Research Article

SPECIES-SPECIFIC ANTIFUNGAL SUSCEPTIBILITY PATTERNS OF CLINICAL DERMATOPHYTES: EVIDENCE FROM BROTH MICRODILUTION TESTING

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Abstract

Dermatophytosis is a frequently observed superficial fungal infection, and mutations in antifungal susceptibility may lead to problems with treatment and chronic infection. A Prospective study was conducted, and 227 clinical samples were collected in a tertiary-care mycology laboratory from January 2022 to December 2024. Direct microscopy and culture were employed for detection of dermatophytes. Antifungal susceptibility testing was performed by broth microdilution method. Out of 227 specimens, 195 (85.9%) produced positive fungal cultures. Trichophyton mentagrophytes was the most prevalent isolate (59.5%), followed by Microsporum gypseum (17.4%), T. rubrum (9.2%), and Epidermophyton floccosum (9.2%). Tinea corporis was the primary clinical manifestation (59.5%). Reported MIC90 values were 0.5, 0.06, 16, 0.125, 0.06, 1, and 8 µg/mL, respectively. The observed average geometric MICs were 0.17, 0.08, 5.51, 0.14, 0.07, 0.51, and 4.25 µg/mL, respectively. There was no statistically significant among the antifungal agents MIC. The results showed a significant variation in the invitro activity of antifungal drugs on the dermatophytes. Terbinafine was generally the most effective and fluconazole had significant MIC higher. These findings emphasize the importance of systematic antifungal susceptibility testing to monitor susceptibility patterns and to facilitate the evidence-based treatment.

Keywords: Dermatophytosis; Antifungal agents; Broth Microdilution;

1. Introduction

Dermatophytes are filamentous fungi that colonize and decompose keratin, specifically targeting keratinized tissues such as nails, hair, and skin. Trichophyton, Microsporum, and Epidermophyton are the common pathogens causing dermatophytosis. Clinically, such infections are referred to as tinea or ringworm and are categorized based on the affected anatomical region, including Tinea cruris, Tinea corporis, Tinea capitis, Tinea pedis, and Tinea unguium [1]. Approximately 20-25% of the worldwide population is impacted by dermatophytosis or superficial fungal infections. The World Health Organization (WHO) estimated fungal dermal infections impact over 650 million individuals worldwide at a given time, with ringworm constituting about 50% of these cases; in a few countries, scalp ringworm affects more than 25% of children under the age of 10 [2]. The 2021 Global Burden of Disease study estimated 616.5 million existing and 1.73 billion new cases of fungal skin infections worldwide, with age-adjusted prevalence and incidence rates of 7,789.6 and 21,668.4 per 100,000 people, respectively. In comparison to 1990, the number of prevalent and incident cases rose by 67.73% and 67,93%, respectively, highlighting the persistent worldwide challenge of superficial fungal infection [3].
The prevalence of dermatophytosis is affected by worms, humid environments, population density, profuse perspiration, restrictive clothing, poor hygiene, occupational risks, and interaction with sick individuals or animals [4]. Dermatophytes are conventionally categorized as anthropophilic, zoophilic, and geophilic based on their biological habitats, with anthropophilic varieties being significant contributors to human-to-human transmission. Infections are often localized to keratinized tissues; however, chronic and recurrent ailments may result in significant morbidity, reduced quality of life, and prolonged antifungal therapy [5].
Broth microdilution has shown reliable efficacy in evaluating dermatophyte susceptibility. The CLSI M38 reference

method provides standardized broth dilution procedures for evaluating susceptibility in filamentous fungi, including dermatophytes. Moreover, clinical breakpoints are lacking for several dermatophyte–antifungal pairings, rendering MIC distributions essential for monitoring and the prospective establishment of interpretative standards [6].

The novelty of the current research is in the systematic comparative evaluation of six therapeutically relevant antifungal agents – sertaconazole, terbinafine, fluconazole, amphotericin B, griseofulvin, and itraconazole—against clinical dermatophyte isolates using broth microdilution. Consequently, this research sought to ascertain the antifungal susceptibility assessed in vitro characteristics of pathogenic dermatophyte isolates using the CLSI broth microdilution methods and to delineate the MIC ranges and distributions of these six antifungal compounds. The findings may provide contemporary baseline susceptibility information and enhance antifungal observation and therapeutic techniques used in dermatophytosis.

Materials and methods:

Study design and setting:

A prospective study was performed over the period of 24 months (January 2022 to December 2024) at the Department of Microbiology, Sri Lalithambigai Medical College and Hospital, Chennai, India. A total of 227 clinical specimens obtained during the research period from individuals with presumed superficial fungal infections were included. The research received endorsement from the Institutional Ethics Committee.

Specimen Processing and Fungal Culture:

Clinical samples were handled with standard mycological techniques. A direct microscopic analysis was conducted with a 10% potassium hydroxide (KOH) mount to identify fungal components. Specimens were then inoculated into Sabouraud dextrose agar and/or oatmeal agar and incubated at 25ºC for a duration of up to 7 days. Fungal growth was assessed in cultures, and isolates were identified according to colony morphology. Isolates suggestive of dermatophytes were subjected to microscopic.

Identification of dermatophytes:

Direct KOH preparations were analyzed using bright-field microscopy to identify distinctive fungal hyphae and arthroconidia. Fungal samples were recognized based on their morphological and macroscopic characteristics. Lactophenol cotton blue staining and slide culture were performed as required to demonstrate unique hyphal and conidial formations. Trichophyton isolates were differentiated using the urease assay on Christensen's urea medium.

Broth microdilution method:

It was done against seven antifungal drugs - sertaconazole, terbinafine, fluconazole, amphotericin B, griseofulvin, and itraconazole. Fungal inoculum were prepared as per the 0.5 McFarland standard diluted in RPMI 1640. CLSI M 38-A2 were used as the reference protocol for broth microdilution method. Testing was performed on a sterile flat-bottom 96-well microtiter plate. Serial dilutions of each antifungal agent were prepared in RPMI1640 at specified concentration intervals, along with the standardized fungal inoculum. A growth control with the fungal inoculum without antifungal agents and a sterility control with uninoculated RPMI 1640 were included in every experiment. The plates were incubated at 25% for 72 h. Following incubation, fungal growth was measured visually in contrast with the growth control. The MIC was characterized as the minimal concentration of the antifungal substance that achieves the specified suppression of fungal proliferation in accordance with the relevant CLSI endpoint standards. MIC values were reported in µg/mL.

Quality assurance was performed with *Trichophyton mentagrophytes* ATCC 4439, which was included in every antifungal susceptibility-testing procedure. The assay was considered valid when the MIC for the quality-control strain was within the appropriate CLSI quality-control values. Statistical correlation were analysed using IBM SPSS software 31

Result:

Study population and demographic characteristics:

A total of 227 clinical samples were gathered from individuals diagnosed with dermatophytosis. Among these, 195 (85.9%) produced positive fungal cultures and were included in the current examination. The age group of most participants was 31–45 years (30.8%), followed by 18–30 years (28.6%), below 18 years (18.1%), 46–60 years (17.6%),

and above 60 years (4.9%). Among 195 culture-positive instances, 121 (53.3%) were male, and 106 (46.7%) were female. Out of the 195 culture cases, 63 patients (27.8%) had previously had antifungal treatment, whereas 164 patients (72.2%) had not. Diabetes mellitus was recorded in 59 cases (26.0%), whereas 168 cases (74.0%) had no previous history of the infection. The use of topical corticosteroids was recorded in 96 subjects (42.3%), while 131 patients (57.7%) reported no corticosteroid use (Table 1).

Table 1: Demographic and clinical characteristics of patients with the suspected dermatophytosis (n-227)

Variable	Category	Number n (%)
Age (years)	<18	41 (18.1%)
	18-30	65 (28.6%)
	31-45	70 (30.8%)
	46-60	40 (17.6%)
	>60	11 (4.9%)
Gender	Male	121 (53.3%)
	Female	106 (46.7%)
Previous antifungal treatment	Yes	63 (27.8%)
	No	164 (72.2%)
Diabetes mellitus	Yes	59 (26%)
	No	168 (74%)
Topical corticosteroid use	Yes	96 (42.3%)
	No	131 (57.7%)

Microscopy and Distribution of Dermatophyte species:

Among 134 (59%) shows positive for KOH mount whereas fungal culture showed growth in 195 (85.9%) specimens. In the culture-positive group (n=195), Tinea corporis was identified as the predominant clinical presentation, occurring in 116 (59.5%) cases, followed by Tinea cruris in 53 (27.2%), Tinea faciei in 14 (7.2%), Tinea barbae in 5 (2.6%), Tinea capitis in 3 (1.5%), and Tinea pedis and Tinea manuum in 2 (1.0%) cases each. Trichophyton species were the predominant isolates, accounting for 141 (72.3%) of the total 195 isolates, whereas Microsporum species, *Trichophyton mentagrophytes*, emerged as the predominant isolates, with 116 cases (59.5%), followed by *T. rubrum* (18; 9.2%), *T. tonsurans* (4; 2.1%), and *T.violaceum* (3; 1.5%). Among the Microsporum isolates, *M. gupseum* was the most common, accounting for 34 (17.4%) occurrences, while *M. canis* represented 2 (1.0%) occurrences. *Epidermophyton floccosum* was identified in 18 cases, representing 9.2%. (Table 2)

Table 2: Clinical presentation and species wise distribution among the culture-positive isolates (n-195)

Variable	Category	Number n (%)
Clinical presentation	Tinea corporis	116 (59.5%)
	Tinea cruris	53 (27.2%)
	Tinea faciei	14 (7.2%)
	Tinea barbae	5 (2.6%)
	Tinea capitis	3 (1.5%)
	Tinea pedis	2 (1%)
	Tinea mannum	2 (1%)
Dermatophytes species	*Trichophyton mentagrophytes*	116 (59.5%)
	Trichophyton rubrum	18 (9.2%)
	Trichophyton tonsurans	4 (2.1%)
	Trichophyton violaceum	3 (1.5%)
	Microsporum gypseum	34 (17.4%)
	Microsporum canis	2 (1%)
	Epidermophyton floccosum	18 (9.2%)

Antifungal susceptibility and MIC distributions:

The MIC distributions of the seven antifungal drugs investigated against the 195 dermatophyte isolates are summarized in (Table 3). Terbinafine exhibited MICs between 0.06 and 1 µg/mL. An MIC of 0.06 µg/mL was detected in 122 (62.6%) isolates, with 0.5 µg/mL noted in 58 (29.7%) isolates. The MIC_{50} was recorded at 0.06 µg/mL, whilst the MIC_{90} was observed at 1 µg/mL. The GM MIC measured 0.17 µg/mL Itraconazole had MICs of 0.06 to 8 µg/mL. The majority of isolates, 179 (91.8%), had an MIC of 0.06 µg/mL. The MIC_{50} and MIC_{90} were both noted at 0.06 µg/mL, whereas the GM MIC was 0.08 µg/mL. Fluconazole had the widest MIC range, extending from 2 to 64 µg/mL. The predominant MIC was 4 µg/mL, identified in 73 (37.4%) isolates, followed by 8 µg/mL in 56 (28.7%) and 2 µg/mL in 42 (21.5%) isolates. The $MIC5_0$ was ascertained to be 4 µg/mL, the MIC_{90} was set at 16 µg/mL, and the GM MIC was computed as 5.51 µg/mL. Voriconazole exhibited MICs between 0.125 and 2 µg/mL. A total of 185 (94.9%) isolates exhibited a MIC of 0.125 µg/mL. The MIC_{50} and MIC_{90} were both recorded at 0.125 µg/mL, whereas the GM MIC was 0.14 µg/mL. Sertaconazole had a limited MIC range of 0.06–0.5 µg/mL. An MIC of 0.06 µg/mL was detected in 184 (94.4%) isolates. The MIC_{50} and MIC_{90} were each 0.06 µg/mL, whereas the GM MIC was 0.07 µg/mL. Griseofulvin exhibited MICs ranging from 0.125 to 16 µg/mL. The predominant MIC was 0.5 µg/mL, detected in 102 (52.3%) isolates. The MIC_{50} measured 0.5 µg/mL, the MIC_{90} recorded 1 µg/mL, and the GM MIC was 0.51 µg/mL. Amphotericin B demonstrated MICs between 2 and 64 µg/mL. The majority of isolates, 154 (79.0%), had a MIC of 4 µg/mL, whereas 24 (12.3%) isolates had a MIC of 8 µg/mL. The MIC_{50} was recorded at 4 µg/mL, the MIC_{90} at 8 µg/mL, and the GM MIC was 4.25 µg/mL (Table 4).

Table 3: Invitro antifungal susceptibility profile of dermatophyte (n-195)

Antifungal agent	Observed MIC range (µg/mL)	MIC_{50} (µg/mL)	MIC_{90} (µg/mL)	GM MIC (µg/mL)
Terbinafine	0.06-1	0.06	1	0.17
Itraconazole	0.06-8	0.06	0.06	0.08
Fluconazole	2-4	4	16	5.51
Voriconazole	0.125-2	0.125	0.125	0.14
Sertaconazole	0.06-0.5	0.06	0.06	0.07
Griseofulvin	0.125-16	0.5	1	0.51
Amphotericin B	2-64	4	8	4.25

Table 4: Distribution of MIC values of antifungal agents against dermatophyte isolates (n-195)

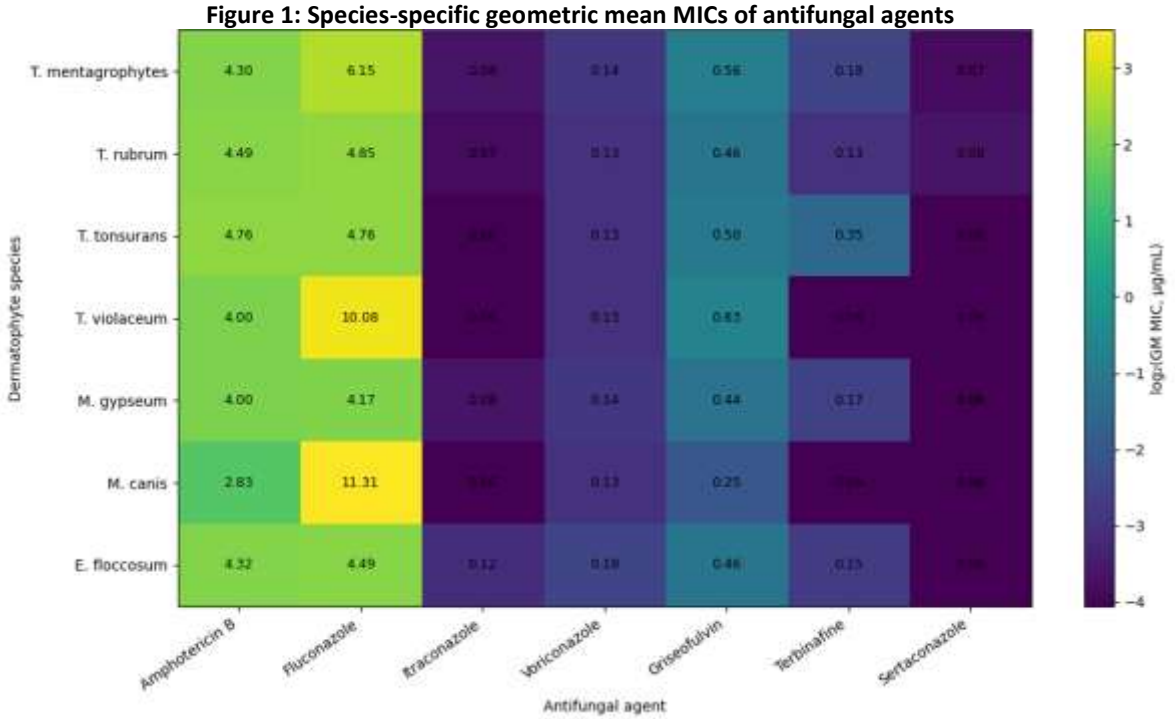
Antifungal agent	64	32	16	8	4	2	1	0.5	0.25	0.125	0.06
Terbinafine	-	-	-	-	-	-	5 (2.6%)	58 (29.7%)	6 (3.1%)	4 (2.1%)	122 (62.6%)
Itraconazole	-	-	-	2 (1%)	8 (4.1%)	-	-	-	6 (3.1%)	-	179 (91.8%)
Fluconazole	14 (7.2%)	-	10 (5.1%)	56 (28.7%)	73 (37.4%)	42 (21.5%)	-	-	-	-	-
Voriconazole	-	-	-	-	-	2 (11%)	-	8 (4.1%)	-	185 (94.9%)	-
Sertaconazole	-	-	-	-	-	-	-	5 (2.6%)	6 (3.1%)	-	184 (94.4%)
Griseofulvin	-	-	2 (1%)	-	-	6 (3.1%)	39 (20%)	102 (52.3%)	39 (20%)	7 (3.6%)	-
Amphotericin B	2 (1%)	-	-	24 (12.3%)	154 (79%)	15 (7.7%)	-	-	-	-	-

Species-specific geometric mean MICs:

In this study, *T. mentagrophytes* (n = 116), the GM MICs were recorded as follows: 4.30 µg/mL for amphotericin B, 6.15 µg/mL for fluconazole, 0.08 µg/mL for itraconazole, 0.14 µg/mL for voriconazole, 0.56 µg/mL for griseofulvin, 0.18 µg/mL for terbinafine, and 0.07 µg/mL for sertaconazole. For *T. rubrum* (n = 18), the associated GM MICs were 4.49, 4.85, 0.07, 0.13, 0.46, 0.13, and 0.08 µg/mL, respectively. *T. tonsurans* (n = 4) exhibited GM MICs of 4.76, 4.76, 0.06, 0.13, 0.50, 0.35, and 0.06 µg/mL, whereas *T. violaceum* (n = 3) had values of 4.00, 10.08, 0.06, 0.13, 0.63, 0.06, and 0.06 µg/mL. Among the Microsporum species, *M. gypseum* (n = 34) exhibited GM MICs of 4.00 µg/mL for amphotericin B,

4.17 µg/mL for fluconazole, 0.08 µg/mL for itraconazole, 0.14 µg/mL for voriconazole, 0.44 µg/mL for griseofulvin, 0.17 µg/mL for terbinafine, and 0.06 µg/mL for sertaconazole. In contrast, *M. canis* (n = 2) revealed values of 2.83, 11.31, 0.06, 0.13, 0.25, 0.06, and 0.06 µg/mL. *E. floccosum* (n = 18) exhibited GM MICs of 4.32, 4.49, 0.12, 0.18, 0.46, 0.15, and 0.06 µg/mL, respectively (Figure 1).

Figure 1: Species-specific geometric mean MICs of antifungal agents



Comparison of MICs among dermatophyte species:

The MIC distributions of the seven antifungal agents were analyzed across the reported dermatophyte species using the Kruskal–Wallis test. No statistically significant variations were detected for amphotericin B (H = 6.27, p = 0.399), fluconazole (H = 11.60, p = 0.071), itraconazole (H = 3.16, p = 0.789), voriconazole (H = 6.61, p = 0.356), griseofulvin (H = 8.41, p = 0.210), terbinafine (H = 5.25, p = 0.510), or sertaconazole (H = 3.41, p = 0.760). Consequently, none of the evaluated antifungal drugs exhibited a statistically significant variation in MIC distribution across the dermatophyte species analyzed (all p > 0.05) (Table 5).

Table 5: Species-specific MIC comparison

Antifungal	H statistic	P value
Terbinafine	5.25	0.510
Itraconazole	3.16	0.789
Fluconazole	11.6	0.071
Voriconazole	6.61	0.356
Sertaconazole	3.41	0.760
Griseofulvin	8.41	0.210
Amphotericin B	6.27	0.399

Discussion:

Dermatophytosis remains a significant superficial fungal infection in India, with considerable changes in its clinical manifestation, causative agents, duration, and antifungal efficacy during the last ten years. The present study examines 195 culture-positive dermatophytosis isolates and offers a comprehensive evaluation of demographic traits, clinical symptoms, predisposing factors, species distribution, and in-vitro antifungal resistance. The frequency of Trichophyton mentagrophytes, together with the recorded MIC distributions for seven antifungal agents, offers significant geographical insights into the current epidemiology of dermatophytosis and the changing patterns of antifungal resistance.

The culture positive population in the present study was composed of 53.3% males and 46.7% females. This high prevalence of patriarchy corroborates other studies in India. A previous study from tertiary care in Tamil Nadu revealed that 57.7% of the dermatophytosis cases were males and 42.3% were females which is comparable to the present study [7]. A study conducted in Western India with 300 participants showed a male to female ratio of 1.22:1 [8]. Males may be more vulnerable to heat, sweating, restrictive clothing and social situations, and differences in health care seeking behavior may also contribute to the higher prevalence.

We examined 227 specimens, from which culture-positive fungi were isolated from 195 specimens (culture positivity rate: 85.9%). KOH microscopy was positive in 134 (59.0%). The increased yield obtained by culture compared to direct microscopy may suggest the improved analytical sensitivity of culture in some clinically suspected cases, notwithstanding the extended processing time and possible effects of sample quality and prior antifungal therapy. A recent study in Tamil Nadu demonstrated a KOH positivity rate of 76.3% and a culture positivity rate of 87.1%, suggesting a rather high culture yield [7]. Conversely, a study from Western India reported 86.7% positivity by KOH and 83.3% positivity by culture [8]. Such discrepancies are expected since KOH and culture results are influenced by the timing of specimen collection, lesion characteristics, prior treatment, specimen integrity, and laboratory techniques.

In this study tinea corporis (59.5%) followed by tinea cruris (27.2%). This finding correlates with the changing clinical trend seen in India where Tinea corporis and Tinea cruris have become the main clinical presentation [9]. The study carried out in Tamil Nadu similarly identified Tinea corporis as the primary symptom (58.7%), followed by Tinea cruris (20.1%) [7]. A multicentric study carried out in India similarly revealed that Tinea cruris and Tinea corporis are the predominant [10]. The occurrence of glabrous-skin dermatophytosis may be linked to perspiration, obstruction, close contact, shared clothing or fomites, and environmental humidity.

The comparatively infrequent occurrence of Tinea pedis and Tinea manuum in this study may suggest the clinical setting and demographic characteristics. Significantly, dermatophytosis in India is increasingly characterized by extensive and recurrent conditions, with multicenter research indicating frequent involvement of many anatomical sites [11]. As a result, the clinical spectrum shown in this study corresponds with the broader contemporary trend in India, while also emphasizing the ongoing occurrence of isolated glabrous-skin infections.

Previous antifungal treatment was recorded in 32.3% of the study population, indicating that more than one-third of patients had received antifungal therapy before microbiological evaluation. Previous treatment has therapeutic importance as exposure to antifungal agents may influence both fungal burden and in vitro susceptibility profiles. A thorough examination of dermatophyte susceptibility studies highlighted the difficulties in establishing a dependable relationship between previous antifungal therapies, MIC values, and clinical outcomes [12]. Therefore, prior treatment history should be considered when evaluating susceptibility results, particularly in instances of chronic or recurrent diseases.

Diabetes mellitus was seen in 26.0% of the participants in this investigation. This ratio exceeds that seen in a South Indian investigation of chronic dermatophytosis, when diabetes was noted in 20.3% of individuals [13]. Diabetes may make individuals susceptible to dermatophytosis because of weakened immune responses, altered skin barrier function, and favourable conditions for fungal proliferation.

Topical corticosteroids were used by 42.3% of participants. This is particular pertinent to the Indian scenario where the misuse of steroid-laden combination creams has been consistently associated with chronic diseases, unusual morphology and difficulties in treatment. A multicentric study in India on chronic and recurrent dermatophytosis revealed that about 50.9% of the patients misused topical corticosteroids [11]. Another Indian study showed topical steroid application in 49.5% of cases [9]. The closely aligned ratio emphasizes the significance of corticosteroid exposure as an important clinical and public health issue. Abuse of corticosteroids may suppress local inflammatory responses, change the characteristics of lesions and favor persistent fungal growth, thus delaying diagnosis and appropriate treatment.

The most significant microbiological finding in this study was the dominance of T. mentagrophytes, accounting for 59.5% of all isolates, followed by *M. gypseum* at 17.4%. T. rubrum and *E. floccosum* each represented 9.2%. In the genus

categorization, Trichophyton accounted for 72.3% of the isolates. This distribution demonstrates the notable epidemiological transition seen in India, where *T. mentagrophytes* has gradually replaced or attained co-dominance with *T. rubrum*.

The present study revealed notable discrepancies in the MIC distributions of the seven antifungal agents assessed. Terbinafine had a MIC range of 0.06-1 µg/mL, a MIC50 of 0.06 µg/mL, a MIC90 of 1 µg/mL, and a geometric mean MIC of 0.17 µg/mL. Despite the majority of isolates exhibiting low terbinafine MICs, the existence of isolates with elevated MIC values is significant due to the rise of terbinafine-reduced susceptibility among Indian Trichophyton populations.
A comprehensive Indian investigation including 498 *T. mentagrophytes/interdigitale* complex isolates indicated a maximum wild-type distribution of 8 µg/mL for terbinafine, with 11.4% of isolates exhibiting increased terbinafine MICs [15]. In separate multicentre research conducted in India, 71% of isolates exhibited in vitro resistance to terbinafine, with the F397L SQLE mutation identified in 91% of resistant *T. mentagrophytes* isolates.

In the current study, itraconazole exhibited a narrow MIC distribution with 91.8% of the isolates with a MIC50 of 0.06 µg/mL and a MIC90 of 0.06 µg/mL. This result correlates with the substantial Indian study on the *T. mentagrophytes/interdigitale* complex, where itraconazole displayed a comparably low MIC distribution, with only 0.2% of isolates over the expected upper threshold of the wild-type population [15]. An independent Indian investigation revealed that itraconazole had the most advantageous sensitivity profile among systemic antifungal drugs [16].

Fluconazole had the least favourable MIC distribution among the assessed azoles, with MICs ranging from 2 to 64 µg/mL, a MIC50 of 4 µg/mL, a MIC90 of 16 µg/mL, and a geometric mean MIC of 5.51 µg/mL. This discovery corresponds with other research suggesting somewhat increased fluconazole MICs in dermatophytes. A study of Indian T. mentagrophytes/interdigitale showed a wild-type threshold of 32 µg/mL for fluconazole, which again indicates a wide range of MICs [15]. In addition, a study of dermatophyte isolates with reduced fluconazole sensitivity showed fluconazole MICs of ≥16 µg/mL, but the geometric mean for sertaconazole was 0.41 µg/mL, which was much lower [17]. Voriconazole had a notably restricted MIC distribution, with 94.9% of isolates showing a MIC_{50} of 0.125 µg/mL and a MIC_{90} of 0.125 µg/mL. This finding corresponds with other Indian studies suggesting relatively low voriconazole MIC distributions for species within the *T. mentagrophytes/interdigitale* complex [10]. In this study, sertaconazole exhibited a notably concentrated MIC distribution, with 94.4% of isolates showing a MIC_{50} of 0.06 µg/mL and a MIC_{90} similarly of 0.06 µg/mL. Previous studies on dermatophytes with reduced fluconazole sensitivity indicated markedly lower sertaconazole MICs in comparison to fluconazole, with no evidence of cross-resistance [17].

Griseofulvin exhibited a MIC_{50} of 0.5 µg/mL and a MIC_{90} of 1 µg/mL, while amphotericin B showed MIC_{50} and MIC_{90} values of 4 and 8 µg/mL, respectively. The relatively high amphotericin B MIC distribution may suggest differences in intrinsic antifungal potency and mechanism of action against dermatophytes. Crucially, comparisons of MIC among studies should be undertaken with care, since the susceptibility testing of dermatophytes may vary due to differences in inoculum preparation, culture medium, incubation conditions, endpoint criteria, and methodological techniques [18]. The susceptibility profile in this study was marked by very low MIC distributions for itraconazole, voriconazole, sertaconazole, and terbinafine, but fluconazole had the widest MIC variation. These findings provide a useful local susceptibility benchmark, although they should not be interpreted as definitive evidence of clinical therapy superiority.

Conclusion:

The present study showed significant burden of dermatophytosis with Trichophyton mentagrophytes as the dominant species among 195 culture positive isolates and Tinea corporis as the major clinical manifestation. The antifungal susceptibility profile showed similar lower MIC distributions for itraconazole, voriconazole, sertaconazole and terbinafine. Fluconazole, however, had a significantly wider and comparatively higher MIC range. No statistically significant differences were observed in MICs between the dermatophyte species for any of the tested antifungal drugs. These results provide an important regional baseline for surveillance of antifungal susceptibility and emphasize the need for continued surveillance for emerging reduced antifungal susceptibility. The combination of molecular species identification, resistance-marker analysis, standardized susceptibility testing, and prospective clinical outcome evaluation is essential for improving epidemiology monitoring and evidence-based therapy of dermatophytosis.

References:

1. Moskaluk AE, VandeWoude S. Current topics in dermatophyte classification and clinical diagnosis. Pathogens. 2022;11(9):957. doi:10.3390/pathogens11090957.
2. World Health Organization. Ringworm (tinea). Published June 19, 2025. Accessed November 7, 2026. https://www.who.int/news-room/fact-sheets/detail/ringworm-(tinea).
3. Chen SJ, Chen S, Wang Y. Global burden of fungal skin diseases and future projections: an analysis of the 2021 Global Burden of Disease Study. Mycoses. 2025;68(11):e70134. doi:10.1111/myc.70134.
4. Segal E, Elad D. Human and zoonotic dermatophytoses: epidemiological aspects. Front Microbiol. 2021;12:713532. doi:10.3389/fmicb.2021.713532.
5. Jartarkar SR, Patil A, Goldust Y, Cockerell CJ, Schwartz RA, Grabbe S, Goldust M. Pathogenesis, immunology and management of dermatophytosis. J Fungi (Basel). 2022;8(1):39. doi:10.3390/jof8010039.
6. Dutta S, Joshi PA, Jangale NP, Kulkarni VA, Jain P. A descriptive study of antifungal susceptibility of the dermatophytes isolates by microbroth dilution technique. J Lab Physicians. 2025;17(4):309-316. doi:10.25259/JLP_254_2025.
7. Jahappriya J, Aruna M, Rajalakshmi R. Clinico-mycological profile of dermatophytosis in a tertiary care hospital in Tamil Nadu, India. Cureus. 2025;17(3):e79961. doi:10.7759/cureus.79961.
8. Shah SR, Vyas HR, Shah BJ, Jangid NC, Choudhary A, Gehlawat T, et al. A clinical-mycological study of dermatophytosis in Western India with focus on antifungal drug resistance as a factor in recalcitrance. Indian J Dermatol. 2023;68(2):234. doi:10.4103/ijd.ijd_999_22.
9. Verma SB, Panda S, Nenoff P, Singal A, Rudramurthy SM, Uhrlass S, et al. The unprecedented epidemic-like scenario of dermatophytosis in India: I. Epidemiology, risk factors and clinical features. Indian J Dermatol Venereol Leprol. 2021;87(2):154-175. doi:10.25259/IJDVL_301_20.
10. Tahiliani S, Saraswat A, Lahiri AK, Shah A, Hawelia D, Shah GK, et al. Etiological prevalence and antifungal sensitivity patterns of dermatophytosis in India: a multicentric study. Indian J Dermatol Venereol Leprol. 2021;87(6):800-806. doi:10.25259/IJDVL_1025_19.
11. Shenoy MM, Rengasamy M, Dogra S, Kaur T, Asokan N, Sarveswari KN, et al. A multicentric clinical and epidemiological study of chronic and recurrent dermatophytosis in India. Mycoses. 2022;65(1):13-23. doi:10.1111/myc.13360.
12. Khan SS, Hay RJ, Saunte DM. A review of antifungal susceptibility testing for dermatophyte fungi and its correlation with previous exposure and clinical responses. J Fungi (Basel). 2022;8(12):1290. doi:10.3390/jof8121290.
13. Rajamohanan R, Raj R, Chellam J, Rengasamy M. Epidemiological trends and clinicomycological profile of chronic dermatophytosis: a descriptive study from South India. Indian J Dermatol. 2021;66(4):445. doi:10.4103/ijd.IJD_539_20.
14. Nenoff P, Verma SB, Vasani R, Burmester A, Hipler UC, Wittig F, et al. The current Indian epidemic of superficial dermatophytosis due to Trichophyton mentagrophytes—a molecular study. Mycoses. 2019;62(4):336-356. doi:10.1111/myc.12878.
15. Shaw D, Singh S, Dogra S, Jayaraman J, Bhat R, Panda S, et al. MIC and upper limit of wild-type distribution for 13 antifungal agents against a Trichophyton mentagrophytes-Trichophyton interdigitale complex of Indian origin. Antimicrob Agents Chemother. 2020;64(4):e01964-19. doi:10.1128/AAC.01964-19.
16. Das S, De A, Saha R, Sharma N, Khemka M, Singh S, et al. The current Indian epidemic of dermatophytosis: a study on causative agents and sensitivity patterns. Indian J Dermatol. 2020;65(2):118-122. doi:10.4103/ijd.IJD_203_19.
17. Carrillo-Muñoz AJ, Fernández-Torres B, Cárdenes DC, Guarro J. In vitro activity of sertaconazole against dermatophyte isolates with reduced fluconazole susceptibility. Chemotherapy. 2003;49(5):248-251. doi:10.1159/000072449.
18. Dogra S, Shaw D, Rudramurthy SM. Antifungal drug susceptibility testing of dermatophytes: laboratory findings to clinical implications. Indian Dermatol Online J. 2019;10(3):225-233. doi:10.4103/idoj.IDOJ_146_19.