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CHARACTERISTICS OF DERMATOPHYTOSIS, CLINICAL MANIFESTATIONS, SPECIES COMPOSITION, AND ANTIFUNGAL SUSCEPTIBILITY AMONG PATIENTS AT CAN THO UNIVERSITY OF MEDICINE AND PHARMACY HOSPITAL (2023 - 2025)

Major: Infectious diseases and tropical diseases

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The thesis can be found at:

- Vietnam National Library;
- The Library of the National Institute of Malariology, Parasitology and Entomology

INTRODUCTION

Dermatophytosis is a common disease, estimated to affect approximately 25% of the global population. The causative agents mainly belong to the three genera *Trichophyton*, *Microsporum*, and *Epidermophyton*, among which *Trichophyton rubrum* is the most common causative species.

Epidemiological studies have demonstrated a relatively high prevalence of dermatophytosis. Although the disease is not life-threatening, it commonly causes pruritus, and the lesions may become extensive if not properly treated, thereby affecting cosmetic appearance and quality of life.

Different dermatophyte species possess distinct biological characteristics that are associated with transmission sources, lesion sites, and therapeutic response. Therefore, accurate identification of species composition plays an important role in epidemiological investigations and in selecting appropriate treatment regimens. However, most previous studies have primarily relied on morphological methods, whereas molecular identification data in Vietnam are still limited.

Furthermore, antifungal resistance is an emerging concern. The results of in vitro antifungal susceptibility testing are important for guiding therapeutic decisions, especially in cases of treatment failure or recurrent infection. However, such testing has not yet been routinely implemented in clinical practice.

Can Tho, the central city of the Mekong Delta region, has a hot and humid climate throughout the year, providing favorable conditions for the growth and transmission of dermatophytes. However, data on species composition and antifungal susceptibility in this region remain limited. Therefore, based on this situation, this dissertation was conducted entitled: "***Characteristics of dermatophytosis, clinical manifestations, species composition, and antifungal susceptibility among patients at Can Tho University of Medicine and Pharmacy Hospital (2023 – 2025)***", aiming at the following three objectives.

1. To describe the infection and clinical characteristics of dermatophytosis among patients at the Dermatology Clinic, Can Tho University of Medicine and Pharmacy Hospital, from 2023 to 2025.
2. To determine the species composition of dermatophytes isolated from the study participants by morphological and molecular identification methods.
3. To evaluate the susceptibility of dermatophyte isolates to selected antifungal agents.

SCIENTIFIC AND NOVEL CONTRIBUTIONS

1. Novelty of the Study

- This study is the first to document the presence of *Trichophyton indotineae* among patients with dermatophytosis in the Mekong Delta region using ITS region sequencing, providing important epidemiological evidence for the circulation of this emerging dermatophyte species in Vietnam.
- The study highlights the limitation of *Mva*I PCR–RFLP in differentiating *T. indotineae* from *T. interdigitale*, thereby emphasizing the value of DNA sequencing for the accurate identification of closely related dermatophyte species.
- The study provides updated data on dermatophyte species composition, associated risk factors, and antifungal susceptibility patterns in the Mekong Delta, contributing to improved diagnosis, treatment, and epidemiological surveillance of dermatophytosis in the region.

2. Scientific and Practical Significance

- The dissertation determined the prevalence and distribution characteristics of dermatophytosis among patients presenting with skin lesions suspected of fungal infection at

Can Tho University of Medicine and Pharmacy Hospital.

- The dissertation characterized the clinical features of dermatophytosis and identified several factors associated with infection, thereby providing scientific evidence to support prevention, diagnosis, and disease management strategies.
- The dissertation characterized the species composition of dermatophytes through combined morphological and molecular identification, revealing *Trichophyton rubrum* as the predominant species (68%), followed by *Trichophyton interdigitale* (18%), *Trichophyton indotineae* (13%), and *Trichophyton tonsurans* (1%).
- The dissertation provides data on the antifungal susceptibility patterns of dermatophyte isolates, demonstrating high susceptibility rates to itraconazole (93%), miconazole (63%), and ketoconazole (59%), whereas susceptibility to griseofulvin (11%) and fluconazole (5%) was markedly lower. These findings have important practical implications for optimizing antifungal therapy and monitoring local susceptibility trends.

THESIS STRUCTURE

The 136-page thesis includes: 2-page introduction; 31-page literature review; 24-page research object and method; 34-page research results; 42-page discussion; 2-page conclusion; 1-page recommendation; 1-page new contributions. The thesis has 17 figures, 33 data tables. There are 105 references and 29.5% references in the past 5 years.

Chapter 1. LITERATURE REVIEW

1.1. Overview of Fungi and Dermatophytes

1.1.1. Definition of Fungi

Fungi are eukaryotic organisms with a true nucleus and cell wall. Unlike plants, they lack chlorophyll and are therefore unable to synthesize their own nutrients through photosynthesis. The fungal cell wall is composed mainly of chitin. It is estimated that approximately 1.5 million fungal species exist, of which around 400 are known to cause diseases in humans and animals.

1.1.2. Medical mycology

Medical mycology is the branch of medical science concerned with the study of fungi that infect humans, including their biological characteristics, pathogenic potential, diagnosis, treatment, and prevention of fungal diseases.

1.1.3. Dermatophytes

Dermatophytes are fungi belonging to the class Fungi Imperfecti that specifically parasitize keratinized tissues. They produce asexual spores in the saprophytic state or under culture conditions. Although several classification systems have been proposed, the classification developed by C. W. Emmons based on macroconidia is considered the most straightforward and widely used. According to the characteristics of macroconidia, dermatophytes are classified into three genera: *Epidermophyton*, *Microsporum*, and *Trichophyton*, comprising approximately 40 different species.

1.1.4. Characteristics of dermatophytes

1.1.4.1. Morphology characteristics

- Macroscopic morphology: Dermatophyte colonies are filamentous in appearance and may exhibit a velvety, cottony, or powdery texture due to abundant spore production. Colony topography may be flat or raised, with folds or radial furrows. Some species produce pigments that diffuse into the culture medium

- Microscopic morphology: Dermatophytes possess hyaline, septate hyphae. In some species, characteristic structures may be observed, such as racket hyphae, comb-like hyphae, spiral hyphae, and antler-like (favic chandelier) hyphae. Asexual spores, including microconidia and macroconidia, are produced from the hyphae and serve as important characteristics for species identification.

1.1.4.2. Nutritional and metabolic characteristics

Dermatophytes are capable of colonizing dead keratinized tissues because they produce proteases that degrade keratin. Despite their affinity for keratinized tissues, they can be cultivated on media lacking keratin, including potato dextrose agar, rice medium, and Sabouraud dextrose agar.

1.1.4.3. Ecological characteristics

Dermatophytes exhibit optimal growth at temperatures between 25°C and 30°C. High relative humidity (62%–95%) further promotes fungal growth and spore production. The optimal pH range for dermatophyte development is 6.9–7.2.

1.1.5. Epidemiology of dermatophyte infections

Many dermatophyte species, including *T. rubrum*, *M. canis*, *M. gypseum*, and *E. floccosum* have a worldwide distribution. The prevalence of *T. rubrum*, *T. interdigitale*, *T. tonsurans*, and *M. canis* has progressively increased, making them the predominant dermatophyte species globally. In contrast, species such as *T. violaceum*, *T. verrucosum*, and *M. ferrugineum* are largely restricted to specific areas of Africa, Asia, and Europe.

Dermatophyte infections can be transmitted through anthropophilic, zoophilic, or geophilic routes. Direct transmission occurs via contact with infected skin containing fungal spores or hyphae, whereas indirect transmission occurs through contaminated fomites, including towels, combs, hats, clothing, bedding, mats, and seating surfaces.

1.2. Clinical manifestations of dermatophytosis

1.2.1. Definition of dermatophytosis

Dermatophytosis is the term used to describe dermatophyte infection of the skin, characterized clinically by small papules, erythematous plaques, vesicles, fissures, and scales arranged in a ring-shaped pattern. The typical lesion is an erythematous plaque with centrifugal expansion and a tendency toward central clearing.

1.2.2. Classification of dermatophytosis

According to the site of infection, dermatophytosis includes tinea corporis, tinea capitis, tinea faciei, tinea cruris, tinea unguium (onychomycosis), tinea pedis, and tinea manuum.

According to the mode of transmission, dermatophytosis may be classified as anthropophilic (human-to-human transmission), geophilic (soil-to-human transmission), and zoophilic (animal-to-human transmission).

1.2.3. Clinical characteristics of dermatophytosis

Clinically, dermatophytosis presents in several forms, including tinea corporis, tinea capitis, tinea faciei, tinea barbae, tinea cruris, tinea unguium (onychomycosis), tinea manuum, and tinea pedis.

1.3. Methods for dermatophyte identification

Dermatophyte species are traditionally identified based on their cultural and morphological characteristics, together with biochemical tests such as the urease test. More accurate species identification can be achieved using molecular methods, including polymerase chain reaction (PCR) and DNA sequencing.

1.4. Antifungal agents and antifungal susceptibility testing of dermatophytes

1.4.1. Commonly used antifungal agents for the treatment of dermatophytosis

Antifungal agents are classified according to their targets within fungal cells. Differences in the mechanisms of action among antifungal classes lead to variations in their spectrum of activity against different fungal species and strains.

1.4.2. Methods for antifungal susceptibility testing of dermatophytes

Antifungal susceptibility testing can be performed using several methods, the most commonly used being the broth microdilution method and the agar disk diffusion method.

1.4.3. Current status of antifungal resistance in dermatophytes

Studies investigating the antifungal susceptibility of dermatophytes have shown significant differences in susceptibility patterns among antifungal agents and between different geographic regions.

Chapter 2. STUDY METHODS

2.1. Objective 1

To describe the infection and clinical characteristics of dermatophytosis among patients at the Dermatology Clinic, Can Tho University of Medicine and Pharmacy Hospital, from 2023 to 2025.

2.1.1. Study population, study period, and study setting for objective 1

2.1.1.1. Study population for objective 1

Patients presenting with skin lesions suspected of dermatophytosis at the Dermatology Clinic, Can Tho University of Medicine and Pharmacy Hospital, during the study period.

2.1.1.2. Study period: From 01/2023 to 06/2025.

2.1.1.3. Study setting: Can Tho University of Medicine and Pharmacy Hospital.

2.1.2. Sample size and study methods for objective 1

2.1.2.1. Study design: Cross-sectional descriptive study.

2.1.2.2. Study sample size

- Sample size calculation for the prevalence of dermatophytosis. The minimum sample size for estimating a proportion is calculated using the formula:

$$n = Z^2_{(1-\alpha/2)} \frac{p \times (1-p)}{d^2}$$

n: minimum sample size.

$Z_{1-\alpha/2}$: standard normal deviation (1.96 for 95% confidence level)

p = 0.472 (based on the prevalence of dermatophyte infection reported by Tăng Tuấn Hải et al (2021). at the Ho Chi Minh City Hospital of Dermatology and Venereology).

d = 0,05 (desired margin of error)

Based on the selected parameters, the required sample size was calculated to be 383 participants. However, in this study, 385 patients were actually recruited.

- **Sampling method:** Convenience sampling.

2.1.2.3. Study content

- Description of epidemiological characteristics of dermatophytosis.
- Description of the clinical characteristics of patients with dermatophytosis.
- Analysis of factors associated with dermatophytosis.

2.1.2.4. Techniques used in the study

- Data were collected through patient interviews and clinical examinations using a standardized case report form.
- Diagnostic techniques for dermatophytosis Using 20% KOH direct microscopy and culture on DTM medium.

2.2. Objective 2

To determine the species composition of dermatophytes isolated from the study participants by morphological and molecular identification methods.

2.2.1. Study population, study period, and study setting for objective 2

2.2.1.1. Study subjects

Dermatophyte isolates obtained from skin scales of patients with dermatophytosis attending the Dermatology Clinic of Can Tho University of Medicine and Pharmacy Hospital

during the study period and meeting the inclusion criteria.

2.2.1.2. Study period: From 01/2023 to 6/2025

2.2.1.3. Study setting

Dermatophyte isolation and morphological identification were carried out at the Parasitology Laboratory, Department of Laboratory Medicine, Can Tho University of Medicine and Pharmacy Hospital.

PCR-RFLP analysis for dermatophyte identification was carried out at the Molecular Biology Laboratory, Department of Laboratory Medicine, Can Tho University of Medicine and Pharmacy Hospital

2.2.2. Sample size and study methods for objective 2

2.2.2.1. Study design: Laboratory-based descriptive study.

2.2.2.2. Study sample size

- Sample size: All dermatophyte isolates obtained from patients with dermatophytosis attending the dermatology clinic of Can Tho University of Medicine and Pharmacy Hospital during the study period.

- Sampling method: total sampling.

2.2.2.3. Study ccontent

- Identification of dermatophyte species based on morphological characteristics and molecular techniques.

2.2.2.4. Techniques used in the study

The isolates were subcultured on Sabouraud dextrose agar (SDA) containing chloramphenicol. Dermatophyte species were identified using conventional morphological methods and molecular techniques, including PCR-restriction fragment length polymorphism (PCR-RFLP) analysis and DNA sequencing.

2.3. Objective 3

To evaluate the susceptibility of dermatophyte isolates to selected antifungal agents.

2.3.1. Study population, study period, and study setting for objective 3

2.3.1.1. Study population

Dermatophyte isolates obtained from skin scales of patients with dermatophytosis attending the Dermatology Clinic of Can Tho University of Medicine and Pharmacy Hospital during the study period and meeting the inclusion criteria.

2.3.1.2. Study period: From 01/2023 to 6/2025

2.3.1.3. Study setting

Antifungal susceptibility testing was performed at the Parasitology Laboratory, Department of Laboratory Medicine, Can Tho University of Medicine and Pharmacy Hospital.

2.3.2. Study methods for objective 3

2.3.2.1. Study design: Laboratory-based descriptive study.

2.3.2.2. Sample size and study methods for objective 3

- Sample size: All dermatophyte isolates obtained from patients with dermatophytosis attending the dermatology clinic of Can Tho University of Medicine and Pharmacy Hospital during the study period.

A total of 100 dermatophyte isolates were included in the antifungal susceptibility analysis.

- Sampling method: total sampling

2.3.2.3. Study content

- Assessment of the susceptibility of isolated dermatophyte species to selected antifungal agents.

2.3.2.5. Techniques used in the study

- The isolates were cultured on chloramphenicol sabouraud agar to promote sporulation.
- Antifungal susceptibility testing of dermatophytes using the agar disk diffusion method.

2.4. Data entry and analysis

Data collected through interviews, observations, and laboratory testing were entered and analyzed using SPSS version 20.0 and MEGA version 12.0.

2.5. Errors in the study

To reduce potential bias and errors, the following measures were undertaken: (1) ensuring an adequate sample size based on the sample size calculation; (2) strictly adhering to the predefined inclusion and exclusion criteria during participant selection to ensure equal eligibility for study enrollment; and (3) employing appropriate statistical software and statistical tests for data analysis.

2.6. Ethics in study

All study procedures were carried out in strict compliance with the regulations and ethical principles governing biomedical research.

Chapter 3. RESULTS

3.1. Demographic characteristics of participants suspected dermatophytosis

A total of 385 patients with suspected dermatophytosis were enrolled. The 20–39-year age group was the most prevalent (42.34 %), whereas individuals aged <20 years accounted for the lowest proportion (10.39 %). Females and males represented 51.43 % and 48.57 % of participants, respectively. The majority belonged to the Kinh ethnic group (93.5%), followed by the Hoa (3.65 %) and Khmer (2.86 %) ethnic groups. Most participants lived in urban areas (59.48 %).

3.2. Infection patterns and Clinical characteristics of dermatophytosis in patients attending the Dermatology Clinic of Can Tho University of Medicine and Pharmacy Hospital

3.2.1. Epidemiological characteristics of dermatophytosis

The overall prevalence of dermatophytosis was 25,57 %.

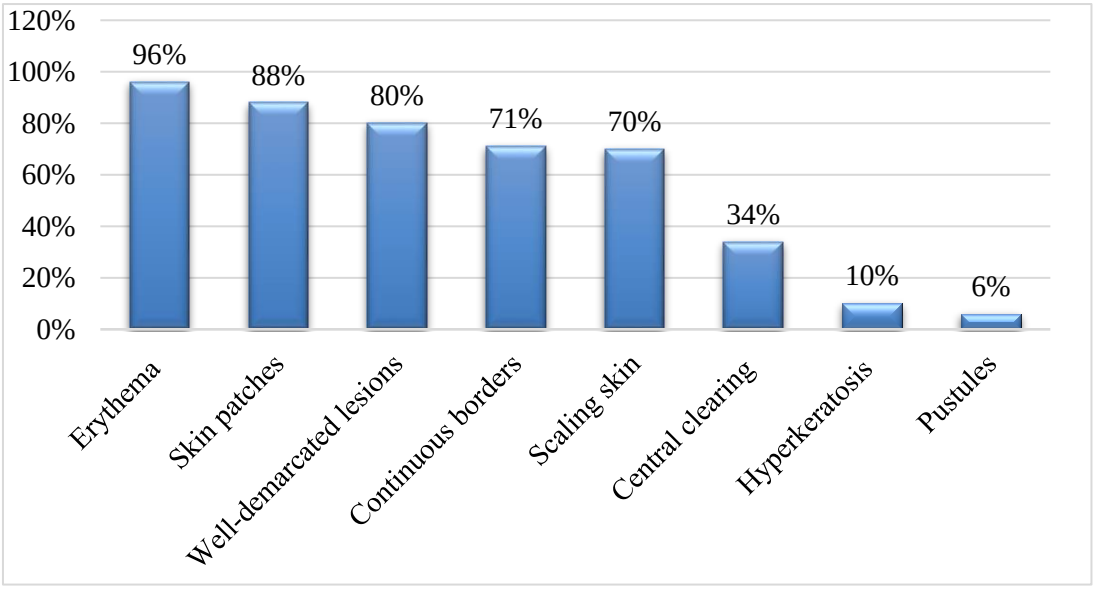
A significantly higher prevalence was observed among patients aged ≥ 60 years compared with those aged < 20 years ($p = 0.03$). Although the prevalence was higher in males (27.81 %) than in females (24.24 %), the difference did not reach statistical significance ($p = 0.42$). The prevalence of dermatophytosis among patients living in rural areas was 35.3%, which was significantly higher than that among those living in urban areas (19.7%). This difference was statistically significant ($p < 0.05$).

3.2.2. Demographic characteristics of patients with dermatophytosis

Among the 100 confirmed cases of dermatophytosis, the highest proportion of patients was observed in the 20–39 year age group (40%), followed by those aged ≥ 60 years (31%), while patients aged < 20 years accounted for the lowest proportion (7%). The prevalence of dermatophytosis was slightly higher in males (52%) than in females (48%). Regarding residence, 55% of patients lived in rural areas, whereas 45% resided in urban areas. The highest proportion of patients had completed high school education (39%), while those with a college or university degree accounted for the lowest proportion (8%). The most common occupations were students (23%) and farmers (22%), whereas homemakers and self-employed individuals represented the lowest proportion (17%).

3.2.3. Clinical manifestations of dermatophytosis

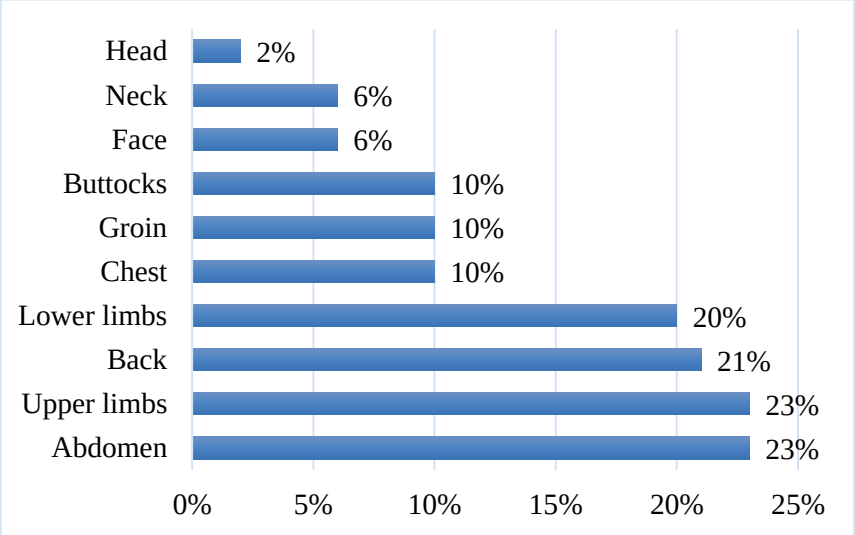
3.2.3.1. Morphological characteristics of skin lesions



Picture 3.3. Morphological characteristics of dermatophytosis lesions (n = 100)

The most common skin lesions observed in patients with dermatophytosis were erythema (96%), skin patches (88%), well-demarcated lesions (80%), continuous borders (71%), scaling (70%), and central clearing (34%). Less common manifestations included pustules (6%) and hyperkeratosis (10%).

3.2.3.2. Anatomical distribution of lesions



Picture 3.4. Distribution of dermatophytosis lesion sites (n = 100)

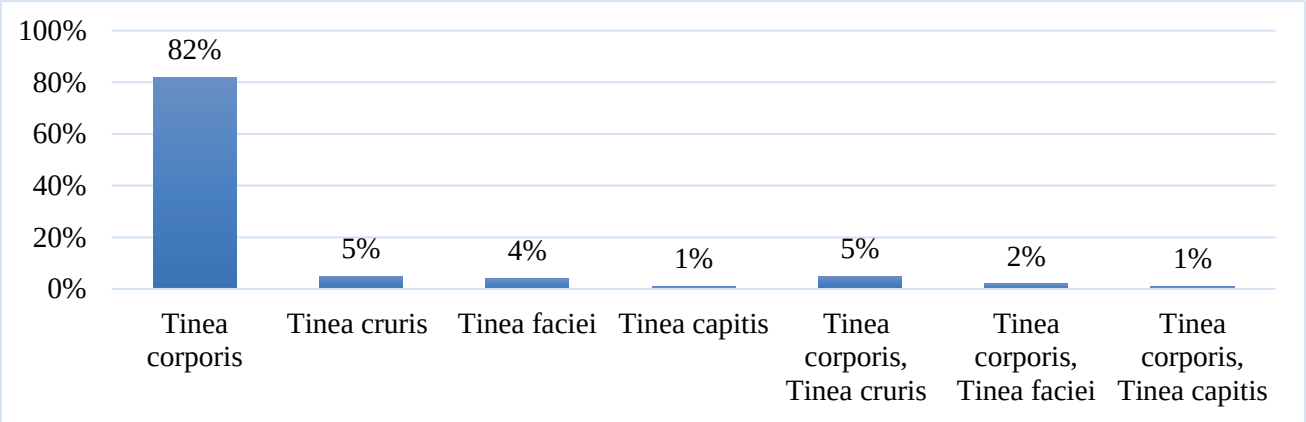
The most frequently affected sites were the abdomen (23%), back (21%), limbs. In contrast, the scalp (2%), face (6%), and neck (6%) were the least commonly affected areas.

3.2.3.3. Characteristics of the number, extent, and severity of dermatophytosis lesions

Most patients had 2–5 lesions (43%), and lesion involvement of ≤ 1 hand surface area (HSA) was the most common extent of disease, observed in 53% of cases.

The majority of patients presented with moderate lesions (40%), followed closely by severe lesions (39%), while mild lesions accounted for a smaller proportion of cases (21%).

3.1.3.4. Clinical Forms of Dermatophytosis.



Picture 3.5. Clinical forms of dermatophytosis

Among patients with dermatophytosis, tinea corporis was the most prevalent clinical form, representing 82% of cases. Other forms occurred less frequently, including tinea cruris (5%), tinea faciei (4%), and tinea capitis (1%). Concurrent involvement of multiple anatomical sites was observed in a small proportion of patients. The most common combination was tinea corporis with tinea cruris (5%), followed by tinea corporis with tinea faciei (2%) and tinea corporis with tinea capitis (1%).

3.2.3.5. Duration of Dermatophytosis

Most patients had a disease duration of less than 3 months (51%), while only 19% had been affected for more than 6 months.

3.2.4. Factors Associated with Dermatophytosis

Table 3.18. Factors associated with dermatophytosis

Factors		OR, 95% CI	p	aOR, 95% CI	p*
Place of residence	Rural	2.23 (1.40 – 3.54)	0.001	2.23 (1.21 – 4.10)	**0.01**
	Urban				
Job	Famer	2.08 (1.15 – 3.77)	0.014	1.23 (0.31 – 4.91)	0.77
	Other				
Literacy	Below college	2.21 (1.01 – 4.87)	0.044	1.45 (0.56 – 3.75)	0.44
	College, University				
Contact with soil	Yes	2.09 (1.20 – 3.65)	0.008	1.25 (0.36 – 4.36)	0.72
	No				
Raising dogs and cats	Yes	1.58 (0.95 – 2.63)	0.075	1.16 (0.63 – 2.13)	0.63
	No				
Use of corticosteroids	Yes	6.00 (3.66 – 9.84)	< 0.001	5.90 (3.34 – 10.42)	< **0.001**
	No				
Wear damp clothes	Yes	4.69 (2.62 – 8.39)	< 0.001	6.28 (3.03 – 13.03)	< **0.001**
	No				
Share a towel.	Yes	4.20 (2.25 – 7.84)	< 0.001	2.04 (0.95 – 4.42)	0.069
	No				
Obesity	Yes	2.77 (1.14 – 6.73)	0.002	2.30 (0.76 – 6.93)	0.14
	No				
Sweating a lot	Yes	2.43 (1.53 – 3.87)	< 0.001	0.71 (0.35 – 1.44)	0.34
	No				
Oily skin	Yes	2.05 (1.28 – 3.26)	0.002	0.94 (0.46 – 1.92)	0.86
	No				

Rural residence was independently associated with dermatophytosis (aOR = 2.23; 95% CI: 1.21 – 4.10; p < 0.05). Corticosteroid use was independently associated with dermatophytosis (aOR = 5.90; 95% CI: 3.34 – 10.42; p < 0.001). Wearing damp clothing was significantly associated with dermatophytosis. (aOR = 6.28; 95% CI: 3.03 – 13.03; p < 0.001)

3.3. Species composition of dermatophytes based on morphological and molecular identification

3.3.1. Morphological characteristics of dermatophytes

Based on macroscopic and microscopic characteristics, the 100 fungal isolates were classified into three main phenotypic groups, designated as Groups I, II, and III. Within each group, the isolates were further subdivided into subgroups according to differences in colony reverse pigmentation.

Bảng 3.19. Morphological characteristics of dermatophytes (n = 100)

Group	Subgruop	Macroscopic morpholy	Microscopic morphology	Colony reverse	Number	Percentage (%)
I	IA	Colonies were white, downy to fluffy in texture, surface from flat to raised.	septate and straight hyphae, tear-shaped microconidia, smooth-walled macroconidia with blunt ends.	Reddish-brown with a white margin.	49	49
	IB			Bright yellow to yellowish-brown, with a white margin.	17	17
	IC			unpigmented	2	2
	Total				**68**	**68**
II	IIA	Colonies were white to cream in color, texture ranging from downy to powdery, surface varying from flat to raised.	Spiral hyphae, round microconidia, Arranged in clusters, smooth-walled macroconidia with blunt ends	light yellow	27	27
	IIB			Dark yellow-brown	3	3
	IIC			unpigmented	1	1
	Total				**31**	**31**
III		Yellow colonies with a fine downy texture and a flat surface; yellow reverse; straight hyphae; and tear-shaped microconidia.			1	1
Total					**100**	**100**

The distribution of phenotypic groups indicated that Group I was the most prevalent (68%), followed by Group II (31%) and Group III (1%). Although isolates within each group shared similar macroscopic and microscopic characteristics, they were primarily differentiated by variations in colony reverse pigmentation.

The observed morphological characteristics, including colony morphology, hyphal structures, and conidial features, initially suggested that the isolates belonged to the genus

Trichophyton.

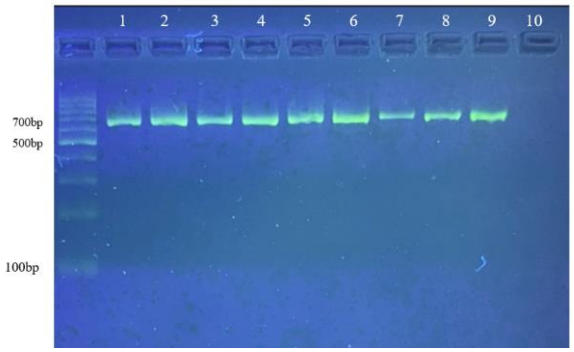
3.3.2. PCR-RFLP identification results of dermatophyte isolates.

Based on phenotypic classification results, all isolates were further analyzed using PCR–RFLP with two restriction enzymes, *Mva*I and *Hae*II. Gel electrophoresis of the digested products revealed that the isolates were grouped into three main genotypic clusters, corresponding to phenotypic Groups I, II, and III.

Table 3.20. Identification results of dermatophytes using PCR-RFLP analysis (n = 100)

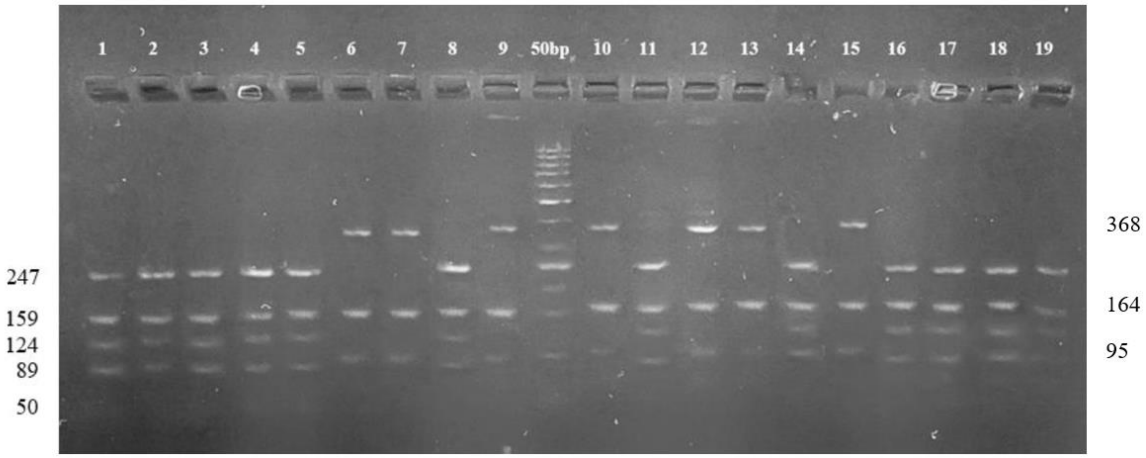
Gruop	PCR product	Restriction enzyme *Mva*I digested products	Restriction enzyme *Hae*III digested products	Number	Species
I	# 650 – 690 bp	368, 164, 95 bp	320, 100 bp	68	*T. rubrum*
II	# 650 – 690 bp	247, 159, 124, 89 bp	400, 100 bp	31	*T. interdigitale*
III	# 650 – 690 bp	250, 125, 90, 60 bp	400, 100 bp	1	*T. tonsurans*

The ITS region amplified using the ITS1/ITS4 primer pair produced PCR products of approximately 650–690 bp. PCR–RFLP analysis using the MvaI enzyme classified the isolates into three distinct groups, whereas *Hae*III digestion yielded two main restriction patterns. The observed banding profiles were consistent with those described in the literature, suggesting correspondence with species such as *Trichophyton rubrum*, *T. interdigitale*, and *T. tonsurans*.



Picture 3.6. Gel electrophoresis of dermatophyte PCR products amplified using the ITS1/ITS4 primer.

Lanes 1, 2, 3, 4, 5, 6, 7, 8, 9 yielded PCR products approximately 650bp - 690bp



Picture 3.7. Fragment sizes of MvaI-digested PCR products from selected samples.

Lanes 1, 2, 3, 4, 5, 8, 11, 14, 16, 17, 18, 19 yielded 4 fragments (247, 159, 124, 89 bp).

Lanes 6, 7, 9, 10, 12, 13, 15 yielded 3 fragments (368, 164, 95 bp).

3.3.3. Results of DNA sequencing analysis of dermatophytes

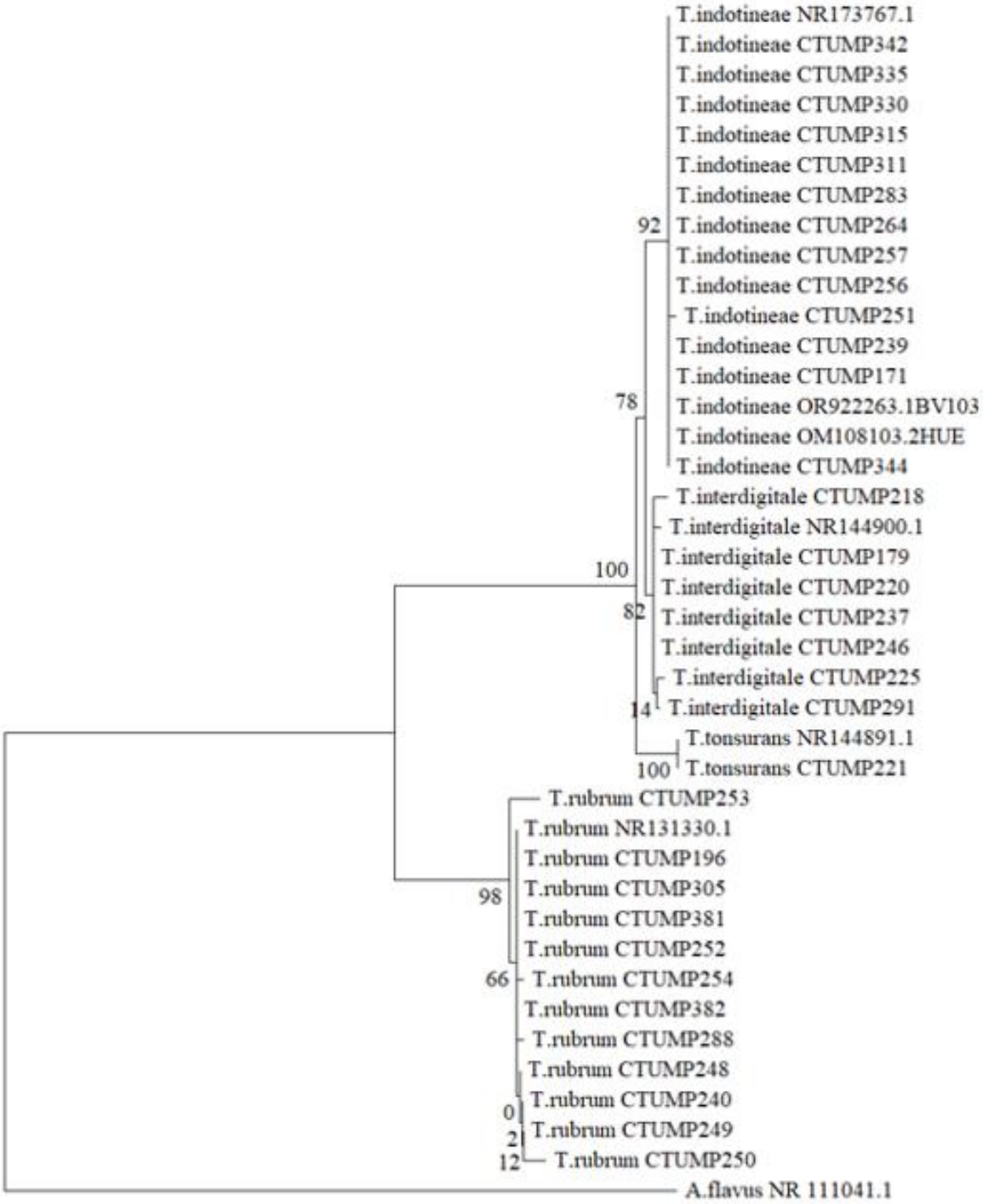
Table 3.21. ITS region sequencing results confirming the identification of dermatophyte isolates

Group	Number	Morphology	PCR – RFLP	Sequence identity (%)	Sequencing results	GenBank accession number
I	12	*Trichophyton Rubrum*	*Trichophyton rubrum*	99.25 - 100	*Trichophyton rubrum*	PX455207, PX455208 PX455209, PX455210 PX455211, PX455212 PX455213, PX455214 PX455215, PX455216 PX455217, PX455218
II	7	*Trichophyton Interdigitale*	*Trichophyton Interdigitale*	99.36 – 99.52	*Trichophyton interdigitale*	PX394019, PX394020 PX394021, PX394022 PX394023, PX394024 PX394025
	13	*Trichophyton Interdigitale*	*Trichophyton Interdigitale*	100	*Trichophyton indotineae*	PX248615, PX248616 PX248617, PX248618 PX248619, PX248620 PX248621, PX248622 PX248623, PX248624 PX248625, PX248626 PX248627
III	1	*Trichophyton tonsurans*	*Trichophyton Tonsurans*	100	*Trichophyton tonsurans*	PX781569

ITS region sequencing results showed that representative isolates from Groups I and III were consistent with morphological and PCR–RFLP-based classification. Specifically, isolates in Group I (n = 12) exhibited sequence similarity ranging from 99.25% to 100% and were all identified as *Trichophyton rubrum*. Group III consisted of a single isolate, which showed 100% sequence similarity and was identified as *Trichophyton tonsurans*.

Group II, among the 20 sequenced isolates, 7 were identified as *Trichophyton interdigitale* with sequence similarity ranging from 99.36% to 99.52%, while the remaining 13 isolates showed 100% identity with *Trichophyton indotineae*. These isolates belong to two

closely related species within the *Trichophyton mentagrophytes* species complex. Although they were initially grouped together based on morphological characteristics and PCR–RFLP patterns, molecular sequencing revealed their clear genetic distinction.



Picture 3.16. Phylogenetic tree of *Trichophyton* species based on ITS region sequences

3.3.4. Species composition of dermatophytes

The species composition of the fungal isolates in this study was determined based on PCR–RFLP results and ITS region sequencing of representative samples from each subgroup. For isolates that were not subjected to sequencing, species assignment was based on PCR–RFLP restriction patterns.

Table 3.26. Species composition of dermatophytes (n = 100)

Species	Number	Percentage (%)	p
Trichophyton rubrum	68	68	(1: 2,3,4) < 0.001
Trichophyton interdigitale	18	18	
Trichophyton indotineae	13	13	
Trichophyton tonsurans	1	1	
Tổng	100	100	

The dermatophyte species composition in this study belonged to the genus *Trichophyton*, with *T. rubrum* being the predominant species, accounting for 68%, which was significantly higher than the other species ($p < 0.001$). *T. tonsurans* was detected at a low frequency (1%). Species belonging to the *T. mentagrophytes/T. interdigitale* complex were also observed at notable proportions, including *T. interdigitale* (18%) and *T. indotineae* (13%).

Table 3.27. Distribution of dermatophyte species by clinical form

Species	Tinea corporis n (%)	Tinea cruris n (%)	Tinea facei n (%)	Tinea capitis n (%)	Tinea corporis, Tinea cruris n (%)	Tinea corporis, Tinea facei n (%)	Tinea corporis, Tinea capitis n (%)	**Total**
T. rubrum	55 (67.07)	3 (60)	4 (100)	1 (100)	2 (40)	2 (100)	1 (100)	**68**
T. interdigitale	16 (19.51)	-	-	-	2 (40)	-	-	**18**
T. indotineae	10 (12.20)	2 (40)	-	-	1 (20)	-	-	**13**
T. tonsurans	1 (1.22)	-	-	-	-	-	-	**1**
Tổng	**82**	**5**	**4**	**1**	**5**	**2**	**1**	**100**

Tinea corporis was the most common clinical presentation (82%), in which *T. rubrum* accounted for the highest proportion (67.07%), followed by *T. interdigitale* (19.51%) and *T. indotineae* (12.20%). At other anatomical sites, *T. rubrum* remained the predominant species, accounting for 60% of tinea cruris cases and 100% of both tinea faciei and tinea capitis cases. Other species were less frequently observed and showed a more limited distribution. Notably, *T. indotineae* accounted for 40% of tinea cruris cases, while *T. interdigitale* was not detected at these sites.

In cases of mixed infections, *T. rubrum* remained the predominant species, particularly in tinea corporis combined with tinea faciei and tinea corporis combined with tinea capitis. In contrast, *T. interdigitale* and *T. indotineae* were mainly observed in cases of isolated tinea corporis or in combination with tinea corporis–tinea cruris.

3.4. Antifungal susceptibility of dermatophyte species

3.4.1. Susceptibility of isolated dermatophytes to antifungal agents

Table 3.29. Overall susceptibility, resistance, and intermediate susceptibility of dermatophytes to antifungal agents (n = 100)

Drug	Antifungal susceptibility characteristics					
	Susceptibility		Intermediate		Resistance	
	Number	(%)	Number	(%)	Number	(%)
Griseofulvin	11	11	19	19	70	70
Fluconazole	5	5	0	0	95	**95**

Ketoconazole	59	59	12	12	29	29
Miconazole	63	63	31	31	6	6
Itraconazol	93	**93**	0	0	7	7

The susceptibility rates of dermatophytes were 93% for itraconazole, 63% for miconazole, and 59% for ketoconazole. In contrast, susceptibility to griseofulvin and fluconazole was low, at 11% and 5%, respectively.

3.4.2. Antifungal susceptibility of dermatophyte isolates according to species

Table 3.30. Antifungal susceptibility profile of *Trichophyton rubrum* (n = 68)

Drug	Antifungal susceptibility characteristics					
	Susceptibility		Intermediate		Resistance	
	Number	%	Number	%	Number	(%)
Griseofulvin	9	13.24	11	16.18	48	70.58
Fluconazole	4	5.88	0	0	64	**94.12**
Ketoconazole	34	50.00	23	33.82	11	16.18
Miconazole	49	72.06	14	20.59	5	7.35
Itraconazol	64	**94.12**	0	0	4	5.88

T. rubrum showed the highest susceptibility to itraconazole (94.12%), followed by miconazole (72.06%) and ketoconazole (50%).

Table 3.31. Antifungal susceptibility profile of *Trichophyton interdigitale* (n = 18)

Drug	Antifungal susceptibility characteristics					
	Susceptibility		Intermediate		Resistance	
	Number	%	Number	%	Number	(%)
Griseofulvin	1	5.55	8	4.45	9	50.00
Fluconazole	1	5.55	0	0	17	**94.45**
Ketoconazole	12	66.67	5	27.78	1	5.55
Miconazole	6	33.34	11	61.11	1	5.55
Itraconazol	16	**88.89**	0	0	2	11.11

T. interdigitale showed high susceptibility to itraconazole (88.89%) and moderate susceptibility to ketoconazole (66.67%). In contrast, it exhibited high resistance to fluconazole (94.45%) and resistance to griseofulvin (50%).

Table 3.32. Antifungal susceptibility profile of *Trichophyton indotineae* (n = 13)

Drug	Antifungal susceptibility characteristics					
	Susceptibility		Intermediate		Resistance	
	Number	%	Number	%	Number	(%)
Griseofulvin	1	7.69	0	0	12	**92.31**
Fluconazole	0	0	0	0	13	**100**
Ketoconazole	13	**100**	0	0	0	0
Miconazole	8	61.51	5	38.46	0	0
Itraconazol	12	**92.31**	0	0	1	7.69

T. indotineae showed 100% susceptibility to ketoconazole and high susceptibility to itraconazole (92.31%). In contrast, it exhibited complete resistance to fluconazole (100%) and high resistance to griseofulvin (92.3%).

Table 3.33. Association between dermatophyte species and antifungal susceptibility

Drug	Susceptibility characteristics	*T. rubrum* n (%)	non *T. rubrum* n (%)	Number	P
Griseofulvin	(S)	9 (13.23)	2 (6.25)	11	0.495
	(I+R)	59 (86.77)	30 (93.75)	89	

	Total	68 (100)	32 (100)	100	
Fluconazole	(S)	4 (5.88)	1 (3.12)	5	1.00
	(I+R)	64 (94.12)	31 (96.88)	95	
	Total	68 (100)	32 (100)	100	
Ketoconazole	(S)	34 (50)	25 (78.12)	59	**0.008**
	(I+R)	34 (50)	7 (21.88)	41	
	Total	68 (100)	32 (100)	100	
Miconazole	(S)	49 (72.06)	14 (43.75)	63	**0.006**
	(I+R)	19 (27.94)	18 (56.25)	37	
	Total	68 (100)	32 (100)	100	
Itraconazole	(S)	64 (94.12)	29 (90.62)	93	0.68
	(I+R)	4 (5.88)	3 (9.4)	7	
	Total	68 (100)	32 (100)	100	

The susceptibility rates to ketoconazole and miconazole differed significantly between *T. rubrum* and the non-*T. rubrum* group ($p < 0.05$). Specifically, the susceptibility rate to ketoconazole was higher in the *non-T. rubrum* group than in *T. rubrum* (78.12% vs. 50.0%). In contrast, *T. rubrum* exhibited a higher susceptibility rate to miconazole than the *non-T. rubrum* group (72.06% vs. 43.75%). In contrast, no statistically significant differences were observed in susceptibility to griseofulvin, fluconazole, and itraconazole between the two groups ($p > 0.05$).

Chapter 4. DISCUSSION

4.2. Characteristics of dermatophytosis

4.2.1. Characteristics of dermatophytosis

4.2.1.1. Prevalence of dermatophytosis

Among the 385 patients presenting with skin lesions suspected of fungal infection, 100 cases were confirmed positive, yielding a prevalence of 25.97%. This prevalence was considerably lower than those reported in previous Vietnamese studies conducted among similar populations with suspected dermatophytosis, including the study by Tang Tuan Hai (47.2%) and that by Nguyen Thai Dung (42.4%). This discrepancy may be explained by differences in study sampling strategies. Specifically, the inclusion of clinically suspected cases, including patients with atypical skin lesions, increased the likelihood of enrolling individuals with non-fungal dermatological conditions such as contact dermatitis, seborrheic dermatitis, psoriasis, or bacterial skin infections, thereby reducing the overall positivity rate. Furthermore, prior treatment before clinical presentation may have significantly affected the diagnostic yield. In routine practice, many patients self-medicate with antifungal preparations or corticosteroid-containing products before seeking medical care. Such treatments may reduce the fungal burden within lesions and consequently increase the likelihood of false-negative test results.

Compared with studies conducted in other countries, the prevalence of dermatophytosis observed in the present study (25.97%) was comparable to that reported by Ali Rezaei-Matehkolaei in Iran (27.25%) and by Mina Ali Dawa in Ethiopia (28.4%). However, it was lower than the prevalence reported by Lakshmi Vasantha Poluri in India (56.36%). The substantial variation in prevalence rates across studies may be attributed to differences in geographic location, climatic conditions, study populations, diagnostic methods, and inclusion criteria. Nevertheless, these findings consistently indicate that dermatophytosis remains a common fungal infection and continues to represent an important public health concern in many regions of the world.

4.2.1.2. Prevalence of dermatophytosis by age group

The highest prevalence of dermatophytosis was observed among patients aged 60 years and older (36.58%), whereas the lowest prevalence was found in those younger than 20 years (17.50%). The prevalence of dermatophytosis in the 20 – 39 and 40 – 59 year age groups was 24.54% and 23.0%, respectively. Patients aged ≥ 60 years had a significantly higher prevalence of dermatophytosis compared with those aged < 20 years. Currently, most studies on dermatophytosis mainly describe the age distribution of confirmed cases, whereas data on age-specific prevalence in screened populations remain limited. Therefore, direct comparison of our findings with previous

studies is difficult.

The higher prevalence observed among older adults in the present study may be associated with age-related decline in immune function, impairment of the skin barrier, and the presence of chronic underlying diseases, all of which may increase susceptibility to infection and contribute to prolonged or overlooked lesions. These findings suggest that greater attention should be paid to the clinical examination, laboratory testing, and diagnosis of dermatophytosis in older adults. Early recognition and appropriate management in this population may help reduce missed diagnoses and improve treatment outcomes.

4.2.1.3. Prevalence of dermatophytosis by gender

The prevalence of dermatophytosis in males (27.81%) was higher than in females (24.24%); however, this difference was not statistically significant. The results showed that dermatophytosis was relatively evenly distributed between males and females in the study population. However, several previous studies have reported a higher prevalence of dermatophytosis in males compared with females, with statistically significant differences. A study by Mina Ali Dawa in Ethiopia found that males had a significantly higher risk of dermatophytosis (aOR = 2.5; p = 0.001). Similarly, a study by Joon Ho Son (2022) in South Korea reported a prevalence of 20.92% in males and 16.5% in females, with females having a lower risk compared with males (OR = 0.848).

The gender differences in dermatophytosis prevalence may be explained by various biological factors and differences in occupational and physical activity patterns. However, in the context of modern society, with changes in lifestyle and environmental exposure, these differences may be diminishing, which may explain why some studies, including the present study, did not observe a statistically significant difference between the two sexes.

4.2.1.4. Prevalence of dermatophytosis by place of residence

Among the 385 participants with suspected dermatophyte lesions, the prevalence of dermatophytosis was higher in rural residents (35.3%) compared with urban residents (19.65%), and this difference was statistically significant ($p < 0.05$). These findings are consistent with a study by Nguyen Thai Dung (2017) in Nghe An, which also reported a higher prevalence of dermatophytosis in rural areas (45.2%) than in urban areas (35%), although the difference was not statistically significant.

Although the study was conducted in an urban healthcare setting and the majority of participants resided in urban areas, the higher prevalence observed in rural residents suggests that this difference may be related to the timing of healthcare access. Patients from rural areas may tend to seek medical care at a later stage, when lesions have become more prolonged or recurrent, thereby increasing the likelihood of detecting dermatophyte infection.

4.2.2. Demographic Characteristics of Patients with Dermatophytosis

The demographic characteristics of patients with confirmed dermatophytosis were analyzed according to age group, sex, place of residence, educational level, and occupation. Analysis of these factors provides an overview of the demographic profile of patients with dermatophytosis attending the Dermatology Clinic, Can Tho University of Medicine and Pharmacy Hospital during the study period.

- Age group

The distribution of patients by age group showed that the **20–39-year** age group accounted for the highest proportion (40%), followed by the **≥60-year** age group (31%), while the **<20-year** age group had the lowest proportion (7%). Our findings are consistent with numerous national and international studies reporting that dermatophytosis predominantly affects young and middle-aged individuals. The proportion of patients aged 20–39 years was 59.24% in the study by Nguyen Thai Dung (2017), 66.9% in the study by Nguyen Thi Quynh (2022), and 48.9% in the study by Cao Bich Ngoc (2023). Similarly, Chau Van Tro (2019) in Binh Thuan reported that individuals aged 21–40 years accounted for 54.6% of cases. Shymaa Yahia's study at Zagazig University Hospital (Egypt) also found that the 21–40-year age group represented 43% of cases. These findings suggest that dermatophytosis is more common among young and middle-aged individuals who have a high frequency of work, study, and social activities, resulting in greater exposure to conditions favorable for fungal growth, such as hot and humid environments, excessive sweating, and physical activity.

In addition, the present study found that patients aged >60 years accounted for a relatively high proportion (31%). This proportion was higher than that reported in previous studies. For example, Nguyen Minh Quyen (2023) at Military Hospital 103 reported that patients aged >60 years accounted for the lowest proportion (6.7%), while Nguyen Thai Dung (2017) in Nghe An also found that the ≥60-year age group represented the smallest proportion of cases (3.8%). This discrepancy may be attributable to differences in the age structure of the study populations. In Nguyen Minh Quyen's study, military personnel constituted a large proportion of the participants, resulting in a predominance of younger patients with dermatophytosis. Likewise, in Nguyen Thai Dung's study, only 6.22% of the screened participants with suspected dermatophytosis were aged ≥60 years. In contrast, individuals aged ≥60 years accounted for 21.3% of the screened population in the present study. Therefore, the higher proportion of patients aged ≥60 years observed in this study may partly reflect differences in the baseline age distribution of the study population rather than a higher risk of dermatophytosis in this age group.

- Sex

The present study found that males accounted for 52% of patients, while females accounted for 48%. These findings are comparable to those reported by Cao Bich Ngoc (2023), in which males and females represented 51.7% and 48.3% of cases, respectively, and by Nguyen Huu Sau at the National Hospital of Dermatology and Venereology, where the proportions were 58.8% in males and 41.2% in females. Several other studies have reported a male predominance. Nguyen Thai Dung (2017) in Nghe An found that 66% of dermatophytosis cases occurred in males compared with 34% in females. Pham Van Tuan (2021) in Bac Ninh reported that males accounted for 68.2% of patients with tinea corporis, whereas females accounted for 31.8%. Similarly, Nguyen Minh Quyen (2025) reported that 84.3% of patients were male and 15.7% were female. International studies have also demonstrated a higher proportion of dermatophytosis among males than females. Poluri et al. in southern India reported that 67.27% of cases occurred in males and 32.73% in females, while Yogesh Poudyal et al. in Nepal reported corresponding proportions of 68.9% and 31.1%, respectively. The marked male predominance observed in some studies may be attributable to differences in the study populations. For example, Nguyen Minh Quyen conducted the study at a military hospital, where military personnel constituted the majority of participants. As military service is predominantly a male occupation, this population structure likely contributed to the higher proportion of dermatophytosis observed among men.

- Place of residence

Patients residing in rural areas accounted for 55% of all cases, whereas those living in urban areas accounted for 45%. This distribution is consistent with previous studies, which also reported a predominance of dermatophytosis among individuals from rural areas. Pham Van Tuan's study in Bac Ninh found that 69.7% of patients resided in suburban/rural areas, compared with 30.3% in urban areas. Similarly, Chau Van Tro (2020) in Binh Thuan reported that 63.3% and 36.7% of patients were from rural and urban areas, respectively. Likewise, Abhineetha Hosthota and colleagues reported that 65.3% of patients with dermatophytosis lived in rural areas.

- Educational level

The present study found that patients with a high school education accounted for the highest proportion (39%), whereas those with a college or university education accounted for the lowest proportion (8%). Patients with secondary school and primary school education represented comparable proportions, accounting for 26% and 27%, respectively. In comparison, Chau Van Tro's study conducted in Binh Thuan reported that the highest proportion of patients had a secondary school education (56.2%), while 30.1% had a high school education or higher.

- Occupation

Among the 100 patients with dermatophytosis, students accounted for the highest proportion (23%), followed by farmers (22%). Homemakers and self-employed individuals represented the lowest proportion (17%). Similarly, Pham Van Tuan (2021) at Bac Ninh Dermatology Hospital reported that farmers constituted the largest occupational group (24.3%), followed by students (21.2%). Chau Van Tro's study in Binh Thuan found that workers and office employees accounted for the highest proportion (28.1%), followed by students (24.5%) and farmers (21.4%). Likewise,

Abhineetha Hosthota reported that factory workers comprised 36% of patients, followed by those engaged in agricultural work (20%) and students (18%). Overall, most studies have shown that dermatophytosis is more commonly distributed among farmers and students.

4.2.3. Clinical characteristics of dermatophytosis

4.2.3.1. Characteristics of skin lesions

The most common clinical manifestations of dermatophytosis included erythema (96%), macules (88%), well-demarcated lesions from surrounding healthy skin (80%), continuous borders (71%), scaling (70%), and central clearing (34%). Less frequently observed lesions included hyperkeratosis (10%) and pustules (6%).

Erythema was recorded in 96% of cases, representing the most prominent clinical feature, which is consistent with findings reported in several domestic studies. In addition, well-defined lesion margins (80%) and continuous borders (71%) were also characteristic features, aiding in the differentiation of dermatophytosis from other dermatological conditions. The well-demarcated border reflects centrifugal fungal spread, while the active growth at the periphery compared to the central area contributes to the typical sharply defined lesion outline.

The presence of scaling (70%) was also relatively high, consistent with the keratinophilic nature of dermatophytes, which leads to stratum corneum desquamation. In contrast, central clearing (34.0%) was less frequently observed, indicating that not all cases presented with the classic annular morphology. Features such as hyperkeratosis and pustules were less common and were typically associated with chronic lesions or secondary bacterial infection.

Overall, the clinical characteristics observed in this study are consistent with the classical presentation of dermatophytosis; however, the severity and expression of lesions may vary depending on anatomical location and stage of disease.

4.2.3.2. Anatomical distribution of lesions

The most frequently affected anatomical sites were the abdomen and upper extremities, each accounting for 23% of cases. This was followed by the back (21%) and lower extremities (20%). The least commonly affected site was the scalp (2%), while the neck and face showed similar proportions of involvement (6% each).

Compared with previous domestic and international studies, the distribution of lesion sites in the present study was generally consistent. Pham Van Tuan reported that the most common sites of dermatophytosis were the abdomen (25.8%), upper extremities (13.6%), back (18.2%), and lower extremities (30.3%). Nguyen Thai Dung found that tinea corporis was the predominant clinical form, accounting for 74.4% of cases, while infections of the hands, feet, and scalp were less frequently observed. Similarly, Lakshmi Vasantha Poluri reported that tinea corporis was the most common clinical presentation, occurring in 40% of cases.

The distribution of dermatophytosis can be explained by environmental and anatomical factors. Temperature and humidity are key determinants of fungal growth. Body sites such as the trunk (abdomen, back, and chest) and intertriginous areas (axillae, elbows, and groin) typically have higher temperature and moisture levels, creating a favorable environment for fungal proliferation. In tropical climates characterized by high temperature and humidity, such conditions further enhance fungal survival and invasion. In addition, direct exposure to environmental sources of infection may contribute to involvement of exposed areas such as the forearms and lower legs.

4.2.3.3. Characteristics of the number, extent, and severity of dermatophytosis lesions

Regarding lesion number, the group with 2–5 lesions accounted for the highest proportion of patients (43%), followed by those with more than 5 lesions (36%), while patients with a single lesion represented 21%. This finding is consistent with the study by Cao Bich Ngoc, in which the most common lesion number was also in the range of 2–5 lesions (61%). However, the proportion of patients with more than 5 lesions in the present study was higher than that reported by Cao Bich Ngoc (19.2%) and Nguyen Minh Quyen (3.4%). These differences suggest that more extensive cutaneous involvement was more frequently observed in our study population compared with previous reports.

Regarding lesion extent, the majority of patients had an affected area of ≤ 1 hand surface area (53%), whereas extensive lesions involving more than 5 hand surface areas were less common (14%). These findings are generally consistent with previous studies, in which lesions involving ≤ 1 hand

surface area and 2–5 hand surface areas were the most frequently observed patterns. However, the proportion of patients with extensive involvement (> 5 hand surface areas) in our study was higher than that reported by Cao Bich Ngoc (12.1%) and Huynh Phan Ngoc Buu (9.7%), indicating that a notable proportion of patients still presented with widespread lesions.

In the present study, most patients exhibited moderate (40%) and severe (39%) disease severity, which was higher than that reported by Nguyen Thi Quynh, in which severe cases accounted for 26.6%. This discrepancy may be attributed to differences in study settings, as Can Tho University of Medicine and Pharmacy Hospital is a tertiary referral center that receives a considerable number of patients with prolonged or advanced disease, thereby contributing to a higher proportion of moderate and severe cases.

4.2.3.4. Clinical forms of dermatophytosis

The present study recorded that the predominant clinical form was tinea corporis, accounting for 90% of cases, with most patients presenting with isolated tinea corporis (82%). Combined infections involving the groin, face, or scalp were observed at a much lower frequency. Other isolated clinical forms, including tinea cruris (5%), tinea faciei (4%), and tinea capitis (1%), were relatively uncommon.

These findings are consistent with several domestic and international studies, in which tinea corporis was also the most prevalent clinical form, with reported proportions ranging from 31.2% to 74.4% in studies conducted by Nguyen Thai Dung, Chau Van Tro, Nguyen Huu Sau, and Yogesh Poudyal. However, some studies have reported tinea cruris as the dominant clinical presentation, such as those by Nguyen Thi Quynh (64.2%) and Abhineetha Hosthota (50%), suggesting that the distribution of clinical forms may vary depending on the study population and local epidemiological characteristics.

Overall, the trunk and groin regions are recognized as the most common sites of dermatophyte infection compared with other body areas, as these regions are typically less exposed and more prone to moisture accumulation due to sweating. The higher proportion of tinea corporis observed in the present study compared with others may be explained by local environmental conditions in the Mekong Delta region, characterized by a hot and humid climate. In addition, local habits such as wearing multiple layers of clothing for sun protection during outdoor labor may increase sweating and moisture retention, thereby creating favorable conditions for the development of tinea corporis.

4.2.3.5. Duration of dermatophytosis

Regarding disease duration, the group with a duration of less than 3 months accounted for the highest proportion (51%), followed by those with 3–6 months (30.0%) and more than 6 months (19%). These findings indicate that most patients sought medical care at an relatively early stage; however, a considerable proportion still presented with prolonged disease duration.

This trend is consistent with several domestic studies. Nguyen Minh Quyen reported that 66.3% of patients had a disease duration of less than 3 months, while 10.1% had a duration of more than 6 months. Nguyen Thi Quynh (2022) found that 31.2% of cases had a duration of less than 3 months and 17.4% exceeded 6 months. Similarly, Cao Bich Ngoc reported that 11% of patients had a disease duration of more than 6 months. In contrast, Chau Van Tro observed that the group with a duration of more than 6 months accounted for the highest proportion (45.4%). These differences suggest that disease duration may vary depending on the characteristics of the study population and the timing of healthcare-seeking behavior.

In addition, the predominant causative species in the present study was *Trichophyton rubrum*, a anthropophilic dermatophyte with strong adaptive capacity to the human host and a tendency to cause chronic and persistent infections. According to Deng et al. (2023), anthropophilic dermatophyte species tend to persist for prolonged periods on human skin due to their adaptation to the host environment and modulation of the host immune response, thereby contributing to prolonged infection duration. Furthermore, recent epidemiological studies have also reported the predominance of anthropophilic species in the community, characterized by human-to-human transmission and a tendency toward chronic disease.

4.2.4. Factors associated with dermatophytosis

In the univariate analysis, several factors were significantly associated with dermatophytosis,

including rural residence, farming occupation, educational attainment below college level, soil exposure, corticosteroid use, wearing damp clothing, sharing towels, obesity, excessive sweating, and oily skin.

However, after adjustment in the multivariable logistic regression model, only three factors remained independently associated with dermatophytosis: rural residence (adjusted OR [aOR] = 2.23, $p < 0.05$), corticosteroid use (aOR = 5.90, $p < 0.001$), and wearing damp clothing (aOR = 6.28, $p < 0.001$). The remaining factors were no longer statistically significant after adjustment ($p > 0.05$).

- Place of residence:

The results showed that individuals residing in rural areas had a significantly higher risk of dermatophytosis than those living in urban areas (aOR = 2.23; $p = 0.01$). This association remained significant after adjustment for potential confounding factors, indicating that rural residence is an independent predictor of dermatophytosis.

This finding is consistent with the study conducted by Alma Aimoldina in Kazakhstan, which reported that the risk of dermatophytosis among rural residents was 2.3 times higher than that among urban residents. A similar trend was also observed in the study by Nguyen Thai Dung, although the association did not reach statistical significance. Differences between studies may be attributable to variations in population characteristics and environmental conditions. Overall, the available evidence suggests that living environment and lifestyle conditions, particularly in rural areas, play an important role in the risk of dermatophyte infection.

- Corticosteroid use

In the multivariable logistic regression model, corticosteroid use was identified as a strong risk factor for dermatophytosis (aOR = 5.90; $p < 0.001$). This finding is consistent with the pathophysiology of the disease, as corticosteroids suppress local immune responses, reduce inflammation, mask clinical manifestations, and create favorable conditions for fungal growth and spread. Furthermore, inappropriate or prolonged corticosteroid use may impair the skin barrier function, thereby increasing susceptibility to infection and complicating clinical diagnosis.

This result is in agreement with the study by Abhineetha Hosthota, in which topical corticosteroid use was identified as a major risk factor for dermatophytosis. The widespread and often unsupervised use of corticosteroid-containing preparations in the community may therefore contribute substantially to the persistence and increasing burden of dermatophyte infections.

- Wearing damp clothing

Wearing damp clothing was identified as an important environmental factor and remained independently associated with dermatophytosis in the multivariable model (aOR = 6.28; $p < 0.001$). This finding is consistent with the study by Nguyen Thi Quynh, which reported that wearing tight and damp clothing was a significant risk factor for dermatophytosis.

Dermatophytes grow optimally under conditions of high humidity and temperatures ranging from 25°C to 35°C. Therefore, wearing damp clothing increases skin moisture and reduces ventilation at the skin surface, particularly in intertriginous areas, creating a favorable microenvironment for fungal colonization and proliferation. These conditions may facilitate the establishment and persistence of dermatophyte infections, thereby increasing the risk of disease occurrence.

4.3. Species composition of dermatophytes based on morphological and molecular identification

4.3.1. Morphological characteristics of dermatophytes

In the present study, dermatophyte isolates exhibited considerable diversity in their macroscopic characteristics, including colony color ranging from white and cream to yellow, texture varying from cottony to powdery, and surface morphology ranging from flat to slightly raised. These findings are consistent with the general descriptions of dermatophytes reported in the literature, in which species of the genus *Trichophyton* typically produce slow-growing colonies with cottony or powdery surfaces and variable pigmentation depending on the species and culture conditions. In addition, substantial variation was observed in the reverse pigmentation of colonies, reflecting the biological diversity of the dermatophyte population investigated. However, several studies have reported that macroscopic colony characteristics may be influenced by culture media, incubation conditions, and duration of growth. Therefore, these features are primarily useful for preliminary identification and should be interpreted in conjunction with microscopic and molecular findings to

achieve accurate species identification.

Group I accounted for the largest proportion of dermatophyte isolates and exhibited white, fine cottony colonies with reddish-brown to yellowish-brown reverse pigmentation, consistent with the typical characteristics of Trichophyton rubrum. Microscopically, straight hyphae, tear-shaped microconidia, and smooth-walled macroconidia were commonly observed. These findings are in agreement with previous descriptions of T. rubrum, the most prevalent dermatophyte worldwide. However, colony morphology and pigmentation may vary depending on culture conditions; therefore, morphological identification should be complemented by molecular methods for accurate species determination.

Group II isolates were characterized by white to cream-colored colonies with cottony to powdery textures, yellowish-brown reverse pigmentation, and the presence of spiral hyphae and clustered spherical microconidia. These features are consistent with the morphological characteristics of the *T. mentagrophytes/T. interdigitale* species complex. Previous studies have reported that *T. interdigitale* typically produces white to cream, flat, cottony to powdery colonies with yellowish to reddish-brown reverse pigmentation and clustered spherical microconidia. However, substantial morphological overlap exists among species within this complex, making accurate identification based solely on macroscopic and microscopic features difficult. In addition, recent studies have recognized *T. indotineae* as a distinct species closely related to the *T. mentagrophytes/T. interdigitale* complex. Because *T. indotineae* shares many morphological characteristics with these species, differentiation based on morphology alone is often unreliable and requires molecular identification methods.

Group III comprised a single isolate characterized by a yellow colony with a fine cottony texture, a flat surface, and yellow reverse pigmentation. Microscopically, straight hyphae and tear-shaped microconidia were observed. These features are consistent with the morphological characteristics of *Trichophyton tonsurans*.

4.3.2. Molecular characteristics of dermatophytes

The isolates identified as *T. rubrum* and *T. tonsurans* showed concordant results across morphological identification, PCR–RFLP, and ITS region sequencing. However, discrepancies among identification methods have also been reported in previous studies, even for species such as *T. rubrum* and *T. tonsurans*.

A total of 31 isolates exhibited morphological characteristics and *Mva*I PCR–RFLP patterns consistent with Trichophyton interdigitale, characterized by fragments of 247, 159, 124, 89, and 50 bp. These findings are in agreement with previous studies, including those by Nguyen Thai Dung (2017) and A. Rezaei-Matehkolaei et al (2012).

Among the isolates showing PCR–RFLP patterns consistent with *Trichophyton interdigitale*, 20 isolates were selected for ITS1–5.8S–ITS2 sequencing. Sequence analysis revealed that 13 of these isolates were actually *T. indotineae*. Although A. Rezaei-Matehkolaei et al (2012) demonstrated that ITS-PCR followed by *Mva*I-RFLP is a useful and reliable method for the identification and differentiation of several dermatophyte species and can serve as a rapid screening tool for closely related species in clinical and epidemiological settings, the emergence of *T. indotineae* has highlighted an important limitation of this approach. Due to the high genetic similarity between *T. indotineae* and *T. interdigitale*, both species may generate identical or highly similar *Mva*I-RFLP profiles, making accurate discrimination difficult when relying solely on this method. Therefore, DNA sequencing remains necessary for definitive identification of these closely related species.

4.3.3. Species composition of dermatophytes

In the present study, *T. rubrum* was the predominant species, accounting for 68% of all isolates, whereas *T. tonsurans* was the least frequently identified species (1%). Among the 31 isolates initially identified as *T. interdigitale* based on morphological characteristics and PCR–RFLP analysis, 20 isolates were selected for ITS sequencing for confirmation. Sequence analysis revealed that 13 isolates showed 100% similarity to *T. indotineae*, while 7 isolates showed 99.52% similarity to *T. interdigitale*. The remaining isolates were not subjected to sequencing and therefore retained their original identification based on morphological and PCR–RFLP findings.

In the present study, *T. rubrum* was the predominant dermatophyte species, accounting for

68% of all isolates. This finding is consistent with numerous domestic and international studies, including those of Nguyen Thai Dung (67.2%), Tang Tuan Hai (63.55%), Hari (55.32%), and Lakshmi Vasantha Poluri (58.06%). Although the reported prevalence varies among studies, likely due to differences in geographic location, climatic conditions, and population characteristics, *T. rubrum* is consistently recognized as the most common causative agent of dermatophytosis worldwide. The second most frequently identified species was *T. interdigitale* (18%), which is comparable to the findings of Nguyen Thai Dung, who reported a prevalence of 12.4%, ranking it as the second most common dermatophyte species. *T. tonsurans* was identified in only 1% of cases, consistent with its relatively low prevalence reported in most studies. Notably, the detection of *Trichophyton indotineae* in the Mekong Delta provides important epidemiological evidence for the geographic expansion of this emerging dermatophyte species in Vietnam.

4.4. Antifungal susceptibility of dermatophyte species

4.4.1. Antifungal Susceptibility of Isolated Dermatophytes

The antifungal susceptibility testing results showed that the dermatophyte isolates in the present study remained susceptible to several azole antifungal agents; however, intermediate susceptibility and antifungal resistance were also observed.

- Itraconazole

In the present study, the susceptibility rate of dermatophytes to itraconazole was 93%, which was lower than the 100% susceptibility reported by Tang Tuan Hai and Ngo Thi Minh Chau. Our findings are comparable to those of Shymaa Yahia, who reported that 8% of the isolates were resistant to itraconazole. The high susceptibility rate observed in the present study indicates that itraconazole remains an effective therapeutic option for the treatment of dermatophytosis. However, the detection of 7% itraconazole-resistant isolates is noteworthy and may indicate an emerging trend toward reduced susceptibility to itraconazole.

- Miconazole

The susceptibility rate to miconazole was 63%, while the resistance rate was 6%. In contrast, Pakshir (2009) reported that none of the dermatophyte isolates were resistant to miconazole. Compared with previous studies, our findings indicate the emergence of miconazole-resistant dermatophyte isolates, suggesting a trend toward reduced susceptibility to topical azole antifungal agents, likely associated with their widespread use in the treatment of dermatophytosis.

- Ketoconazole

In the present study, 59% of dermatophyte isolates were susceptible to ketoconazole, 29% showed intermediate susceptibility, and 12% were resistant. Compared with the findings of Tang Tuan Hai (2021), who reported a susceptibility rate of 52.9%, and Nguyen Thi Ngoc Yen (2019), who reported a susceptibility rate of 52.73% and a resistance rate of 25.45%, our study demonstrated a higher susceptibility rate and a lower resistance rate. Our findings are also comparable to those of Shymaa Yahia, who reported that 11% of dermatophyte isolates were resistant to ketoconazole.

- Griseofulvin

The susceptibility rate to griseofulvin in the present study was 11%, which was substantially lower than the 98% susceptibility reported by Tang Tuan Hai. Ngo Thi Minh Chau reported a 43.8% resistance rate to griseofulvin. These findings suggest a marked decline in the susceptibility of dermatophytes to griseofulvin in the study population, indicating a potential increase in antifungal resistance.

- Fluconazole

In the present study, the susceptibility rate of dermatophytes to fluconazole was very low (5%), whereas the resistance rate was 95%, indicating that fluconazole currently has limited efficacy against dermatophyte infections. A trend toward reduced susceptibility to fluconazole has also been reported in previous studies. For example, Sundar Khadka reported that 100% of dermatophyte isolates exhibited intermediate susceptibility to fluconazole. Ngo Thi Minh Chau reported a 75.2% resistance rate, while Shymaa Yahia found that 39% of the isolates were resistant to fluconazole. Collectively, these studies consistently demonstrate that the proportion of fluconazole-resistant isolates is higher than that observed for other antifungal agents. These findings suggest that fluconazole is no longer an optimal therapeutic option for the treatment of dermatophyte infections,

particularly in the context of the increasing emergence of isolates with reduced susceptibility or antifungal resistance.

4.4.2. Antifungal Susceptibility of Individual Dermatophyte Species Isolated

At the species level, susceptibility to itraconazole remained consistently high across the three predominant dermatophyte species, ranging from 88.89% to 94.12%. Susceptibility to ketoconazole ranged from 50% to 100%, while susceptibility to miconazole ranged from 33.34% to 72.06%. In contrast, susceptibility to fluconazole and griseofulvin was uniformly low among all three species, ranging from 0% to 5.88% and from 5.55% to 13.24%, respectively.

Among *Trichophyton rubrum* isolates, 94.12% were susceptible to itraconazole, 72.06% to miconazole, and 50.0% to ketoconazole. In contrast, resistance rates were 94.12% for fluconazole and 70.58% for griseofulvin. Yamada et al. (2021) elucidated an important mechanism of azole resistance in *T. rubrum* involving the ATP-binding cassette (ABC) transporter TruMDR2. Itraconazole-resistant *T. rubrum* isolates exhibited upregulated expression of the TruMDR2 gene, which enhanced drug efflux from fungal cells, thereby reducing intracellular drug concentrations and diminishing antifungal efficacy.

Among *Trichophyton interdigitale* isolates, 88.89% were susceptible to itraconazole, while 66.67% were susceptible to ketoconazole. Resistance rates were 94.45% for fluconazole and 50.0% for griseofulvin.

All *Trichophyton indotineae* isolates (100%) were susceptible to ketoconazole, and 92.31% were susceptible to itraconazole. In contrast, *T. indotineae* exhibited 100% resistance to fluconazole and 92.3% resistance to griseofulvin. Azole resistance in *T. indotineae* has also been associated with overexpression of ATP-binding cassette (ABC) transporters and mutations in the *ERG11/CYP51* gene. The *ERG11* gene, which encodes the enzyme lanosterol 14-α-demethylase, is the molecular target of azole antifungal agents and plays a key role in the ergosterol biosynthesis pathway.

CONCLUSION

1.1. Characteristics of dermatophytosis

Among patients presenting with skin lesions suspected of dermatophytosis, the prevalence of confirmed dermatophyte infection was 25,97%. The highest prevalence was observed in patients aged 60 years and older (36.58%), which was significantly higher than that in patients younger than 20 years. In addition, patients residing in rural areas had a markedly higher prevalence of dermatophytosis than those living in urban areas (35.26% vs 19.65%).

1.2. Demographic Characteristics of Patients with Dermatophytosis

The demographic distribution of patients with confirmed dermatophytosis showed that the highest proportion was observed in the 20–39-year age group (40%), followed by the ≥60-year age group (31%). Males accounted for 52% of cases. Regarding place of residence, 55% of patients lived in rural areas and 45% in urban areas. The highest proportion of patients had a high school education (39%)

1.3. Clinical characteristics of dermatophytosis

The most common clinical manifestations of dermatophytosis were erythema (96%), macules (88%), well-demarcated lesions from surrounding healthy skin (80%), continuous borders (71%), and scaling (70%). Lesions were predominantly located on the abdomen, back, and extremities. The most common lesion count was 2–5 lesions (43%), and the affected area was most frequently ≤ 1 hand surface area (53%). Tinea corporis was the predominant clinical form, isolated tinea corporis 82% of cases. Other clinical presentations included concomitant tinea corporis and tinea cruris (5%), tinea faciei (2%), and tinea capitis (1%).

1.4. Factors associated with dermatophytosis

Rural residence, corticosteroid use, and the habit of wearing damp clothing were identified as independent risk factors for dermatophytosis.

2. Species composition of dermatophyte isolates identified by morphological and molecular methods.

The species composition of the 100 dermatophyte isolates consisted predominantly of *Trichophyton rubrum* (68%), followed by *Trichophyton interdigitale* (18%), *Trichophyton indotineae* (13%), and *Trichophyton tonsurans* (1%).

3. Antifungal susceptibility of dermatophyte species

The antifungal susceptibility testing results showed that 93% of dermatophyte isolates were susceptible to itraconazole, 63% to miconazole, and 59% to ketoconazole. In contrast, susceptibility to griseofulvin and fluconazole was markedly lower, at 11.0% and 5.0%, respectively.

Trichophyton rubrum demonstrated high susceptibility to itraconazole (94,12%) and miconazole (72.06%). *Trichophyton interdigitale* was most susceptible to itraconazole (88.89%) and ketoconazole (66.67%). *Trichophyton indotineae* exhibited complete susceptibility to ketoconazole (100%) and high susceptibility to itraconazole (92.31%).

RECOMMENDATIONS

1. Community health education should be strengthened to raise awareness of dermatophytosis prevention, with emphasis on promoting behavioral changes, particularly avoiding the wearing of damp clothing and limiting the inappropriate use of corticosteroids. Preventive interventions should prioritize high-risk populations, especially individuals aged >60 years and those residing in rural areas. Public awareness of early dermatophytosis symptoms should also be promoted to encourage timely healthcare seeking, thereby reducing chronicity, treatment delays, and transmission within the community.
2. The study findings demonstrated that dermatophyte isolates exhibited high susceptibility to itraconazole, suggesting that this agent may be considered a preferred therapeutic option for the treatment of dermatophytosis, particularly in extensive or recurrent cases. In contrast, caution should be exercised when prescribing fluconazole and griseofulvin because of the high rates of reduced susceptibility observed in this study. Appropriate antifungal selection based on local susceptibility patterns may help minimize treatment failure and limit the emergence and spread of antifungal-resistant dermatophyte strains.
3. Further research is warranted to characterize local dermatophyte species distribution and antifungal susceptibility patterns, while promoting the routine use of molecular diagnostic methods for species identification. These efforts will facilitate the detection and monitoring of emerging species such as *Trichophyton indotineae* and provide essential evidence for the development of appropriate prevention measures and treatment strategies.

THESIS-RELATED PUBLICATIONS

1. Epidemiological characteristics and associated factors of dermatophytosis among patients at Can Tho University of Medicine and Pharmacy Hospital
Nguyen Thi Thao Linh, Tran Quang Phuc, Le Tran Anh, Phan Hoang Dat, Huynh Gia Bao
Journal of Community Medicine, 67, 2026, Special Issue 4, pages190 – 195.

2. Some clinical features of dermatophytosis at Can Tho University of Medicine and Pharmacy Hospital
Nguyen Thi Thao Linh, Tran Quang Phuc, Le Tran Anh, Phan Hoang Dat, Huynh Gia Bao
Journal of Community Medicine, 67, 2026, Special Issue 4, pages 209 – 213.

3. Antifungal susceptibility of dermatophytes isolates from patients at Can Tho University of Medicine and Pharmacy Hospital
Nguyen Thi Thao Linh, Tran Quang Phuc, Le Tran Anh, Phan Hoang Dat, Trinh Thi Hong Cua
Journal of Community Medicine, 67, 2026, Special Issue 2026.