Review Article

Dermatophytosis: A Review of Epidemiology, Pathogenesis, Clinical Features, Diagnosis and Treatment Strategies in Nepal

ABSTRACT

Fungal infection of the skin, hair, and nail are the most common clinical conditions caused by dermatophytes. The most common cause of dermatophytic infections are *Trichophyton, Epidermophyton*, and *Microsporum* spp. If left untreated, they can lead to increased morbidity and secondary bacterial infections. This review highlights the knowledge on dermatophytes, its epidemiology, prevalence, pathogenesis, diagnosis, and their treatment among Nepalese on the basis of electronic databases (Google Scholar, NCBI, Pubmed, and Scopus).

Terai region has a higher prevalence of dermatophytoses cases than the mountainous area, primarily because of the hot and humid climate. *Trichophyton rubrum* and *Trichophyton mentagrophytes* are the two most typical infections. In Nepal's tertiary medical facilities, only microscopy and culture techniques are used for diagnosis. Nevertheless, the sole diagnostic technique available in community settings is clinical observation. In the scenario of Nepal, topical therapy with azoles or terbinafine is the first line drugs for treating cutaneous tinea while systemic medication with terbinafine is the first line of treatment for onychomysis and tinea capitis. There is a need for further research to develop better prevention and treatment strategies to lessen the burden of this infection.

Keywords: Fungal infection, Dermatophytes, Epidemiology, Pathogenesis, Diagnosis, Treatment

1. INTRODUCTION

Fungal infections of the skin, hair, and nail are common clinical conditions that affect a large population worldwide. These infections can result in substantial illness and potentially result in lasting complications if left untreated. Various socio-demographic factors, such as age, gender, occupation, geographic location, personal hygiene, socio-economic status, and lifestyle factors like smoking or alcohol consumption, and immunocompromised state can influence the risk of both communicable and non-communicable fungal infections affecting the skin, hair, and nails (A. K. Jha & Gurung, 2006).

1.1. Dermatophytes

Superficial skin infections in humans are primarily caused by dermatophytes, which affect a significant portion of the world's population, estimated to be around 20-25% (Sharma & Gupta, 2022). Skin, hair and nail infections are brought on by dermatophytes that infiltrate the stratum corneum or keratinized structures formed from the epidermis (Al-Khikani, 2020; Duek et al., 2004). Moisture and warm conditions are the most suitable factors to a wide distribution of dermatophytosis in tropical countries (Havlickova et al., 2009). *Trichophyton* genus, which typically affect the skin, hair, and nail, *Epidermophyton* genus, which mainly affect the skin, and *Microsporum* genus, which usually infect the skin and hair are the three genera of dermatophytes.

The hot and humid temperature may contribute to the higher prevalence of dermatophytoses in the Terai region. It creates an ideal environment for dermatophytes to thrive and survive. Furthermore, people in rural areas are unaware of personal cleanliness and lack health seeking behavior. In the Terai region, agriculture is the most common occupation among the people. Because of the continuous exposure to mud and increased chance of injury dermatophytoses may be seen in higher frequency. Furthermore, men are involved in outdoor activities and the agriculture profession while women are confined to indoor activities which may explain the higher rate of cases among males.

1.2. Epidemiology and Prevalence of dermatophytes

Tinea is the most frequent skin infection, and the trend has been consistent over the previous 20 years. In a community-based investigation, tinea cases were greater in the terai than in the mountainous zone (Paudel et al., 2021). A survey of skin illnesses in five villages in the Bara district of rural Nepal revealed a high prevalence of dermatophytoses. They were more common in males than in females (Walker et al., 2007). A study was conducted on patients visiting the tertiary hospital from three districts in Nepal's Terai area, and dermatophytosis was shown to be the most common skin ailment. Males were affected more frequently than females (Poudyal & Rajbhandari, 2014).

Tinea corporis was found to be the most common infection in a study done between 2008 and 2009 at the College of Medical Science in Chitwan, Nepal. The age range most commonly affected was between 26 and 30 years old, and males (56.5%) were more frequently impacted than females (Mathur et al., 2012). Likewise, tinea corporis was found to be the most common infection in a study conducted at Kathmandu Medical College between 2017 and 2018. The study also showed that *T. rubrum* (50%) and *T. mentagrophytes* (35%) were the most prevalent dermatophytes (B. Jha et al., 2019). In a study conducted at Grande International Hospital in Kathmandu, tinea corporis was identified as the most frequent infection, and *T. rubrum* (14.2%) was the most commonly detected dermatophyte (Jaishi et al., 2022). The incidence of dermatophytes was reported to be 4.54% in a research conducted at the B.P. Koirala Institute of Health Sciences in eastern Nepal, with a M: F ratio of 2.5: 1. The age range from 11 to 20 was the most affected. According to the study,

tinea corporis (43%) was found to be the most prevalent clinical type (Agarwalla et al., 2001). Nepal is a country where regional differences in the country's climate, socioeconomic standing, religion, and customs are extremely common. In poorer nations, dermatophytosis is significantly caused by factors such as inadequate cleanliness, limited access to water, and overcrowding in addition to hot and humid weather (Karn et al., 2021).

1.3. Risk factors

With the exception of tinea capitis, dermatophytosis generally affects post-pubertal hosts more commonly. The fact that males are more likely to work outside in hot, sweaty settings that favor the growth of dermatophytes, men are typically more affected than women (Browning, 2018). According to recent studies, direct contacts have a relatively high incidence (72–82%) of dermatophytosis (Mahajan et al., 2017).

Dermatophytic infections are more common in rural population. Studies from the early 2000s revealed a rural preponderance that is probably related to the high frequency of outside work, especially agriculture, which makes people likely to perspire more (Pathan et al., 2013). According to a study by Alolofi and colleagues, those who live in rural areas are more likely to have superficial fungal infections (70.6%) than those who reside in urban areas (29.4%). The environmental and hygienic disparities between urban and rural settings may be accountable for these findings. Additionally, rural residents are poor socio-economic group members who are uninformed of the condition and do not receive any treatments, resulting in multiple sites of lesions (Alolofi et al., 2022).

The outbreak of chronic and resistant skin infection may be due to the misuse of combo creams that contain steroids, antifungal, and antibiotics. These creams are easily available in cities and often used without medical advice, leading to a rise in difficult-to-treat cases (Verma et al., 2021a).

According to research, the incidence of dermatophyte infections is 61-67%, with a higher percentage of patients coming from lower socio-economic categories (Noronha et al., 2016). Lower-middle and medium socio-economic levels come next. Among lower socio-economic groups, poor living conditions, a lack of hygiene, congestion, and inadequate nutrition encourage the formation of dermatophytes, raising the chances of infection, chronicity, and recurrence (Agarwal et al., 2014)

Individuals who indulge in outdoor activities in hot, humid climates are more likely to get an infection since these conditions are suitable for dermatophytes. Additionally, recent research have revealed that manual laborers are most frequently impacted (Hazarika et al., 2019). Due to their frequent contact with soil and animals as well as their greater exposure to environmental fungal infections, farmers are at a higher risk (Agarwal et al., 2014). However, more housewives with active infections were discovered in investigations after 2016 (Vineetha et al., 2019). Homemakers are

more vulnerable to dermatophytes because of the warm kitchen environment and excessive sweating. In their study, Rudramurthy and team discovered that homemakers were the most often impacted category (25.1%) (Rudramurthy et al., 2018).

1.4. Pathogenesis and virulence factors

The establishment of the fungus in the host tissue, which is necessary for fungal disease, depends on both fungal and host factors (Martinez-Rossi et al., 2017). Dermatophytes are spore-producing fungi and are mainly composed of mycelium. Under specific circumstances, they have the ability to infect both human and animals. Depending on the dermatophyte species and the surrounding environment, many forms of conidia are generated. Arthroconidia are infectious fragments of hyphae, although macroconidia, microconidia, and arthroconidia can all develop from asexual spores (Moskaluk & VandeWoude, 2022).

The initial stage of a dermatophyte infection involves the attachment and adherence of the infectious components. These elements stick to the surface of keratinized tissue and proceed to the epidermis through the germination of arthroconidia. To facilitate infection, dermatophytes produce a range of virulence factors, including enzymes and non-enzymes. When invading tissue, they secrete enzymes in response to the skin components. Protease, lipase, and cellulose are just a few of the virulence enzymes that dermatophytes secrete, all of which have different substrate preferences. According to their active sites, aspartic, cysteine, glutamic, metallo, serine, and threonine proteases are categorized. A non-enzymatic virulence factor for *Penicillium* and *Aspergillus* infections in humans is also predicted to be Xanthomegnin, a mutagenic mycotoxin known to induce nephropathy and mortality in farm animals exposed to these fungi in food. It is also hypothesized that melanin or melanin-like substances, which are non-enzymatic virulence factors found in dermatophytes, will play a role in the pathogenesis of dermatophytic disorders during infection (Achterman & White, 2012; Chinnapun, 2015). Within 7 days of infection, arthroconidia are formed, enabling the fungus to travel to new anatomical structures of the original hosts, infect further hosts, and pollute other habitats (Moskaluk & VandeWoude, 2022).

1.5. Host immune response

When dermatophytes enter keratinized tissue, they trigger an innate immune response in the host tissue through the antigens or metabolites they produce. The main antigens from dermatophytes are the components of their cell walls, including chitin, glucan, and glycopeptides. In order for the pathogen-host interaction to take place, the fungus must first overcome the host's initial defense mechanisms, which include the skin and mucous membranes (Celestrino et al., 2021). The skin acts not only as a physical barrier but also as an integral part of the innate and adaptive immune systems. When the tissue is under attack by invading pathogens, these immune systems are activated to combat the pathogen and

protect the host. After successfully overcoming the host's defense mechanisms, dermatophytes will interact with the epidermal cells, including keratinocytes and Langerhans cells (Reis et al., 2019).

Keratinocytes, which are the most common cells found in the epidermis, play a crucial role in the initial response to dermatophytes or their antigens. They directly participate in defense against the pathogen and activate further immune cells by releasing multiple inflammatory cytokines such as IL-8, IL-6, and TNF-α. Zoophilic species (*Microsporum canis*, *Trichophyton mentagrophytes*, and *Trichophyton verrucosum*) infect animals and humans and induce a stronger immune response. In contrast, anthropophilic species (*Trichophyton rubrum*, *Trichophyton tonsurans*, and *Epidermophyton floccosum*) infect primarily humans. The type of cytokines released by keratinocytes varies depending on the species of dermatophyte. Zoophilic species induce a stronger immune response than anthropophilic species. In addition, natural antimicrobial peptides, such as cathelicidins and defensins, are produced as part of the innate immune defense against dermatophytes. These peptides are expressed by various barrier and secretory epithelial cells in response to infection (Miller, 2008).

1.6. Clinical features

1.6.1 Cutaneous tinea

Cutaneous tinea is a fungal infection of the skin. It can appear in various forms, including tinea pedis (athlete's foot), tinea corporis (ringworm), tinea cruris (jock itch), tinea barbae, and tinea manuum. Tinea corporis usually manifests as a well-defined, sharply outlined, oval or circular, slightly erythematous, scaly patch or plaque with a raised leading edge. The irritation is typically not severe (Leung et al., 2020). When the palmar and interdigital regions of the hand are affected by dermatophytes, it is known as tinea manuum (Marks & Miller, 2019). Tinea cruris is an infection of the groin brought on by dermatophytes. It presents as a pruritic, scaling lesion or plaque in the crease between the scrotum and the leg (Deshmukh et al., 2021; Verma et al., 2021b). A fungus infects the skin on the feet, causing tinea pedis, also known as athlete's foot (Makola et al., 2018). Scaling and maceration of the interdigital spaces, which often begin on the lateral side and extend to the medial side of the foot, are its defining characteristics. In the plantar and lateral parts of the foot, the infection frequently manifests as a dry pattern and is accompanied by hyperkeratosis. These are the physical manifestations of tinea pedis that are most frequently observed. A less frequent pattern of the infection, however, is when it appears as small vesicles and blisters on a reddish base on the plantar surface of the foot (Shy, 2007). A dermatophyte fungus infection affects the facial regions of the beard and moustache known as tinea barbae.

1.6.2. Tinea capitis

A fungal condition called tinea capitis affects the scalp and hair. There are two clinical subtypes of tinea capitis: inflammatory and non-inflammatory. While the inflammatory kind can result in painful nodules packed with pus and

scarring hair loss, the non-inflammatory variety typically does not. Although it can affect people of any age, it most frequently affects youngsters between the ages of 3 and 14 years. Eyelashes and eyebrows may also be impacted by tinea capitis (B. N. Jha et al., 2006).

1.6.3. Onychomycosis

A fungal nail infection known as onychomycosis can take many different forms, including distal subungual, proximal subungual, endonyx, superficial white, and complete dystrophic. Distal subungual is the most prevalent type, which begins with tinea pedis and results in thick, discolored nails. Similar symptoms are seen in the proximal subungual, endonyx, and superficial white types, whereas total dystrophic onychomycosis completely destroys the nail (Neupane et al., 2009).

1.7. Diagnosis

Most dermatophyte infections can be diagnosed easily by taking into account the patient's medical history, conducting a physical examination, using wood's lamp and potassium hydroxide (KOH) microscopy (Dowd, 2007). The gold standard for prescription of systemic therapy for the fungal infections is culture. Colony traits that can be distinguished include color, texture, growth rate, and distinctive morphological elements including spirals, pectinate branches, pedicels, and nodular organs (Vishnu et al., 2015). As conventional methods of dermatophyte detection (KOH microscopy and culture) were found to have delayed diagnostic capability and low accuracy, the development of molecular diagnostic techniques allowed for a more precise and swift diagnosis of dermatophytosis. A prompt and precise laboratory diagnosis is crucial for effective treatment as relying solely on clinical appearance leads to a 50% misdiagnosis rate (Gräser et al., 2012). This accurate diagnosis enables the timely administration of appropriate antifungal therapy, which avoids non-specific self-medication.

Identification of fungi in dermatological samples using PCR is reliable and provides significantly improved results in comparison with cultures. By utilizing direct DNA isolation and PCR-ELISA technique, dermatophytes can be identified at the species level quickly and accurately, without the need to consider their morphological or biochemical traits (Beifuss et al., 2011). The identification of dermatophytoses involves detecting dermatophyte DNA in patient samples. However the DNA extraction procedure and the fact that molecular taxonomy and species classification don't always agree provide challenges (Jensen & Arendrup, 2012). The methods for diagnosing dermatophytoses are still driven by time, cost, complexity, the variety of species spectrum observed, despite breakthroughs in the molecular field. Consequently, the conditions present and the resources in the laboratory affect several decisions involved in the pursuit of a dermatophytoses diagnosis.

Even tertiary care facilities in Nepal use microscopy and culture methods to identify dermatophytoses cases. This is likely due to the high cost associated with using more advanced molecular techniques like PCR and ELISA.

1.8. Treatment

1.8.1. General Measures

As general preventive measures, the patient should be advised to wear loose-fitting cotton clothing that is comfortable. They should also be reminded to change their underpants frequently. They need to be encouraged not to exchange clothing, towels, or bed linens. It is critical to emphasize to patients the importance of constant medication use (Kaul et al., 2017).

1.8.2. Pharmacologic Measures

The infection site, etiological agent, and drug penetration potential all have a role in the therapy decision. Antifungal medicines used to treat dermatophytes must be able to penetrate the keratinocytes that make up the stratum corneum since they dwell there. The site of infection and the symptoms are the main factors that affect the duration of treatment. Treatment for skin lesions normally takes two to three weeks, whereas foot inflammation takes four to six weeks (Lakshmipathy & Kannabiran, 2010).

Topical antifungal medications are typically the first choice for treating localized dermatophytoses, with the exception of tinea capitis and onychomycosis. Topical antifungals include drugs such as imidazoles (such as clotrimazole, ketoconazole, and miconazole), triazoles (like fluconazole and itraconazole), and allylamines (such as terbinafine), which work by inhibiting the formation of cell membranes through the suppression of ergosterol biosynthesis. Miconazole, clotrimazole, and ketoconazole are well-known azole antifungals that have been widely used to treat dermatophytose. Luliconazole and efinaconazole are two more recent azoles to appear; luliconazole is approved for the treatment of tinea corporis, tinea cruris, and tinea pedis, while efinaconazole is approved for the treatment of onychomycosis (Gupta et al., 2021). However, topical antifungals cannot penetrate the hair shaft, making oral antifungals necessary in cases of tinea capitis (Table 1).

Table 1: Treatment of cutaneous tinea, onychomycosis, and tinea capitis (Kaul et al., 2017; Lim et al., 2022)

Treatment of cutaneous tinea

Topical therapy (only treatment required in limited disease)	• Azoles once daily or twice daily for 2-4 weeks • Terbinafine 1% twice daily for 2 weeks
Systemic therapy	**1st choice:** • Terbinafine 250 mg/day for 2-3 weeks In children: • Weight (Wt) < 20 kg = 62.5 mg/day • Wt (20-40) kg = 125 mg/day • Wt > 40 kg = 250 mg/day **2nd choice:** • Itraconazole 100 mg/day for 1-4 weeks

Treatment of onychomycosis

Systemic therapy(1st line)	**1st choice:** • Terbinafine – 250 mg/day for 6 weeks (fingernails) and for 12 weeks (toenails) In children: • Wt < 20 kg = 62.5 mg/day • Wt (20-40) kg = 125 mg/day

	• Wt > 40 kg = 250 mg/day **2nd choice:** • Itraconazole- 200 mg twice daily for 1 week every month for 2 cycles (fingernails) and for 3 cycles (toe nails) In children: • Pulse therapy – 5 mg/kg/day for 1 week every month 2 pulses (fingernail) and 3 pulses (toenail)
Topical therapy	Ciclopirox 8% once daily Amorolfine 5% once/week
Adjunctive	1. Surgical/chemical nail avulsion 2. Laser 3. Photodynamic therapy (PDT)

<u>Treatment of tinea capitis</u>

Systemic (1st line)	• Terbinafine 250 mg/day for 2-4 weeks (*Trichophyton* species) - Dosage wt < 20 kg = 62.5 mg/day for 2-4 weeks

	- Wt (20- 40) kg = 125 mg/day for 2-4 weeks - Wt > 40 kg = 250 mg/day for 2-4 weeks • Griseofulvin – higher efficacy against *Microsporum* species - Dosage wt < 50 kg = 15-20 mg/kg/day for 6-8 weeks - Wt > 50 kg = 1g/day for 6-8 weeks • Itraconazole- effective against both *Trichophyton* and *Microsporum* species - Dose : 50-100 mg/day for 4 weeks
Topical therapy (only to prevent transmission)	• 2% ketoconazole • 1-2.5% selenium sulfide • 2.5% povidone iodine shampoo

Unlike other antifungals, griseofulvin (an oral antifungal) works by inhibiting fungal mitosis by targeting microtubules. Griseofulvin is commonly used for tinea capitis due to its safety, effectiveness, and affordability, but it requires a long course of treatment that may impact patient compliance. Itraconazole is another effective option, but it can be expensive. In addition to these treatments, adjuvant therapy with topical 2 percent ketoconazole or selenium sulfide shampoo may also be used to reduce the spread of infection (Richard L. Guerrant, 2011). For onychomycosis, oral antifungal agents (terbinafine, itraconazole, and fluconazole) are used as they are effective against fungal infection of the nail. However, terbinafine has been found to be superior regarding the effectiveness. When oral antifungals are ineffective at treating the infection, surgical avulsion of the nails and chemical nail ablation with potassium iodide are further options (Gupta & Tu, 2006) (Table 2).

Table 2: Characteristics of antifungal agents for the treatment of dermatophyte infections (Del Palacio et al., 2000)

	Griseofulvin	**Ketoconazole**	**Fluconazole**	**Itraconazole**	**Voriconazole**	**Terbinafine**
Keratin binding	Low	Strong	Low	Strong	*	Strong
Excretion by sweat	High	High	High	Moderate	*	Low
Grease affinity	Low	Low	Low	High	*	High
Mechanism of action	Disrupts micotic spindle/microtubules	Inhibits 14- α demethylation of lanosterol	Inhibits 14- α demethylation of lanosterol	Inhibits 14- α demethylation of lanosterol	Inhibits fungal cytochrome P-450 dependent 14- α lanosterol demethylase	Inhibits squalene epoxidation
Fungicidal	No	No	No	No	*	Yes

Cost-effectiveness is a key consideration for choosing antifungals in the country like Nepal since many people here have the low socio-economic condition. The easy availability of steroids and antibiotics without a prescription leads to self-treatment of fungal infections, which can contribute to disease chronicity. Furthermore, non-compliance after a few days of utilizing the prescribed drugs is responsible for inadequate therapy and recurring fungal infection. As a result, it is critical to treat the patient by selecting the appropriate treatment based on the organism, the portion of the body affected, the chronic disease conditions, and the patient's socio-economic status. Furthermore, even if the disease is treated after the initial administration of the prescription, the patient should be instructed to continue using the drug for the specified period of time.

Joshi and his team's investigation at Nepal Medical College over the course of a year found that many patients neglect to see a doctor despite having an infection. The majority of patients who were looking for medication did so from their neighborhood community pharmacy (Joshi et al., 2020). Joshi and his team reported that itraconazole followed by fluconazole and terbinafine are the most commonly used antifungals, whereas a study by Khadka found that

miconazole, followed by ketoconazole, and clotrimazole is the most effective treatment for dermatophytes (Khadka et al., 2017).

Antifungal medication abuse has resulted in the establishment of resistant strains that are difficult to cure. Over the past ten years, antifungal drug resistance has surged in Nepal (Khadka et al., 2017). In a study conducted at the National Medical College and Teaching Hospital, Birgunj, Nepal, it was discovered that itraconazole was the most effective medication while fluconazole was the most resistant (Pradhan & Paudel, 2021). Similar result was seen in a study done by Karn and team at Universal College of Medical Science, Bhairahawa, Nepal (Karn et al., 2021).

1.9. Contraindication antifungal drugs

There are various contraindications to the antifungal drugs. Azoles, terbinafine and griseofulvin should be avoided or used with great caution in case of hepatic impairment. Itraconazole is contraindicated in left ventricular dysfunction (McKeny et al., 2023). A summary of some important contraindications to the drugs used against dermatophytes is shown in **Table 3**.

Table 3: Contraindication of antifungal drugs (Durdu & Ilkit, 2023; Hay, 2015; Kaul et al., 2017)

Drug	Contraindications
Terbinafine	Hepatic, renal impairment, Depression
Itraconazole	Heart failure, Hepatotoxicity,
Griseofulvin	Hepatic impairment, Lupus erythematous, Porphyria
Fluconazole	Hepatic, renal impairment and QTc prolongation

4. CONCLUSION

Dermatophytosis is a global illness that poses a severe threat to public health, particularly in poor nations such as Nepal. There is an increase in recurrent dermatophyte infections and treatment-resistant cases, leading to morbidity in people. The primary cause is a lack of personal hygiene awareness, as well as the inadvertent use of locally available combination creams including steroids, antibiotics, and antifungals. Another reason for the low accuracy in the diagnosis of dermatophytes and thus the over-the-counter use of anti-fungal drugs can be attributed to the use of conventional methods (clinical observation and microscopy using KOH) for the diagnosis even in most tertiary centers. It is critical to enhance public knowledge about dermatophytosis and the importance of receiving a full treatment regimen from an expert after receiving an accurate diagnosis. Similarly, it is vital to take rigorous policy measures to prohibit the sale of unprescribed drugs at pharmacies. Furthermore, diagnostic techniques should be updated with new diagnostic instruments such as PCR, which have great accuracy and thus aid in the proper diagnosis and treatment of patients.

CONSENT (WHERE EVER APPLICABLE)

Since this is a review article, no consent is applicable in this case.

ETHICAL APPROVAL (WHERE EVER APPLICABLE)

Not applicable since it is a review article.

REFERENCES

Achterman RR, White TC (2012) Dermatophyte virulence factors : Identifying and analyzing genes that may contribute to chronic or acute skin infections. Int. J. Microbiol 2012(1), 358305. https://doi.org/10.1155/2012/358305

Agarwal US, Saran J, Agarwal P (2014) Clinico-mycological study of dermatophytes in a tertiary care centre in northwest India. Indian J. Dermatol. Venereol. Leprol 80(2), 194. https://doi.org/10.4103/0378-6323.129434

Agarwalla A, Jacob M, Sethi M, Parija SC, Singh NP (2001) A clinico-mycological study of dermatophytoses in Nepal. J. Dermatol 28(1), 16–21. https://doi.org/10.1111/j.1346-8138.2001.tb00080.x

Al-Khikani F (2020) Dermatophytosis a worldwide contiguous fungal infection: Growing challenge and few solutions. Biomed. Biotech. Res. J Wolters Kluwer Medknow Publications. 4(2), pp 117-122. https://doi.org/10.4103/bbrj.bbrj_1_20

Alolofi SAY, Yagoub SO, Nimir AH (2022) Dermatophytosis: Etiological agents and associated risk factors. Elect. J. Univ. Aden Basic Appl Sci 3(2), 57–65. https://doi.org/10.47372/ejua-ba.2022.2.153

Beifuss B, Bezold G, Gottlöber P, Borelli C, Wagener J, Schaller M, Korting HC (2011) Direct detection of five common dermatophyte species in clinical samples using a rapid and sensitive 24-h PCR-ELISA technique open to protocol transfer. Mycoses 54(2), 137–145. https://doi.org/10.1111/j.1439-0507.2009.01771.x

Browning J (2018) Dermatology edited by Jean L.Bolognia Julie V.Schaffer Lorenzo Cerroni, 4th edition, China

Elsevier, 2018, ISBN 978-0-7020-6275-9. Pediatr Dermatol 35(2), 289–289. https://doi.org/10.1111/pde.13439

Celestrino GA, Verrinder Veasey J, Benard G, Sousa MGT (2021) Host immune responses in dermatophytes infection. Mycoses, 64(5), 477–483. https://doi.org/10.1111/myc.13246

Chinnapun D (2015) Virulence factors involved in pathogenicity of dermatophytes. Walailak J. Sci.Technol 12(7), 573–580.

Del Palacio A, Garau M, Gonzalez-Escalada A, Calvo MT (2000) Trends in the treatment of dermatophytosis. Rev. Iberoam. Micol 17(SUPPL.), 148–158.

Deshmukh SG, Thakre T, Gupta J, Waskar R (2021) A case study on management of Tinea cruris with classical vaman karma. J.Pharm. Res. Int 195–202. https://doi.org/10.9734/jpri/2021/v33i33B31811

Dowd FJ (2007) Dermatophyte infections. XPharm: The Comprehensive Pharmacology Reference, 1–4. https://doi.org/10.1016/B978-008055232-3.60907-9

Duek L, Kaufman G, Ulman Y, Berdicevsky I (2004) The pathogenesis of dermatophyte infections in human skin sections. J. Infect 48(2), 175–180. https://doi.org/10.1016/j.jinf.2003.09.008

Durdu M, Ilkit M (2023) Strategies to improve the diagnosis and clinical treatment of dermatophyte infections. Expert Rev. Anti-Infect. Ther 21(1), 29–40. https://doi.org/10.1080/14787210.2023.2144232

Gräser Y, Czaika V, Ohst T (2012) Diagnostic PCR of dermatophytes - An overview. JDDG: Journal Der Dtsch. Dermatol. Ges 10(10), 721–725. https://doi.org/10.1111/j.1610-0387.2012.07964.x

Gupta AK, Mays RR, Foley KA (2021) Topical antifungal agents. In Comprehensive Dermatologic Drug Therapy (pp. 480-492.e5). Elsevier. https://doi.org/10.1016/B978-0-323-61211-1.00042-5

Gupta AK, Tu LQ (2006) Dermatophytes: Diagnosis and treatment. J. Am. Acad. Dermatol 54(6), 1050–1055.

https://doi.org/10.1016/j.jaad.2006.01.016

Havlickova B, Czaika VA, Friedrich M (2009) Epidemiological trends in skin mycoses worldwide. Mycoses 52(1):95. https://doi.org/10.1111/j.1439-0507.2008.01668.x

Hay RJ (2015) Antifungal drugs. In European Handbook of Dermatological Treatments (pp. 1361–1371). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-45139-7_132

Hazarika D, Jahan N, Sharma A (2019) Changing trend of superficial mycoses with increasing nondermatophyte mold infection: A clinicomycological study at a tertiary referral center in Assam. Indian J.Dermatol 64(4), 261. https://doi.org/10.4103/ijd.IJD_579_18

Jaishi VL, Parajuli R, Dahal P, Maharjan R (2022) Prevalence and risk factors of superficial fungal infection among patients attending a tertiary care hospital in central Nepal. Interdiscip. Perspect. Infect. Dis 2022. https://doi.org/10.1155/2022/3088681

Jensen RH, Arendrup MC (2012) Molecular diagnosis of dermatophyte infections. Curr. Opin. Infect. Dis 25(2), 126–134. https://doi.org/10.1097/QCO.0b013e32834f5f6e

Jha AK, Gurung D (2006) Seasonal variation of skin diseases in Nepal: a hospital based annual study of out-patient visits. Nepal Med. Coll. J NMCJ, 8(4), 266–268.

Jha B, Bhattarai S, Sapkota J, Sharma M, Bhatt CP (2019) Dermatophytes in skin, nail and hair among the patients attending out patient department. J. Nepal Health Res. Counc 16(41), 434–437. https://doi.org/10.33314/jnhrc.v16i41.1651

Jha BN, Garg VK, Agrawal S, Khanal B, Agarwalla A (2006) Tinea capitis in eastern Nepal. Int. J. Dermatol 45(2), 100–102. https://doi.org/10.1111/j.1365-4632.2004.02343.x

Joshi S, Shrestha S, Timothy U, Jha A, Thapa D (2020) Health seeking behavior and cost of care of chronic

dermatophytosis: A hospital-based cross-sectional study. Nepal Med. Coll.J 22(3), 181–188. https://doi.org/10.3126/nmcj.v22i3.32656

Karn S, Gurung A, Shrivastava A, Poudel S, Adhikari S, Sah C (2021) Dermatophytosis in Bhairahawa, Nepal: Prevalence and resistance pattern of dermatophyte species. The Ulutas Med. J 7(2), 115. https://doi.org/10.5455/umj.20201208055254

Kaul S, Yadav S, Dogra S (2017) Treatment of dermatophytosis in elderly, children, and pregnant women. Indian Dermatol. Online J 8(5), 310. https://doi.org/10.4103/idoj.IDOJ_169_17

Khadka S, Sherchand JB, Pokhrel BM, Parajuli K, Mishra SK, Sharma S, Shah N, Kattel HP, Dhital S, Khatiwada S, Parajuli N, Pradhan M, Rijal BP (2017) Isolation, speciation and antifungal susceptibility testing of Candida isolates from various clinical specimens at a tertiary care hospital, Nepal. BMC Res. Notes, 10(1), 1–5. https://doi.org/10.1186/s13104-017-2547-3

Lakshmipathy DT, Kannabiran K (2010). Review on dermatomycosis: pathogenesis and treatment. Nat. Sci 02(07), 726–731. https://doi.org/10.4236/ns.2010.27090

Leung AK, Lam JM, Leong KF, Hon KL (2020) Tinea corporis: an updated review. Drugs in Context, 9, 1–12. https://doi.org/10.7573/dic.2020-5-6

Lim SS, Shin K, Mun J (2022) Dermoscopy for cutaneous fungal infections: A brief review. Health Sci. Reports, 5(1). https://doi.org/10.1002/hsr2.464

Mahajan S, Tilak R, Kaushal S, Mishra R, Pandey S (2017) Clinico-mycological study of dermatophytic infections and their sensitivity to antifungal drugs in a tertiary care center. Indian J. Dermatol, Venereol Leprol, 83(4), 436. https://doi.org/10.4103/ijdvl.IJDVL_519_16

Makola NF, Magongwa NM, Matsaung B, Schellack G, Schellack N (2018) Managing athlete's foot. South African Family Practice, 60(5), 37–41. https://doi.org/10.4102/safp.v60i5.4911

Marks JG, Miller JJ (2019) Scaling papules, plaques, and patches. Lookingbill and Marks' principles of dermatology. Elsevier Health Sci. 113–134. https://doi.org/10.1016/b978-0-323-43040-1.00009-9

Martinez-Rossi NM, Peres NTA, Rossi A (2017) Pathogenesis of dermatophytosis: Sensing the host tissue. Mycopathologia, 182(1–2), 215–227. https://doi.org/10.1007/s11046-016-0057-9

Mathur M, Kedia SK, Ghimire RBK (2012) Epizoonosis of dermatophytosis: A clinico - mycological study of dermatophytic infections in central Nepal. Kathmandu Uni. Med. J 10(37), 30–33. https://doi.org/10.3126/kumj.v10i1.6910

McKeny PT, Nessel TA, Zito PM (2023) Antifungal Antibiotics. In StatPearls.

Miller LS (2008) Toll-like receptors in skin. Adv. Dermatol 24, 71–87. https://doi.org/10.1016/j.yadr.2008.09.004

Moskaluk AE, VandeWoude S (2022) Current topics in dermatophyte classification and clinical diagnosis. Pathogens, 11(9), 957. https://doi.org/10.3390/pathogens11090957

Neupane S, Pokhrel DB, Pokhrel BM (2009) Onychomycosis: a clinico-epidemiological study. Nepal Med. Coll. J : NMCJ, 11(2), 92–95.

Noronha T, Tophakhane R, Nadiger S (2016) Clinico-microbiological study of dermatophytosis in a tertiary-care hospital in North Karnataka. Indian Dermatol Online J 7(4), 264. https://doi.org/10.4103/2229-5178.185488

Pathan N, Sharma R, Vyas L, Vyas A (2013) A clinicomycological study of cutaneous mycoses in Sawai Man Singh Hospital of Jaipur, North India. Annals Med. Health Sci Res 3(4), 593. https://doi.org/10.4103/2141-9248.122125

Paudel S, Sharma R, Dahal S, Paudel I (2021) Epidemiological profile of patients with skin diseases in a tertiary

hospital in Kathmandu, Nepal: A cross sectional retrospective study. Nepal J. Dermatol, Venereol Leprol 19(1), 14–19.

Poudyal Y, Rajbhandari S (2014) Pattern of skin diseases in patients visiting Universal College of Medical Sciences-Teaching Hospital (UCMS-TH) from the three districts of terai region in Nepal. J. Universal Coll. Med. Sci 2(3), 3–8. https://doi.org/10.3126/jucms.v2i3.11820

Pradhan MB, Paudel V (2021) Clinico-mycological study of dermatophytosis and their antifungal susceptibility: A hospital based study. Nepal J. Dermatol, Venereol Leprol 19(1), 30–36. https://doi.org/10.3126/njdvl.v19i1.34693

Reis APC, Correia FF, Jesus TM, Pagliari C, Sakai-Valente NY, Belda Júnior W, Criado PR, Benard G, Sousa MG T (2019) In situ immune response in human dermatophytosis: possible role of Langerhans cells (CD1a+) as a risk factor for dermatophyte infection. Revista Do Instituto de Medicina Tropical de São Paulo, 61. https://doi.org/10.1590/s1678-9946201961056

Guerrant RL, Walker DH, Weller PF (Ed.). (2011). Tropical infectious diseases: Principles, pathogens and practice. Elsevier Health Sci https://doi.org/10.1016/C2009-0-40410-0

Rudramurthy SM, Shankarnarayan SA, Dogra S, Shaw D, Mushtaq K, Paul RA, Narang T, Chakrabarti A (2018) Mutation in the Squalene Epoxidase gene of Trichophyton interdigitale and Trichophyton rubrum associated with Allylamine resistance. Antimicrobial Agents and Chemotherapy, 62(5). https://doi.org/10.1128/AAC.02522-17

Sharma A, Gupta S (2022) Protective manifestation of herbonanoceuticals as antifungals: A possible drug candidate for dermatophytic infection. Health Sci. Rep 5(5). https://doi.org/10.1002/hsr2.775

Shy R (2007). Tinea Corporis and Tinea Capitis. Pediatrics Rev 28(5), 164–174. https://doi.org/10.1542/pir.28-5-164

Verma SB, Panda S, Nenoff P, Singal A, Rudramuruthy SM, Uhrlass S, Das A, Bisherwal K, Shaw D, Vasani R (2021) The unprecedented epidemic-like scenario of dermatophytosis in India: I. Epidemiology, risk factors and clinical features. Indian J. Dermatol, Venereol Leprol, 87, 154. https://doi.org/10.25259/IJDVL_301_20

Vineetha M, Sheeja S, Celine M, Sadeep M, Palackal S, Shanimole P, Das S (2019) Profile of dermatophytosis in a tertiary care center. Indian J. Dermatol 64(4), 266. https://doi.org/10.4103/0019-5154.265814

Vishnu S, Tarun KK, Anima S, Ruchi S, Subhash C (2015) Dermatophytes: Diagnosis of dermatophytosis and its treatment. African J. Microbiol. Res 9(19), 1286–1293. https://doi.org/10.5897/ajmr2015.7374

Walker SL, Shah M, Hubbard VG, Pradhan HM, Ghimire M (2007) Skin disease is common in rural Nepal: Results of a point prevalence study. British J. Dermatol 158(2), 334–338. https://doi.org/10.1111/j.1365-2133.2007.08107.x