While most fungi are harmless or even beneficial, some have the ability to invade humans and cause infections. Fungal infections can be superficial, affecting the skin, hair, and nails; subcutaneous, affecting tissues beneath the skin; or systemic, affecting internal organs and posing life-threatening risks. [4]

Characteristics of fungi

- Fungi are eukaryotic organisms with a true nucleus.
- Their cell wall is made of chitin.
- They are heterotrophic, absorbing nutrients from organic matter.
- Fungi reproduce sexually or asexually and produce spores.
- They can be unicellular (yeasts) or multicellular (molds) and some show dimorphism.

Classification of fungi

1. Yeasts – Unicellular fungi, reproduce by budding (e.g., *Saccharomyces*).
2. Molds – Multicellular fungi with hyphae, form mycelium (e.g., *Aspergillus*).
3. Dimorphic Fungi – Can exist as yeast or mold depending on temperature (e.g., *Histoplasma*).
4. Pathogenic Fungi – Cause diseases in humans (e.g., *Candida*, *Trichophyton*).
5. Non-Pathogenic Fungi – Harmless, used in food/industry (e.g., *Penicillium*).

GENERAL TYPES OF FUNGAL INFECTIONS

Superficial Fungal Infections

Affect skin, hair, and nails.

- Common examples: Dermatophytosis (ringworm), *Tinea* infections.
- Usually mild, cause itching, redness, scaling.

Subcutaneous Fungal Infections

- Affect deeper layers of skin, muscles, and connective tissue.
- Usually enter through cuts or injuries.
- Example: Sporotrichosis.

Systemic (Deep) Fungal Infections

- Affect internal organs like lungs, brain, or bloodstream.
- Usually in immunocompromised patients.
- Examples: Histoplasmosis, Candidemia.

Opportunistic Fungal Infections

- Occur when immune system is weak (HIV, chemotherapy, diabetes).
- Can be mild or life-threatening.
- Examples: Aspergillosis, Cryptococcosis.

Epidemiology of fungal infection

Global Burden

Fungal infections affect millions of people worldwide each year. They range from mild superficial infections, such as skin, hair, and nail infections, to severe systemic infections that can be life-threatening, especially in immunocompromised individuals. Superficial infections, including dermatophytosis, are very common in tropical and subtropical regions where hot and humid climates favor fungal growth. Systemic fungal infections, such as candidemia, aspergillosis, and cryptococcosis, are more prevalent in hospitalized or immunocompromised patients and are associated with high mortality if untreated. Opportunistic fungal infections are also increasing globally due to advanced medical treatments like chemotherapy, organ transplantation, and the rising prevalence of HIV/AIDS. The burden is especially high in areas with limited healthcare access, where early diagnosis and treatment are often delayed. [5]

Indian Scenario

India has a high prevalence of fungal infections due to its warm and humid climate, dense population, and variable sanitation standards. Superficial fungal infections, especially dermatophytosis (ringworm), are the most common and affect all age groups. Opportunistic infections, such as candidiasis and aspergillosis, are also rising, particularly in immunocompromised individuals, including patients with HIV/AIDS, diabetes, or those on long-term corticosteroid therapy. Rural and urban overcrowding, poor hygiene, and lack of awareness contribute to the rapid spread of infections. Many cases go unreported or are self-treated, leading to recurrence and chronic infections.

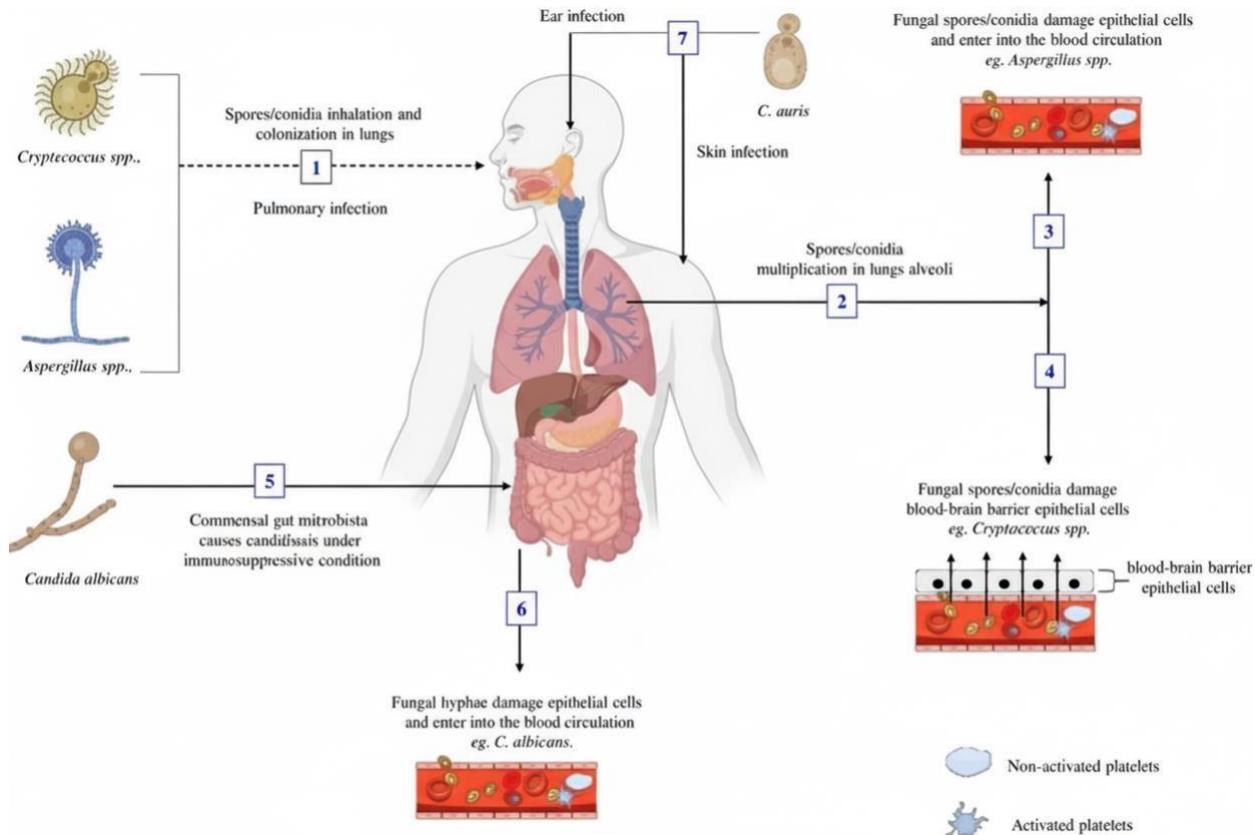
Factor influencing spread of fungal infection

1. Climate – Warm and humid conditions favor fungal growth.
2. Hygiene – Poor personal and community hygiene increases infection risk.
3. Immunity – Weak immune system due to HIV, diabetes, or immunosuppressive drugs makes infections more likely.
4. Occupation – Jobs involving soil, water, or animals increase exposure.
5. Lifestyle – Wearing tight or damp clothing, excessive sweating, and poor skin care promote infection.

Pathogenesis of fungal infection

How Fungi Infect the Human Body

Fungi cause infection by entering the body through various routes such as broken skin, inhalation of spores, or mucosal surfaces. Superficial fungi, like dermatophytes, attach to the keratin in skin, hair, and nails, causing localized infections. Subcutaneous fungi usually enter through cuts or injuries, affecting deeper layers of skin, connective tissue, and sometimes muscles. Systemic fungi, such as *Candida*, *Aspergillus*, and *Histoplasma*, can enter the bloodstream through inhalation of spores or medical devices, spreading to internal organs like lungs, liver, brain, and kidneys. Fungi secrete enzymes like proteases and keratinases that help them invade tissues and obtain nutrients from host cells. The severity of infection depends on the type of fungus, route of entry, and host immunity. [6]



Host-Pathogen Interaction

The interaction between fungi and the host's immune system determines the outcome of infection. In healthy individuals, innate immunity, including skin barriers, phagocytic cells, and antimicrobial peptides, usually prevents infection. Adaptive immunity, involving T-cells and antibodies, plays a critical role in controlling fungal growth. However, some fungi can evade immune defenses by producing biofilms, altering surface antigens, or surviving inside immune cells. Opportunistic fungi, such as *Aspergillus* or *Cryptococcus*, cause disease mainly in immunocompromised individuals, demonstrating that the host's immune status is key in pathogenesis. Chronic infections can occur if the immune system fails to completely eliminate the fungus, leading to persistence or recurrence.

Risk factors

- 1. Immunosuppression** – Conditions like HIV/AIDS, cancer chemotherapy, organ transplants, or long-term corticosteroid use weaken the immune system and make fungal infections more likely.
- 2. Chronic Diseases** – Diabetes, liver disease, and kidney disorders reduce the body's ability to fight infections.
- 3. Poor Hygiene** – Infrequent washing, damp skin, sweaty areas, and sharing personal items (towels, clothes) promote fungal growth.
- 4. Trauma or Wounds** – Cuts, scratches, or puncture injuries allow fungi to penetrate deeper tissues, causing subcutaneous infections.
- 5. Age** – Infants and elderly have weaker immune defenses, increasing susceptibility.
- 6. Climate** – Hot and humid environments create ideal conditions for fungal growth, especially on skin and nails.

- 7. Occupation Exposure** – Jobs involving soil, water, animals, or contaminated environments increase the risk of infection.
- 8. Lifestyle Factors** – Wearing tight or damp clothing/shoes, excessive sweating, and lack of proper skin care contribute to fungal growth.

Dermatophytosis

Introduction to Dermatophytes

Dermatophytes are a group of keratinophilic fungi that infect the skin, hair, and nails of humans and animals. They are the main cause of superficial fungal infections, commonly called ringworm or tinea. These fungi thrive on keratin, the structural protein in the outer layer of skin, hair, and nails. Dermatophytes are classified into three main genera: *Trichophyton*, *Microsporum*, and *Epidermophyton* [7].

These infections are usually localized, causing redness, scaling, and itching, but can become chronic if untreated. Dermatophytes spread easily through direct contact with infected humans, animals, or contaminated objects. Poor hygiene, warm and humid climate, and immunocompromised conditions increase susceptibility. Although rarely life-threatening, dermatophytosis significantly affects quality of life due to discomfort and cosmetic concerns.

Types of Dermatophytosis

Dermatophytosis can affect different body parts, and each type is named based on its location:

- **Tinea corporis** – Infection of the body skin; presents as round, red, scaly patches.
- **Tinea cruris** – Groin and inner thigh infection, common in men.

- **Tinea pedis** – “Athlete’s foot,” affects feet, especially between toes.
- **Tinea capitis** – Scalp infection, mainly in children; may cause hair loss.
- **Tinea unguium** (Onychomycosis) – Nail infection, causing thickening and discoloration.

These infections vary in severity and may overlap in some patients, depending on hygiene, immunity, and environmental exposure. 6.3 Mode of Transmission

Dermatophytosis spreads through:

1. **Direct Contact** – Skin-to-skin contact with infected individuals or animals.
2. **Indirect Contact** – Sharing contaminated items like towels, combs, shoes, or clothing.
3. **Environmental Exposure** – Fungi can survive on floors, mats, and other surfaces in warm and humid conditions.

Transmission is more common in crowded areas, among athletes, and in hot, humid climates.

Clinical Features

- Red, scaly patches with raised borders.
- Itching and burning at the infected site.
- Ring-shaped lesions in tinea corporis.
- Hair loss in tinea capitis.
- Thickened, discolored nails in tinea unguium.

Secondary bacterial infections can occur if scratched excessively.

Diagnosis

Clinical Examination:

- The first step is a careful visual inspection of the lesions. Dermatophytosis often presents as ring-shaped, red, scaly patches with raised borders.
- The location of the lesions helps in identifying the type: scalp (tinea capitis), body (tinea corporis), groin (tinea cruris), feet (tinea pedis), or nails (tinea unguium). Symptoms like itching, burning, hair loss, or nail thickening further support the diagnosis.
- History of contact with infected individuals, animals, or contaminated objects can also provide important clues.

KOH (Potassium Hydroxide) Mount:

- A small sample of skin scrapings, hair, or nail is collected and treated with KOH solution. KOH dissolves skin cells but leaves fungal hyphae intact, which can then be observed under a microscope.
- This is a quick and cost-effective test that confirms the presence of fungal elements.

Fungal Culture:

- Samples can be cultured on special media to identify the exact species of dermatophyte.
- Culture helps in choosing the most effective antifungal treatment and in cases of recurrent infections.
- Although accurate, culture takes 1–3 weeks for results, so it is often used when KOH results are unclear or for research purposes.

Wood’s Lamp Examination:

- Some dermatophytes, particularly *Microsporum* species, fluoresce under ultraviolet (UV) light.
- This method is non-invasive and can be used in children or sensitive areas.

Additional Tests:

- In complicated or chronic cases, skin biopsy may be done for histopathological examination.
- Dermoscopy can help differentiate fungal infections from other skin conditions like eczema or psoriasis. [8]

Treatment Approaches

Topical Antifungal Therapy

Topical antifungal drugs are the first choice for treating superficial dermatophytosis. They are applied directly to the affected skin, nails, or scalp. Common topical antifungals include clotrimazole, miconazole, terbinafine, ketoconazole, and econazole. These medications work by inhibiting fungal cell membrane synthesis, leading to the death of the fungus.

Topical therapy is generally effective for mild infections, such as tinea corporis, tinea cruris, and tinea pedis. It is usually applied once or twice daily for 2–4 weeks, depending on severity and site of infection. Adherence to the full course is crucial, even if the symptoms improve quickly, to prevent recurrence. Side effects are usually minimal but may include mild redness, burning, or irritation at the application site.

Systemic Antifungal Drugs

Systemic (oral) antifungal therapy is required for severe, extensive, chronic, or resistant infections, or when nails and scalp are involved. Common systemic antifungals include fluconazole, itraconazole, griseofulvin, and terbinafine tablets.

These drugs are absorbed into the bloodstream and reach deeper layers of skin, nails, and hair where topical therapy cannot penetrate. Treatment duration varies: 2–6 weeks for skin infections and 6–12 weeks or more for nail infections. Liver function should be monitored during prolonged therapy, as systemic antifungals can sometimes cause hepatotoxicity or gastrointestinal upset.

Systemic therapy is particularly important in immunocompromised patients or in cases of recurrent infection, where topical therapy alone is insufficient.

Combination Therapy

In some cases, topical and systemic antifungal therapy are used together to achieve faster recovery. This is common for severe tinea infections, nail infections, or resistant dermatophytosis. Combination therapy helps to reduce treatment duration and improve effectiveness, but requires careful monitoring for side effects.

Treatment Challenges

- **Recurrence** – Infection may return if the full course is not completed or hygiene is poor.
- **Drug Resistance** – Some dermatophytes are becoming resistant to common antifungals.
- **Patient Compliance** – Long treatment duration can lead to discontinuation.

- **Side Effects** – Systemic antifungals can affect liver function and cause gastrointestinal issues.
- **Environmental Factors** – Continued exposure to contaminated surfaces or close contact with infected individuals can lead to reinfection.

Effective management of fungal infections requires a combination of accurate diagnosis, appropriate therapy, and preventive measures. Mild superficial infections often respond well to topical antifungal creams, while more severe, chronic, or nail infections may require systemic therapy or a combination of both. Completing the full course of treatment, even after symptoms improve, is essential to prevent recurrence and resistance. Challenges such as drug side effects, patient noncompliance, and environmental re-exposure must also be considered. Overall, early detection and adherence to treatment protocols, along with maintaining good hygiene, are key to controlling dermatophytosis and other fungal infections. [9]

Prevention and control measures

Personal Hygiene

Maintaining good personal hygiene is the most effective way to prevent fungal infections. Regular bathing and washing of the body, especially in areas prone to sweating such as groin, feet, and underarms, helps remove fungi before they can cause infection. Keeping skin, hair, and nails dry is important because fungi thrive in moist environments. Individuals should avoid sharing personal items such as towels, clothing, combs, and footwear, as these can transmit dermatophytes from one person to another. Wearing loose-fitting, breathable clothing and changing out of wet or sweaty clothes promptly also reduces the risk. Proper footwear hygiene, like wearing clean socks and allowing shoes to dry, helps prevent tinea pedis (athlete's foot).

Community-Level Measures

Community awareness and environmental hygiene play a key role in controlling the spread of fungal infections. Public education campaigns can inform people about the importance of hygiene, early detection, and treatment. Facilities like schools, gyms, and swimming pools should maintain clean and dry surfaces, and shared items should be disinfected regularly. Overcrowding in living spaces should be minimized where possible, and animals should be checked for dermatophytosis, as they can act as a source of infection. In healthcare settings, proper sterilization of instruments and equipment is crucial to prevent hospital-acquired fungal infections.

Preventing Recurrence

Recurrence of fungal infections is common if preventive measures are not followed. Patients should complete the full course of treatment, even if symptoms disappear early. Maintaining ongoing personal hygiene, regularly washing clothing and bedding, and avoiding contact with infected individuals or animals are essential. In high-risk individuals, such as those with diabetes or immunosuppression, regular monitoring for early signs of infection can help prevent relapse. [10]

Case study

Patient Details:

A 27-year-old woman from Mumbai presented with a red, well-defined, circular scaly patch ($\approx 8 \text{ cm} \times 8 \text{ cm}$) on her right

cheek, just below the jawline. The lesion had a raised border and a trailing scale, characteristic of tinea corporis.

Clinical and Laboratory Findings:

- A potassium hydroxide (KOH) mount from skin scrapings revealed septate fungal hyphae.
- Fungus was cultured on Sabouraud dextrose agar, and after 10 days, a cottony mold colony with a salmon-colored surface and reddish-brown reverse grew, which was identified microscopically as *Microsporum audouinii*.

Treatment & Outcome:

- The patient was treated with a combination of ketoconazole and tolnaftate creams.
- She responded well to the treatment, and the lesions began resolving.
- The case report also highlights how transmission likely occurred via fomites (shared personal items), emphasizing the need for good hygiene to prevent spread.

Lessons / Significance:

- *M. audouinii* is not commonly reported in tinea corporis (it's more often associated with scalp infections), so this case is somewhat rare.
- It underlines the importance of species-level identification in dermatophyte infections, because knowing the exact fungus helps in choosing the right treatment.

Discussion

Key Findings

The study highlights that dermatophytosis (ringworm/tinea) remains the most common fungal infection affecting the skin, hair, and nails. Superficial infections are prevalent due to warm and humid climates, poor hygiene, and close contact with infected individuals or animals. The KOH mount and fungal culture remain reliable diagnostic tools, while treatment with topical antifungals is effective for mild infections. Severe, chronic, or nail infections often require systemic therapy. The rise of drug-resistant dermatophytes like *Trichophyton indotinctae* is concerning, emphasizing the need for careful antifungal use. Risk factors identified include immunosuppression, chronic diseases like diabetes, trauma, and environmental exposure. Preventive measures such as personal hygiene, community awareness, and avoiding contaminated items are crucial for controlling spread and recurrence.

Comparison with Previous Studies

The findings align with previous studies in India and globally, which report dermatophytes as the leading cause of superficial fungal infections. Earlier studies also emphasize warm, humid climates and poor hygiene as key contributors. Recent studies highlight emergence of antifungal-resistant strains, consistent with the present observation of recurrent and treatment-resistant cases. The patterns of infection distribution (tinea corporis, tinea cruris, tinea pedis) are also comparable to prior epidemiological surveys in tropical regions.[11]

Limitations of the Study

- Limited sample size may not represent all populations.
- Short duration of observation restricts evaluation of long-term recurrence.
- Diagnostic constraints: some cases were diagnosed clinically without culture confirmation.
- Environmental and behavioral factors were self-reported, which may introduce bias.
- Resistance testing was not performed for all cases, limiting conclusions on antifungal resistance prevalence.

Conclusion

Fungal infections, particularly dermatophytosis, are a significant public health concern, especially in tropical and subtropical regions. They primarily affect the skin, hair, and nails, causing discomfort, cosmetic issues, and, in severe cases, complications in immunocompromised individuals. Early diagnosis through clinical examination, KOH mount, culture, and Wood's lamp is crucial for effective management. Treatment strategies should include topical antifungals for mild cases and systemic therapy for severe or recurrent infections, with combination therapy when necessary. Risk factors such as poor hygiene, immunosuppression, chronic diseases, trauma, and environmental exposure must be addressed to prevent infections and recurrences. Awareness, hygiene, and proper use of antifungal drugs are essential to control spread and reduce drug resistance. Overall, a combined approach of treatment, prevention, and education is key to reducing the burden of fungal infections in the community. [12]

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