

Antifungal Resistance in Dermatophytosis: An Emerging Concern in India**Indurkar VA¹****¹ Dr. Vishal Ashok Indurkar, Professor, Dermatology, Government Medical College & Hospital, Dharashiv, Maharashtra**

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Publication Process**Received: 12/04/2025****Revision: 20/05/2025****Accepted: 01/06/2025****Published: 30/06/2025****Abstract**

Dermatophytosis is a superficial fungal infection involving keratinized tissues such as skin, hair, and nails, mainly caused by species of Trichophyton, Microsporum, and Epidermophyton. India has recently experienced an epidemic-like rise in chronic, recurrent, and treatment-resistant dermatophytosis. Contributing factors include hot and humid climate, overcrowding, poor hygiene, excessive sweating, and irrational use of topical corticosteroid-containing creams. The emergence of terbinafine-resistant strains, particularly Trichophyton indotineae, has significantly complicated disease management and altered the epidemiology of dermatophytosis.

This review summarizes the epidemiology, etiological agents, mechanisms of antifungal resistance, diagnostic challenges, and current management strategies of resistant dermatophytosis in India. A comprehensive literature search was conducted using PubMed, Scopus, MEDLINE, and Google Scholar databases for English-language articles published between 2015 and 2026.

Mutations in the squalene epoxidase (SOLE) gene are considered the major mechanism responsible for terbinafine resistance. Additional factors such as self-medication, poor treatment adherence, reinfection, and inadequate hygiene practices further contribute to resistance and recurrence. Resistant dermatophytosis is associated with chronic disease, psychosocial stress, and increased economic burden. Early diagnosis, rational antifungal therapy, patient education, avoidance of steroid misuse, and implementation of antifungal stewardship programs are essential for effective disease control and prevention of further resistance.

Keywords: Dermatophytosis; Antifungal resistance; Trichophyton indotineae; Terbinafine resistance

Introduction

Dermatophytosis refers to superficial fungal infections involving keratinized tissues such as skin, hair, and nails caused mainly by fungi belonging to the genera Trichophyton, Microsporum, and Epidermophyton ⁽¹⁾. Dermatophytosis has traditionally been considered an easily treatable superficial infection; however, during the past decade, India has witnessed an epidemic-like increase in chronic, recurrent, and treatment-resistant cases ⁽²⁾.

The hot and humid climate, overcrowding, poor hygiene, increased sweating, and widespread misuse of topical corticosteroid-containing

creams have significantly contributed to this changing clinical pattern ⁽³⁾. The emergence of terbinafine-resistant strains, particularly Trichophyton indotineae, has further complicated disease management ⁽⁴⁾.

Earlier, Trichophyton rubrum was considered the most common dermatophyte causing infection worldwide. Recent Indian studies have demonstrated a shift toward T. indotineae, which is associated with extensive disease, chronicity, relapse, and resistance to antifungal therapy ^(5,6).

This review aims to comprehensively discuss the epidemiology, etiological agents, mechanisms of resistance, diagnostic challenges, clinical

implications, and current management strategies of antifungal-resistant dermatophytosis in India.

Methodology of Literature Review

A comprehensive literature search was conducted using PubMed, Scopus, MEDLINE, and Google Scholar databases. Search terms included “Dermatophytosis,” “Antifungal resistance,” “Terbinafine resistance,” “Trichophyton indotineae,” “Tinea infections,” and “India.” Boolean operators such as AND and OR were used to refine the search.

Articles published in English between 2015 and 2026 were included. Review articles, systematic reviews, clinical studies, observational studies, and case reports related to antifungal-resistant dermatophytosis were analyzed. Duplicate articles, conference abstracts without full text, and non-English studies were excluded.

Epidemiology of Dermatophytosis in India

India currently faces an epidemic-like scenario of dermatophytosis, with increasing prevalence of chronic and recurrent infections⁽²⁾. Tinea corporis and tinea cruris are the most common clinical presentations reported in Indian studies⁽³⁾.

Young adults are more commonly affected because of occupational exposure, increased sweating, and close interpersonal contact. Risk factors contributing to increased disease prevalence include overcrowding, obesity, diabetes mellitus, poor personal hygiene, sharing of clothes and towels, and humid environmental conditions^(1,3).

The widespread use of irrational fixed-dose topical steroid-antifungal combinations has significantly modified disease presentation, resulting in atypical morphology, extensive lesions, chronicity, and treatment failure⁽⁷⁾.

Etiological Agents and Emerging Species

Dermatophytosis is primarily caused by species belonging to Trichophyton, Microsporum, and Epidermophyton genera⁽¹⁾. Traditionally, Trichophyton rubrum was considered the predominant pathogen worldwide. However, recent Indian studies have shown increasing prevalence of Trichophyton indotineae, previously classified under T. mentagrophytes genotype VIII^(4,5).

Trichophyton indotineae is an emerging anthropophilic dermatophyte strongly associated with terbinafine resistance and chronic recurrent disease⁽⁵⁾. The organism has now spread beyond India and has been reported in several countries including Germany, France, the United Kingdom,

and the United States, raising concerns regarding global dissemination⁽⁸⁾.

Antifungal Agents Used in Dermatophytosis

Topical antifungal agents commonly used in dermatophytosis include azoles, allylamines, ciclopirox olamine, and amorolfine. Systemic therapy is recommended in extensive, chronic, recurrent, or nail and scalp infections⁽¹⁾.

Oral antifungal agents commonly prescribed include terbinafine, itraconazole, fluconazole, and griseofulvin. Terbinafine acts by inhibiting the fungal enzyme squalene epoxidase, thereby impairing ergosterol synthesis and fungal cell membrane formation⁽⁴⁾.

Although terbinafine was previously considered highly effective, increasing resistance has markedly reduced its clinical efficacy in India⁽⁶⁾. Itraconazole currently demonstrates better therapeutic response in many resistant cases, particularly when administered for prolonged duration^(6,9).

Mechanisms of Antifungal Resistance

Antifungal resistance in dermatophytes is multifactorial. The most important mechanism involves mutations in the squalene epoxidase (SQLE) gene, resulting in reduced susceptibility to terbinafine^(4,10). Common mutations include Leu393Phe and Phe397Leu substitutions⁽¹⁰⁾.

Additional mechanisms contributing to resistance include increased drug efflux pump activity, biofilm formation, altered drug targets, and reduced intracellular drug accumulation⁽¹¹⁾.

Biofilm formation enables fungal survival under hostile conditions and significantly reduces antifungal penetration, thereby contributing to chronicity and recurrence⁽¹¹⁾.

Factors Responsible for Resistance in India

Several factors contribute to antifungal resistance in India:

1. Irrational use of topical steroid combinations
2. Self-medication and over-the-counter drug availability
3. Incomplete treatment and poor compliance
4. Reinfection among family members
5. Inadequate hygiene practices
6. Delayed diagnosis and inappropriate therapy

Topical corticosteroid misuse suppresses local immunity and alters lesion morphology, promoting fungal persistence and chronic infection^(3,7). Inadequate dosing and premature discontinuation of therapy expose dermatophytes

to subtherapeutic drug concentrations, facilitating development of resistance ⁽⁴⁾.

Clinical Implications

Antifungal-resistant dermatophytosis is associated with chronic disease, recurrence, extensive lesions, severe itching, psychosocial stress, and reduced quality of life ⁽⁶⁾. Patients often experience repeated treatment failures and prolonged disease duration.

The disease also imposes a significant economic burden because of repeated consultations, investigations, and prolonged therapy ⁽¹²⁾. Increased household transmission contributes to community spread and public health burden.

Diagnostic Approaches

Conventional diagnostic methods include potassium hydroxide (KOH) microscopy and fungal culture. However, these methods are often time-consuming and may fail to accurately identify resistant strains ⁽¹⁾.

Advanced molecular diagnostic techniques such as polymerase chain reaction (PCR), internal transcribed spacer sequencing, and MALDI-TOF mass spectrometry enable more accurate identification of *T. indotineae* and other resistant dermatophytes ⁽¹¹⁾.

Antifungal susceptibility testing helps determine minimum inhibitory concentrations and guides appropriate antifungal therapy, although standardized clinical breakpoints remain limited ⁽¹⁰⁾.

Current Treatment Challenges and Management Strategies

Management of resistant dermatophytosis remains challenging because of increasing terbinafine resistance and recurrent disease patterns ⁽⁴⁾. Itraconazole currently appears more effective in resistant infections and is frequently recommended as first-line systemic therapy in chronic dermatophytosis ⁽⁶⁾.

Combination therapy using systemic and topical antifungal agents may improve treatment outcomes. Important management principles include adequate treatment duration, patient counseling, maintenance of hygiene, avoidance of steroid-containing creams, and treatment of affected family members ⁽⁷⁾.

Antifungal stewardship programs and strict regulation of irrational over-the-counter steroid combinations are urgently required to prevent further emergence of resistance ⁽⁷⁾.

Emerging Therapies and Future Directions

Recent advances include development of rapid molecular diagnostic methods and investigation

of newer antifungal agents ⁽¹³⁾. Nanotechnology-based drug delivery systems may improve antifungal penetration and therapeutic efficacy in future ⁽¹³⁾.

Improved surveillance systems, standardized susceptibility testing methods, and molecular epidemiological studies are required to better understand resistance patterns and guide therapy ⁽¹⁴⁾.

Discussion

Antifungal-resistant dermatophytosis has emerged as a major public health problem in India. The widespread misuse of topical steroid combinations, poor treatment adherence, and increasing terbinafine resistance have contributed significantly to the current epidemic-like situation ^(2,3). The emergence of *T. indotineae* has dramatically altered the epidemiology of dermatophytosis both in India and globally ⁽⁵⁾. Several studies have demonstrated increasing resistance associated with SQLE gene mutations ^(4,10).

Although itraconazole currently appears more effective than terbinafine in resistant cases, concerns regarding prolonged therapy, drug interactions, and possible emergence of azole resistance remain important challenges ⁽⁶⁾.

Public awareness, physician education, rational prescription practices, and implementation of antifungal stewardship programs are essential to control the spread of resistant dermatophytosis in India.

Limitations

This review is limited by heterogeneity among included studies, variability in antifungal susceptibility testing methods, and limited availability of large-scale molecular epidemiological studies from India.

Conclusion

Antifungal-resistant dermatophytosis represents an emerging and serious healthcare challenge in India. The rise of *Trichophyton indotineae*, increasing terbinafine resistance, and irrational steroid use have significantly contributed to chronic and recurrent infections. Early diagnosis, rational antifungal therapy, patient education, and antifungal stewardship are essential for effective disease control. Further research focusing on molecular diagnostics, resistance mechanisms, and newer therapeutic strategies is urgently needed.

Author contribution

All authors have contributed equally

Conflict of Interest

Nil

Source of Funding

Nil

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Citation:

Indurkar VA, Antifungal Resistance in Dermatophytosis: An Emerging Concern in India *VIMS Health Science Journal*. 2025;12(2).