

Dermatophyte infections in environmental contexts

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Abstract

Fungal dermal diseases caused by the molds of the Dermatophyte family are among the most frequent infectious diseases affecting quality of life. There are 3 attributed sources of infection by Dermatophytes: 1) humans; 2) animals and 3) soil. Dermatophytes possess the ability to utilize keratin from human and animal tissues, or debris from dead animal sources found in soil, such as feathers, skin or nails. Hence, Dermatophytes are abundant in different ecological niches. All 3 groups can infect humans, causing dermatophytoses manifested in different clinical entities involving skin, hair or nails. The mode of infection of the Dermatophytes is via direct or indirect contact. Dermatophytes are found universally, however the relative prevalence of dermatophytoses caused by different Dermatophytes may vary in different geographic areas according to climatic conditions or lifestyle.

Thus, studies in different geographic areas assessing the specific fungal etiology involved are of epidemiological relevance serving as baseline information for management of dermatophytoses at the local level.

The present article will focus, mostly, on epidemiological data from published surveys conducted in different geographic/climatic areas analyzing the prevalence of specific Dermatophyte species in regard to gender, age, type of infection in context of environmental factors.

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Keywords: Dermatophytoses; Epidemiology; Environment

1. Introduction

Fungal dermal diseases – the dermatomycoses, are among the most frequent infections worldwide [1] affecting human wellbeing. Dermatomycoses are caused primarily, by keratinophilic molds of the Dermatophyte family, the yeast species of the genera *Candida* and *Malassezia*, and more rarely, also by other mold and yeast species [2]. Since the Dermatophytes are the major pathogens causing dermatomycoses, the following article will focus on this group of pathogens.

The Dermatophyte family includes over 40 species assigned to 3 genera: *Trichophyton*, *Microsporum* and *Epidermophyton* [3,4]. Dermatophytes are the etiological agents of human and animal dermatophytoses, manifested in various

clinical entities (the “Tineas”) involving skin, hair and nails. Nail infections – *Tinea unguium* caused by the Dermatophytes or onychomycosis – a broader term indicating an infection caused by Dermatophytes and other fungi as well, are a major clinical problem in dermal medicine [5,6] as these infections are most difficult to treat. A part of this article will be devoted also to covering specifically this topic, based on a large survey reported recently by the authors.

There are 3 attributed sources of infection by Dermatophytes, by which they are also characterized: 1) humans – the antropophilic Dermatophytes, 2) animals – the zoophilic Dermatophytes and 3) soil – the geophilic Dermatophytes [7]. Dermatophytes possess the ability to utilize keratin from human and animal tissues, or debris from dead animal sources found in soil, such as feathers, skin or nails. Hence, Dermatophytes are abundant in different ecological niches [7]. All 3 groups can infect humans, causing dermatophytoses. The mode of infection of the Dermatophytes is via direct or indirect contact.

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Most of Dermatophytes are found worldwide, however there are species which have a more restricted distribution and are found in specific geographic areas, such as *Trichophyton soudanense* in Central and West Africa or *Trichophyton concentricum* in Pacific Islands, South East Asia and South America [4,8,9]. Thus, the dermatophyte infections are found universally, however the relative prevalence of the dermatophytoses caused by the different Dermatophytes may vary in different geographic areas according to climatic conditions or lifestyle [10].

Epidemiological data indicate that dermatophytoses are seen more frequently in tropic climates [11]. *Trichophyton*



rubrum, an anthropophilic species, is the most common Dermatophyte in skin and nail infections [10,11] accounting for 80–90% of the isolates, followed by *Trichophyton mentagrophytes* (>11%) and more rarely by *Epidermophyton floccosum* (~7%). The latter species is often isolated from the skin infection *Tinea cruris*, but rarely from infected nails (*Tinea unguium*). The hair infections (*Tinea capitis*) seen more frequently in children [12], can be caused by the zoophilic *Microsporum canis* through contact with an infected pet, that itself may be asymptomatic. In Europe *Tinea capitis* is caused primarily by *M. canis* [10]. The anthropophilic species, *Trichophyton tonsurans* and *Trichophyton violaceum* are also major causes of *Tinea capitis* [10]. The former is a primary cause of the infection in the American continent and the latter in North Africa or Middle East, respectively. As cited by Seebacher et al. [10], data from studies in the Nablus district in Palestine and in Iran showed that 82.7% and 37.3%, respectively, of *Tinea capitis* cases were caused by *T. violaceum*, while *T. tonsurans* was found only in 5.3% of cases in the Iran study. In contrast, *T. tonsurans* accounts for 50–90% of *Tinea capitis* cases [7] in the American continent and is there the predominant causative agent of this infection.

Demographic changes resulting from emigration of populations from one geographic area to another may also be reflected in the different distribution of Dermatophytes [10]. This can be demonstrated by distribution of *T. tonsurans*, which was mostly found in Latin America, but following significant emigration from Latin America to the USA, it became a major cause of infection there as well [7]. Hence, studies in different geographic areas assessing the specific fungal-etiology involved in the dermatophytoses are of epidemiological relevance serving as baseline information for management of these diseases.

The following main text will concentrate, mostly, on epidemiological data from published surveys and other studies

conducted in different geographic/climatic areas, analyzing the prevalence of specific Dermatophyte species in regard to gender, age, type of infection in context of environmental factors.

2. Main text: dermatophytes, dermatophytoses and environmental aspects

2.1. Pets and dermatophytoses

The subject of pets being a source for human dermatophytoses has been covered in the scientific-medical literature in the last few years quite elaborately, as shown by the quote of just a few of the publications [13–18]. The reports originate from different countries and different parts of the world, such as Poland [13] or Switzerland [14] in Europe, Chile in South America [15] or Japan in Asia [17].

The most common pets are cats and dogs, which may be the source of infections of *M. canis* or zoophilic strains of *T. mentagrophytes* [11,13]. Nenoff and colleagues [12] state that 100% of stray cats in Italy were carriers of *M. canis* and in Germany over 21% of asymptomatic household cats were carriers of *M. canis*. *M. canis* can also be found in other animals, such as monkeys, horses or rabbits.

Pets are not limited to cats and dogs, but may include rabbits, guinea pigs or hedgehogs, the latter more frequently in the Far East [11,17,19,20]. These animals may be the source of *T. mentagrophytes* infection or the less common Dermatophyte *Trichophyton erinace*. The study of Thomson et al. [15] is of interest as the authors reported that *Trichophyton verrucosum*, which is generally transmitted by infected calves, was isolated from a dog.

In the human host the zoophilic dermatophytes elicit a strong inflammatory response. Hence, the clinical presentations of the dermatophytoses originating from pets can be manifested as inflammatory hair infection (*Tinea capitis*, *Tinea barbae*) [16] or skin infection (*Tinea corporis*), and less commonly as nail infection. *Tinea capitis* caused by the zoophilic dermatophytes is mostly a childhood infection, with *M. canis* being the most frequently isolated Dermatophyte from *Tinea capitis* in Europe [11].

An interesting aspect of pets and dermatophytoses is in regard to immuno-compromised children [18,21]. Due to the suppression of their immunity these children are at greater risk of infection, which may present a more severe form than in an

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