



Increasing Prevalence of *Trichophyton rubrum* Identified through an Analysis of 115,846 Cases over the Last 37 Years

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Trichophyton rubrum is the most common dermatophyte in the world with the highest prevalence in Korea. There are few reports about epidemiological and mycological characteristics of *T. rubrum* based on long-term, large-scale studies. The purpose of this study was to investigate the clinical and epidemiological characteristics of *T. rubrum* infections in Korea. We retrospectively investigated with patients' records about the epidemiological and mycological status of 115,846 cases with *T. rubrum* infection that was mycologically diagnosed at Catholic Skin Disease Clinic from 1979 to 2013. Direct microscopy in 15% KOH solution and culture was done in each case. The annual incidence of patients with *T. rubrum* infection had been increasing during the period; and of 131,122 patients with dermatophytosis, 115,846 patients (88.35%) had *T. rubrum* infection. Disease was most prevalent among patients in their twenties in the 1970s and 1980s; in their thirties in the 1990s; in their forties in the 2000s; and in their fifties in the 2010s. The sex ratio was 1.5:1. *T. rubrum* infection was most commonly seen in summer and was found predominantly in patients living in urban areas. Toe webs were most frequently involved, followed by toenails and groin. This epidemiologic findings provide useful information for prevention of *T. rubrum* infection and future dermatophytosis prospects.

Keywords: Dermatophytosis; Epidemiology; Incidence; Mycology; *Trichophyton rubrum*

INTRODUCTION

Fungal infections are influenced by interactions between the host, the infectious agents, and the environment (1). During the past 80 yr, there have been dramatic changes in Korean dermatophytosis, including common causative agents of dermatophytosis and clinical characteristics (2-8). These have resulted from changes in socioeconomic status, lifestyle, and population, as well as the development of new antifungal drugs and diagnostic methods. Therefore, an epidemiologic study will provide useful information for prevention of infection and future dermatophytosis prospects.

Trichophyton rubrum, *T. mentagrophytes*, *Microsporum canis*, *Epidermophyton floccosum*, *T. verrucosum*, *M. gypseum*, *M. ferrugineum*, *T. tonsurans*, *T. schoenleinii*, and *T. violaceum* have been isolated in Korea (9-18). *T. rubrum* has been known to be a main causative agent in dermatophytosis in Korea since the 1960s (2). *T. tonsurans* was newly introduced to Korea in the 1980s (10). Conversely, *T. schoenleinii* has disappeared from Korea (8). Similarly, *T. mentagrophytes* and *M. canis* have been decreasing in prevalence since the 2000s (19, 20).

We conducted this study to investigate the clinical and epidemiological characteristics of *T. rubrum* infection in Korea through the retrospective analysis of medical records of 115,846 patients

infected with *T. rubrum* from 1979 to 2013.

MATERIALS AND METHODS

Patients

Using patient records from the Catholic Skin Disease Clinic from 1979 to 2013, we retrospectively investigated the epidemiological and mycological status of 115,846 cases of mycologically diagnosed *T. rubrum* infections.

Diagnosis of *Trichophyton* infection

Using their medical records, 115,846 patients with *T. rubrum* were retrospectively surveyed to determine annual prevalence of infection and the distribution of age, sex, season, involved sites, and place of residence. Samples for fungal examinations were obtained by scraping the lesions with a scalpel, and microscopic examination in 15% KOH solution was performed. Diagnosis of *T. rubrum* infection was confirmed with fungal culture using potato dextrose agar corn meal Tween 80 media. The cultures were kept at 24-26°C and examined after 2 to 4 weeks. In addition, microscopic examination was performed with lactophenol cotton blue stain to identify filamentous fungi with conidia.

Ethics statements

This study was approved by the institutional review board of Kyungpook National University Hospital (IRB No. 2014-06-015). Informed consent was waived by the board.

RESULTS

Prevalence

The annual incidence of *T. rubrum* infection ranged from 1,436 to 5,565 patients between 1979 and 2013 (Fig. 1). The mean annual incidence of *T. rubrum* infections was 3,310 patients. The incidence was the lowest in 1986 and the highest in 2002. The prevalence of *T. rubrum* infection increased from 1979 to 2013. Out of 131,122 patients with dermatophytoses during the study period, 115,846 patients (88.35%) had a *T. rubrum* infection. The proportion of *T. rubrum* among dermatophytes was the lowest in 1979 (70.39%) and highest in 2013 (94.28%) (Fig. 2). *T. rubrum* has been the prevailing cause of dermatophytoses, constituting more than 90% of dermatophytoses since 1991.

Age distribution

There were 27,485 patients (23.73%) in their thirties, the largest overall age group. Of the remaining patients, 25,265 (21.81%)

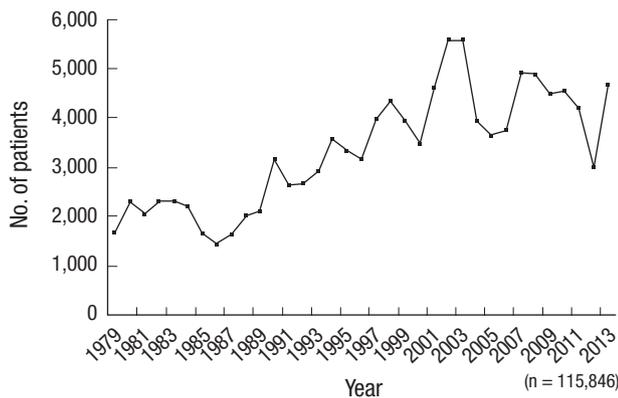


Fig. 1. Annual number of patients with *T. rubrum* infection.

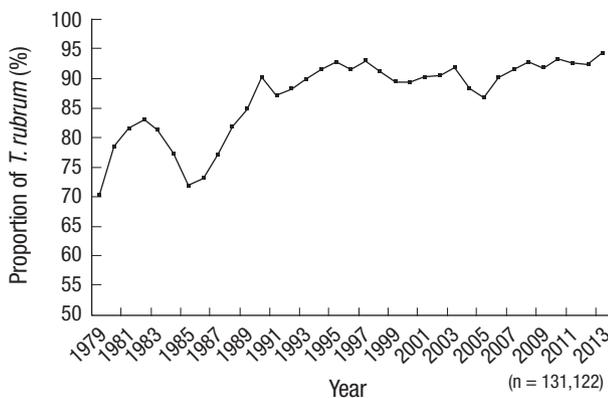


Fig. 2. Prevalence of *T. rubrum* infection in all dermatophytoses.

were in their forties; 22,711 patients (19.60%) were in their twenties; and 17,414 patients (15.03%) were in their fifties (Fig. 3). Out of the total 115,846 patients, 92,875 patients (80.17%) were 20-59 yr old. In the 1970s and 1980s, infection was most prevalent in patients in their twenties. In the 1990s, infection was most prevalent in patients in their thirties. In the 2000s, infection was most prevalent in patients in their forties, and in the 2010s, infection was most prevalent in patients in their fifties (Table 1). The age of patients with *T. rubrum* infection has been steadily increasing (Fig. 4).

Sex distribution

Out of 115,846 patients, 69,976 patients (60.41%) were male and 45,870 patients (39.60%) were female. The male:female ratio was 1.5:1. Females had a higher prevalence of infection than males in the 1970s. Over time, the prevalence in males has been increasing compared to prevalence in females (Fig. 5). In the group less than 70 yr old, more than half of *T. rubrum* infections occurred in males. However, in the group more than 70 yr old, the prevalence of *T. rubrum* in females was predominant (Fig. 6).

Seasonal distribution

Out of 115,687 patients, 49,681 patients (42.89%) visited our hospital in summer, more than in any other season (28,119 patients

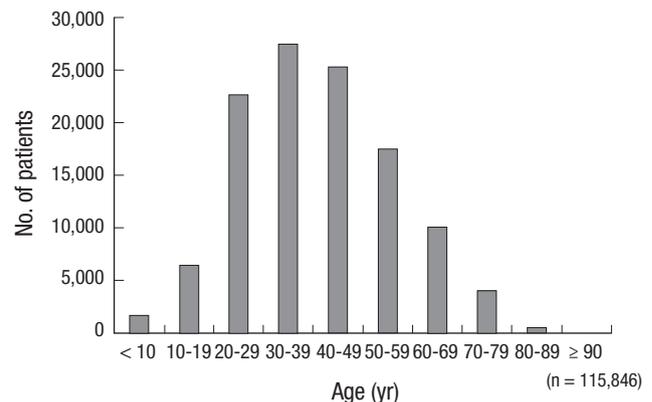


Fig. 3. Age distribution of patients with *T. rubrum* infection.

Table 1. Age distribution (%) of patients with *T. rubrum* infection by decade

Age (yr)	1970s	1980s	1990s	2000s	2010s
< 10	3.02	2.40	1.84	0.94	0.73
10-19	11.59	10.20	6.19	3.67	3.39
20-29	45.44	40.74	19.56	13.08	9.07
30-39	20.82	22.15	31.03	21.93	15.79
40-49	12.61	13.83	19.63	26.84	23.26
50-59	4.22	7.03	12.50	17.37	24.71
60-69	1.63	2.72	6.78	11.28	13.75
70-79	0.48	0.86	2.21	4.27	7.76
80-89	0.12	0.07	0.24	0.57	1.33
≥ 90	0.06	0.00	0.01	0.05	0.19
Total (%)	100.00	100.00	100.00	100.00	100.00

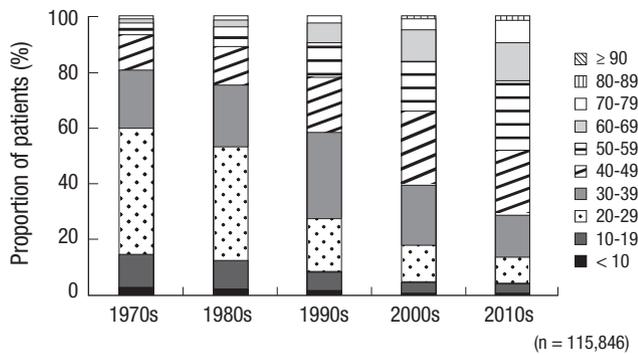


Fig. 4. Age distribution of patients with *T. rubrum* infection by decade.

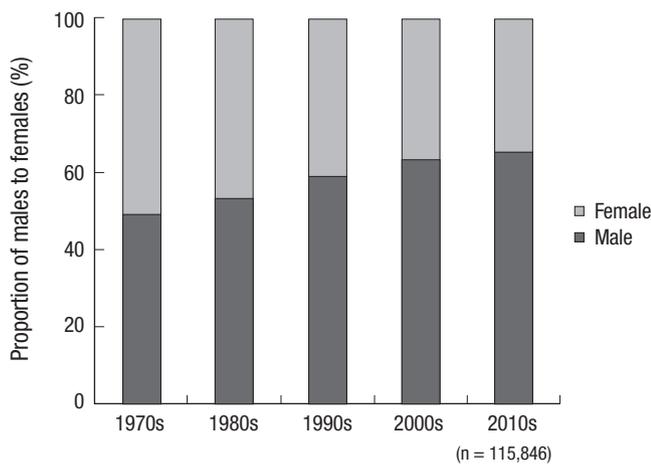


Fig. 5. Proportion of male to female patients with *T. rubrum* infection by decade.

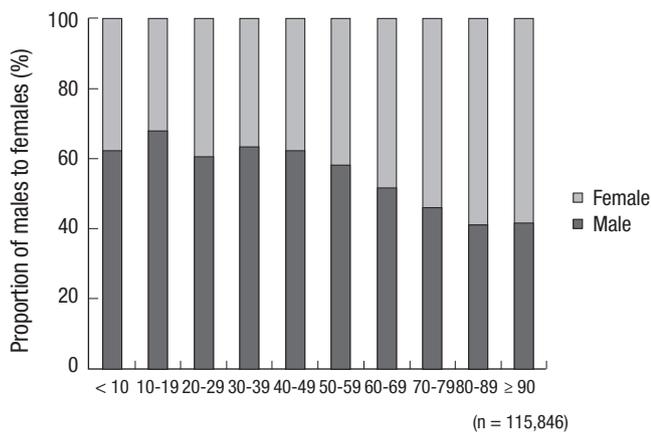


Fig. 6. Proportion between male and female by age.

[24.27%] in spring; 20,525 patients [17.72%] in fall; and 17,521 patients [15.12%] in winter).

Topographical distribution

T. rubrum infection developed most commonly in the toe web (36,543 patients, 31.53%), followed by the toenail (25,268 patients, 21.80%), and the groin (20,249 patients, 17.47%) (Table 2). Out of 115,905 patients, 51,466 (44.40%) had tinea pedis; 26,573

Table 2. Involved site distribution of patients with *T. rubrum*

Site	Number of patients	Proportion (%)
Palm	25	1.20
Hand dorsum	1,265	1.09
Finger nail	1,305	1.13
Finger web	1,798	1.55
Sole	12,701	10.96
Foot dorsum	2,222	1.92
Toe nail	25,268	21.80
Toe web	36,543	31.53
Scalp	143	0.12
Face	1,779	1.53
Neck	477	0.41
Chest	318	0.27
Back	430	0.37
Abdomen	603	0.52
Axilla	225	0.19
Arm	1,008	0.87
Leg	1,429	1.23
Hip	6,191	5.34
Groin	20,249	17.47
Scrotum	167	0.14
Vagina	25	0.02
Vulvae	13	0.01
Oral mucosa	1	0.00
Anus	21	0.02
Ear	151	0.13
Others	185	0.16
Total	115,905	100

patients (22.93%) had onychomycosis; 20,249 patients (17.47%) had tinea cruris; 10,681 patients (9.22%) had tinea corporis; 4,451 patients (3.84%) had tinea manus; 1,779 patients (1.53%) had tinea faciei; and 143 patients (0.1%) had tinea capitis. Tinea pedis was defined as dermatophytosis of the toe web, sole, and dorsal area of the foot. Onychomycosis was defined as dermatophytosis of the toenail and fingernail. Tinea corporis was defined as dermatophytosis of the neck, chest, back, abdomen, axilla, upper and lower extremities, and buttocks. Tinea manus was defined as dermatophytosis of the palm, finger web, and dorsal area of the hand. Additionally, 167 patients had a scrotal infection, 38 patients had a vulvogenital infection, 1 patient had an oral infection, 21 patients had an anal infection, and 151 patients had an ear infection. From the 1970s through the 1990s, tinea pedis was the most common dermatophytosis, followed by tinea cruris, onychomycosis, and tinea corporis. From the 2000s through the 2010s, onychomycosis was the second most common dermatophytosis, followed by tinea cruris and tinea corporis (Table 3). Tinea pedis and onychomycosis increased in prevalence with patient age. The prevalence of patients with tinea capitis was much higher in winter than any other *T. rubrum* infection subtypes.

Inhabitancy distribution

Out of 115,846 patients, 97,892 (84.50%) lived in an urban area.

Table 3. Involved site percentage (%) of *T. rubrum* patients by decade

Disease	1970s	1980s	1990s	2000s	2010s
Tinea pedis	43.38	40.48	39.54	46.02	54.90
Onychomycosis	10.50	11.73	18.29	31.02	25.40
Tinea cruris	24.75	27.58	22.20	11.94	9.71
Tinea corporis	9.26	9.11	12.48	7.56	7.14
Tinea manus	8.90	7.64	4.70	2.06	1.74
Tinea faciei	2.20	2.22	2.18	0.99	0.78
Tinea capitis	0.53	0.31	0.11	0.05	0.08
Others	0.47	0.93	0.49	0.37	0.26
Total (%)	100.00	100.00	100.00	100.00	100.00

A 17,954 (15.50%) lived in a rural area.

DISCUSSION

The spectrum of dermatophytes isolated from skin lesions has changed over the last 80 yr (3). *T. rubrum* has been the most common dermatophyte since the 1960s, accounting for 80%-90% of all isolated species, followed by *T. mentagrophytes* (22). This study also showed that *T. rubrum* has been the most common dermatophyte in Korea since the data collection began. The number of patients with *T. rubrum* infection among dermatophytoses has been continuously increasing since the late 1980s. Out of all patients with dermatophytoses during this study, 88.35% had a *T. rubrum* infection. The prevalence of *T. rubrum* among dermatophytes was highest in 2013, accounting for 94.28% of cases. A temporary decrease in the prevalence of *T. rubrum* infection in the 1980s was caused by a surge of *M. canis* infection (19).

This evolution of prevailing *T. rubrum* infection is connected with the parallel increase in the prevalence of tinea pedis and onychomycosis. *T. rubrum* is one of the anthropophilic dermatophytes that has been isolated from tinea corporis, tinea cruris, tinea pedis, and onychomycosis worldwide (23). In this study, the proportion of tinea pedis (44.40%) and onychomycosis (22.93%) among dermatophytoses caused by *T. rubrum* was 67.33%. The prevalence of onychomycosis in the United States is also estimated to be at least 12% (24). Sigurgeirsson and Baran reported that *T. rubrum* was the most common fungal cause of onychomycosis and was cultured on average in 44.9% of cases (25). Tinea pedis is also caused by *T. rubrum* (1).

A major risk factor for developing a *T. rubrum* infection in the feet is modern occlusive footwear (26). In addition, incidence of tinea pedis is higher among those using communal baths, showers, or pools. A family history of tinea pedis and onychomycosis and advanced age are also risk factors (27). Because *T. rubrum* is an anthropophilic dermatophyte, it can be transmitted from infected to healthy persons. It is transmitted via direct contact with infected skin or hair retained in clothing, combs, caps, socks, and towels. The present study revealed that the prevalence of *T. rubrum* infection has historically been highest among

patients in their thirties. However, the age with the highest prevalence has recently advanced to patients in their fifties. Host factors, such as immune responses and peripheral circulation, play a determining role in the acquisition of tinea pedis. Additional factors, such as urbanization and obesity, have also contributed to the increase in *T. rubrum* infections.

An analysis of the frequency and distribution of tinea pedis in different occupations and leisure-time activities as well as the routes of infection were reported. The spreading of *T. rubrum* infections in most developed countries represents a considerable economic problem, especially since it was accompanied by a parallel increase in the frequency of onychomycosis.

An epidemiological survey of dermatomycoses and their causative fungi in Japan was conducted (28). Dermatophytosis was the most prevalent cutaneous fungal infection. Among dermatophytoses, tinea pedis was the most frequent, followed by onychomycosis, tinea corporis, tinea cruris, tinea manuum, and tinea capitis. This distribution was similar to that seen in our study. Tinea pedis and onychomycosis incidence increased in the summer season, suggesting that hot and humid weather is one of the main causes of dermatophytoses.

As the causative dermatophyte species, *T. rubrum* was the most frequently isolated among all dermatophyte infections, as was seen in our study. Specific areas, such as the scrotum and mucosal area, were involved in infection. *T. rubrum* was isolated from the whole body, including the face and scalp (29, 30). In patients with tinea capitis, zoophilic dermatophytes, such as *M. canis* and *T. verrucosum*, were isolated most frequently (31, 32). Recently, Lee et al. (19) also reported that the prevalence of *M. canis* infection decreased markedly in the 2000s. The prevalence of *T. mentagrophytes* has decreased in Korea since 2005 (20). Choe et al. (33) reported that the prevalence of *T. verrucosum* infection decreased much more in the 2000s than in the late 1900s. In addition, the prevalence of *T. schoenleinii*, *T. violaceum*, *M. gypseum*, *M. ferrugineum*, and *E. floccosum* is also decreasing, and prevalence of *T. tonsurans* infection has shown a recent decrease (34). The observed decreases in dermatophytoses infections, except for *T. rubrum*, may have been caused by public health education, improved hospital accessibility, environmental improvement, and increased lifestyle diversity.

In conclusion, while dermatophytoses pathogen, including *T. mentagrophytes* and *M. canis*, are decreasing in prevalence, *T. rubrum* infections are increasingly prevalent in Korea. We can obtain useful information for *T. rubrum* infection prevention and future prospects from this epidemiologic study.

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DISCLOSURE

The authors have no conflict of interest to declare.

AUTHOR CONTRIBUTION

Conception and coordination of the study: Lee WJ. Design of ethical issues: Jang YH, Lee SJ, Kim DW. Acquisition of data: Bang YJ, Jun JB. Data review: Lee WJ, Kim SL, Jun JB. Statistical analysis: Lee WJ, Kim SL. Manuscript preparation: Manuscript approval: all authors.

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