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Outbreak of *Microsporum audouinii* in Munich – the return of infectious fungi in Germany

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Summary

After experiencing an unusually high number of *Microsporum* (*M.*) *audouinii* infections at our hospital within only a few weeks, we began to investigate and control an outbreak in Munich, Germany. Main goals of our health management were to treat infected persons, identify extent and form of transmission and to prevent new infections. We analysed data from structured interviews with patients and mycological cultures of swabs taken of patients and investigated involved public facilities. Outbreak management included antifungal treatment of patients, decontamination of affected facilities, the introduction of a temporary kindergarten ban for *M. audouinii* positive children and the organisation of educational meetings. Between March and August 2011, 16 children and 4 adults were identified with *M. audouinii* infections. The fungus was brought to Munich by the index patients from a family vacation in Africa and then spread to fellow children in kindergarten and subsequently to their families. All patients were treated successfully and the epidemic was declared ceased after 40 weeks but causing considerable financial damage. Due to travelling and migration, *M. audouinii* infections will rise in Germany and Europe. Sufficient and sustainable strategies are needed for the management of future outbreaks of highly contagious fungi.

Key words: *Microsporum audouinii*, tinea, mycosis, fungi, outbreak control, economic damage, public health.

Introduction

Tinea capitis is worldwide one of the most common diseases in childhood¹ and it is the classic type of an infection with dermatophytes. Varying with geographical location and environmental factors, *Trichophyton* (*T.*) *tonsurans*, *T. mentagrophytes*, *T. soudanese*, *T. violaceum* and *Microsporum* (*M.*) *canis* are today's

most common causative agents.^{2–5} In Germany, the distribution of dermatophytes isolated from skin lesions has changed significantly in the last 100 years. In the first part of the 20th century, the anthropophilic and highly contagious dermatophyte *M. audouinii* dominated among human pathogenetic dermatophytes, but continuously disappeared in the following decades after the introduction of the systemic antifungal drug griseofulvin in 1958. It was considered practically eradicated after 1975 and today is replaced by *M. canis* and *T. mentagrophytes* as the two most prevalent dermatophytes in tinea capitis.^{2–5} In recent years, a growing number of published cases of tinea capitis caused by *M. audouinii*, especially in kindergarten and school children in European countries indicates the revival of *M. audouinii* in Europe.^{5–8}

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Kindergarten and school settings provide an optimum environment for dermatophyte transmission due to high rates of social interaction and shared household goods, toys, and so on, which in susceptible populations can trigger an outbreak. We describe the investigation of an outbreak of *M. audouinii* involving 16 kindergarten and school children and 4 adults in Munich, Germany along with successful infection-control measures and explore potential options for the prevention of future epidemics with *M. audouinii* or other dermatophytes.

Methods

Index patients

In March 2011, two children, 6 and 7 years old, were admitted to our outpatient clinic with a scaly erythematous rash on their heads. When scraping from the rash was examined, *M. audouinii* could be isolated and the children were medically treated. A few weeks later, we isolated *M. audouinii* in four more children between 3 and 10 years old presenting with the same clinical findings as the children in March. Usually, the average number of infections with *M. audouinii* in Munich, a city with 1.4 Million inhabitants, is one or two cases per year.⁹ On the basis of the conspicuously high number of six *M. audouinii* infections seen within only a few weeks, we began to investigate the outbreak.

Epidemiological investigation

After reporting the unusually frequent cases to the Munich City Department of Health and Environment according to the German *Infection Protection Act*, we interviewed all patients together with their families. The information we collected included date of birth, age, gender, race, address of residence, address of kindergarten or school as well as recent travels abroad. We analysed the data obtained for similarities and differences between the index patients and marked the addresses of residences and kindergartens of affected individuals on a city map. These simple steps made obvious that all children were living within one area of Munich and were attending two different kindergartens and one school.

We informed the Munich City Department of Health and Environment and they issued a legal notification requirement for every person with positive *M. audouinii* culture as well as the requirement of a medical certificate for every child attending one of the affected kindergartens: all children had to consult a dermatologist

for further evaluation of a potential infection with *M. audouinii*. If the children were positive for *M. audouinii*, children were not allowed to go to kindergarten until three consecutive mycological culture swabs became negative after treatment. In the case of an unremarkable clinical examination without signs for tinea and a negative *M. audouinii* culture, a medical certificate was handed out that the respective child could regularly go back to kindergarten.

Together with officials of the Munich City Department of Health and Environment, we also made a site visit to inspect the affected kindergartens for potential ways of transmission or potential sources of infection. Furniture was carefully checked, curtains, toys including stuffed animals, plants and different other objects on-site were accurately examined. Educational meetings for parents and nurses were organised to bring awareness of dermatophytes, ways of transmission, treatment options and prevention strategies.

Specimen collection

After full clinical examination, we used sterile, soft-headed toothbrushes¹⁰ to massage over conspicuous lesions as well as the entire scalp of all persons to obtain fungal elements for plating onto solid culture medium (Oxoid Dermasel Agar with chloramphenicol and cycloheximide [Oxoid Germany]). Plates were maintained at 25 °C for 3 weeks and evaluated twice after the second and third week considering the known slow growth of *M. audouinii*. Positive culture was used to define the necessity for medical treatment of *M. audouinii*, irrespective of whether the patient had clinical signs or did not show any lesions ('asymptomatic carrier')^{3,6}. In addition, we collected mycological swabs of toys, mattresses used by children for afternoon naps, curtains and other furnitures with the same technique during our inspection of the affected kindergartens.

Microsporum audouinii was identified in accordance with the literature¹¹ by its characteristic fast-growing colony with radiating margins while the reverse was salmon-rose in colour, developing after 3 days and spreading tannish-white colonies. Racket mycelium and terminal chlamydospores were present, the typical spindle-shaped macroconidia with constriction near the middle were very rare to absent.

Medical treatment and infection control measures

Persons with clinical signs of an infection with *M. audouinii* and persons with a positive *M. audouinii* culture

were treated systemically with Itraconazole and locally with Ciclopirox olamine cream twice daily and Ciclopirox shampoo once daily. Adults received 200 mg Itraconazole per day, children 5 mg per kg body weight and infants 10 mg Griseofulvin per kg body weight under careful surveillance of potential adverse effects until culture negativity of *M. audouinii*.^{12–14} Children with a positive *M. audouinii* culture were not allowed to go to kindergarten until three specimen collections were negative as proof of a successful treatment. In addition, all family members of a patient were advised to use Ciclopiroxolamine shampoo once daily as a prophylactic measure. Further infection control measures included a professional antifungal decontamination of the kindergartens during temporary closure.

Simple descriptive statistics (mean, standard deviation) were used to analyse the demographic and geographic characteristics of the outbreak and the costs incurred were estimated in Euros (US \$) for prescribed medication, decontamination of kindergartens and economic damage.

Results

Epidemiological investigation

In this outbreak of *M. audouinii* infections in Munich, a total of 20 cases were identified and treated between March and December 2011. Affected were members of 12 families with 1 infant (2 months old), 11 kindergarten children between the age of 1 and 6 years, 4 school children between 7 and 10 years and 4 adults with an age range from 30 years to 62 years. All children went to two different kindergartens and two different schools. Of 20 patients, 9 were of African origin and 11 Caucasian. About 15 patients lived within the zip code area 809xx in the North of Munich, four patients within the zip code area 817xx in the East of Munich and one patient within the zip code 821xx bordering Munich (Table 1).

Among these, 13 of 20 patients (1 infant, 7 kindergarten children, 2 school children and 3 adults) had an infection of the scalp with 8 patients showing only discrete erythema and scaling, 3 patients showed alopecia and 2 patients were without any clinical signs. Here 7 of 20 patients (4 kindergarten children, 2 school children and 1 adult) had scaling erythema on different body parts other than the scalp, for example, on extremities. Considering that all family members (34 people) of the 20 patients with *M. audouinii* infection were asked to use Ciclopirox shampoo prophylactically, a total of 54 people were treated. The detailed

Table 1 Population infected with *Microsporium audouinii*.

Characteristics	n (%)
Total population	20 (100%)
Gender	
Male	13 (65%)
Female	7 (35%)
Age	
Infant (<1 year)	1 (5%)
Kindergarten (1–6 years)	11 (55%)
School (7–10 years)	4 (20%)
Adult (>18 years)	4 (20%)
Race	
Caucasian	11 (55%)
African origin	9 (45%)
Zip code (first three digits)	
809xx	15 (75%)
816xx	4 (20%)
821xx	1 (5%)

interrogation of all patients and their families revealed that the index family had travelled to Mozambique, Africa before the clinical symptoms developed. All families lived in two neighbourhoods and their children went to two schools and two kindergartens close to the families' homes.

Swabs collected during our inspection of the kindergartens showed *M. audouinii* on a curtain, a mattress and one blanket, both used by children during nap times.

Three of the four adults were parents of kindergarten or school children and most likely became infected by their kids. For the fourth adult, a 62-year-old lady, with infection of *M. audouinii*, we could not find any connections, geographically or socially, to the kindergartens or affected families. Probably, she was diagnosed at the same time of the epidemic with an *M. audouinii* infection just by chance.

Time period

The time until culture negativity was reached, defined as three consecutively collected swabs without growth of *M. audouinii*, was between 7 and 23 weeks (mean 14.4 ± 4.7 weeks) of topical and systemic treatment with antifungal drugs for every individual. According to the postulated regulations of Munich's Department for Health and Environment, the children were not allowed to go to kindergarten/school during this time. At an age between 2 months and 10 years, they had to be supervised at home by a parent, relative or babysitter which in some cases led to family problems, e.g. the parents' loss of

working hours and income or additional costs for hiring a babysitter.

All together, it took 40 weeks from the first presentation of the index patients in March until the last patient with three negative *M. audouinii* cultures after successful treatment in December of the same year to combat the epidemic.

Financial burden

As described above, Itraconazole was used for children and adults and Griseofulvin for one infant as the systemic treatment. With a price of 4.3€ (\$5.7) for the daily dose of 200 mg itraconazole for adults and about 10.5€ (\$14) for the daily treatment of children, the cost of systemic treatment for 14.4 weeks (average) for the 4 adults can be calculated as 1700€ (\$2,000) and the cost for the 16 children as 17 000€ (\$22 000). In addition, the daily treatment of 54 people with Ciclopirox shampoo was about 9700€ (\$12 500) and the topical treatment with Ciclopirox olamin cream for body lesions of 7 of 20 people with tinea corporis about 1100€ (\$1500) for the average of 14.4 weeks.¹⁵

Summing up the costs for systemic and topical treatment as well as prophylactic treatment of family members, the expenses for medication were about 29 500€ (\$39 000). The total amount charged for professional decontamination of the kindergartens was 40 000€ (\$53 000).

Not yet mentioned is the amount for financing dermatologists and nurses involved in clinical examination and treatment, the cost for laboratory supplies as well as an estimation of the economic damage for the employers of the family members, who had to stay at home. Germany's *Federal Institute for Occupational Safety and Health* specifies that every day an average person in Germany misses work due to any reason costs about 270€ (\$350).¹⁶ Expecting, that 16 children with *M. audouinii* were supervised by one parent on 5 working days per week during the average 14.4 weeks, a total of 311 000€ (407 000\$) was 'lost' (Table 2).

Table 2 Financial burden of the *Microsporum audouinii* outbreak (estimated).

	Amount in € (US\$)
Prescription medication	29 500€ (39 000\$)
Decontamination of kindergarten	40 000€ (53 000\$)
Economic damage	311 000€ (407 000\$)
Total	380 500€ (499 000\$)

Discussion

We present the findings of an extensive epidemiological and laboratory investigation of a *Microsporum audouinii* outbreak in kindergartens and elementary schools in Munich, Germany along with successful treatment options and combat methods. To the best of our knowledge, this is the first epidemiologically investigated outbreak of *M. audouinii* in Germany, since 1990.¹⁷

The index family reported travelling to different countries in Africa, where they originally come from, for vacation and family visits (grandparents, relatives). *M. audouinii* is endemic in many African countries and has been reported to affect up to 30% of school children.^{18–21} Several studies have also shown *M. audouinii* emerging in urban immigrants of African origin in Europe, Australia and USA.^{5,7,8,22} Reasons are not fully understood, although a lower hygienic environment is assumed and a higher susceptibility of Africans due to a genetic basis as well as of kids due to prepubertal biochemical differences is discussed.^{8,23} Nevertheless, it is obvious that especially smaller children (travelling or at home in kindergarten) have a higher risk for infection due to the usually close body contact, e.g. when playing with each other. The index family explained that their children had close contact to many local children in Africa, some with noticeable hairless and scaling areas on their scalp.

Similar to other studies, which described a transfer of *M. audouinii* by immigrants or travellers on vacation in countries endemic for the dermatophyte to Western countries^{3,5–8,24–26} our index patients therefore brought *M. audouinii* to Munich. Further transmission then occurred in kindergartens and later by older siblings of newly infected children to schools. Next to the human-to-human transmission of *M. audouinii*, an infection through infected objects has to be taken into account. Swabs collected at kindergartens, for example, showed a contamination of blankets and curtains with *M. audouinii*. The blankets were used by most children during nap times without being washed regularly and therefore could have acted as a potential source of infection. More interestingly was the contamination of curtains with *M. audouinii*. Generally being a low potential source of infections on first sight, meticulously observations and interrogations found that the children enjoyed curling up in the curtains as a daily self-invented game, turning the curtains into a high potential source of infections. Highly interesting for future studies and for confirming our shown transmissions would be the genetic analysis of different *M. audouinii* swabs regarding strain commonalities.

Oral treatment of tinea capitis is well reviewed.^{27–29} Fewer reports are published on the management specifically of *M. audouinii* infections.^{6,30} Griseofulvin is still the treatment of choice against *Microsporum*, and it is the only systemic antifungal substance allowed for children in Germany. We were, however, strongly confronted with extending irrational fears among parents concerning reported side effects of griseofulvin by the package insert. By reason of compliance and preferring for children a liquid pharmaceutical form, we decided on itraconazole, since fluconazole is not recommended by the European Medicines Agency (EMA) for treatment of tinea capitis.³¹

In general, all persons with a positive culture of *M. audouinii* in the Munich epidemic could be successfully treated with the therapeutic approach used. But due to the very slow growth of *M. audouinii*, which allows an interval of taking control swabs of lesions during treatment only every 2 weeks, a successful treatment requires maximum compliance over a long period of time by affected persons and their families. Naturally, the requirements were not met by every patient, which explains our desperate and disappointing treatment period of one family over a total of 23 weeks. Unfortunately, there are not yet enough studies focusing on the treatment of *M. audouinii*. Until today, it is not exactly known, how long an infection with *M. audouinii* has to be treated and if there is a point during treatment, when contagiousness stops. Concerning potential future epidemics with a higher number of patients and thus a probable higher public interest, it supposably will become more and more difficult to account for the absence of people at their jobs, schools or kindergartens due to the medical treatment of a disease, which is not seen as very dramatic by the general public due to ignorance and the usually good general state of health of individuals infected with *M. audouinii*. As a result, accusations challenging the treatment approaches will be brought in and doctors and city officials potentially sued for damages. Quicker, time saving and affordable diagnostic tools as well as possible new treatment options could help to solve this issue. The above-mentioned striking costs incurred in our epidemic with only 20 patients underline the necessity of new options.

Families today not only travel within the country they live, but also to remote and more 'exotic' destinations, even with small children. According to the *Federal Statistical Office of Germany*, 3 million Germans, for example, travelled to Africa in the year 2012, this is a rising trend.³² At the same time, migration movements continue to rise due to job opportunities or

many other reasons. Nowadays, it is common for people from all over the world to work in different countries worldwide ('expatriates').³³ As a consequence, diseases spread much easier worldwide than they did 50 years ago. Most probably, we will see presumably 'disappeared' diseases again at increasing numbers. *M. audouinii*, playing a basically meaningless role in the last decades in Europe and Germany, will likely become a growing public health problem in the next years along with other anthropophilic fungi and consequently should move back in focus.

Worth discussing are also alternative combat strategies as well as potential preventive approaches. Is it really necessary to keep children out of kindergarten or school until three consecutive swabs are negative for *M. audouinii* growth in order to avoid further outbreak? To the best of our knowledge, until today the contagious index of *M. audouinii*, especially during topical and systemic treatment, can only, if at all, roughly be estimated. So although the decision of Munich's City Department of Health and Environment, that three negative swabs are required, may seem overcautious at first sight, it is definitely the most certain combat method when looking solely at containing the epidemic. The cost-benefit analysis is questionable. An alternative model could be to keep infected children at home during the first week of treatment and then let them return to school/kindergarten under special conditions, e.g. not to participate in sports and physical education.^{34,35} Other considerable options could be the professional training of kindergarten workers and teachers to detect children with tinea at the earliest possible stage and contain further spread or the re-introduction of *M. audouinii* to the list of notifiable infectious diseases. Every mycological laboratory or medical staff detecting *M. audouinii* must report the case to the appropriate authorities, who could then in return induce combat strategies at the early stages.

Conclusions

Due to travelling and migrations, *Microsporum audouinii* infections will presumably rise within the next years not only in Germany, but generally in the Northern Hemisphere. Concerning the difficult and long-standing treatment of this highly contagious dermatophyte and the high financial burden of a possible epidemic, medical and public health interventions have to be adopted as soon as possible. For the prevention of recurrent outbreaks of *M. audouinii* and other anthropophilic dermatophytes, long-term surveillance and control are needed. This automatically demands

continuous monitoring and intervention efforts performed jointly by public health and healthcare systems with a multi-disciplinary team, including health and municipal officials, medical staff, specialised laboratories and many more. Future studies on *M. audouinii* are needed to develop sustainable public health strategies with convincing cost-benefit-analyses in the case of an outbreak of *M. audouinii*.

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Conflict of interest

None.

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