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Oiginal Article

Factors associated with the occurrence of various skin fungal infections in patients at Al-Qadisiyah Province, Iraq

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Abstract

Introduction: Fungal infections may damage the skin and become invasive with the possibility of spreading to other individuals. The goal of the current study was to detect the most common fungal agents causing skin infections, and to investigate the various factors associated with such infections.

Methodology: The study involved 100 patients; who had suffered from various skin infections. All information related to the site of lesion, age, gender, date of collection, and history was recorded. Statistical analysis was carried out using SPSS version 27.

Results: All the patients included in the study were diagnosed clinically and confirmed by laboratory diagnosis. The skin infections were caused by dermatophytes (72%), *Trichophyton rubrum* (56.9%), *Microsporum canis* (20.8%), and yeast (24%). Among the yeast infections, 54.2% were by *Malassezia furfur*, and 45.8% by *Candida albicans*. There was significant association between type of fungal infection and age group, and the majority of the patients with dermatophytes were ≤ 30 years old. Males constituted 62% and females 38%. There was a significant association between the type of fungal infection and family history of patients, and there was a positive association with households with animals.

Conclusions: Dermatophytes (such as *Trichophyton rubrum*, *Microsporum canis*) were a crucial health problem. Males were more susceptible to fungal skin infections than females, with the majority of infections happening in the 11–40 years age group. Households with animals and family history of infection had significant association with the occurrence of fungal skin infections.

Key words: dermatophytes; dermatitis; factors, Iraq.

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Introduction

The skin is a multifunctional organ and it is considered a primary environmental barrier [1]. It protects us from mechanical impacts, prevents dehydration, and also cools us off when we are hot. The skin is absolutely critical to our survival. One of the most important functions of the skin is to protect against infection by blocking invading pathogens [2]. In addition to the physical barrier created, skin cells selectively respond to the presence of skin pathogens to induce production of antimicrobial peptides [3].

A hallmark trait of many skin diseases is an aberrant microbiome accompanying a breakdown in skin barrier function and an increased risk of infection. Knowledge of skin immune function is largely based on the inflammatory immune response to pathogens [4]. However, the majority of microbe-immune interactions on healthy, uncompromised skin involve the resident skin microbiota, which has evolved intimately with the immune system to maintain a symbiotic host-microbe relationship [5].

Some examples of fungi with opportunistic organisms include: Zygomycetes, *Aspergillus* spp, *Fusarium* spp; and, rarely, dimorphic fungi that are agents of endemic fungemia, *Candida* spp [6,7]. A common fungal infection of the skin is tinea pedis, colloquially known as ‘athlete’s foot’, and is the most common dermatophyte infection [8]. Tinea capitis is a dermatophyte infection of the scalp and hair, and it predominantly occurs in pre-pubertal children [9]. Tinea unguium also known as onychomycosis, is a dermatophyte infection of the nails. Onychomycosis is very common in the elderly [10]. Tinea corporis, commonly known as ringworm, refers to a dermatophyte infection on the skin of sites other than the face, hands, feet, or groin. Tinea incognito is a term for a tinea infection that has been misdiagnosed and inappropriately treated with a topical corticosteroid or other immunosuppressive agents [11].

Tinea versicolor (also known as pityriasis versicolor) is a common superficial fungal infection of the skin. Patients with tinea versicolor typically present with asymptomatic hypopigmented or hyperpigmented, finely scaled, oval or round macules/patches on the trunk and upper arms. Patients occasionally report pruritus, particularly when the condition is more extensive [12]. Tinea versicolor is characterized by mildly scaly hypopigmented or hyperpigmented macules/patches, most commonly affecting areas of skin that are rich in sebum production, such as the trunk (especially the upper part), neck, shoulders, and upper arms. Facial involvement is less common in adults. On the other hand, facial involvement is common in children and may be the only site involved [13]. It is important that the immune system, especially antibodies such as IgM and IgG, play a crucial role in eradicating various microbial infections (such as fungal infections) [14].

The present study aimed to determine the most common fungal causative agent of skin infections diagnosed clinically and in the laboratory by investigating various factors that relate to their occurrence.

Methodology

Patients

The study included patients who visited a private dermatology clinic during the period from February to December 2024 in Al-Qadisiyah Province in Iraq. All patient cases that visited the dermatology clinic, suffered from various symptoms of skin infection (e.g. itching, redness, skin lesions), and were diagnosed clinically by a physician, were recorded and included in this study. The very simple, self-limited cases, which depended on physician decision and selection following the clinical investigation were excluded. Information related to demographics, including age, gender, geographical area (rural or urban), family history of skin infection, and animal household, were recorded. All patients were subjected to clinical diagnosis depending on the dermatologist's experience.

Informed consent was obtained from all patients prior to including them in the study.

Collection of specimens/skin scrapings

All patients with skin infections who were clinically diagnosed by a dermatologist, were sent for laboratory confirmation of the infection. Laboratory confirmation involved skin scraping and cultivation of the pathogen. Skin scraping was collected from any skin area around the body (including scalp, arms, legs, groin, feet, and trunk). The lesions were first cleaned with distilled water and alcohol to remove any applied medications or cloth fibers on the lesions. The scrapings were collected from the heavily infected areas of skin or from the active edge of the lesion [15]. The scrapings were collected on black paper for ease of skin debris visualization. All specimens were kept dry to prevent bacterial growth and contamination. The papers were folded, closed with clips, and labeled properly. All patients' information (site of lesion, age, gender, date of collection, history) was recorded on the label.

Potassium hydroxide mount

Each specimen was transferred carefully to a labeled glass slide. One to two drops of 10% potassium hydroxide (KOH) solution were added to each collected specimen, and then a coverslip was pressed down on it. The slides were examined using a light microscope for identification of fungi.

Inoculation/cultivation of specimen

The clinical specimens were inoculated on fungal culture media (Sabouraud dextrose agar, SDA) (Formedium Ltd, King's Lynn, England). SDA media were supplemented with chloramphenicol (to inhibit Gram-positive and Gram-negative bacteria) and cycloheximide (to inhibit most saprophytic non-pathogenic contaminant molds while allowing the other dermatophytes to grow). All culture plates were incubated aerobically at 28–30 ºC for 21 days. All culture plates were examined daily for observation of fungal growth depending on gross characteristics. Dermatophyte species were identified primarily by observing their pigmentation on both the surface and on the reverse side (macroscopic examination), and their colonial morphology and texture were recorded. Generally, dermatophyte colonies appeared as light-colored. Definitive diagnosis was performed through observing the arrangement and shape of microconidia and macroconidia.

Quality control strain

Quality control ensures that the media is selective (inhibits undesired organisms) and supportive (allows the target fungi to grow). The quality control strains used were as follows: positive control dermatophyte was *Trichophyton* spp. (growth was white to cream, granular colonies); positive control yeast was *Candida albicans*, which formed creamy, convex colonies; negative control bacteria was *Escherichia coli* whose growth was inhibited due to chloramphenicol; negative control bacteria was *Staphylococcus aureus* whose growth was inhibited due to chloramphenicol; and negative control saprophyte was *Saccharomyces cerevisiae* whose growth was inhibited due to cycloheximide.

Statistical analysis

Statistical analysis was carried out using SPSS version 27. Categorical variables were presented as frequencies and percentages. Fisher-Freeman-Halton (FFH) exact test was used to find the association between categorical variables. p value ≤ 0.05 was considered significant.

Ethics declaration

The study adhered to the ethical standards of Helsinki and received approval from the local medical ethics committee, as documented in document number 103, approval date: 9/1/2024.

Results

A total of 100 cases were included in the study. All patients included in this study exhibited symptoms of fungal skin infections according to the primary clinical diagnosis of the dermatologist. The number of cases obtained during the hot weather months (July to September) was relatively higher than the number of cases from the other months in the study period. Several types of fungal skin infections were identified based on the dermatologist's clinical diagnosis and the laboratory diagnosis (skin scraping and inoculation/cultivation of the specimen), and these are summarized in Table 1.

The dermatophytes represented the majority of cases (72%); of these, *Trichophyton rubrum* constituted more than half of cases (56.9%), followed by *Microsporum canis* (20.8%). On the other hand, 24% of the cases were yeast infections (54.2% *Malassezia furfur* and 45.8% *Candida albicans*), and only 4 cases were caused by mixed dermatophytes, especially *Trichophyton rubrum* and yeast infections.

Table 1. Types of fungal skin infections recoved in the study.

Types of skin fungal infection	n = 100	%
Dermatophytes (N = 72)		
Trichophyton rubrum	41	56.9%
Trichophyton mentogrophytes	11	15.4%
Epidermophyton floccosum	5	6.9%
Microsporum canis	15	20.8%
Total	72	100.0%
Yeast (N = 24)		
Candida albicans	11	45.8%
Malassezia furfur	13	54.2%
Total	24	100.0%
Dermatophytes and yeast (N = 4)		
Trichophyton rubrum and *Candida albicans*	3	75.0%
Microsporum canis and *Candida albicans*	1	25.0%
Total	4	100.0%

The table shows that dermatophytes made up the majority of cases (72%), with *Trichophyton rubrum* accounting for more than half of the dermatophyte cases (56.9%), followed by *Microsporum canis* (20.8%); additionally, 24% of the cases were yeast infections, including *Malassezia furfur* (54.2%) and *Candida albicans* (45.8%).

The distribution of the patients with fungal skin infection according to socio-demographic characteristics (including age groups, gender, and residence) is summarized in Table 2. Regarding the age of the patients, less than one-third of patients (N = 30; 30.0%) belonged to the age group 21–30 years, only 4 patients (4.0%) were in the age group < 1 year, and only 3 patients were in the age group ≥ 51 years. There were 62 (N = 62, 62.0%) male patients and 38 (N = 38, 38.0%) female patients. More than half of the patients (N = 57, 57.0%) came from urban areas, and less than half of the patients (N = 43, 43.0%) came from rural areas.

There was a significant association between the type of fungal infection and the age of the patients. The majority of patients with dermatophyte or yeast infections belonged to the age group ≤ 30 years, while the majority of those with mixed infections belonged to the age group ≥ 31 years.

Table 3 summarizes the relationships between the occurrence of fungal skin infections, and family history of skin infection and presence of animals in the household (including positive and negative relationships). Patients with fungal skin infections who had positive family histories of fungal infections constituted 30%, while 34% of cases with fungal skin infections had positive animal households. There was a significant association between the type of fungal infection and the family history of patients. Less than

Table 2. Distribution of patients with fungal skin infection according to socio-demographic characteristics.

Socio-demographic characteristics	n = 100	%
Age (years)		
< 1 year	4	4.0%
1–10 years	12	12.0%
11–20 years	26	26.0%
21–30 years	30	30.0%
31–40 years	15	15.0%
41–50 years	10	10.0%
≥ 51 years	3	3.0%
Total	100	100.0%
Gender		
Male	62	62.0%
Female	38	38.0%
Total	100	100.0%
Residence		
Urban	57	57.0%
Rural	43	43.0%
Total	100	100.0%

When the patients were compared based on age groups, 30.0% of cases were in the age group 21–30 years, only 4.0% of patients were with the age group < 1 year, and only 3 patients were in the age group ≥ 51 years. Among the patients, 62% were males and 38% were females. More than half of the patients (57%) came from urban areas, with 43.0% were coming from rural areas.

half of patients with dermatophytes (N = 29, 40.3%) had a positive family history, while all patients with yeast infections (N = 24, 24.0%) had a negative family history.

Regarding the occurrence of fungal skin infections in relation to animal households, there was a significant association between the type of fungal infection and presence of animals in the household. Less than half of the patients with dermatophytes (N = 34, 47.2%) presented with an animal household, while all patients with yeast infections (N = 24, 24.0%) presented with a negative animal household.

Figures 1 and 2 summarize the occurrence of skin infection in relation to family history and animal household, respectively. There was an association between the occurrence of *Microsporum canis* and the presence of animals, especially cats, in the households.

The association between study variables, including socio-demographic characteristics (age, gender, and residence), family history, and animal household with relation to types of fungal skin infection (dermatophytes, yeast, and mixed infection), are summarized in Table 4. As clearly illustrated, there was a significant association between the type of fungal skin infection and study variables, including age, family history, and animal households.

Table 3. Allocation of patients with fungal skin infection according to family history of fungal infection and animal household.

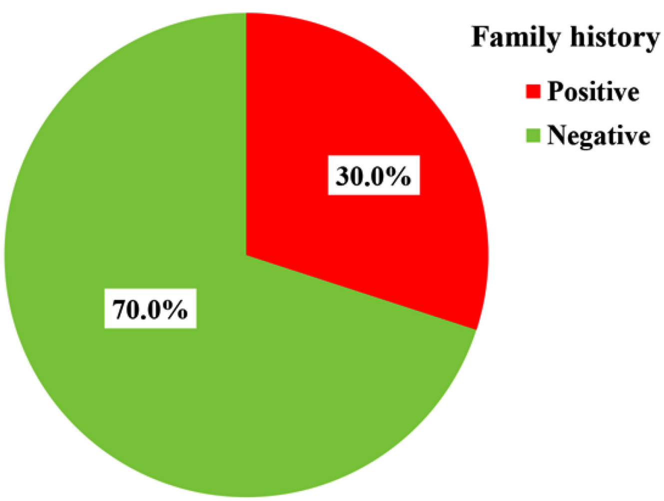
Study variables	n	%
Family history of fungal infection		
Positive	30	30.0%
Negative	70	70.0%
Total	100	100.0%
Member of family with history of infection		
Brother	8	26.6%
Sister	1	3.3%
Son	1	3.3%
Mother	2	6.6%
Husband or wife	8	26.6%
More than one member infected	10	33.3%
Total	30	100.0%
Animal household		
Positive	34	34.0%
Negative	66	66.0%
Total	100	100.0%
Type of animal household		
Cow	9	26.5%
Sheep	3	8.8%
Cat	12	35.3%
Cow and sheep	9	26.5%
Birds and cat	1	2.9%
Total	34	100.0%

Patients with fungal skin infections who had positive family histories constituted 30%, while 34% of cases with fungal skin infections had positive animal households. There was a significant association between the type of fungal infection and the family history of patients. Less than half of the patients infected with dermatophytes (N = 29, 40.3%) had positive family history.

Discussion

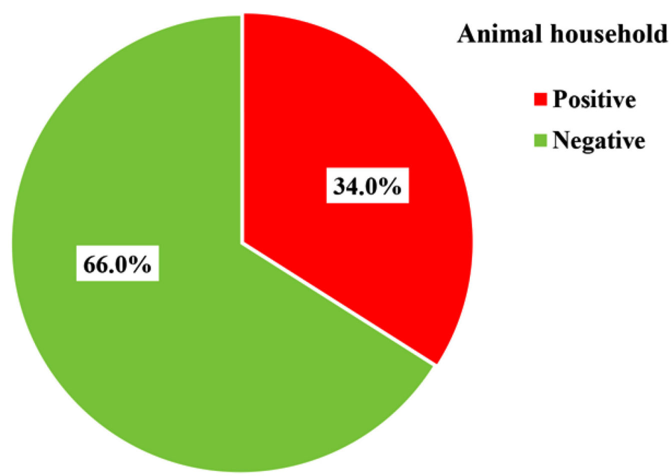
In this study, dermatophytes represented the most common pathogen that caused skin infections, which can be attributed to their ability to utilize keratin (the protein that is found in nails, hair, and skin), which permits them to grow well on the skin surfaces. Additionally, dermatophytes spread through direct contact with infected humans (anthropophilic), infected animals (zoophilic), infected surfaces, and soil [16].

Figure 1. Occurrence of fungal skin infection according to family history (N = 100).



Patients with fungal skin infections with a positive family history constituted 30%. A significant association was identified between the type of fungal infection and the family history of patients.

Figure 2. Occurrence of fungal skin infection according to animal household (N = 100).



Patients with fungal skin infections and with positive animal households represented 34% of cases. A significant association was identified between the type of fungal infection and animal households.

Table 4. Association between study variables and type of fungal skin infection.

Study variables	Fungal skin infection			Total (N = 100)	*p* value
	Dermatophytes (N = 72)	Yeast (N = 24)	Dermatophytes and yeast (N = 4)		
Age (years)					
< 1 year	0 (0.0)	3 (12.5)	1 (25.0)	4 (4.0)	0.003*
1–10 years	12 (16.7)	0 (0.0)	0 (0.0)	12 (12.0)	
11–20 years	19 (26.4)	7 (29.2)	0 (0.0)	26 (26.0)	
21–30 years	22 (30.6)	8 (33.3)	0 (0.0)	30 (30.0)	
31–40 years	11 (15.3)	3 (12.5)	1 (25.0)	15 (15.0)	
41–50 years	7 (9.7)	2 (8.3)	1 (25.0)	10 (10.0)	
≥ 51 years	1 (1.4)	1 (4.2)	1 (25.0)	3 (3.0)	
Total	72 (100.0)	24 (100.0)	4 (100.0)	100 (100.0)	
Gender					
Male	47 (65.3)	14 (58.3)	1 (25.0)	62 (62.0)	0.234
Female	25 (34.7)	10 (41.7)	3 (75.0)	38 (38.0)	
Total	72 (100.0)	24 (100.0)	4 (100.0)	100 (100.0)	
Residence					
Urban	38 (52.8)	15 (62.5)	4 (100.0)	57 (57.0)	0.16
Rural	34 (47.2)	9 (37.5)	0 (0.0)	43 (43.0)	
Total	72 (100.0)	24 (100.0)	4 (100.0)	100 (100.0)	
Family history					
Positive	29 (40.3)	0 (0.0)	1 (25.0)	30 (30.0)	< 0.001*
Negative	43 (59.7)	24 (100.0)	3 (75.0)	70 (70.0)	
Total	72 (100.0)	24 (100.0)	4 (100.0)	100 (100.0)	
Animal household					
Positive	34 (47.2)	0 (0.0)	0 (0.0)	34 (34.0)	< 0.001*
Negative	38 (52.8)	24 (100.0)	4 (100.0)	66 (66.0)	
Total	72 (100.0)	24 (100.0)	4 (100.0)	100 (100.0)	

* This means a significant association. Several study variables, including socio-demographic characteristics (age, gender, and residence), family history, and animal household with relation to types of fungal infections of the skin (dermatophytes, yeast, and mixed infections), are summarized in the table. There was a significant association between the type of fungal skin infection and study variables, including age, family history, and animal household.

Skin surfaces are warm and humid, and present favorable conditions for the growth of dermatophytes; therefore, dermatophytes have higher rates of infection on skin areas. Dermatophytes have the ability to produce a variety of extracellular enzymes. One of the most important enzymes is keratinase, which is an important factor in tissue infection because it can solubilize keratin. Hot weather creates an optimum environment for fungal growth because fungi prefer warm, moist, and dark areas; and hence fungal skin infections are common in relatively hot weather. This is attributed to the excessive sweating (which keeps skin damp) and skin fold areas (like the groin, under the breasts, and between the toes) trap sweat and heat, making them prime targets. During summer, people usually spend more time in public pools and showers which are warm and wet, and can harbor fungi; and this can cause infections [17]. The present study revealed that *Trichophyton rubru*m was the pathogen in more than half of cases caused by dermatophytes. A study conducted in South Korea from 1979 to 2013 examined around 116,000 cases of skin infection and reported that *Trichophyton rubrum* was the predominant causative agent, accounting for 88.35% of all dermatophyte infections [18].

In the present study, the second most important cause of dermatophyte skin infection was *Microsporum canis*, which secretes virulence factors such as keratinase enzyme that have keratinolytic activities. Keratinase helps the pathogen survive on host tissues, infect keratinized tissues, and results in the formation of skin lesions [19]. This study revealed a significant relationship between animal households, especially cats, and *Microsporum canis* skin infections. *Microsporum canis* is the most prevalent dermatophyte in cats. It is very contagious and transmitted through direct contact, but is not associated with life-threatening infections since it is easily treated [20]. Recent studies in Iraq highlight that *Microsporum canis* remains a significant public health concern, particularly as a zoonotic agent transmitted from domestic cats to humans [21,22]. Besides, *Microsporum canis* can secrete protease enzymes (fungalisins are the most prevalent), which, with the aid of subtilisins, act on the epidermis of the host and persist in adhesion [23]. Many related studies found that *Microsporum canis* was the most common isolated dermatophyte in skin infections [24].

Furthermore, there were only a few cases (4 cases) of mixed dermatophyte and yeast infections in the current study. This finding aligns with a recent study [25] and is largely attributed to the concept of antagonistic relationships, such as the inhibition of *Candida albicans* filamentation by other dermatophytes, and the secretion of secondary metabolites that eliminate competitors. Dermatophytes are keratinophiles which favor dry and tough surfaces like nails); while yeasts are hydrophiles which favor moist, mucous-rich environment like mouths.

In the present study, dermatophytes were observed more frequently in patients of age group 21–30 years than in other age groups, and they were found to a lesser extent in age groups 1–20 and 31–40 years. Fewer occurrences of dermatophytes in individuals under 1 year old and in the elderly over 51 years old were noted. Another related study by Shimoyama and Sei reported that the occurrence of dermatophyte skin infection reached its peak values in the elderly between 60 and 79 years [26]. On the other hand, Solis-Arias and Garcia-Romero reported that dermatophyte skin infections were rarely affecting those under the age of 6 years [27].

In recent years, there has been an increase in the presence of household animals (such as cats and cows) living in close contact with the Iraqi families (mainly those between 11 and 40 years) in various areas in Iraq, and especially the area selected for this study (Al-Qadisiyah Province). Based on the observations in this study, cats and cows played a crucial role in the occurrence of fungal skin infections (dermatophytes and yeast) among younger individuals compared to elderly patients. Thus, there was a significant relationship between household animals and the occurrence of skin infections. These findings were in accordance with those obtained by another study in Ethiopia [28]; whereas these results were unlike those of another study in South Jakarta, where the majority of dermatophyte skin infections occurred in the 40–59 years age group [29].

The distribution of all types of dermatophytes, especially anthropophilic dermatophytes, has undergone significant changes since the beginning of the 20th century. *Trichophyton rubrum*, which was first discovered in 1910 (and was named *Epidermophyton rubrum*), evolved during the second half of this century and is now the major cause of dermatophytosis. Other anthropophilic dermatophytes (such as *Epidermophyton floccosum*) were primary dermatophytes in the late 19th and early 20th centuries, but their prevalence has pronouncedly declined [30].

Family history of infection was significantly associated with the occurrence of fungal skin infection, indicating a higher opportunity for accelerating transmission. Despite this, human dermatophytes are primarily related to anthropophilic dermatophytes (mainly *Trichophyton rubrum* in the present study), and zoophilic species that are associated with zoonotic infections constituted a prominent second proportion of cases in this study (mostly *Microsporum canis* and *Trichophyton mentogrophytes*). As previously mentioned, animal households had a significant correlation with the diagnosis of many cases of dermatophyte skin infections. Similar results were reported by other studies [31,32].

Zoophilic species of dermatophytes lose their virulence and become less contagious following human infection [33,34], and most infections are transmitted to humans through direct contact with the animals. As a result, one of the most important ways to prevent infection with zoophilic species is to avoid direct contact with animals. Furthermore, we can prevent anthropophilic dermatophytes from infecting healthy individuals by avoiding direct contact with patients infected with anthropophilic species, thus minimizing the transmission rate of these species and hence reducing pathogenicity [35,36].

Conclusions

Dermatophyte skin infection is crucial health problem. The majority of the fungal infections identified in this study were caused by dermatophytes (especially *Trichophyton rubrum*, *Microsporum canis*, and *Trichophyton mentogrophytes*), followed by yeasts (such as *Malassezia furfur* and *Candida albicans*). Males were more susceptible to fungal skin infections than females; and the majority of infections happened among age group 11–40 years, whereas children under 1 year and elderly people above 51 years experienced the lowest vulnerability for skin infections. Animal households had a significant role in the occurrence of fungal skin infections by increasing the likelihood of transmission through contact. Family history of infection was correlated with a higher possibility of skin infection.

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Conflict of interest

No conflict of interest is declared.

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