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Increasing incidence of *Trichophyton tonsurans* in Munich—A single-centre observation

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Abstract

Background: *Tinea capitis* and *tinea corporis* are highly prevalent fungal skin infections, which globally are mainly caused by *Microsporum canis* and *Trichophyton rubrum*, respectively. While in the United States and Great Britain *Trichophyton tonsurans* is widely prevalent as a causative pathogen, it so far only plays a minor role in Germany.

Objectives: Since the frequency of pathogenic species varies regionally and temporally, this study assesses the proportion of *Trichophyton tonsurans* infections in the dermatology department of a large university hospital in Germany from 2019 to 2022 and thoroughly characterises the affected patient population.

Patients/Methods: This retrospective study at the Technical University of Munich analyses mycological culture results regarding the identified dermatophyte and infection site. Detailed patient and disease-related information on *Trichophyton tonsurans* positive patients was obtained.

Results: In 2022, 23 patients of 111 dermatophyte culture-positive patients tested positive for *Trichophyton tonsurans*. This accounted for 20.7% and represented a tenfold increase from 2.1% in 2019. Contact sports were only practiced by 21.7% of patients, and no common hotspot or other linkage could be identified between the cases. Additionally, 47.8% of the patients received a systemic treatment, with 30.4% visiting the clinic more than three times. In 2022, 21.7% were diagnosed with a simultaneous infection of the capillitium and body, whereas this was only observed in 7.1% of cases in 2019 to 2021.

Conclusions: This study suggests an increase of *Trichophyton tonsurans* infections via several routes of transmission.

KEYWORDS
dermatophytes, fungal skin infections, Germany, *tinea capitis*, *tinea corporis*, *Trichophyton tonsurans*

1 | INTRODUCTION

Tinea corporis and *tinea capitis* represent highly prevalent fungal skin infections, accounting for 18.7% of all dermatophytoses in Germany.[1] They not only significantly reduce patient quality of life while negatively influencing their emotions and personal relationships,[2] but also can have a far-reaching health, social and economic impact on a given population. For example, an estimated €380,500 ($388,000) in damages was caused by a single *Microsporum* (*M.*) *audouinii* outbreak in Munich in 2011 in which 20 individuals and several public schools and kindergartens were involved.[3]

On a global and European scale, *tinea capitis* is most often caused by the zoophilic dermatophyte *M. canis*,[4,5] while anthropophilic *Trichophyton* (*T.*) *rubrum* and *M. canis* are the dominant species involved in *tinea corporis*.[6–12] In Germany, *M. canis*, *T. mentagrophytes* and *T. benhamiae* are the three most frequent pathogens in *tinea capitis*. *T. rubrum* accounts for 70% of all *tinea corporis* cases, followed by *T. benhamiae* and *T. interdigitale*.[1]

Due to immigration patterns, globalisation, socioeconomic conditions and changes in lifestyle, the prevalence and transmission patterns of causative fungal species are changing constantly.[4–6] For example, Ziegler et al. revealed an absolute rise from 8 to 11 different fungus species in *tinea capitis* in Germany from 1990 to 2014.[13] Additionally, Kupsch et al. described a new genotype of zoophilic *T. mentagrophytes*, which is primarily transmitted via sexual contact and not via animals.[14]

T. tonsurans, another causative fungal species of *tinea capitis* and *tinea corporis*, is distributed worldwide[6] but has been observed to be particularly widespread in Great Britain[4,15] and the United States.[16–18] Foster et al. demonstrated that 95% of *tinea capitis* cases in the United States are caused by *T. tonsurans*.[16] *T. tonsurans* is known for being the leading pathogen of *tinea gladiatorum*, a fungal skin infection that occurs among martial arts athletes through close body contact or shared sporting equipment like training mats.[19,20] It has also been linked to outbreaks in other areas with social interaction, like kindergartens, schools and workplaces.[21–24] In Germany, however, *T. tonsurans* has thus far only played a minor role in *tinea corporis* and *tinea capitis*,[1,13] with only a few local outbreaks being described.[25–28]

This study aims to determine the proportion of *T. tonsurans* culture-positive patients relative to all dermatophyte culture-positive patients in the dermatology department of a large university hospital in Germany from 2019 to 2022. Furthermore, the affected patient population and disease patterns are thoroughly characterised.

2 | MATERIALS AND METHODS

2.1 | Clinical data

This study identified all patients who tested culture-positive for *T. tonsurans* at the Department of Dermatology and Allergy of the Technical University of Munich from 1 January to 31 May of the years 2019 to 2022.

The absolute number of recorded *T. tonsurans* culture-positive patients was compared to the clinic's total number of dermatophyte culture-positive patients, patients with mycological laboratory diagnostics, and patients with a culture-positive *tinea capitis* and/or *tinea corporis*. Furthermore, the dermatophyte distribution of culture-positive *tinea capitis* and *tinea corporis* patients was assessed by comparing causative agents from 2019 to 2021 with those from 2022.

Only information that was obtained during routine patient visits was used. The analysed data included date of birth, age, gender, place of residence, assumed source of infection (workplace/school/kindergarten, hairdresser/barber, recent travels abroad, sports/membership in a sports club or other activities involving close body contact), number of infected contact persons, previous infections with *T. tonsurans*, clinical diagnosis, skin findings and prescribed treatment. To identify possible geographical correlations, patient places of residence and other routinely visited places were marked on a city map.

Tinea capitis was defined as involvement of the scalp, eyebrows or beard. Infection of the trunk, limbs, face or inguinal region was classified as *tinea corporis*. As this study was conducted according to Bavarian state law (Bavarian Hospital Act/Bayerisches Krankenhausgesetz, Art. 27 paragraph 4), informed consent was not necessary.

2.2 | Statistical analyses

Epidemiological data were analysed using simple descriptive statistics including mean, standard deviation (SD), absolute numbers and proportions.

3 | RESULTS

3.1 | Proportion of *T. tonsurans* cases throughout the years

A total of 23 patients were identified as culture-positive for *T. tonsurans* between January and May 2022. This accounted for 20.7% of all dermatophyte culture-positive patients during the analysed time frame. In 2019, 2020 and 2021, the proportion of *T. tonsurans* culture-positive patients amounted to 2.1%, 3.7% and 6.0%. Thus, the number of *T. tonsurans* culture-positive patients relative to the total number of dermatophyte culture-positive patients increased tenfold (Table 1). An equal result was seen when *T. tonsurans* culture-positive patients were compared to the total number of patients with mycological laboratory diagnostics (Table S1). The percentage of *T. tonsurans* culture-positive patients relative to the total number of *tinea capitis* and/or *tinea corporis* culture-positive patients rose from 8.7% in 2019 to 46.9% in 2022 (Table S1).

Regarding the distribution of causative agents, *T. tonsurans* accounted for 33.3% of all culture-positive *tinea capitis* patients from

2019 to 2021, while this number rose to 68.8% in 2022. Among *tinea corporis* patients, the proportion of *T. tonsurans* increased from 10.3% in 2019 to 2021 to 44.7% in 2022 (Figure 1).

3.2 | Patient characteristics

Overall, 18 of the 23 patients (78.3%) who tested positive for *T. tonsurans* in 2022 were male. The mean age was 21 ± 11 years. All 23 patients showed clinical signs of a *T. tonsurans* infection and had been infected for the first time.

The study population comprised two families with three family members each. There was no social or geographical relation between the two families and the other seventeen patients.

All patients were residents of different neighbourhoods in and around Munich, with 39.1% living in the zip code area 80xxx, 43.5% in 81xxx, 4.3% in 83xxx and 13.0% in 85xxx. Concerning other places patients routinely visited such as workplaces, hairdressers and gyms, no distinct clusters were observed (Table 2).

Regarding possible places of transmission, 5 patients (21.7%) assumed they had infected themselves with *T. tonsurans* while doing contact sports. Among those, 4 patients (17.4%) did martial arts, and

TABLE 1 Number of *T. tonsurans* culture-positive patients relative to the total number of dermatophyte culture-positive patients from January to May of the years 2019 to 2022

	2019	2020	2021	2022
T. tonsurans culture-positive patients, *n*	2	4	8	23
Dermatophyte culture-positive patients, *n*	94	109	133	111
Proportion of *T. tonsurans* culture-positive patients among the total number of dermatophyte culture-positive patients	2.1%	3.7%	6.0%	20.7%

Abbreviation: n, number.

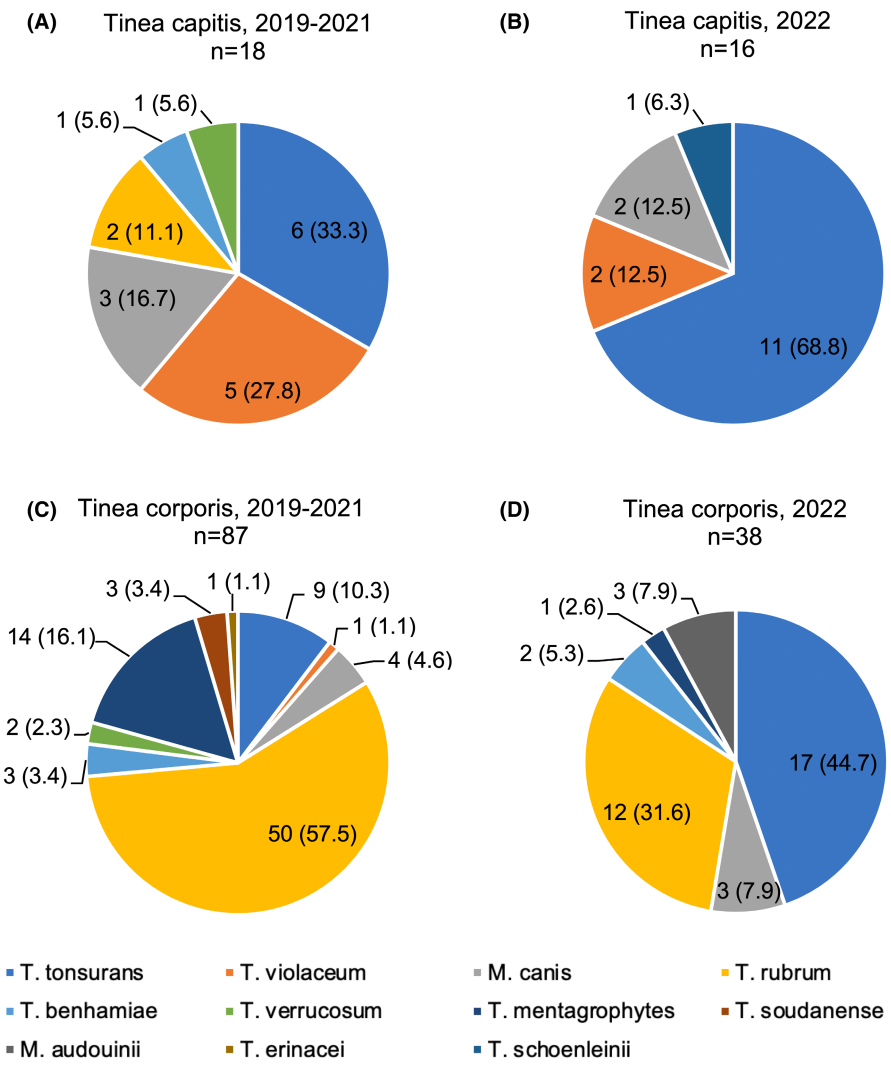

FIGURE 1 Causative agent distribution of *tinea capitis* and *tinea corporis*. The dermatophyte distribution of culture-positive *tinea capitis* and *tinea corporis* patients from January to May of 2019 to 2021 (A and C) and of 2022 (B and D) was assessed. *n*, total number; absolute numbers and percentages in brackets.

1 patient (4.3%) was part of a hip hop dance group. A total of 17.4% (4/23) of patients suspected that they were infected during a visit to the hairdresser or barber. In one of those cases, the hairdresser also noticed the fungal infection of the patient. Apart from contact sports and hairdressers/barbers, patients also named kindergartens (8.7%), family members (8.7%) and sexual partners (4.3%) as relevant sources of infection. In 9 of 23 patients (39.1%), the source of infection remained unknown. Overall, 22 of the 23 patients (95.7%) infected themselves in Munich, Germany (Table 2).

Concerning treatment modalities, 47.8% (11/23) received topical and systemic treatment, whereas 52.2% (12/23) only received topical treatment. In all cases, topical antifungal therapy consisted of 1% ciclopirox olamine cream. Furthermore, 3 of the 11 patients suffering from *tinea capitis* were treated additionally with 2% ketoconazole shampoo. For systemic treatments, 6 out of 11 patients (54.5%) received terbinafine, 5 out of 11 (45.5%) itraconazole and 1 out of 11 (9.1%) fluconazole. One patient received terbinafine and subsequently itraconazole therapy. Overall, 30.4% (7/23) had three or more appointments at the outpatient clinic due to the *T. tonsurans* infection.

TABLE 2 Patients tested culture-positive for *T. tonsurans* from January to May 2022 (SD = Standard deviation)

Characteristic	*n* (%)
Total population	23 (100)
Demographics	
Male gender	18 (78.3)
Age in years, mean ± SD	21 ± 11
Place of residence (zip code)	
80xxx	9 (39.1)
81xxx	10 (43.5)
83xxx	1 (4.3)
85xxx	3 (13.0)
Assumed source of infection	
Contact sport	5 (21.7)
Martial arts	4 (17.4)
Dance group	1 (4.3)
Hairdresser/Barber	4 (17.4)
Family member	2 (8.7)
Kindergarten	2 (8.7)
Sexual partner	1 (4.3)
Unknown	9 (39.1)
Therapy	
Systemic therapy	11 (47.8)
≥3 clinic visits	7 (30.4)
Infection of contact persons	
Yes	7 (30.4)
≥3 persons	2 (8.7)
No	14 (60.9)
Not known	2 (8.7)

Abbreviation: n, number.

Seven patients (30.4%) reported having transmitted the infection to another person. Among those, two patients (8.7%) infected three or more people. All infected contact persons were family members of the seven index patients, with four participating in this study (Table 2).

3.3 | Infection patterns

A total of 37 patients tested culture-positive for *T. tonsurans* from 2019 to 2022 in the months of January to May.

Age and gender distributions were similar in all four analysed five-month time frames. In 2019 and 2021, all identified patients were male. In 2020 and 2022, approximately three-quarters of the patients were male. Of all cases analysed between 2019 and 2022, only 1 patient was older than 40 years.

Concerning the involved body areas, patients were infected on the scalp, eyebrows, beard, trunk, limbs, face and inguinal region. No cases had *T. tonsurans* affecting the fingernails, toenails or feet.

In 2022, 5 of the 23 patients (21.7%) suffered simultaneously from *tinea capitis* and *tinea corporis*, whereas in 2019 and 2020 no patients and in 2021 only 1 patient (7.1%; 1/14) had an involvement of the scalp and body simultaneously (Table 3).

4 | DISCUSSION

The aim of this study was to assess the proportion of fungal infections caused by *T. tonsurans* and to characterise the affected patient population. In 2022, the proportion of affected patients accounted 20.7% of all dermatophyte culture-positive patients, representing a 10-fold increase from 2.1% in 2019. Of the patients affected in 2022, only a limited number practiced contact sports, and no common hotspots or other commonalities could be identified between cases. Nearly half of all patients received a systemic treatment, and almost a third needed several medical consultations. A total of 30.4% infected contact persons. Comparing cases from 2019 to 2022 showed an increasing share of patients who were diagnosed simultaneously with *tinea corporis* and *tinea capitis*.

Kromer et al. reported that *T. tonsurans* accounted for approximately 0.5% of all dermatophyte cultures in a multicenter study in Germany from 2014 to 2016.[1] In the here presented study, the still relatively low rate of 2.1% in 2019 increased to 20.7% in 2022, thereby suggesting an increase of *T. tonsurans*-mediated fungal skin infections.

Clusters of *T. tonsurans* cases have been investigated in Germany since 2000. Two studies described frequent occurrences of *T. tonsurans* among German children and adolescents in wrestling programs,[25,26] and one study reported an outbreak in a German kindergarten.[27] A different study hypothesised that elevated numbers of *T. tonsurans* positive patients were due to contaminated hairdressing tools in German barber shops.[28] In all four studies, the reported locally increased number of *T. tonsurans* cases could be attributed to a single source, but this did not indicate a general increase in *T. tonsurans* infections.

TABLE 3 Patients infected with *T. tonsurans* from January to May of the years 2019 to 2022 (SD = Standard deviation)

Characteristic	2019, *n* (%)	2020, *n* (%)	2021, *n* (%)	2022, *n* (%)
Total population	2 (100)	4 (100)	8 (100)	23 (100)
Gender				
Male	2 (100)	3 (75.0)	8 (100)	18 (78.3)
Age (in years)				
Mean age ± SD	24 ± 23	18 ± 16	19 ± 7	21 ± 11
0–20	1 (50.0)	2 (50.0)	5 (62.5)	11 (47.8)
21–40	1 (50.0)	2 (50.0)	3 (37.5)	11 (47.8)
>40	0	0	0	1 (4.3)
Diagnosis				
Tinea capitis[a]	0	3 (75.0)	2 (25.0)	6 (26.1)
Tinea corporis/faciei[b]	2 (100)	1 (25.0)	5 (62.5)	12 (52.2)
Tinea capitis + *Tinea corporis/faciei*	0	0	1 (12.5)	5 (21.7)
Tinea pedis/unguium	0	0	0	0

Abbreviation: n, number.

[a]*Tinea capitis* includes hairy scalp, eyebrows, beard.

[b]*Tinea corporis/faciei* includes trunk, limbs, face, inguinal region.

The fact that the patients presented here lived in different neighbourhoods with no geographical or social link between them indicates that the observed increased number of *T. tonsurans* infections is most likely independently acquired.

A number of studies have shown that *T. tonsurans* is widely distributed in contact sports, particularly martial arts.[19,26,29–33] However, in this study only 4 of 23 patients practiced martial arts and only 1 person practiced another contact sport. The data therefore highlight that *T. tonsurans* is not limited to outbreaks in contact sports but more widely distributed in the general population.

Overall, *T. tonsurans* infections are considered to primarily cause mild inflammatory symptoms.[34–36] In 47.8% of the cases presented here, local treatment of the *T. tonsurans* infection was not sufficient and patients required systemic antifungals. A considerable number of patients (30.4%) had three or more appointments at the outpatient clinic, suggesting that they had long-lasting symptoms and/or a poor treatment response. Moreover, the proportion of patients suffering from *tinea corporis* and *tinea capitis* simultaneously was higher in 2022 than in the previous 3 years. These results indicate that *T. tonsurans* may increasingly cause more severe infections that may be more difficult to treat and involve multiple predilection sites.

Regarding transmission, dermatophytes have been found to lead to family member infections with a probability of 20%.[37] Here, the observed transmission rate of 30.4% among close contact persons of patients and the fact that 8.7% of patients infected as many as three or more persons underline the high infectious potential of *T. tonsurans*.

A main limitation of the study is that it was only conducted at a single university hospital in Munich with a relatively low total number of patients. Consequently, this study alone does not provide evidence for an increased incidence of *T. tonsurans* cases on a larger scale. Furthermore, a selection bias could be present. German university hospitals are intended for the care of complex diseases,[38] with more severely affected and harder-to-treat patients potentially being preselected. However, this bias was also present in the years 2019 through 2021, in which no increase of cases could be observed. A third limitation is that some data like assumed infection sites or infection of third parties were only patient-reported. Patients may have adapted their answers according to the social-desirability bias. Nevertheless, key findings of this study were assessed objectively.

5 | CONCLUSION

In summary, this study suggests a rapidly increasing incidence of *T. tonsurans* infections via different routes of transmission. *T. tonsurans* is no longer restricted to outbreaks in contact sports, is highly contagious and can cause more severe infections than previously believed. Consequently, increasing awareness of *T. tonsurans* among health professionals and the general public is essential for controlling and preventing the spread of this emerging anthropophilic fungus. Multicenter studies are needed to evaluate whether this trend can also be observed in other parts of Germany.

AUTHOR CONTRIBUTION

JFP, AZ and ACP involved in conceptualization. JFP and MK involved in data curation and formal analysis. AZ and TB involved in funding acquisition/resources. JFP, PS and ACP involved in investigation. JFP, AK, AZ and ACP involved in methodology. JFP, AZ, TB and ACP involved in project administration. AZ, TB and ACP involved in supervision. JFP, AK and ACP involved in visualisation. JFP, MK, AK, AZ and ACP involved in writing—original draft preparation. JFP and PS involved in writing—review and editing.

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CONFLICT OF INTEREST

ACP, TB, AZ, PS, AK, JFP and MK have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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