

Epidemiology of Dermatophytic Infections

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INTRODUCTION

Dermatophytes thrive on keratin and commonly belong to *Trichophyton*, *Microsporum* and *Epidermophyton* genera, although recent taxonomical revision has recognized newer genera. According to the host it infects, it can be classified as Anthrophilic (Human), Zoophilic (animals) and Geophilic (soil). The target tissues of human infection include skin, hair and nail. In the last few years there has been an alarming increase in the incidence of this infection. The clinical manifestations of the disease has seen a lot of modifications and transformations over last few years. Extensive disease, atypical morphologies and more severe forms are common nowadays. There is also a multi-fold increase in the incidence of chronic, relapsing and recurrent cases.

Superficial dermatophytosis is a commonly encountered infection affecting 20–25% of the population worldwide.¹ According to recent studies, there has been an alarming increase in the incidence of dermatophytosis across the country in the past decade and especially so over the past 5–6 years.^{2,3}

Dermatophytosis has been clinically classified based on the site of infection. There are differences in the epidemiology, triggers and species causing these infections. They are summarized in **Table 1.1**.

INCIDENCE AND PREVALENCE

It is difficult to calculate the exact incidence and prevalence of dermatophytosis because of paucity of community-based surveys. Over the last 7–8 years there has been a rising trend of dermatophytosis all over the country.^{2,3} Most of this data comes from hospital-based studies over periods ranging from 1–2 years.^{4–6} The current reported prevalence in India ranges between 2.41% and 61.5%^{4–6} based on the hospital statistics.

Chronic dermatophytosis is defined as dermatophytosis occurring for more than 6 months with or without recurrence despite being treated.³ **Recurrent dermatophytosis** refers to re-occurrence of the glabrous tinea after 4 weeks of stopping treatment following clinical cure. Chronic and recurrent dermatophytosis (CRD) has been a matter of serious concern in the current scenario in India.

GEOGRAPHIC AREA

Studies are from hospital statistics, and hence the true prevalence may not be clearly recognized. A prevalence of 4.1–27.6% has been reported in studies from south India,^{4,6} while

Type	Site of infection	Common agents	Risk/trigger factors
Tinea capitis	Hair and skin on the scalp	<i>Trichophyton tonsurans</i> , <i>Trichophyton violaceum</i> , <i>Microsporum canis</i> , <i>Microsporum audouinii</i> , <i>Trichophyton mentagrophytes</i> , <i>Trichophyton schoenleinii</i>	Children, contact with pets, sharing combs, hats and other articles
Tinea barbae	Hair and skin in the beard and moustache area	<i>Trichophyton violaceum</i> , <i>Trichophyton schoenleinii</i> , <i>Trichophyton tonsurans</i> , <i>Microsporum canis</i>	Contact with pets, and domestic animals, diabetes mellitus, local trauma (barber shop), steroid use
Tinea faciei	Glabrous skin of the face	<i>Trichophyton mentagrophytes</i> / <i>Trichophyton interdigitale</i> species complex (including <i>Trichophyton indotineae</i>), <i>Trichophyton verrucosum</i> , <i>Trichophyton rubrum</i> , <i>Trichophyton violaceum</i>	Humid environmental conditions, excessive sweating, poor hygiene, low socioeconomic status, overcrowding, sharing of clothes and soap
Tinea corporis	Glabrous skin of the body except face and groin/pubic area	<i>Trichophyton mentagrophytes</i> / <i>Trichophyton interdigitale</i> species complex (including <i>Trichophyton indotineae</i>), <i>Trichophyton verrucosum</i> , <i>Trichophyton rubrum</i> , <i>Trichophyton violaceum</i>	Humid environmental conditions, excessive sweating, poor hygiene, low socioeconomic status, overcrowding, sharing of clothes and soap
Tinea manuum	Palm, fingers and other parts of hands	<i>Trichophyton rubrum</i> , <i>Trichophyton interdigitale</i> , <i>Epidermophyton floccosum</i> , <i>Microsporum canis</i>	Humid environmental conditions, excessive sweating, fungal infection in feet or groin
Tinea cruris	Groin, genital, pubic, perineal, and perianal skin	<i>Trichophyton mentagrophytes</i> / <i>Trichophyton interdigitale</i> species complex (including <i>Trichophyton indotineae</i>), <i>Trichophyton verrucosum</i> , <i>Trichophyton rubrum</i> , <i>Trichophyton violaceum</i>	Humid environmental conditions, excessive sweating, poor hygiene, low socioeconomic status, overcrowding, sharing of clothes and soap, synthetic inner garments
Tinea pedis	Sole, toes, web spaces and other parts of feet	<i>Trichophyton rubrum</i> , <i>Trichophyton interdigitale</i> , <i>Epidermophyton floccosum</i> , <i>Microsporum canis</i>	Wearing occlusive shoes, using community baths, showers, and pools
Tinea unguium	Nail plate and nail bed	<i>Trichophyton rubrum</i> , <i>Trichophyton interdigitale</i> , <i>Epidermophyton floccosum</i>	Old age, diabetes, peripheral vascular disease, occlusive footwear, using community baths, showers, and pools

a high prevalence of 61.5% is reported from a study from north India.⁵ CRD was more prevalent in Amritsar as compared to Mumbai as per the hospital survey,⁶ however, there are no population studies that defines the true prevalence of the disease in different geographical regions of India.

AGE AND GENDER

Except for tinea capitis, which is commoner in pediatric age group, all other forms of dermatophytosis occur more frequently in post-pubertal age group. There may be an increase of pediatric glabrous dermatophytosis (tinea corporis, tinea cruris and tinea faciei) in the recent times which is in parallel to the increasing prevalence of dermatophytosis in general.⁷ Approximately 20% of the infections seem to occur in children and adolescents under 18 years of age.⁶

Men are usually more frequently affected than women because of the outdoor work-related activities that predispose men to hot, humid and sweaty ambience. There is an increase in female cases recently as evidenced in literature. Earlier the ratio across various studies was 3–5:1 which has come down to <2 in last 3–4 years.^{8,9} Lately there are reports of men to women ratio reversal.^{10,11}

Chronic and recurrent dermatophytosis may be more common in the late middle age group, around fifth decade, which may be due to waning immunity, comorbidities like diabetes, use of topical steroid-antifungal creams and immunosuppressants intake.¹² A large multicentric study has reported high prevalence of CRD with a magnitude of 27.86% of the total dermatophytosis cases, of which approximately 78% and 22% were chronic dermatophytosis and recurrent dermatophytosis respectively.⁶ CRD was reported at equal frequency in both genders.⁶ The mean age of patients with chronic dermatophytosis was 32.5 years as reported by Pathania et al.¹³

FAMILY HISTORY

History of dermatophytosis in close contacts up to the extent of 50–82% has been reported recently across multiple studies.^{6,11,13,14} Prevalence is reported to be very high in people living in overcrowded homes, slums, hostel rooms and dormitories. Familial dermatophytosis is an important contributing factor to the increasing rates of treatment failure. Untreated cases of dermatophytosis might be associated with increased frequency of infection in a single family.¹⁵ Patients of recurrent chronic dermatophytosis usually have more than one family member who is affected.⁸ This imposes a financial burden on the entire family.

Fomites act as a medium of transfer of the organism. Soaking the clothes of all the family members together in cold water tub may be a factor favouring transfer of the infection.¹⁶ Sharing of bath stool, soaps, towels or other articles while taking a bath is more prevalent in India compared to the West, and hence these articles may serve as fomites and promote transmission. Fomite sharing was common and accounted for up to 69% of the patients.^{6,13}

SOCIOECONOMIC FACTORS

Previous studies reported a rural predominance of various dermatophytosis probably because of the outdoor type of work people are engaged in and the resultant perspiration they have.^{4,17} However recent studies have focussed more on an urban background of the patients.^{5,18} Majority of patients (61–67%) belong to a poor socioeconomic background.^{4,18,19} Overcrowding, linen sharing, lack of hygiene and poor nutrition promote the growth of dermatophytes.

OCCUPATION

People engaged in various sweat inducing physical activities in hot and humid environments are at a higher risk of infection. Manual laborers are more commonly affected.^{10,18,20} Farmers

have an additional risk due to increased exposure to fungal pathogens from the environment and frequent contact with soil and animals.⁷ Housewives who work near a fire source are prone to dermatophytosis.^{6, 21} Student community is affected possibly due to tight-fitting shoes and synthetic clothes, especially with the use of denims.^{6, 10}

MIGRATION

Migration has a major role in demographic changes of dermatophytosis as exemplified by *Trichophyton tonsurans* and *Trichophyton soudanense*. *T. tonsurans* originated from Southeast Asia and Australia, it spread to Latin America and from there with work immigrants to North America and to other parts of the globe, including the African continent.²²⁻²⁴ *Trichophyton rubrum* accounted for the majority of the infections in the 1980s and 90s.²⁴

Trichophyton tonsurans was first reported in the early 2000s in Japan, and its number increased among the Judo-club members and school age children. *T. tonsurans* is a major cause of pediatric tinea capitis (95% of cases) in US.²⁵ Two other dermatophytes: *T. violaceum* and *T. soudanense* are also significant causes of tinea capitis in children in association with migration, specifically in African immigrants. A tinea capitis outbreak was also reported in children of African immigrants in Israel in 2016.²⁶

There are not many studies related to the migration from India. Higher incidence of dermatophyte infections has been reported from north east Bihar, an area which shares border with West Bengal and Nepal and has a lot of migratory population.²⁷

TOPICAL STEROID ABUSE

This is a problem specific to India and certain other countries where potent corticosteroids are rampantly used by layman because of lack of federal control. Easily available topical steroid formulations are prone to abuse and is one of the most important contributory factor of the current outbreak of chronic and recalcitrant dermatophytosis. India has seen a huge increase in the caseload of recalcitrant dermatophytosis over last 10 years parallel to the easy availability of cheap and potent topical steroid containing combination creams. Over the last 1–2 years studies have revealed that the frequency of prior application of topical steroid-containing combination creams is very high among patients accounting up to 80%.^{2, 6}

Epidemiology of Tinea Incognito

Ive and Mark²⁸ first described tinea incognito in 1968 for various atypical clinical presentations of tinea due to prior use of topical or systemic steroids or other topical immunomodulators like topical calcineurin inhibitors. Atzori et al.²⁹ suggested *tinea atypica* for the same and proposed that it could be due to variable dermatophyte invasiveness, the site of invasion, excessive washing and sun exposure.

Tinea incognito most commonly affects females as per various studies probably due to the skin lightening effect of the steroid based creams which are being inadvertently marketed as fairness creams. This also explains face as the commonest site of involvement though other studies have shown trunk as the commonest site of involvement. *Trichophyton* group is the most common species isolated from the lesions followed distantly by *Microsporum* species. The various clinical morphologies described as a part of tinea incognito are eczema-like, psoriasis-like, lupus erythematosus-like, rosacea-like, etc.

Last few years have seen an exponential increase in the case load of tinea incognito. This reflects the proportionate increase in the sale of over the counter irrational steroid containing

creams. A whopping 42–81%^{30, 31} of patients who present to the dermatologist with tinea incognito have history of topical steroid abuse whereas use of only topical antifungal is present in only 6–47%.^{2, 32}

CLIMATE CHANGE

Though dermatophytosis is expected to be more prevalent in the hot and humid climates of south India and less so in north India, no such association was apparent across various Indian literature in the current scenario. In fact, higher prevalence has been reported from north India.^{5, 6} Statistically significant increased prevalence of dermatophytosis in rainy season as compared to the dry season has been observed in a multicentric study from India, however the prevalence of CRD was higher in dry season.⁶

Superficial fungal infections, particularly tinea corporis, have been reported to occur more frequently following flooding; e.g. after the Indian Ocean Tsunami (2004) and Hurricane Katrina in the US (2005).^{33, 34} In the last two decades, the epidemiology of dermatophytosis in India has shifted substantially. First, its overall prevalence is rising, and it has been hypothesized that increasing average ambient temperature and humidity in India, where there have been especially severe heat waves recently, may be a causative factor.³⁵ Now it is amply clear that the species variations is the cause and climate change as a factor is not important.

DERMATOPHYTE SPECIES

Trichophyton mentagrophytes has emerged as the predominant organism of late, surpassing *Trichophyton rubrum*. Various factors have been implicated including the belief that the zoophilic *Trichophyton mentagrophytes* has acclimatised itself and has undergone anthropization leading to this epidemiological shift among humans.² In the past decade, more so in the last 5–7 years, the reported prevalence of *Trichophyton mentagrophytes* has not only increased,^{4, 5, 18–20} but it has even replaced *Trichophyton rubrum* in a few studies.^{7, 19, 36} In a multicentric study from India, *Trichophyton mentagrophytes* isolates amounted to 93.2%, whereas, *Trichophyton rubrum* was isolated in only 6.8%.² Yet another study recently demonstrated 97.2% of isolated dermatophytes to be *Trichophyton mentagrophytes* complex with the most significant species being *Trichophyton interdigitale*.¹²

Earlier studies from India have described *Trichophyton rubrum* as the most common agent causing dermatophytosis.^{37, 38} It was the most prevalent dermatophyte in central and northern Europe where it accounted for 80–90% of the strains isolated.²⁴ A similar epidemiological situation was also seen in America.²⁴ Studies from Rajasthan, Tamil Nadu and Goa published approximately in 2010 have shown higher isolation of *Trichophyton rubrum*.^{39, 40} However, studies from Karnataka, Sikkim and central India published after 2014 have mostly shown high isolation of *Trichophyton mentagrophytes*.^{41, 42} The causes for the shift of causative organisms are not known, but it can be postulated due to multiple factors, including changing agent, indiscriminate use of oral and topical antifungals, host immune factors as well as environmental changes.

Few studies done in India utilizing the molecular diagnostic techniques (genomic sequencing) have been published.^{2, 21, 43, 44} All these studies have shown that *Trichophyton mentagrophyte* complex as the most common species with very low isolation of *Trichophyton rubrum*. There has been a confusion regarding the nomenclature of the identified species, however, recently the species prevailing in India has been identified as a new species and has been named as *Trichophyton indotineae*.⁴⁵ Culture is inadequate to correctly identify *T. indotineae*, and differentiate it from *T. mentagrophytes*, and studies based on culture

identification alone thus label it as *T. mentagrophytes*. Currently, its isolation has also been reported from Bahrain, Canada, Denmark, Finland, France, Germany, Iran, Japan, Vietnam, Russia, and Switzerland due to travel and migration.^{46–48} This accounts for the existence of pandemic of recalcitrant tinea infection that has not been able to draw sufficient attention of the health authorities across the world.

Various factors proposed for the shift include the increasing environmental temperature due to global warming, prevalence of diabetes, increased use of immunosuppressives, indiscriminate use of topical steroids, use of tight fitting synthetic clothes and shoes and sharing of fomites, though no good answer is there for this problem.

ANTIFUNGAL RESISTANCE

Current epidemic of dermatophytosis has also seen an antifungal resistance, especially, squalene epoxidase gene mutation-related terbinafine resistance.^{2, 21, 43, 44} It has now been understood that the new agent has high *in vitro* terbinafine resistance that has transformed into therapeutic failure of terbinafine.

FUTURE DIRECTIONS

Broad classification of dermatophytes on the basis of ecological and clinical parameters leads to three types of dermatophytes namely geophilic, zoophilic and anthropophilic. Both the geophilic and zoophilic produce inflammatory lesions that may culminate into self-limiting infections and epidemics. Recent taxonomical revisions based on multilocus gene sequencing such as internal transcribed spacer region (ITS) and partial β -tubulin (BT) sequences has led to identification of newer genera of dermatophytosis.⁴⁸ Hence, new genera have been identified and added to the existing three genera namely *Trichophyton*, *Microsporum* and *Epidermophyton*. They include *Arthroderma*, *Lophophyton*, *Paraphyton* and *Nannizzia*.⁴⁹ Nearly all anthropophilic dermatophytes belong to the *Trichophyton* and *Epidermophyton*, along with some zoophilic species that regularly infect humans. *Microsporum* is restricted to some species around *Microsporum canis*, while the geophilic species and zoophilic species that are more remote from the human sphere are included in the *Arthroderma*, *Lophophyton* and *Nannizzia*.^{48, 49}

There is increasing data looking at reasons for failure of Itraconazole which includes efflux mechanisms and transporters apart from mutations and there is a need for proteomic data on the prevalent species to modulate therapy in difficult cases of Tinea in India.^{53, 54}

Table 1.2 shows some of the clinico-mycological studies conducted in India depicting the important epidemiological characteristics of dermatophytosis in the current scenario (after 2014). Future epidemiological studies and information is likely to be based on identifying the species by genomic sequencing of the dermatophytes. Molecular diagnosis will also find a place in the surveillance of dermatophytosis which is essential to determine the likely changes in etiological trends and distribution profile of this infection.

CONCLUSION

Defining epidemiology of dermatophytosis in India has become more important than ever before due to the pandemic of recalcitrant dermatophytosis that has silently affected entire India and many other countries. Defining various epidemiological factors and identifying the causative agent by conventional and molecular methods are the important measures to tackle this current burden of dermatophytosis. There is a need for identifying host immune factors that may contribute to recurrent dermatophytosis.

Author	Place	Time line	Study population	Number	Age	M:F	Positive family history	TCS misuse	Clinical type	Culture positivity	Isolated agent
Mahajan S et al. 2017 ¹⁴	Varanasi (UP)	Jan to Oct 2014	All patients	265	20–40 years	3:1	–	71%	Mixed type (46.8%)	139 (52%)	<i>T. mentagrophytes</i> (104, 75.9%), <i>T. rubrum</i> (30, 21.9%), <i>T. tonsurans</i> (1, 0.7%)
Rudramurthy SM et al. 2018 ²¹	Chandigarh	Jul to Dec 2014	Consecutive patients	195	Median age – 33.5 years	3:1	–	–	Tinea corporis (59, 30.2%)	133 (6%)	<i>T. interdigitale</i> (88, 66.1%), <i>T. rubrum</i> (35, 26.3%), <i>T. tonsurans</i> (4, 3%), <i>M. gypseum</i> (4, 3%), <i>M. canis</i> (2, 1.5%)
Sharma R et al. 2017 ³⁶	Sikkim	Jan to Dec 2015	All patients	192	16–30 years (55%)	1.8:1	–	NA	Tinea corporis (54%)	60 (31%)	<i>T. mentagrophytes</i> (24, 40%), <i>T. schoenleinii</i> (20, 33.33%), <i>T. tonsurans</i> (10, 16.66%), <i>T. rubrum</i> (4, 6.66%)
Pathania S et al. 2018 ¹³	Chandigarh	Jan to Dec 2015	Recurrent dermatophytosis	150	Mean age– 32.5 years	3:2	72%	53%	Multiple sites (97, 64.6%)	90 (60%)	<i>T. mentagrophytes</i> (36, 40%), <i>T. rubrum</i> (29, 32.2%), <i>T. interdigitale</i> (10, 11.1%)
Tigga et al. 2018 ¹²	New Delhi	Nov 2015 to Apr 2017	All cases	300	15–30 year (66.33%)	2:1	–	–	Tinea corporis and tinea cruris (53.0%)	212 (71%)	<i>T. mentagrophytes</i> (206, 97.2%), <i>T. rubrum</i> (5, 2.3%), <i>T. violaceum</i> (1, 0.5%)
Nenoff P et al. 2019 ²	Many cities	Aug 2017 to Jan 2018	–	199	–	2:1	–	81.3%	Tinea corporis (65.6 %)	149 (75%)	<i>T. mentagrophytes</i> (138, 92.62%) <i>T. rubrum</i> 11 (7.38%)

(Contd.)

TABLE 1.2: Clinico-mycological studies on dermatophytosis conducted after 2014 in India (Contd.)

Author	Place	Time line	Study population	Number	Age	M:F	Positive family history	TCS misuse	Clinical type	Culture positivity	Isolated agent
Saxena V et al. 2020 ³⁸	Mangalore	May to Jul 2017	All cases	154	20–30 years (41%)	2:1	–	–	–	96 (62%)	<i>T. Mentagrophytes</i> (55, 57.3%), <i>Trichophyton</i> spp (17, 17.7%), <i>M. gypseum</i> (15, 15.6%), <i>T. rubrum</i> (6, 6.3), <i>M. canis</i> (2, 2.1%), <i>E. floccosum</i> (1, 1%)
Singh BS et al. 2020 ³¹	Bhubaneswar	Jan to Jun 2018	All cases	340	Mean age- 31.35 year	1.2:1	48.8%	21.7%	Multiple site (77.17%)	221 (74%)	<i>T. mentagrophytes</i> (79.91%), <i>T. rubrum</i> (13.53%), <i>T. tonsurans</i> (4.36%), <i>T. verrucosum</i> (0.9%), <i>E. floccosum</i> (0.9%), <i>M. audouinii</i> (0.4%)
Das S et al. 2022 ⁵⁰	Kolkata	Apr to Sep 2018	All naïve cases	103	18–40 years	2:1	50.4%	–	<i>T. corporis</i>	55 (53%)	<i>T. verrucosum</i> (26, 47%), <i>T. rubrum</i> (15, 27%), <i>T. mentagrophytes</i> (8, 15%), <i>Microsporum</i> (1, 2%), <i>E. floccosum</i> (5, 9%)
Vanapalli S et al. 2022 ⁵¹	Vizianagaram	Jan 2018 to Jun 2019	Extensive dermatophytosis	150	18 to 40 years (64%)	1.0: 0.8	43%	–	<i>Tinea corporis et cruris</i> (62.7%)	78 (52%)	<i>T. mentagrophytes</i> (78, 92.8%), <i>M. gypseum</i> (6, 7.2%)
Amin N et al. 2022 ⁵²	Mangalore	Jul to Dec 2019	Therapy resistant tinea	190 screened, 64 analysed	18–45 years (79.68)	1:1	78.2%	71.8%	<i>T corporis</i> (100%), <i>Tinea cruris</i> (78%)	64	<i>T. mentagrophytes</i> (55, 85.9%), <i>T. rubrum</i> (7, 10.9%); <i>Nannizzia gypsea</i> (2, 3.1%)
Das D et al. 2022 ²⁷	Kishanganj	Jan to Dec 2021	All cases	198	21–30 years (40%)	1.0: 0.8	–	–	92 (54.76)	68 (34%)	<i>T. mentagrophytes</i> 36 (52.9%), <i>T. rubrum</i> (16 (23.5%), <i>T. verrucosum</i> 10 (14.7%), <i>Epidermophyton</i> (6 (8.8%))

Key Points

- There is a rise in the prevalence of dermatophytosis and recalcitrant dermatophytosis in India. Majority of the data is collected from the hospital-based studies. Face of dermatophytosis may also be changing in the world.
- There may be some variation in the prevalence based on the region, climate, socioeconomical factors and migration, however, current scenario of dermatophytosis has shown a consistent rise in the prevalence from all parts of India.
- There is a high incidence of spread among close contacts probably due to high contagious nature and fomite transmission of the infecting agent.
- There is a near complete dominance of *T. indotineae* in the country, and this has largely replaced *T. rubrum* and *T. mentagrophytes* as the commonest cause of dermatophytic skin infections.⁵⁵
- Terbinafine resistance due to Squalene epoxidase gene mutations is widely prevalent in *T. indotineae*, resulting in need of higher drug doses.⁵⁶
- Recent high quality proteomic data from India has shown that there is a combination of mutation of Erg 11 gene and increased efflux pumps that can explain failures of itraconazole.

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