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*Fungal infections of skin as the epidemiological problem*

Cutaneous mycoses are regarded as a serious epidemiologic as well as therapeutic and social problem (6, 7, 8, 13, 14, 15). Mycoses are among the most common skin diseases and, what is more, in recent years their prevalence in general population has increased (1, 6, 7, 8). Epidemiological studies of the population living in the geographic zone of moderate climate showed the chronic fungal infections in 10–30% of the examined inhabitants (1, 6, 7, 8). Infections of skin and mucosa are caused by dermatophytes, yeast-like fungi and moulds. Dermatophytes, the most frequently found as the etiologic agents in cutaneous mycoses in humans, are always exogenous parasites, represented by 3 fungal genera: Trichophyton, Microsporum and Epidermophyton (1, 6, 7, 8). Yeast-like fungi, mostly *Candida albicans* may be endogenous organisms colonizing the mucosa and not pathogenic to healthy immunocompetent subjects (1, 5, 6, 8, 13). Candidosis usually affects oral mucosa, skin folds, nailfolds and nail plates (1, 6, 8, 13). Moulds can easily circulate with air, and ventilation systems and high amounts of them are found in the domestic dust and in areas where the decomposition of organic debris takes place (6, 7, 8, 11). Mould spores are also present on the animal or human skin and can easily develop skin infection when they meet suitable conditions for their growth (1, 6, 11). The most common moulds in the domestic environment are *Aspergillus*, *Penicillium*, *Scopulariopsis*, *Alternaria*, *Cladosporium* (6, 8, 11). Some of them are the etiologic agents in the tinea unguium (2, 3, 11, 15).

About 40 fungal species are regarded as potentially pathogenic organisms (1, 6, 7, 8). They are classified according to their natural environment into three groups: anthropophilic, zoophilic and geophilic fungi (1, 2, 4, 6, 7, 8, 13). Anthropophilic species cause infections transmitted from human to human skin. Zoophilic fungi are widespread among the pet/farmer/ wild animals and geophilic species come from soil. However, the ranges between the natural ecologic niches occupied by these parasites are not sharply separated. Pathogenic fungi can be easily transmitted directly from infected human to other humans in close vicinity and from domestic animals (mostly cats, dogs, guinea pigs, hamsters) to humans (1, 6, 7, 8, 13). What is more, there is also an indirect way of infection through a contact with the fungal spores deposited in carpets, mats, upholstered furniture, car upholstery (1, 2, 6, 7). On the other hand, fungi recognized as geophilic can contaminate the animal skin or vegetables and some wooden material. What is more, the infective material coming from the animal skin (for instance hair and desquamated epithelial cells) can survive a long time in soil (1, 6, 8). However, geophilic fungi are believed to be much less common as causes of disease in humans (1, 6, 8). A common biological feature of the fungal pathogens is their ability to use the keratinized epithelium of humans and animals (mostly mammals and birds). Enzymes released by dermatophytes enable them to decompose epidermal keratin and to invade the human or animal epidermis (5, 6, 8). A constant increase of the frequency of fungal infections observed through the world is connected with

the changing social and working conditions. Some forms of the life style encourage the development of dermatophytoses. Living in hotels, boarding-schools, fitness and sport centers and using the common sanitary equipments, bathrooms, showers, pools directly causes the high risk of infections with dermatophytes (1, 6, 7, 8, 9). High prevalence of skin mycoses is also connected with using clothing and occlusive shoes made from synthetic fabric (1, 7, 15). Although morbidity is observed in both sexes and at various age, there are recognized some subpopulations with increased or cumulated risk factors, e.g. soldiers, sportsmen, miners, pupils/students living in boarding schools and student's homes, some professional workers exposed to contact with fungal pathogens (1, 6, 7, 8, 15).

The majority of skin mycoses can be geographically or endemically related. Anthropophilic tineas caused by infectious fungi transmitted among the humans can be readily spread through the migrations and intercontinental travels. This phenomenon, increasing during the last decades, leads to blurring the geographical differences in distribution of the dermatophyte species of the *Microsporum* or *Trichophyton* genera. Some species believed as unusual or exotic in the European or North American countries have been isolated and identified last years, for instance: *T. soudanense* (coming from Africa), *T. schoenleini* (Mediterranean/East Europe), *T. violaceum* (Africa, Near East), *T. concentricum* (South-East Asia), *T. ferrugineum* (East Asia), *T. nanum* (Cuba), *T. megninii* (Mediterranean) (1, 6, 8, 9). These species, previously limited to certain geographic areas, can now be identified from skin lesions elsewhere (6, 8, 9).

Clinical symptoms of skin mycoses are influenced by many factors, the most important of them being the efficacy of host immune response and other biological properties and virulence of fungal species invading skin structures (5). Dermatophytes do not possess the ability to penetrate deeply into the live tissue of the immunocompetent host, they can invade only dead keratinized epidermal layers (5). Nevertheless, the fungal invasion can induce the reaction of the host, which varies from moderate to intense (5). It has been found that enzymes produced by dermatophytes are not only important invasive agents but they also contribute to the development of skin inflammatory response (5). Among these enzymes, alkaline phosphatase, leucine esterase and arylase seem to be especially important both for the parasitic growth of fungi and cutaneous inflammation (5). A very intense inflammatory response is observed in skin mycoses caused by zoophilic species when the mild chronic skin reaction is characteristic of the anthropophilic fungi infection (1, 6, 8). Some patients can be infected by dermatophytes without development of local inflammatory skin lesions. In these cases known as tinea incognita, the most frequently inflammatory reaction of skin is modified and suppressed by using the local or systemic corticosteroids (6, 8).

Anti-fungal defence depends on the efficiency of innate and acquired immune mechanisms (5, 8). Both cellular and humoral immunity take part in the complex response to fungal infection (5, 6). Involvement of the cellular type immune response has been indirectly proved by the high prevalence of mycoses in immunodeficient subjects, including HIV infected patients (5, 6, 8). Deficiency of the cellular immune response predisposes the host organism to develop the chronic phase of inflammatory reaction or encourage the recurrent invasion by dermatophytes (5). Local immune defence against dermatophytes depends on induction of the specific clones of T lymphocytes, antibodies production, activation of nonspecific answer: granulocyte and macrophage activation (5,8). It has been found that dermatophytes, due to their chemotactic ability, can activate the alternative pathway of complement activation (8). This biological activity has been demonstrated for *Trichophyton rubrum*, *Trichophyton mentagrophytes* and *Trichophyton violaceum* (8). Apart from this, some non-immunological forms of anti-fungal defence are observed (6). It has been showed that changes in the free acids composition of the scalp may produce relative resistance to anthropophilic *Microsporum audouini* after puberty (6).

The presence of microorganisms in the patients' environment directly influences their health conditions. Some domestic moulds are capable to produce extremely potent mycotoxins (11). Mycotoxins, being the lipid-soluble compounds, are readily absorbed by the intestinal mucosa, respiratory tract and skin and may induce a generalized allergic response (8, 11). Some fungal species can act as allergens provoking or worsening the course of allergic diseases or cause other non-allergic symptoms (11). It is well known that fungal spores play a major role in allergic diseases such as asthma, hay fever and hypersensitivity pneumonitis, in which they may cause serious systemic reactions (11).

Frequency of particular fungal species occurrence and prevalence of skin mycoses caused by them have been the objects of numerous studies. However, the obtained data can not be regarded as complete and need to be continuously actualized due to the dynamic character of the fungal flora existing within certain geographic areas (13). Quantitative changes in fungal pathogens are related to the changes in environment created by human beings (13). Epidemiological data indicate that the most frequently observed clinical forms of cutaneous mycoses are tinea pedis and tinea unguium (6, 14). Foot and nail mycoses create not only clinical problems but social, psychological and cosmetic ones as well. First of all, these patients are a chronic reservoir of pathogenic fungi that are the potential origin of fungal infection and fungal allergens for their environment (2, 3, 7, 14, 15). Apart from this, foot and nail mycoses cause anxiety or embarrassment of the affected patient and can unfavorably influence the quality of life (3, 14). Tinea pedis is believed as one of the most common human infections affecting men far more often than women but rarely found in children (6, 15). Coexistence of foot and nail mycoses are often observed because the risk factors for these forms of fungal infections are the same. Literature data indicate that the most frequent pathogenic agents in foot and nail mycoses are *Trichophyton rubrum* and *Trichophyton mentagrophytes* being about 80% of isolated fungal flora (1, 2, 3, 13, 15). Moulds are an acknowledged cause of about 5% of onychomycoses, and yeast-like fungi of about 10% of identified microorganisms (2, 3, 15). The combined infections of nail plates with both *Candida* and mould species are not infrequent (3). Onychomycosis is a very common disease of the nail plates. It has been estimated that fungal infections are about 50% of all nail disorders (3, 13, 14). The number of onychomycoses still increases in general population and nearly 80% are localized on toe nails, but especially on the first toe (1, 2, 14, 15). It has been proved that the toe nails are sevenfold more frequently involved than the finger nails (3). Advanced age of patients is a well known risk factor for dermatophyte nail infection. Epidemiological data indicate that the prevalence of onychomycosis as well as the resistance to antifungal treatment increases with the patient's age (7, 8, 14).

Among the skin mycoses, microsporiosis has its own special place due to its specific biological features. Microsporiosis is caused by zoophilic species *Microsporium canis*, which is easily transmitted from infected animals and humans (8, 10, 12, 13). It has been identified in 3% of all fungal infections of the skin (12). The main reservoir of this fungus are homeless cats, dogs or domestic and pet animals (10, 12, 13). From the epidemiological point of view, it is essential that the skin symptoms of microsporiosis are very slightly expressed in animals; thus, they are often overlooked by the veterinary service. Skin infection with *Microsporium canis* is observed mostly in children and adolescents before puberty, which is connected with the changes in fatty acid composition on the skin surface (10, 13, 15). Infection with *Microsporium canis* is widespread throughout the world and in some geographic regions they can be endemic (12). Endemics are noted especially among the inhabitants of the poor quarters of the overcrowded cities (8, 10, 12). Microsporiosis often spread among the subpopulations of school, kindergarten, families (1, 6, 8, 12, 13). In recent years, infection with *Microsporium canis* has much more frequently than before affected the adults, which was a phenomenon very rarely observed earlier (12). *Microsporium canis* is one of the species often isolated in the Central European countries, Greece, Brasil, Argentina and New Zealand (6, 8, 12).

In Poland, some small epidemic foci are periodically observed in children (2, 4, 10, 12, 13). 44 cases of microsporiosis has been diagnosed in the Kraków region in the years of 1993–1994 (10). The skin lesions observed in these patients were numerous both on the scalp and hairless skin. *Microsporum canis* has been identified as the most frequent fungal species in almost 40% of mycoses in children in the Gdańsk region (13). Similar data have been obtained by other studies carried out in Poland. It has been found that the age of 4-7 years is connected with the highest prevalence of skin mycoses in children (13). However, after the age of 7 year the frequency of microsporiosis dramatically decreases and about the age of 13 this fungal infection is only sporadically observed (13). In central Poland, *Microsporum canis* has been found as the second the most frequently isolated dermatophyte species proved as the causal agent in 15% of the all skin mycoses (12). Results of the epidemiological studies carried out in the Lower Silesia indicate that microsporiosis can be observed in this region of Poland (4, 12, 13).

Mycologic flora is different in various geographic areas and, moreover, is also changeable with time (1, 2, 6, 8, 15). Distinct differences are observed, especially due to the continual changes in the natural and human environment. These changes are connected with geographic, climatic conditions and degree of industrialization and development of agriculture (2, 4, 8). Moreover, there are changes within the reservoir of the pathogenic fungi existing in certain areas. In the early sixties zoophilic dermatophytes were the main infectious agents in skin mycoses diagnosed in humans in the most regions of Poland (2,4,13). From the beginning of the 1980's, there has been pronounced predominance of the antropophilic species observed in Poland (2, 4). Among the fungal species, antropophilic *Trichophyton rubrum* has been commonly identified as prevailing in almost all parts of Poland, only in the northern region it has given way to *Trichophyton mentagrophytes v. interdigitale* (2, 4). Nowadays, antropophilic dermatophytes are isolated the most frequently from the skin lesions. They are involved as a causal pathogen in 64% of mycoses, zoophilic species in 35% of cases, and geophilic only in 0.7% of patients (4, 7). Clinical localization of skin mycoses is connected in some degree with the age of patients: children are mostly affected by the scalp tinea and adults have got foot and nail mycoses (7, 8). Mould-induced nail mycoses are diseases that affect mostly the elderly people, especially those suffering from insufficiency of blood circulation, venal varices, orthopedic foot disorders or diabetes (1, 6, 8). Usually, mould-onychomycosis is preceded by the nail damage caused by repeated microinjuries (1, 6, 8). These fungal infections are often superimposed on other nail diseases, such as psoriasis or lichen planus (6, 8). Persevering predominance of the antropophilic species is observed as characteristic in highly urbanized areas (2). Recently, although zoophilic fungi have been rarely isolated, the frequency of *Trichophyton verrucosum* has heightened considerably (2).

Increased prevalence of cutaneous mycoses is caused by the cumulation of many biological as well as environmental factors. Among them, distinct elongation of the human life seems to be one of the most important. The direct consequence of this fact is increased exposition to numerous risk factors encouraging the development of fungal infection. Paradoxically, the constant progress in contemporary medicine can be also regarded as a risk factor. Development of advanced therapeutic and invasive diagnostic techniques, especially in cardiosurgery and organ transplantation, anti-cancer chemotherapy, immunosuppressive treatment, administration of the wide spectrum antibiotics is connected with introducing the surgical equipment into the body cavities or catheters into the vessels, which increases exposition to the fungal pathogens (1, 6, 7, 8). Another well-recognized risk factor is migrations due to various reasons, including political, economical and touristic travels. The importance of this factor is connected with transmitting the fungal pathogens directly and indirectly through using the public baths and other sanitary equipments, direct contact of skin with fabrics, upholstered furniture in trains, airplanes, hotels (1, 6, 7, 8). Apart from the high opportunity of exposition to some infected materials, there is also a risk factor that should not be

underestimated – travels and migrations are associated with dramatic changes in the climate conditions, which may result in increase in the pathogenic abilities of fungal species.

Prevention of skin mycoses needs continuous updating of the epidemiological studies of the fungal flora, promoting a healthy style of life and education addressed not only to the infected patients but the general population.

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#### SUMMARY

Skin mycoses are regarded as a serious epidemiological as well as therapeutic and social problem. They are not only common skin diseases but in recent years their prevalence has increased. About 40 fungal species are found as potentially pathogenic organisms, among them dermatophytes are the etiologic agents the most frequently identified. Mycologic flora differs in various geographic areas and is also changeable with time. Distinct differences are observed, especially due to the continuous changes in the natural and human environment. These changes are connected with geographic and

climatic conditions, degree of industrialization and development of agriculture. Increased prevalence of cutaneous mycoses is caused by cumulation of many biological and environmental factors. Among them distinct elongation of the human life is one of the most important and this results in the increased exposition to numerous risk factors provoking the fungal infection. Apart from this, changing social and working conditions, some forms of the life style encourage the development of dermatophytoses. Prevention of skin mycoses needs continuous updating of the epidemiological studies, promoting a healthy style of life and education addressed not only to the infected patients but to the general population.

### Zakażenia grzybicze skóry jako problem epidemiologiczny

Grzybice skóry stanowią poważny problem zarówno epidemiologiczny, jak terapeutyczny i społeczny. Należą do najczęstszych chorób skóry, a w ciągu ostatnich lat ich występowanie w populacji stale wzrasta. Około 40 gatunków grzybów uważa się za potencjalnie patogennych, wśród nich najczęściej stwierdzanymi czynnikami chorobotwórczymi są dermatofity. Flora grzybicza różni się w odmiennych strefach geograficznym, a także zmienia się w czasie. Wyraźne różnice są obserwowane zwłaszcza w związku z ciągłymi zmianami w najbliższym otoczeniu człowieka i środowisku przyrodniczym. Te zmiany dotyczą warunków geograficznych i klimatycznych, stopnia uprzemysłowienia i rozwoju rolnictwa. Zwiększona częstość występowania grzybic skóry w populacji ogólnej jest związana z kumulowaniem się licznych czynników biologicznych i środowiskowych. Wśród nich wyraźne wydłużenie życia ludzkiego jest jednym z najważniejszych i oznacza zwiększoną ekspozycję na liczne czynniki ryzyka, prowokujące infekcję grzybiczą. Ponadto zmieniające się warunki społeczne, niektóre formy stylu życia zwiększają narażenie na grzybice skóry. Zapobieganie tym chorobom wymaga stałego aktualizowania danych epidemiologicznych, promowania zdrowego stylu życia oraz edukacji prozdrowotnej, skierowanej nie tylko do chorych, lecz do ogółu społeczeństwa.