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Epidemiology of Superficial Fungal Infections in Guangdong, Southern China: A Retrospective Study from 2004 to 2014

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Abstract Superficial fungal infections are common worldwide; however, the distribution of pathogenic species varies among geographical areas and changes over time. This study aimed to determine the epidemiologic profile of superficial fungal infections during 2004–2014 in Guangzhou, Southern China. Data regarding the superficial mycoses from outpatients and inpatients in our hospital were recorded and analyzed. From the 3367 patients that were enrolled in the study, 3385 samples were collected from skin, hair and nail lesions. Of the 697 positive cultures, dermatophytes were the most prevalent isolates (84.36 %), followed by yeasts (14.92 %) and non-dermatophyte molds (0.72 %). *Trichophyton rubrum* (56.24 %) was the most common dermatophyte isolated from cases of tinea unguium (83.92 %), tinea pedis (71.19 %), tinea cruris (91.66 %), tinea corporis (91.81 %) and tinea manuum (65.00 %). *Trichophyton mentagrophytes* (13.35 %) and *Microsporum canis* (10.19 %) were the predominant species associated with cases of tinea faciei (54.55 %) and tinea capitis (54.13 %), respectively. Yeasts and molds were identified primarily from other cases of superficial fungal infections. In conclusion, when compared to previous studies in the same area, the epidemiology of superficial mycoses in Guangdong did not significantly change from 2004 to 2014. The prevalence of causative agents and the spectrum of superficial fungal infections, particularly tinea caused by dermatophyte infection, are similar to reports from several specific regions in China and Europe, whereas increasing incidences of *Trichophyton mentagrophytes* and *Microsporum canis* occurred in Guangdong, China.

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Introduction

Superficial fungal infections (SFIs) affect millions of people worldwide. The most prevalent causative agents of superficial fungal infections are dermatophytes, yeasts and non-dermatophyte molds. Occasionally, black yeast-like fungi [1] and other fungi [2, 3] are also identified as the causative agent of SFIs. Within this group, the dermatophytes are the most frequently isolated etiological agents and the corresponding infections were also referred to as tinea in the clinic [4]. Forty different species of dermatophytes have been identified, and approximately half of them are responsible for most of the infections in humans, which contribute to 20–25 % of dermatophytes worldwide [5]. The distributions of particular species are influenced by immigration, tourism, lifestyle and improving socioeconomic conditions, which enable changes in the epidemiological profile of dermatophytes in a determined geographical area [5, 6].

In China, the causative agents of SFIs vary among geographical areas, particularly in tinea cases. A national fungal epidemiological survey on three nodes (1986, 1996 and 2006) reported that *Trichophyton rubrum* was the most common fungus cultured in the 1980s and 1990s, whereas the prevalence of the fungus *Candida albicans* increased significantly and reached its peak in the 2006 survey [7]. Another 16-year (1993–2008) retrospective study showed that *Microsporum canis* was the predominant pathogen in cases of tinea capitis, followed by *T. violaceum* and *T. tonsurans*, mainly representing Southeastern China [8]. Recently, Zhan et al. [9] reported that *T. violaceum* was the predominant species in tinea capitis patients in Nanchang, China, followed by the *T. mentagrophytes* complex, *T. tonsurans* and *T. rubrum*. However, in Southern China, only a few previous studies were published as Chinese reports on the trends of tinea capitis and its corresponding agents [10–12], and no reports presented the dynamic epidemiological trends of SFIs for international communication in Southern China. Therefore, we performed a 10-year (2004–2014) retrospective epidemiological study to analyze the pathogenic fungi cultured from both inpatients and outpatients in Guangzhou, Southern China. This is the first study conducted that monitors the spectrum of SFIs and the clinical types of superficial fungal infections in Guangdong, Southern China.

Materials and Methods

This study was a retrospective analysis, and the data were obtained from records in the mycology laboratory at Sun Yat-Sen Memorial Hospital, Sun Yat-Sen University in Guangdong, China, from January 2004 to December 2014. Specimens were collected from dermatological outpatients and inpatients in our hospital. A total of 3385 samples were obtained from 3367 patients for fungal culture during the 10-year study period. Of these specimens, 997 were collected from skin (29.46 %), 546 from hair (16.13 %) and 1842 from nail (1842, 54.41 %) lesions.

Scraping of the lesion was performed when skin infection was suspected; the nail samples were collected by scraping the underside of the nail plate using a sterile dental probe; hair with dull-looking appearance was collected and cut into pieces using sterile tweezers. These materials were subjected to direct microscopic examination using 10–20 % potassium hydroxide (KOH) and stained with water soluble methyl blue, if necessary [13]. Portions of the specimen were then inoculated onto Sabouraud's dextrose agar (chloramphenicol included) (BD, MD, USA) with or without cycloheximide. Cultures were incubated at 25 °C for 2 weeks and examined twice a week. Identification of fungi was based on its macroscopic appearance and the color of the colonies, pigmentation of the medium and the microscopic morphology. A sellotape touch preparation in lactophenol cotton blue was used for further observation of microscopic mold characteristics. Skin sample scrapings from suspect patients with pityriasis versicolor, which showed the typical 'spaghetti and meat balls' appearance upon examination in 10 % KOH, were subjected to culture on a Sabouraud's dextrose agar slant overlaid with sterile olive oil or Dixon/Leeming–Notman agars and incubated at 32 °C. The culture plates were examined daily for growth of *Malassezia*, and 19 biochemical tests using the API20C AUX (bioMerieux Vitek, Hazelwood, Mo.) and CHROMagar medium (CHROMagar Technology, Paris, France) were used to identify *Candida* species [14]. Some of the dermatophytes were not well distinguished; therefore, auxiliary techniques were performed, such as subculturing on Borelli lactrimel agar for *Microsporum* strains, to induce the production of conidia and the application of hair perforation tests [15]. The results of direct microscopic examination, colony growth characteristics and clinical relevance of the isolates were evaluated for a full consideration of identification. In addition, the type of lesions and the clinical symptoms of the patients were compared with the identification of the fungi and contributed to the interpretation of their clinical relevance.

The percentage and median of epidemiology data were calculated using GraphPad Prism 6.0 software (GraphPad, California, USA). The differences within groups were analyzed by ANOVA, followed by the Bonferroni test; $p < 0.05$ was considered significantly different.

Results

Over the 10-year period, a total of 3385 specimens yielded 697 fungal strains in culture. The positive percentages of cultures from the total specimen annually ranged from 10.51 to 28.63 %. Tinea unguium was the most prevalent type of SPI at 28.55 % (199/697, $p < 0.05$), followed by tinea capitis (15.64 %, 109/697), tinea pedis (15.06 %, 105/697), tinea cruris (10.33 %, 72/697) and tinea corporis (8.75 %, 61/697). Tinea manuum and tinea faciei accounted for less than 5 % each. The other types of SPIs accounted for 15.64 % of the total cases (Table 1). Tinea capitis and tinea faciei were mostly found in the population under 22 years of age, with median ages of 6 and 9 years, respectively ($p < 0.05$). The remaining types of SPIs were more frequent in adults (median range from 30 to 44 y) (Table 1) ($p < 0.05$).

Fifteen fungal species were isolated, and their distributions are given in Table 2, including seven dermatophyte species (84.36 %, 588/697), six yeast species (14.92 %, 104/697) and two non-dermatophyte molds (0.72 %, 5/697). *T. rubrum* was the most common dermatophyte pathogen (56.24 %, 392/697, $p < 0.05$) both in male and female populations, followed by *T. mentagrophytes* (13.35 %, 93/697) and *M. canis* (10.19 %, 71/697). *T. violaceum*, *T. tonsurans*, *M. canis*, *M. gypseum* and *Epidermophyton floccosum* were the species frequently infecting the population under 21 years of age ($p < 0.05$). The other species were mainly isolated from adults (Table 2).

The etiological agents and the corresponding SPI types are given in Table 3. *T. rubrum* (56.24 %, 392/697) was the predominant dermatophyte in cases with tinea unguium (83.92 %, 167/199), tinea pedis (71.19 %, 80/105), tinea cruris (91.66 %, 66/72), tinea corporis (91.81 %, 56/61) and tinea manuum (65.00 %, 13/20) ($p < 0.05$) (Table 3). *T. mentagrophytes* was the second most common species (13.35 %, 93/697) and the predominant agent in cases with tinea faciei (54.55 %, 12/22, $p < 0.05$). *M. canis* was the prevalent agent in cases with tinea capitis at 54.13 % (59/109) (Table 3). *Candida* and *Malassezia* were the common yeast species. Together with the mold species, all of the above were involved in other types of SPI cases (Table 3).

The rate of isolated *T. rubrum* showed a constant frequency over the study period, while other dermatophyte species, such as *T. mentagrophytes* and *M. canis*, increased discontinuously. *M. gypseum* and *E. floccosum* were isolated in only a few of the years studied. *T. tonsurans* was not isolated after 2007 (Table 4). *C. albicans* was frequently isolated during this study, whereas other *Candida* species showed a significant increase from 2004 to 2014 (Table 4).

Discussion

The distribution of SFIs and their related fungal pathogens varies among countries [5, 16]. Climate, socioeconomic status, medical intervention and historical factors contribute to these variations [17]. In this study, tinea was the most common SPI in Guangdong, Southern China. Other types of SPIs only accounted for 15.64 % of all the cases. *T. rubrum*, *T. mentagrophytes* and *M. canis* were the three most commonly isolated species. The same observations were described by investigators from Asia, Europe and America [18–22], as well as from Central and Northern China [23, 24]. Yeasts, including *Candida* and *Malassezia* species, were the second most common agents of SFIs. The significant role of these yeasts in SFIs was documented in studies from Brazil and

Table 1 Gender and age distribution of patients according to type of infection

Type of tinea	Gender[a]			Age	
	Male (%)	Female (%)	Total (%)	Mean	Median
Tinea unguium	90 (23.38)	108 (34.73)	199 (28.55)	37.75	35
T. capitis	60 (15.58)	49 (15.76)	109 (15.64)	11.62	6
T. pedis	56 (14.54)	49 (15.76)	105 (15.06)	42.03	41
T. cruris	65 (16.88)	7 (2.25)	72 (10.33)	34.35	30
T. corporis	41 (10.65)	20 (6.43)	61 (8.75)	39.84	34
T. faciei	10 (2.60	12 (3.86)	22 (3.16)	21.28	9
T. manuum	8 (2.08)	12 (3.86)	20 (2.87)	37.7	35
Other SFIs	55 (14.29)	54 (17.35)	109 (15.64)	46.4	44
Total	385 (100)	311 (100)	697 (100)		

[a] The gender information was missing in one tinea unguium case

Table 2 Isolated fungal species according to gender and age during 2004 to 2014

Species	Gender[a]			Age	
	Male (%)	Female (%)	Total (%)	Mean	Median
Dermatophytes					
Trichophyton rubrum	236 (61.29)	156 (50.16)	392 (56.24)	37.35	37
T. mentagrophytes	45 (11.69)	47 (15.12)	93 (13.35)	27.34	28
T. violaceum	5 (1.29)	16 (5.14)	21 (3.01)	20.33	10
T. tonsurans	0 (0.00)	2 (0.64)	2 (0.28)	10	10
Microsporum canis	37 (9.62)	34 (10.94)	71 (10.19)	7.19	5.5
M. gypseum	6 (1.56)	1 (0.32)	7 (1.01)	14	4
Epidermophyton floccosum	1 (0.26)	1 (0.32)	2 (0.28)	14.5	14.5
Molds					
Fusarium species	2 (0.52)	2 (0.64)	4 (0.57)	61.75	60.5
Trichosporon species	0 (0.00)	1 (0.32)	1 (0.14)	51	51
Yeast					
Malassezia species	10 (2.59)	4 (1.28)	14 (2.01)	32.14	31.5
Candida albicans	16 (4.16)	17 (5.47)	33 (4.74)	50.24	54
C. parapsilosis	7 (1.82)	6 (1.93)	13 (1.86)	46.23	44
C. tropicalis	3 (0.78)	2 (0.64)	5 (0.72)	45.2	47
C. glabrata	0 (0.00)	1 (0.32)	1 (0.14)	79	79
The other *Candida* species	17 (4.42)	21 (6.76)	38 (5.46)	46.97	50.5
Total	385 (100)	311 (100)	697 (100)		

[a] The gender information was missing in one tinea unguium case infected by *T. mentagrophytes*

French Guiana [25–27]. The non-dermatophyte molds, such as *Fusarium* species and *Trichosporon* species, were also reported in previous studies [27–29].

Tinea unguium and pedis are the leading types and major clinical examples of SFIs. In this study, *T. rubrum* was the major pathogenic species in patients with tinea unguium, followed by *T. mentagrophytes* and *Candida* species. This predominance has been widely described in archived documents [27, 30–32]. However, this varies in different countries, e.g., *T. mentagrophytes* was the most common species of tinea unguium in Esfahan, Iran. *T. rubrum* was the predominate species followed by *E. floccosum*, *T. violaceum* and *T. mentagrophytes* in Nanchang, China [33]. For tinea pedis, *T. rubrum* and *T. mentagrophytes* accounted for 67.81 and 21.19 % of the isolates recovered in culture, respectively. These pathogens were responsible for tinea pedis to the same extent as was found in the USA, Spain and French Guiana [20,

Table 3 The frequency of agents in all SFIs cases by localization of infection during 2004 to 2014

Species	T. unguium (%)	T. capitis (%)	T. pedis (%)	T. cruris (%)	T. corporis (%)	T. faciei (%)	T. manuum (%)	Other SFIs (%)
Dermatophytes								
Trichophyton rubrum	167 (83.92)	4 (3.66)	80 (71.19)	66 (91.66)	56 (91.81)	6 (27.28)	13 (65.00	
T. mentagrophytes	32 (16.08)	22 (20.19)	25 (28.81)	2 (2.78)	0 (0.00)	12 (54.55)	0 (0.00)	
T. violaceum	0 (0.00)	20 (18.36)	0 (0.00)	0 (0.00)	0 (0.00)	1 (4.54)	0 (0.00)	
T. tonsurans	0 (0.00)	2 (1.83)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
Microsporum canis	0 (0.00)	59 (54.13)	0 (0.00)	0 (0.00)	3 (4.93)	2 (9.09)	7 (35.00)	
M. gypseum	0 (0.00)	2 (1.83)	0 (0.00)	3 (4.17)	1 (1.63)	1 (4.54)	0 (0.00)	
Epidermophyton floccosum	0 (0.00)	0 (0.00)	0 (0.00)	1 (1.39)	1 (1.63)	0 (0.00)	0 (0.00)	
Molds								
Fusarium species								4 (3.67)
Trichosporon species								1 (0.92)
Yeast								
Malassezia species								14 (12.84)
Candida albicans								33 (30.27)
C. parapsilosis								1 (0.92)
C. tropicalis								13 (11.94)
C. glabrata								5 (4.58)
The other *Candida* species								38 (34.86)
Total (%)	199 (100)	109 (100)	105 (100)	72 (100)	61 (100)	22 (100)	20 (100)	109 (100)

27, 34], as well as in Hainan, Handan and Chongqing, China [22–24].

For tinea capitis, *M. canis* was the most common pathogen in our study, followed by *T. mentagrophytes* and *T. violaceum*. This result is similar to a previous Chinese study [8] and may have resulted from the increasing popularity of owning pets in China and the expansion of particular agent populations spread through animal breeding establishments [5, 16]. In addition, an increasing trend was observed in the annual prevalence of *M. canis* during the study period. A similar increase was observed in Europe over the past few decades [6]. This endemic profile is similar to the Mediterranean countries and Central and Eastern Europe where this zoophilic species is the most prevalent in tinea capitis since the mid-twentieth century [6, 35, 36]. However, the prevalent species in tinea capitis in this study was different from the species endemic in Sweden, Northeast Africa, the USA, Canada or the UK. *T. violaceum*, *T. soudanense* and *M. audouinii* were the predominant endemic species in Sweden and Northeast Africa. Drakensjo et al. [37] inferred that the fungal species agents of tinea capitis in Sweden probably originated from Northeast Africa due to immigration, whereas in the USA, Canada and the UK, *T. tonsurans* was the predominant causative agent in tinea capitis [5, 6, 36, 38].

For tinea cruris cases, *T. rubrum* was the major causative agent, which is similar to the results from two other independent studies in Hainan [22] and Nanchang, China [39]. However, in a Spanish study, *E. floccosum* was isolated from 54 % of the tinea cruris cases [34]. Retrospective studies in Tehran, Iran, showed that *E. floccosum* had an incidence of over 70 % in tinea cruris [40, 41]. Conversely, only one isolate was obtained from the single case with tinea cruris (1.39 %) in this study.

Table 4 Annual occurrences of agents in all SFIs cases during 2004–2014 (%)

Species	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Dermatophytes											
Trichophyton rubrum	16 (47.07)	23 (50.00)	5 (20.00)	12 (46.15)	22 (55.00)	28 (57.15)	16 (32.00)	42 (64.62)	82 (70.09)	83 (64.84)	63 (53.86)
T. mentagrophytes	2 (5.88)	1 (2.17)	7 (28.00)	2 (7.69)	5 (12.50)	5 (10.20)	11 (22.00)	12 (18.45)	18 (15.38)	14 (10.94)	16 (13.68)
T. violaceum	4 (11.76)	2 (4.35)	0 (0.00)	1 (3.85)	1 (2.50)	1 (2.04)	4 (8.00)	2 (3.08)	2 (1.71)	1 (0.78)	3 (2.56)
T. tonsurans	0 (0.00)	1 (2.17)	1 (4.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Microsporum canis	7 (20.59)	10 (21.75)	2 (8.00)	2 (7.69)	4 (10.00)	8 (16.33)	6 (12.00)	4 (6.15)	6 (5.13)	15 (11.72)	7 (5.98)
M. gypseum	0 (0.00)	1 (2.17)	1 (4.00)	0 (0.00)	0 (0.00)	1 (2.04)	1 (2.00)	0 (0.00)	0 (0.00)	0 (0.00)	3 (2.56)
Epidermophyton floccosum	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.78)	1 (0.85)
Molds											
Fusarium species	0 (0.00)	0 (0.00)	0 (0.00)	2 (7.69)	0 (0.00)	1 (2.04)	1 (2.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Trichosporon species	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (1.54)	0 (0.00)	0 (0.00)	0 (0.00)
Yeast											
Malassezia species	2 (5.88)	0 (0.00)	0 (0.00)	1 (3.85)	2 (5.00)	1 (2.04)	4 (8.00)	0 (0.00)	0 (0.00)	1 (0.78)	3 (2.56)
Candida albicans	1 (2.94)	5 (10.87)	4 (16.00)	3 (11.54)	4 (10.00)	0 (0.00)	1 (2.00)	0 (0.00)	8 (6.84)	4 (3.13)	3 (2.56)
C. parapsilosis	1 (2.94)	3 (6.52)	4 (16.00)	3 (11.54)	0 (0.00)	0 (0.00)	0 (0.00)	2 (3.08)	0 (0.00)	0 (0.00)	0 (0.00)
C. tropicalis	1 (2.94)	0 (0.00)	1 (4.00)	0 (0.00)	1 (2.50)	0 (0.00)	1 (2.00)	0 (0.00)	0 (0.00)	1 (0.78)	0 (0.00)
C. glabrata	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.85)
The other *Candida* species	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (2.50)	4 (8.16)	5 (10.00)	2 (3.08)	1 (0.85)	8 (6.25)	17 (14.54)
Total (%)	34 (100)	46 (100)	25 (100)	26 (100)	40 (100)	49 (100)	50 (100)	65 (100)	117 (100)	128 (100)	117 (100)

Trichophyton rubrum was also the predominant agent in cases with tinea corporis and tinea manuum in this study, followed by *Malassezia* and *M. canis*. In the USA, *T. rubrum* was the most common pathogen responsible for tinea corporis, followed by *T. tonsurans* [20]. However, *M. canis* was obtained from 60 % of the tinea corporis cases, while *T. rubrum* accounted for only 11 % in Spain [34]. In Iran, the zoophilic dermatophyte *T. verrucosum* was the most frequent species isolated from tinea manuum [40, 41], while *T. mentagrophytes* was responsible for 44 % of the tinea manuum cases in Spain [34]. Although fungi flora varies between different countries, our results were in accordance with Zhan et al. [33], in which *T. rubrum* was the predominant species in tinea manuum cases (93.5 %).

Tinea faciei, similar to tinea capitis, are dermatophyte infections of the scalp and glabrous skin of the face primarily affecting prepubertal children [42]. In this study, compared with other tinea types, tinea faciei and tinea capitis were mostly found in the population of children (mean age < 22y, median age < 9y). Previous studies published about the Chinese in Guangdong from 1997 to 2010 reported that *M. canis* was the predominant agent of tinea capitis, whereas the archived studies from 1964 reported that *M. ferrugineum* account for 48.5 % of the tinea capitis cases, and this changed to *M. canis* (65.1 %) in 1978 within the same area [10, 11]. However, a report from Xinjiang, Western China, found that *T. violaceum* and *T. mentagrophytes* were the predominant agents of tinea capitis cases from 1993 to 2004 [43]. In this study, the major causative agent of tinea faciei was *T. mentagrophytes* (54.55 %), whereas *T. rubrum* and *M. canis* accounted for 37.28 and 9.09 % of the tinea faciei cases, respectively. In Europe, a study in Zurich reported that zoophilic *T. mentagrophytes* were responsible for 73 % of the tinea faciei cases [42]. A survey in Italy showed that *M. canis* was the predominant agent of tinea faciei cases for the ages 11 months to 15 years [44]. The Spanish study found that *M. canis* was responsible for 45 % of the cases followed by *T. mentagrophytes* with 36 % [34], while in Sweden, *T. violaceum*, *T. mentagrophytes* and *T. rubrum* were the major agents of tinea faciei [37].

In conclusion, we found that tinea unguium, followed by tinea pedis, was the most prevalent SFIs in Guangdong, China. *T. rubrum* was the most common dermatophyte species isolated from SFIs in this study. The increase in *T. rubrum* was perhaps related to the improvement of sanitary conditions, traveling, immigration and the use of public facilities, which has been demonstrated in Europe [6, 17, 45, 46]. However, the increasing prevalence of *T. mentagrophytes* and *M. canis* during this study promoted a further study to reveal whether there is an increasing incidence of zoophilic pathogenic infections in this area.

Limitations

The purpose of this study was to investigate the epidemiological characters of superficial fungal infections in Guangdong, Southern China, using data retrieved from the clinical examination laboratory at the Sun Yat-Sen Memorial Hospital. Identification of fungi was based on routine methods, including colony appearance, pigmentation, microscopic morphology and physiological and biochemical tests. Sequencing and other molecular methods were not included in routine clinical identification. Therefore, the potential relationship of *T. rubrum* and *T. mentagrophytes* isolates (complex or sensu stricto species) and the transmission of different *T. mentagrophytes* isolates (zoophilic/anthropophilic) were not evaluated in the present study. The terms '*T. rubrum*' and '*T. mentagrophytes*' referred to the '*T. rubrum* complex' and the '*T. mentagrophytes* complex,' but not sensu stricto species.

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Compliance with ethical standards

Conflict of interest The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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