Occupation, Lifestyle, Diet, and Invasive Fungal Infections

N.V. Sipsas, D.P. Kontoyiannis

Abstract

Background: Although the risk factors for invasive fungal infections (IFIs) in immunocompromised hosts are well described and associated with the net state of immunosuppression, much less is written on the effects of lifestyle on the risk of IFIs in the general population.

Methods: We searched MEDLINE, EMBASE, and Current Contents databases for all reports on IFIs associated with occupation, lifestyle, and diet.

Results and Conclusions: Many professions, especially those involving outdoor activities, are associated with increased environmental exposure to pathogenic fungi and, subsequently, increased risk of IFIs. Inhalation and direct inoculation through minor skin lesions are the most common mechanisms of fungal infection. In addition, different lifestyle practices, such as smoking tobacco or marijuana, body piercing, tattooing, use of illicit intravenous drugs, and pet ownership, various outdoor leisure activities, such as gardening, camping, spelunking, and hunting, and traveling to endemic areas are associated with an increased risk of IFIs. Finally, some modern diet habits dictate the consumption of food or herbal products harboring pathogenic fungi or fungal toxins, which may cause IFIs in susceptible individuals.

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Introduction

Invasive fungal infections (IFIs), i.e., systemic and subcutaneous mycoses, are major causes of morbidity and mortality in immunosuppressed hosts. However, even the general population is at risk for IFIs, especially as a result of specific environmental exposures and lifestyle practices. Many professions and modern hobbies increase the exposure of humans to fungi, making some population groups more vulnerable than others to fungal infections. Furthermore, a variety of contemporary lifestyle practices, such as smoking tobacco or marijuana, body piercing, tattooing, use of illicit intravenous drugs, pet ownership, and outdoor leisure activities, such as gardening, camping, spelunking, and hunting, are associated with an increased risk of IFIs. In addition, the ever-increasing numbers of travelers into and out of areas endemic for fungi have increased the incidence of fungal infections in nonendemic areas. In this review, we summarize the existing body of knowledge on IFIs associated with modern lifestyles, recreational activities, natural phenomena, some professions, and contemporary diet habits.

Search Strategy and Selection Criteria

We searched MEDLINE, EMBASE, and Current Contents databases for all reports on IFIs associated with occupation, lifestyle, and diet. In our search strategy, we used medical subject heading terms and text words, including ''fungal infections'', ''mycoses'', ''occupation'', ''occupational exposure'', ''lifestyle'', ''diet'', ''hobbies'', ''travel'', ''imported fungal infections'', ''pets'', and ''intravenous drug users''. We searched the reference list of each resulting report for additional publications. We used no language or time restrictions; we reviewed English and French language papers, whereas we had papers in other languages translated into English.

Occupations Associated with IFIs

Although allergies that occur following exposure to fungal conidia or toxins are not unusual among people engaged in outdoor activities [1], IFIs caused by occupational exposure are rather uncommon. The majority of fungal infections are caused by organisms that occur in the outdoor and/or indoor environment. Some fungi are

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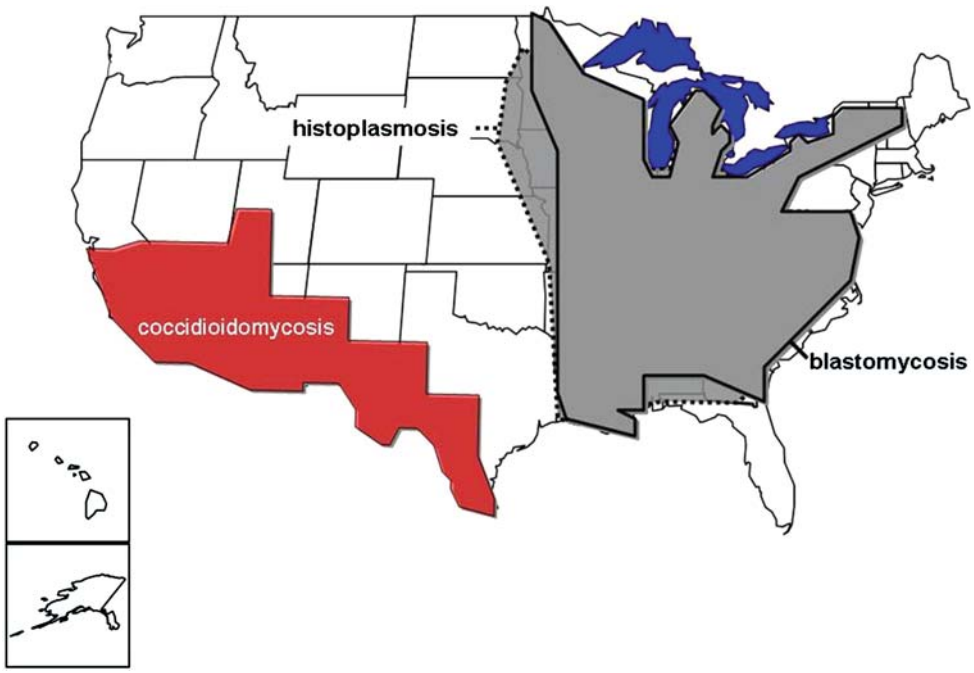

Figure 1. Distribution of endemic mycoses in the USA.

ubiquitous; others are restricted in their geographical distribution. In many cases, the site of infection bears a close relationship to the nature of the environmental exposure: systemic or pulmonary infections usually follow inhalation, while subcutaneous infections are the result of direct inoculation following trauma. None of these diseases are contagious.

Professions Associated with IFIs Secondary to Inhalation of Fungi

Histoplasma capsulatum is a fungus with worldwide distribution. The most endemic areas are the Ohio river and Mississippi river valleys in the USA (Figure 1). Because *H. capsulatum* is found in soil contaminated with bird or bat droppings, farmers, bird handlers, wood cutters, and speleologists are at risk of contracting histoplasmosis [2–5]. Activities that disrupt the soil during excavation and the construction, demolition, and rehabilitation of buildings generate infected dust; therefore, construction workers in endemic areas should also be considered to be at a high risk of contracting histoplasmosis [6]. For example, researchers reported a cluster of cases of acute histoplasmosis associated with exposure to soil during a golf course renovation [7]. Even employees working inside modern air-conditioned buildings may be exposed to low levels of *H. capsulatum* spores in urban settings [8].

Coccidioidomycosis is an infection caused by the dimorphic fungi of the genus *Coccidioides* (*C. immitis* and *C. posadasii*). These fungi are endemic in the soils of certain deserts of the southwestern USA and parts of Central America and South America (Figures 1, 2). Coccidioidomycosis is also associated with outdoor activities involving the disruption of infected soil [9]. Those who are engaged in digging operations in dusty soil in endemic areas, such as archeological excavations and pipeline, highway, and utility construction, are the greatest risk of contracting this infection [9–11]. One study also reported a cluster of coccidioidomycosis cases among cotton mill workers [12]. Maneuvers and training at military training camps in endemic areas are associated with outbreaks of this disease among military personnel [9, 13, 14].

Blastomycosis is a systemic granulomatous infection primarily affecting the lungs that arises following the inhalation of conidia of the dimorphic fungus *Blastomyces dermatitidis*. This disease has a worldwide distribution, with most cases reported in North America, especially in the Midwestern and South Central USA (Figure 1). In four of the 12 outbreaks of blastomycosis reported to date, the inhalation of contaminated dust associated with construction work or crop harvesting was the only potential risk factor [15]. Therefore, farmers and construction workers in endemic areas should be considered to be at increased risk for contracting blastomycosis [16]. Other workers at risk for this infection include forestry workers [17], veterinarians [18] and other professionals working with infected dogs [19], and pathologists [20] and laboratory workers [21], who can be accidentally infected in the laboratory.

Paracoccidioidomycosis affects mainly young and middle-aged men who work outdoors – specifically farmers, miners, field laborers, and hunters [22]. This infection is encountered mainly in South American countries, and the causative agent, *Paracoccidioides*

Figure 2. Distribution of coccidioidomycosis in the Americas.

Table 1
Occupations associated with invasive fungal infections acquired after inhalational exposure.

Invasive fungal infections	Occupation
Histoplasmosis	Farmers
	Bird breeders
	Construction workers
	Excavation
	Construction, demolition, or renovation of buildings
	Wood cutters
	Speleologists
Coccidioidomycosis	Farmers
	Construction workers
	Excavation
	Pipeline or highway construction
	Military personnel
	Cotton mill workers
	Archeologists
Blastomycosis	Farmers
	Construction workers
	Forestry workers
	Veterinarians
	Laboratory workers
	Pathologists
Paracoccidioidomycosis	Farmers
	Miners
	Hunters
Penicilliosis	Farmers
	Field workers
Invasive aspergillosis	Farmers
	Gardeners
Cryptococcosis	Construction workers
	Landscapers
	Bird breeders

brasiliensis, a dimorphic fungus found in the soil and on plants, is acquired through the aspiration of contaminated dust.

Penicillium marneffei is a dimorphic fungus endemic in Southeast Asia, especially Thailand. Its natural habitats are soil and decaying vegetation, and it primarily affects patients with AIDS living in rural areas or those who regularly engage in outdoor activities. A case control study of 80 patients in Thailand found an association between infection with *P. marneffei* and recent history of occupational (agriculture and farming) or other exposure to contaminated soil [23].

Researchers have also reported invasive aspergillosis among individuals engaged in outdoor activities. Specifically, in a report from India, 16 immunocompetent patients with no predisposing factors experienced CNS aspergillosis of sinocranial origin [24]. These patients were either agricultural or manual workers in ''moldy'' environments. In another report from the UK, fatal locally invasive pulmonary aspergillosis occurred in a previously healthy young patient who had no predisposing factors other than exposure to fungal spores in his occupation as a gardener [25].

Cryptococcosis, a systemic infection caused by the yeast *Cryptococcus neoformans*, has emerged as an important cause of illness and death in persons infected with HIV. In a case–control study conducted in the USA [26], non-HIV-infected patients with cryptococcosis were significantly more likely to have a history of outdoor occupations, such as landscaping and building construction . A summary of occupations associated with IFIs acquired after inhalational exposure is given in table 1.

Soft Tissue Mycoses Caused by Direct Inoculation and Associated with Outdoor Professional Activities

Mycotic infections in the dermis and adjacent tissues are caused by the direct inoculation of pathogens into the skin through minor local trauma, such as thorn punctures and wood splinters, which usually occur when walking barefooted. These infections are more common in the tropics and mainly affect persons engaged in outdoor activities, such as farmers, hunters, and forestry workers. In the developed world, factors such as immigration, increasing numbers of tourists in the tropics, and increasing participation in outdoor activities during leisure time, have

Table 2
Occupations associated with subcutaneous mycoses acquired through skin trauma.

Mycosis	Pathogen	Source	Associated occupation	Geographic distribution	References
Sporotrichosis	*Sporothrix schenckii*	Hay Hawthorn spikes Wood splinters Barbed wire Gardening tools Flowers Pottery Cats Cattle	Gardeners Farmers Veterinarians Florists Armadillo hunters Forest rangers Forestry workers Tree nursery workers Horticulturalists Carpenters Miners	Worldwide	[27–30]
Mycetoma	*Madurella mycetomatis* *Pseudallescheria boydii* *Scedosporium* spp. *Fusarium*	Soil Soil Soil, stagnant waters Soil, organic debris	Outdoor workers	Worldwide	[31–34]
Chromoblastomycosis and phaeohyphomycosis	Dark-walled fungi	Soil, plants, flowers, and wood	Outdoor workers	Worldwide	[35]
Cutaneous zygomycosis	*Mucorales*	Soil Decaying vegetation	Outdoor workers Gardeners	Worldwide	[36, 37]
Conidiobolomycosis	*Conidiobolus* species	Soil	Farm workers	Worldwide	[39]
Basidiobolomycosis	*Basidiobolus ranarum*	Soil Amphibian Reptiles	Farm workers Gardeners Landscapers Outdoor laborers	Worldwide (most cases from Africa)	[38, 39]
Lobomycosis	*Lacazia loboi*	Unknown Dolphins	Rubber workers Farmers Miners Fishermen Hunters Aquarium workers	Latin America	[39, 40]
Pythiosis	*Pythium insidiosum*	Swamps	Agricultural occupation	Southeast Asia	[41]

moved these fungal infections from the area of medical curiosity to clinical practice [27–41]. Table 2 provides an overview of the main subcutaneous mycoses and the associated activities/occupations.

Other Types of IFIs Associated with Occupational Exposure

Fungal keratitis, although technically not an invasive mycosis, occurs mainly in agricultural workers and gardeners after trauma to the cornea, usually by fungus-contaminated plant material, such as leaves, grains, branches, and wood splinters. Various researchers have reported that more than 70 species of fungi cause fungal keratitis, with the most common being *Fusarium*, *Aspergillus*, *Acremonium*, and *Curvularia* species [42].

Gastrointestinal basidiobolomycosis is an extremely rare disease caused by *Basidiobolus ranarum*, which has been isolated from decaying vegetation, foodstuffs, fruits, and soil and from the gastrointestinal tracts of reptiles, amphibians, fish, and insectivorous bats. The route of infection seems to be the ingestion of food contaminated by soil. In 1999, a cluster of seven cases of gastrointestinal basidiobolomycosis occurred in Arizona; epidemiological analysis showed that the infection was associated with outdoor activities, such as digging in the soil and camping and picnicking near a lake or river, as well as contact with reptiles and eating uncooked vegetables. The occupations of the patients included gardening, landscaping, plumbing, owning a trailer camp, and respite worker [43].

Hobbies, Lifestyles, and IFIs

Tourism and IFIs

Many clinically important fungi are endemic in certain geographical areas, such as the tropics, where the climatic conditions favor their growth. Over the past few decades, tourism and business-related movement of travelers into and out of endemic areas has increased the number of cases of fungal infections among residents of nonendemic areas [44–47]. According to an international network of travel medicine clinics, the most common imported mycoses in nonendemic areas are histoplasmosis, coccidioidomycosis, cryptococcosis, blastomycosis, and paracoccidioidomycosis [48].

Histoplasmosis affects travelers returning from endemic areas, especially Central and South America [44–46, 48–51]. The majority of infected travelers reported to date were engaged in activities associated with heavy exposure to infected dust, such as exploring bat-infested caves, cleaning sites harboring fungi, and construction work [6, 49]. Occasionally, even traveling through an endemic area by train is enough to cause a cluster of histoplasmosis cases [52].

Coccidioidomycosis is another infection that can be acquired while traveling in endemic areas [44, 45, 53]. Exposure to infecting organisms need not be extensive. For example, travelers have been infected while changing airplanes at the airport in Phoenix, Arizona, and during a single drive across California's Central Valley [54]. In addition, seasonal migration within the USA to endemic regions during the winter has increased the incidence of coccidioidomycosis [55, 56]. International travelers to the southwestern USA have also experienced coccidioidomycosis after returning home; similar cases have occurred in Europe [57] and Asia [45]. In addition to these sporadic cases, in October 2001, a cluster of cases occurred among the 1,300 individuals from 30 countries who participated in the world championship of model airplane flying in Kern County, California [58]. Traveling to Central and/or South America, especially Mexico, is associated with cases of imported coccidioidomycosis [45, 57, 59–61].

Paracoccidioidomycosis occurs mainly in South American countries, but studies have described imported cases in developed counties among travelers to endemic areas [45, 62, 63]. Cases of penicilliosis have occurred in immunocompromised patients with a history of traveling to endemic areas [45, 64–66]. Domestic [67], and international [68] travelers visiting the endemic regions of the United States and Canada may also contract blastomycosis [48].

Subcutaneous mycoses, which are caused by fungi endemic in tropical and subtropical areas, also occur in travelers who engage in outdoor activities in endemic areas. Specifically, studies have described sporadic cases of lobomycosis [69, 70], eumycetoma [47, 71], chromoblastomycosis [71, 72], and phaeohyphomycosis [73] in Europe and the USA among travelers returning from endemic areas. In contrast to IFIs acquired through inhalation, such as histoplasmosis or coccidioidomycosis, the incubation periods for subcutaneous mycoses may be long; therefore, a detailed travel history of the patient should be obtained in each of these cases. For example, an American citizen who traveled to Venezuela had a chest lesion of lobomycosis that developed 2.5 years after his return [70], whereas a German legionnaire was diagnosed with paracoccidioidomycosis 10 years after returning from Brazil [74].

Natural Phenomena and IFIs

Natural phenomena and other catastrophic events may be associated with IFIs. Once example of just such an event occurred in the aftermath of volcanic cataclysm in Armero, Colombia, in 1985, when hundreds of survivors were transferred to hospitals in the capital city of Bogotá. Among the survivors were 38 patients with necrotizing fasciitis, which in eight patients was due to *Mucor* spp. [75]. Epidemics of coccidioidomycosis have been caused by severe dust storms and earthquakes [76]. Following the extensive flooding in New Orleans resulting from hurricanes Katrina and Rita, thousands of homes in the flooded areas had a significant growth of mold [77]. In February 2006, researchers reported a cluster of New Orleans patients with clinical specimens yielding *Syncephalastrum*, a zygomycete that rarely causes infection [77]. In addition, a case of CNS blastomycosis was reported in a young man working in the fields after hurricane Katrina [78]. Survivors of the tsunami of December 26, 2004, also were affected by IFIs. One of these survivors, an Australian traveler who returned to Sydney, had cutaneous zygomycosis that developed on soft-tissue injuries; physicians isolated *Apophysomyces elegans* from the patient's excised wound tissue [79]. Authors have also described two cases of *S. apiospermum* infection manifesting as a cerebral abscess and spondylodiscitis, respectively, in adult European tsunami survivors several weeks after they returned home [80]. A small outbreak of meningitis caused by *Aspergillus fumigatus* was described in patients living in Colombo, Sri Lanka, after the same tsunami. All five victims were mothers receiving spinal anesthesia in order to deliver by cesarean section. Investigations revealed the most likely cause was syringes contaminated with *A. fumigatus*. These syringes were kept in a temporary, dusty, damp warehouse, while the better storage space was filled with overseas aid [81]. Finally, a cluster of candidemia cases occurred among patients who sustained injuries in a bomb blast at a marketplace in Israel [82].

Pet Ownership and IFIs

A major aspect of the modern lifestyle is pet ownership. Pet owners are at risk for fungal zoonoses, mainly because, as a group, they fail to wash their hands after handling their pet [83] .

Cats have been traditionally associated with zoonotic transmission of sporotrichosis. Cats with this infection have skin lesions that are rich in *S. schenckii*, which is spread directly to the human skin via bites and scratches [84, 85]. In addition, rodent and dog bites and bird pecks have been associated with the transmission of *S. schenckii* to humans [84].

Dog owning and hunting have been both associated with blastomycosis, which affects both humans and dogs [86]. Cases of chronic cutaneous mycosis caused by *Paecilomyces lilacinus*, *Candida* species, and *Blastomyces* species after dog bites have been reported [87–89]. Also, armadillos, which are popular attractions in zoos, can be affected by sporotrichosis [90] and paracoccidioidomycosis [91]. Rural workers and hunters in armadillo-endemic

Table 3
Lifestyles and hobbies associated with IFIs.

Lifestyle/hobby	IFI
Pet ownership	
Cats	Sporotrichosis
Dogs	Blastomycosis
	Chronic cutaneous mycoses
Cockatoos and magpies	Cryptococcosis
Pigeons	Histoplasmosis
	Cryptococcosis
Gardening	Sporotrichosis
	Blastomycosis
	Aspergillosis
	Scedosporium infection
Cave exploration	Histoplasmosis
Camping along waterways	Blastomycosis
	GI basidiobolomycosis
Hunting and fishing	Blastomycosis
Smoking	Coccidioidomycosis
	Paracoccidioidomycosis
	GI basidiobolomycosis
	Cryptococcosis
Marijuana use	Aspergillosis
	Penicilliosis
Alcohol abuse	Cryptococcosis
	Invasive aspergillosis
	Candidiasis
Intravenous drug use	Systemic candidiasis
	Aspergillosis
	Zygomycosis
Body piercing	Aspergillosis
Tattooing	Zygomycosis
	Candida endophthalmitis

GI: gastrointestinal

areas (e.g., South America) could be at risk for armadillo-associated fungal disease.

Ownership of pet birds may also be associated with zoonotic transmission of pathogenic fungi in both immunocompetent and immunocompromised individuals. In one study, *C. neoformans* isolated from the cage of a pet cockatoo was molecularly linked with the strain that caused an infection in a transplant recipient who was exposed to the cage [92]. Another report described a case of cryptococcal meningitis in an immunocompetent female patient who had been exposed to a pet magpie (*Pica pica*) [93]. Investigators cultured genetically indistinguishable isolates of *C. neoformans* var. *grubii* from the cerebrospinal fluid of the patient and excreta of the bird. Ownership of pigeons and intense exposure to their excreta are also associated with both histoplasmosis and cryptococcosis [94].

Table 3 provides an overview of the IFIs associated with pet ownership as well as other lifestyles and hobbies.

Hobbies and IFIs

Individuals who explore caves, whether for recreation or scientific reasons, are at great risk of contracting histoplasmosis. Bats, but not birds, may be infected by *H. capsulatum* and may excrete the fungus in their feces. Therefore, visits to bat-infested caves in endemic areas have been associated with both multiple clusters and sporadic cases of acute histoplasmosis [4, 5, 49]. Even trekking through a bat-infested tunnel in an endemic area has been reported to have resulted in an outbreak of this infection [95].

Hobbies such as hunting [86], camping, and canoeing along waterways in endemic areas are associated with blastomycosis [96]. In seven of the 12 reported blastomycosis outbreaks, the participation in recreational activities in forests along lakes and rivers was determined to be the risk factor [15]. In a large outbreak of the infection in two groups of schoolchildren who separately visited a camp in northern Wisconsin in June 1984, researchers isolated *Blastomyces dermatitidis* from the soil at a beaver pond near the camp [97]. Activities such as swimming in contaminated ponds, lakes, and rivers with stagnant waters are also associated with IFIs, and there have been reports of pneumonia and cerebral abscesses caused by *Aspergillus* [98] and *Scedosporium* [80, 99] species after near-drowning.

Fishing has also been associated with IFIs. An epidemiological study from Wisconsin, USA, found that fishing in lakes in endemic areas was associated with human blastomycosis [16]. Invasive subcutaneous infection due to *Fusarium solani* has been described in a previously healthy adult who suffered a wound on his hand by a stingray barb while fishing off the coast of Florida [100].

Gardening exposes the skin to infection, usually after a puncture by a thorn spike, by a variety of plant fungi with pathogenic potential [101]. Sporotrichosis is the most common mycosis associated with gardening, while blastomycosis can affect gardeners in endemic areas [102]. Reported cases of IFIs after minor gardening injuries include otomycosis due to *Scopulariopsis brevicaulis* [103], breast abscess due to *Saksenaea vasiformis* [104], and subcutaneous infections due to *Ssedosporium prolificans* and *Exophiata jeanselmei* [105].

Lifestyle and IFIs

Some practices common in the modern lifestyle are associated with certain mycoses. Smoking, for example, is associated with an increased risk of pulmonary fungal disease, such as coccidioidomycosis [106, 107] and paracoccidioidomycosis [108]. In an epidemiological study, both HIV-infected and non-HIV-infected individuals who were current smokers were found to be at increased risk for cryptococcosis [26].

Smoking marijuana is associated with invasive pulmonary aspergillosis because the leaves of this plant may be contaminated by *Aspergillus* species [109]. The risk of invasive pulmonary aspergillosis after marijuana smoking is greater among immunocompromised hosts, including HIV-infected patients, patients with cancer receiving

chemotherapy, and patients who undergo organ [110] or stem-cell [111] transplantation, than among nonimmunocompromised hosts. Additionally, marijuana and opium smoking are associated with an increased risk of penicilliosis in endemic areas [23].

Alcohol abuse has been associated with IFIs, especially in patients with alcoholic cirrhosis. Although no case–control studies have been reported to date, all of the patients that have been described had no other risk factor for IFI except that of alcohol abuse. Spontaneous peritonitis due to *Cryptococcus neoformans* has been described in patients with decompensated alcoholic cirrhosis and ascites [112]. Other IFIs described in alcoholic patients are invasive pulmonary aspergillosis [113], *Candida* polyarthritis [114] and endocarditis [115], and sporotrichosis [116].

Body piercing and tattooing are popular practices, especially among adolescents [117]. However, these minor skin lesions can be portals of entry for certain fungi, especially among immunocompromised persons. There has been at least one case each of cutaneous zygomycosis and *Candida* endophthalmitis associated with tattooing [118, 119]. Necrotizing auricular aspergillosis that developed after ear piercing in a young female leukemic patient with chemotherapy-induced neutropenia has been reported [120].

Wearing contact lenses is associated with fungal keratitis that is mainly caused by *Candida* spp., although *Cryptococcus* and *Fusarium* contact-lense keratitis has been described [42, 121]. Adherence of fungi to contact lenses occurs with patient handling, including that during cleaning and storage of the lenses, and use of contaminated solutions [122].

Wearing artificial fingernails in a healthcare setting may expose susceptible individuals to fungal infections because artificial fingernails are more likely to promote the subungual growth of pathogens, especially gram-negative bacilli and yeasts, than natural fingernails are [123]. In 1997, three patients in an American hospital experienced postlaminectomy deep-wound infections of the same strain of *Candida albicans* [124]. A case-control study revealed that the source of the infection was a single operating room technician wearing artificial fingernails.

The use of illicit intravenous drugs is also associated with IFIs, which account for 5%–50% of serious infections in intravenous drug users (IVDUs) and for 5–50/100,000 hospital admissions [125]. Disseminated candidiasis is observed primarily in IVDUs, and it may be complicated by *Candida* arthritis [126], myositis, pneumonia [127], spondylodiscitis [128], and endophthalmitis [129]. The intravenous use of brown heroin in particular often leads to a characteristic syndrome that includes pustular cutaneous lesions, endophthalmitis, and osteomyelitis; *C. albicans* can be isolated from all of these lesions [130]. Preserved lemon juice, which is used in heroin paraphernalia, may play a role in the epidemiology of candida endophthalmitis in heroin addicts [131]. Other pathogenic fungi that can cause fungal endophthalmitis in IVDUs are *Aspergillus* spp. [132], *Fusarium* species [133], *Penicillium* species [134], Zygomycetes [135], and *Scedosporium* spp. [33]. *Aspergillus* endophthalmitis in addicts abusing a mixture of intravenous cocaine, pentazocine, and tripelennamine has also been reported [132]. Endocarditis and CNS infections caused by *Candida* spp. are common. Fungi, especially *C. parapsilosis* and *C. tropicalis* as well as *Aspergillus* spp., account for 4% of all infective endocarditis cases among IVDUs [136]. Researchers have also reported brain abscesses caused by *Aspergillus* spp., *Chaetomium strumarium*, and zygomycosis among IVDUs [137, 138].

Diet and IFIs

Many herbal products, supposedly with therapeutic properties, are increasingly used as alternative medicines. Some of these harbor potentially pathogenic fungi. Hepatic zygomycosis developed in a bone marrow transplant recipient after ingestion of multiple naturopathic medications [139]. *Mucor indicus* was isolated from the patient's liver aspirate and from one of the naturopathic medications. Disseminated fusariosis has been described in a neutropenic patient who ate contaminated cereals [140].

Gastrointestinal basidiobolomycosis is also associated with specific dietetic behaviors. A case-control study of seven patients in Arizona showed that fewer patients than controls washed vegetables before eating them, and one patient had pica [43]. This last patient had been consuming dirt daily during the year prior to the diagnosis. In another case in Utah, the patient was a diabetic man who made frequent trips to the desert and often picnicked there [141].

Conclusion

Invasive fungal infections may affect persons with intact immune systems. Many professions, lifestyles, hobbies and traveling to endemic areas expose healthy individuals to pathogenic fungi, resulting in IFIs in some of them, which may be life-threatening. Why some people are vulnerable to IFIs after exposure to environmental fungi whereas others are not is not known. Some possible explanations are different intensities or lengths of exposure, acute vs subacute exposure, delayed treatment, genetic differences affecting the innate immunity such as the expression of mannose-binding lectin genes, and co-morbitities such as diabetes and obstructive pulmonary disease. Future epidemiological and clinical studies should address these issues, as IFIs represent an increasing burden on public health.

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