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Review

Infections associated with adventure travel: A systematic review

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ABSTRACT

Aim: To review infections associated with adventure travel.
Methods: The PubMed, Embase and Scopus databases were searched combining the words **infection** with the following keywords: rafting, whitewater, surfing, (surfer* or windsurf*), (caves or caving or spelunking), (triathlon or trekking) or (hiking or adventure race), bicycling, backpacking, (mountain climb* or bouldering), horseback riding, orienteering, trekking, and skiing.
Results: Adventure travel is becoming much more common among travelers and it is associated with a subset of infectious diseases including: leptospirosis, schistosomiasis, viral hemorrhagic fevers, rickettsial diseases and endemic mycosis. Caving and whitewater rafting places individuals at particular risk of leptospirosis, schistosomiasis and endemic mycosis, while adventure races also place individuals at high risk of a variety of infections including campylobacter, norovirus and leptospirosis.
Conclusion: Travel practitioners need to be aware of the risks associated with adventure travel and should educate individuals about the risks associated with various activities. Doxycycline prophylaxis should be considered for travelers who are susceptible to leptospirosis due to participation in high-risk sports such as whitewater rafting, caving or adventure races.

1. Introduction

Adventure sports or extreme sports have been growing in popularity over past several decades with millions of participants in each sport [1]. In 2012, 42% of travelers reported an adventure activity as their main activity during their last trip. That number continues to grow, in 2013 the Adventure Tourism Market Study performed by George Washington University showed a 65% annual growth in adventure travel from 2009 to 2012 [2]. Examples of high risk adventure sports which are increasing in popularity include: climbing, boardsailing, windsurfing, kayaking, and scuba diving [3].

Since adventure travel is subjective and what is adventurous to one person is not to another, the Adventure Travel Trade Association developed a definition of adventure travel which has three main components, 1) physical activity, 2) connection with nature and 3) immersive cultural experience [4]. To meet the definition an activity must contain two of three components. In this article we included activities that are high risk, require substantial physical activity and are considered less common than conventional travel activities such as sightseeing, cultural experiences, or participating in local festivals. For example, canoeing is considered adventure travel, but is low risk activity, however, whitewater canoeing/kayaking/rafting were included due to the physical exertion and high-risk nature. As this paper's goal is to explore infection risk of adventure travel not yet well defined, several activities with well defined infection risks, such as fishing, hunting and safaris were excluded. Injuries such as fractures, head injuries, eye injuries and lacerations are by far the most common medical problem associated with these activities and education on prevention should be covered during pre-travel consultations [5]. An excellent text by Heggie and Caine provides a comprehensive review of injuries associated with adventure sports. However, in this review, we focus specifically on infections related to adventure travel using case series, case reports, and epidemiologic studies [3]This study will give travel practitioners the ability to educate travelers and give appropriate prophylaxis advice and education based on their activity.

2. Methods

A PubMed search was performed on 9/7/2016 with the term "infection" in combination with each sport: rafting, whitewater, surfing, (surfer* or windsurf*), (caves or caving or spelunking),

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(triathlon or trekking) or (hiking or adventure race), bicycling, backpacking, (mountain climb* or bouldering), horseback riding, orienteering, trekking, and skiing. Medline and Scopus were then searched using the same terms. If additional articles were found during review of other articles these were also included. Search methodology is displayed in Fig. 1. Those that were associated with infection were: whitewater sports, surfing/windsurfing, scuba diving, snorkeling, spelunking, mountain climbing, adventure/endurance racing, cycling, mountain biking, horseback riding, orienteering and trekking. Results were screened for papers that dealt with infections temporally related to the specific activity. Articles dealing with traumatic injuries and subsequent infections were excluded as were articles not in English or translated to English.

2.1. Whitewater sports

Whitewater rafting, kayaking and canoeing are common activities [3]. Injuries and drownings are the primary concern, however, there are significant infectious risks. Whitewater rafting can be performed in mountain, desert, temperate and tropical climates putting participants at risk for a variety of infections. Whitewater sports pose a distinct risk as water can be swallowed or inhaled after aerosolization.

Leptospirosis is a zoonotic spirochete, which uses rodents as a primary reservoir and is spread through water contaminated with infected urine [5]. Recently, other animals have also been suggested as reservoirs including dogs, cattle, bats and sea lions [6]. In 1996 an outbreak in whitewater rafters occurred in Costa Rica during the rainy season when water levels were particularly high. Further analysis of the cases suggested that individuals who were submerged and swallowed a significant amount of water were at increased risk of developing disease [7]. Two cases in 2002 were diagnosed after a whitewater rafting trip in Ecuador and Costa Rica [8]. Van de Werve et al. reported 15 cases of leptospirosis in their Belgian travel clinic from 2008 to 2011, 4 of which occurred after participation in whitewater sports [7]. Outbreaks in rafting groups in Thailand, Sri Lanka and Switzerland have also been reported with some having a Jarisch-Herxheimer reaction upon initiation of beta-lactam therapy [9–11]. For adult patients traveling to endemic areas prophylactic doxycycline at a dose of 200 mg weekly is highly effective [12] and should be considered in those participating in whitewater sports, especially if traveling during the rainy season or a time of flooding.

Schistosomiasis, is a parasitic disease caused by schistosome flukes that also occurs in freshwater. Multiple groups of rafters have been infected on trips of the Omo river in Ethiopia. In 1984 a group of Americans developed schistosomiasis after rafting this river, 6 of 11 members developed *Schistosoma mansoni* infections with 5 having symptoms of acute disease [13]. Schwartz et al. analyzed groups who went on rafting trips in 1993 and 1997, on the Omo river, among those, 44 travelers had serology analysis, 28 with positive serology and 16 developed symptoms [14]. In 1997 Morgan et al. described 69 travelers who used the Nile recreationally and were analyzed pre and post exposure for schistosomiasis with 4/26 seroconversions in rafters or whitewater kayakers [15]. Roser et al. did a similar study in 2009 with 36 travelers exposed to freshwater in Uganda during a whitewater trip. In this group 14/26 developed positive serology after the trip with one developing acute schistosomiasis [16]. It is a common misunderstanding among travelers and whitewater guides that flowing water negates the risk for schistosomiasis, however, travelers should be advised about the risk of schistosomiasis in all endemic freshwater. Travelers should avoid purposeful swimming in freshwater, and if accidental submersion occurs then quick towel drying or alcohol rubbing may be helpful in the prevention of disease [17]. Testing and treatment of

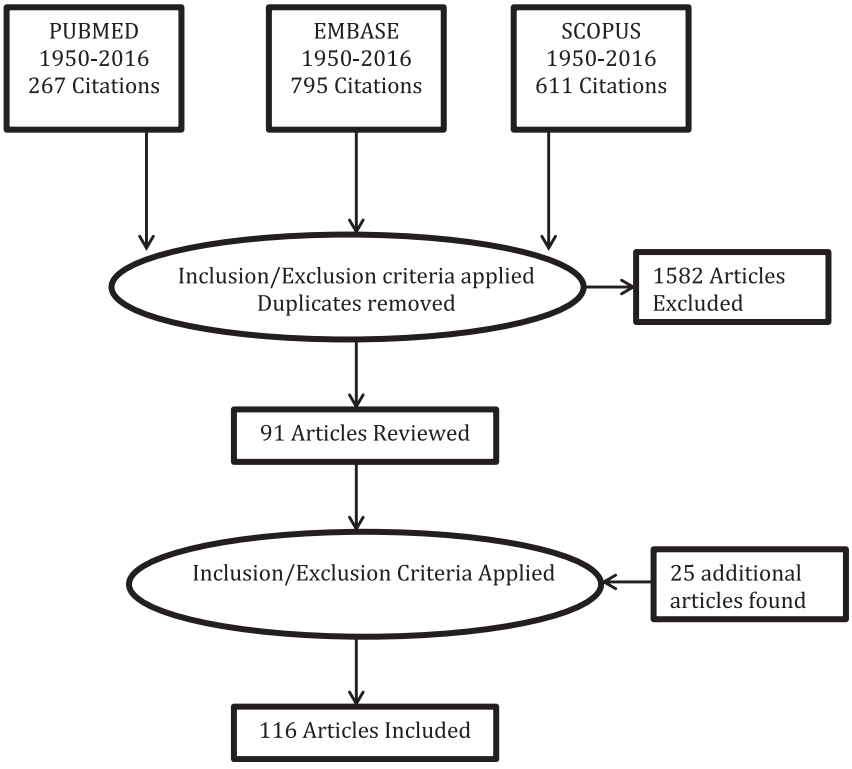

Fig. 1. Flow diagram of searching strategy.

symptomatic individuals upon return if they have participated in recreational water sports in endemic areas should be performed to prevent long-term complications.

Gastrointestinal illnesses also pose a risk during whitewater rafting trips. *Giardia lamblia* (Beaver fever) is a common parasite, which resides in the intestinal tract of animals and can persist in cold water. Rafters exposed to waters which drain large amounts of mountain streams are therefore at high risk of developing infection [18]. In addition there have been several norovirus outbreaks during whitewater rafting trips, presumably as travelers are close together, lack indoor plumbing and hand hygiene [19,20]. Travelers should be advised to bring soap for washing hands and ensure adequate water filtration if going on a rafting excursion.

Participating in whitewater sports in regions with endemic mycosis pose risk for fungal infection [20]. Riverbed soil is the ideal habitat for these organisms and many rivers are hyperendemic for these pathogens. Several outbreaks of blastomycosis and histoplasmosis have occurred in rafters in endemic areas [21,22]. Patients presenting with flu-like illness or pneumonia after rafting in endemic areas should be evaluated for fungal disease. Disease severity is often associated with infective load. Mild blastomycosis and histoplasmosis can be treated with itraconazole on an outpatient basis, however, severe disease often necessitates the use of amphotericin products (Fig. 2).

2.2. Surfing & windsurfing

Injuries and illnesses are common occurrences of windsurfers, kiteboarders and surfers given the high-risk nature of the sports [3]. Ear conditions such as external auditory exostoses, tympanic membrane rupture and external otitis are common among surfers as they undergo frequent pressure changes, and water submersions [23,24]. Surfers are at high risk of lacerations, either from coral, rocks or their own surfboard. These lacerations have the potential to become infected with water-borne organisms such as *Vibrio, Aeromonas, Plesiomonas, Erysipelothrix* and treatment should be initiated with a third generation cephalosporin or a fluoroquinolone [23–25]. *Mycobacterium marinum* should be considered in non-healing water exposed wounds, especially if it is on the extremities. Laboratory diagnosis may require incubation at a lower temperature and can take 2–6 weeks to grow [25]. Harding et al. did a web-based survey of surfers in the Pacific Northwest of the United States to determine how behavior affected the health of surfers [26]. Sore throat, cough, diarrhea were common occurrences in illnesses experienced by surfers. Surfing during a rainy time period, a health advisory or near an outfall increased the likelihood of illness. Interestingly, most surfers were not aware of health advisories; hence, travel practitioners should advise patients to monitor the local health status of the beaches. Heavy rainfall results in contaminated runoff and surfing under these conditions increases the risk of exposure to water contaminated with human waste. Surfers need to be educated that lacerations need to be cleaned thoroughly and immediately after injury. Prompt medical attention should be sought if signs of infection exist so appropriate antibiotics and wound care can be initiated. Windsurfers are at similar risk of superficial infections and GI illnesses. In 1984 an epidemiologic study looked at a population of windsurfers who competed in polluted water [27]. Common symptoms in the study were diarrhea, abdominal pain, otitis, conjunctivitis and superficial skin infections. Relative risk for those who competed in polluted water were 6.7, 5.2, 1.8, 1.9 and 2.3 respectively. Hepatitis A is spread via the fecal-oral route and is a concern for patients who routinely use contaminated beaches. Surfers are at high risk of hepatitis A infection and are three times more likely to have had hepatitis A infection when compared to windsurfers [28,29]. These data suggest that patients participating in surfing or windsurfing should research the areas where they will be surfing to ensure there are no advisories due to pollution. In addition, hepatitis A vaccine should be offered to all surfers and considered for others participating in water sports.

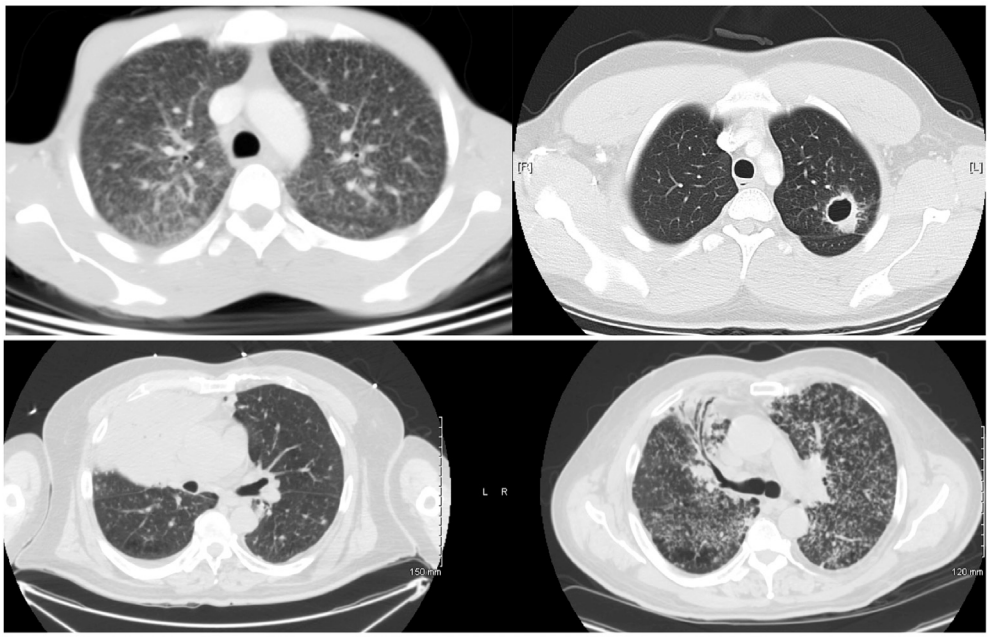

Fig. 2. Endemic mycosis CT chest findings. Upper left: Diffuse infiltrative pattern in patient with histoplasmosis, upper right: Cavitary lesion in patient with Coccidioidomycosis. Bottom left & right: Patient with chronic pneumonia, found to have Blastomycosis. Initially mild with progression to diffuse, ground glass radiographic findings. Travelers with febrile syndrome and/or pneumonia after traveling to areas with endemic mycosis should be evaluated for fungal disease.

2.3. Scuba diving & snorkeling

Scuba diving utilizes self-contained underwater breathing apparatus to breathe atmospheric air. Infections associated with scuba diving are typically associated with exposure to water and include infections with water-based pathogens as described above. Infections related to polluted water, and common skin infections associated with sharing equipment, such as *Staphylococcus aureus* or herpes labialis, are also possible [30–33]. Red tide is a large algae bloom, which can lead to toxin production and dramatically increase the bacterial load in ocean water. Respiratory, gastrointestinal illness or neurologic disease is common after exposure to red tide, however the large bacterial burden can cause a variety of infections. One case reported a scuba diver who presented with bilateral otitis externa, which subsequently developed into bilateral mastoiditis after diving during a known red tide [33]. Scuba divers should avoid areas where red tide is reported and should check local conditions prior to diving [34,35]. Exposure to marine life can place people at risk for uncommon infections such as *Pseudomonas oryzihabitans* cellulitis after a bite from an octopus while snorkeling [36], or cellulitis after brushing against poisonous corral [37]. Schistosomiasis has also been described in scuba divers after exposure to endemic waters [38,39].

2.4. Spelunking

Spelunking is the exploration of caves and has been associated with a variety of injuries and infections [40]. Exploring previously uncharted caves places individuals at a higher risk of infection due to human-bat interaction [41]. The most common cave-associated illness is Histoplasmosis, caused by *Histoplasma capsulatum*. Infection occurs after patients are exposed to bird droppings or bat guano which contain infectious spores. Disease has been documented after exposure to caves, cave entrances, canyoning, cleaning sites, and construction areas in North, Central and South America as well as Africa and Asia [42–47]. Cases have been documented in the following Countries after spelunking: United States [43–45], Cuba, [48], Costa Rica [49], Belize [50,51] Nicaragua [52], Guatemala, Peru [53–55], Ecuador [56], Brazil [57,58], El Salvador [59], Venezuela [60], New Caledonia [61], Cyprus [62], Martinique [63], Australia [64], and Tanzania [65].

Immunosuppressed patients are at higher risk for invasive fungal infections. Cavalcante et al. described a 15 year old patient with systemic lupus erythematosus on chronic immunosuppression who developed cryptococcal meningitis after exploring a cave in Sao Paulo, Brazil [66]. Cryptococcal meningitis is an infection caused by one of two species of Cryptococcus: *C. neoformans* and *C. gattii*. *C. neoformans* is the primary causative agent in the world, however, *C. gattii* exists in a higher proportion in tropical areas but the incidence is increasing in many subtropical areas [67,68]. Presentations involving the central nervous system are common, as are chronic pneumonias. Cryptococcosis is seen mostly in immunocompromised individuals, but cases in immunocompetent patients exist.

The recent outbreak of Ebola in West Africa has increased awareness to wide variety of cave associated viral infections. Bats are suspected to carry hantavirus, lyssavirus, coronavirus, henipavirus, and filovirus including Marburg and Ebola [69]. Interestingly, in rural Ghana almost 50% of individuals visit bat caves with 37% of people reporting exposure either via bites, scratches or urine. In addition, 46% of individuals reported eating bat meat. Vora et al. report a study done after a bat festival in Idandre, Nigeria, where males entered caves to hunt bats. Many of the participants sustained scratches and bites from bats, but none reported a serious illness [70]. In 2008, two patients developed Marburg hemorrhagic fever after exploring Python cave in Uganda, the fatal case was imported to the Netherlands and another was imported to Colorado, USA. In 2011 4 miners in Uganda were diagnosed with Marburg virus after working in a tunnel mine, a roosting site for thousands of bats [7,71,72]. Marburg virus has a case fatality rate of almost 80% [73] and is strongly associated with cave exposure. Nipah virus is a henipavirus and a cause of encephalitis and respiratory illness in Asia. This virus utilizes fruit bats and pigs as a reservoir, cases to date have been associated with pig farming and contaminated date palm sap. No cases of Nipah virus infection have been associated with caving. Despite wide publicity little evidence of a link between spelunking and Ebola virus infection exists. Human-cave and human-bat interactions have occurred for thousands of years with relatively few outbreaks, despite a high frequency of bites, scratches and exposure to aerosolized bat excreta. Alternative theoretical reservoirs are also possible such as an insect that interacts with humans and bats or a host in rivers or river beds [74]. Spelunking may pose a risk and clinicians should have a high suspicion of viral hemorrhagic fevers in patients who have returned from tropical destinations with fever, rapid clinical deterioration and hemorrhage. Travelers should also check local sources to ensure there is not a local outbreak in the area they will be spelunking.

Rabies virus is a lyssavirus that is almost universally fatal. It continues to cause tens of thousands of deaths in the developing world, 95% of which are spread through canine bites [74]. However, adventure travelers are exposed primarily through bats [75]. Spelunkers are at high risk of rabies exposure as bite and scratches are common and the rabies vaccine series should be offered to all spelunkers [76]. Despite widespread knowledge among spelunkers regarding the risk of rabies, relatively few are given pre-exposure prophylaxis. In 2014 Mehal et al. showed that even though more cavers were aware of the increased risk of rabies from bat bites compared to years prior (100% compared to 85% in 2010 and 2000 respectively), pre-exposure prophylaxis for rabies has actually decreased from 56% to 45% over the ten years studied [77]. While it is unclear why this decrease has occurred, the price of the vaccine and the multiple doses needed are likely prohibitive for many people.

Spelunking often involves blindly traversing through stagnant water placing travelers at risk of leptospirosis as rodents and bats can both excrete the spirochetes in their urine and feces. Water in caves tends to have a higher pH allowing for a more suitable environment for leptospirosis. If wounds are exposed to contaminated water the risk of systemic leptospirosis is high. Prophylactic doxycycline should be considered for all travelers who will be partaking in spelunking [78].

Ticks typically associated with bats will sometimes feed on humans as well. The *Argas* genus ticks are found worldwide and can be highly aggressive toward humans. While it is unclear if they are a competent disease vector, the bites can result in blisters, bruising and pruritus. The genus *Ornithodoros* ticks are also frequent bat parasites and can bite humans if they enter caves. *Ornithodoros tholozani* lives from China to eastern Libya and can transmit *Borrelia persica*, the cause of Persian relapsing fever, a sometimes severe and fatal infection [79]. In Texas, ticks associated with caves have been the vector for other tick borne relapsing fevers. Prevention measures include avoiding areas where these ticks are present, wearing clothing that protects all skin and using insect repellent [80].

2.5. Mountain climbing/bouldering

Falls, dehydration, avalanche or altitude related illnesses like high altitude cerebral edema or high altitude pulmonary edema are

common risks in mountaineering sports [81]. If travelers become sick while mountaineering, a search and rescue is often necessary as easy evacuation may be difficult. Cases of severe diarrhea and pertussis have been described while mountaineering, and highly contagious infections such as these can spread rapidly in the close quarters required while climbing [81,82]. Vaccination with tetanus/diphtheria/pertussis should be offered if it is time for a booster. Hand hygiene and proper waste disposal is extremely important and groups should bring a first aid kit and consider bringing basic antibiotics to treat severe disease.

2.6. Trekking/orienteering/adventure races

Hiking, trekking, and adventure races have been associated with several infectious outbreaks. Orienteering involves traversing the wilderness at a rapid pace using primitive means of navigation. Risks associated with these activities include dehydration, hyperthermia, hypothermia, trauma, and excessive exposure to UV radiation [83]. Adventure race participation has doubled yearly since 2010 and in 2013, over 4 million people participated in adventure races in the United States [84]. These races consist of biking, running, kayaking, swimming, and orienteering through areas of wilderness with no marked trails. These races are frequently held on farmlands where there is potential for exposure to feces from a variety of farm animals including cattle, poultry, and swine. This risk is even higher in the "slurry fields" which are mud fields made by combining water with soil-frequently contaminated with animal feces [85]. Campylobacter enteritis is an infection caused by *Campylobacter jejuni* or *C. coli* and is a frequent cause of foodborne disease, but can also be transmitted from direct contact with animals, their feces, or infected bodies of water. Cases of campylobacter infections associated with adventure racing have been reported in Nevada and British Columbia [85,86] An outbreak of norovirus occurred in France during an obstacle race and resulted in over 800 cases of acute gastroenteritis [87]. Public health experts postulated that contamination of the mud occurred and then resulted in the majority of cases. Trekking may also increase the risk for travelers of contracting typhoid fever [88]. Physicians should counsel travelers to avoid swallowing water during these races and discuss the potential for acute diarrheal illnesses and other infections transmitted via fecal-oral routes. If a patient presents after an adventure race or mountain bike race with diarrhea, there should be a high suspicion and low threshold to test and treat for campylobacter or other fecal-oral pathogens. Patients with infectious gastroenteritis generally improve with conservative treatment, however, in severe cases or immunocompromised hosts, cases should be treated with either azithromycin or fluoroquinolones.

Trekkers are also at risk for vector borne infections including dengue, chikungunya, Zika, and malaria, which should suspected in trekkers returning from endemic countries with a fever. It is important to consider the country where the infection was acquired and the involved malaria species. Resistance to antimalarial medications including artemisins is a growing concern in Asia, Africa and can affect adventure travelers [89,90]. Hantavirus has been reported in a trekkers returning from both the United States and Ecuador [91,92]. Trekkers are also at risk for gastrointestinal parasites. Reinthaler et al. conducted a study looking at stool samples of Austrians returning from vacations abroad with diarrhea. Parasitic infections were more common in individuals who had participated in trekking during their vacations [93]. Trekkers who return with diarrhea should have a full stool ova and parasite exam performed. Returning trekkers with chronic respiratory problems should also be evaluated for nematode and trematode infections which can cause chronic pulmonary disease, especially eosinophilic pneumonitis [94]. A report of Loa Loa in a woman with a history of trekking in the Himalayas was described in 2012. A 10.5 cm gravid female was removed from her subconjunctival space [95]. Leptospirosis has been described in adventure races, triathlons, and trekking vacations in several regions including Illinois [96], Florida [97], Reunion Island [98], Germany [99], Guam [100], Southeast Asia [101] and Borneo [102]. A retrospective analysis of participants in an adventure race in Borneo supported the use of pre-exposure prophylaxis with doxycycline 200 mg/week [102]. In Wisconsin, USA, 12 patients developed blastomycosis after participating in a wide variety of outdoor activities.

Trekkers are at risk of tick-borne disease as they spend a prolonged period of time outdoors, are often in solitude and have limited facilities. Lyme disease is an infection caused by *Borrelia burgdorferi* and transmitted by the *Ixodes scapularis* tick in the United States. In Europe and Asia, *Borellia afzelii* and *Borerelia garinii* can cause Lyme disease. Shelters used by trekkers in the USA are inhabited by the mouse *Peromyscus leucopus*, the preferred host of the *I. scapularis* tick, placing many of these hikers at risk of Lyme disease if they visit endemic areas, yet few recognize the early stages of Lyme disease. In a study by Knoll et al., only 54% of hikers were able to recognize the rash of erythema migrans [103]. Trekkers in Lyme endemic areas should be aware of the initial signs and symptoms of Lyme disease so they can get treated early. Similarly, an outbreak of *Rickettsia africae* or African tick bite fever, was reported after an adventure race in South Africa. *R. africae* is transmitted by the very aggressive *Amblyomma* ticks. The patients in this case presented with fever, headaches, lymphadenopathy, and multiple eschars. Most participants were diagnosed by serology and successfully treated with doxycycline [104]. While we could not find reports of Crimean Congo hemorrhagic fever, tick borne encephalitis, severe fever with thrombocytopenia syndrome, Q fever, brucellosis or other rickettsial diseases in adventure travelers, the potential exposure to ticks and wildlife places them at risk for these or other vector-borne diseases.

Trekkers and orienteers are also at risk for tularemia, an infection caused by *Francisella tularensis*. Two individuals who participated in an orienteering contest in Denmark became sick with fever, fatigue and lymphadenitis with serologies positive for *Francisella tularensis*-one improved with doxycycline, the other spontaneously. It was postulated that both contracted tularemia through contact with dirt and contaminated water on open cuts [105]. Given the high risk of laceration and soil exposure individuals participating in orienteering contests should be up to date on their tetanus vaccine [106]. A study performed in Scandinavia showed an increase prevalence of positive serologies for Bartonella spp.: 31% in elite orienteers compared to 7% in healthy blood donor controls. It was thought that this could possibly be the reason for an increase in sudden cardiac death seen in competitors in orienteering events [107]. Pandey et al. conducted a study looking at individuals visiting Nepal who presented to clinic with possible rabies exposure. The data from their study did not show an increase in rabies exposure in those trekking in nepal, but did show an increase in foreign residents over tourists [108].

2.7. Snow skiing

Risks from snow skiing are mostly associated to trauma and accidents while skiing [109]. However, infections related directly with skiing are not frequently reported in literature. Snow skiers are at risk for reactivation of herpes labialis. It is thought that this increased risk is due to increased exposure to UV radiation at high altitudes. Sunscreen does not appear to lower the risk of reaction, however prophylactic acyclovir taken during the ski holiday may prevent reactivation [110,111].

Table 1
Recommendations for prophylaxis for adventure travel activities.

Infection	Activities	Pre-Travel Consideration
Leptospirosis	Whitewater sports Spelunking Adventure races	Doxycycline 200 mg/week for those in endemic areas at high risk
Schistosomiasis	Whitewater sports	Avoidance of freshwater, Testing and treatment of symptomatic or high risk individuals upon return
Hepatitis A	Surfing	Pre-travel vaccination
Endemic mycosis	Spelunking Whitewater sports	None
Diarrheal diseases	Adventure races Whitewater sports Mountain climbing	Hand hygiene Carry loperamide [124]
Arboviral diseases	Trekking Orienteering Adventure races	Personal protection measures including repellents and impregnated clothing
Rabies	Spelunking	Pre-travel vaccination
Rickettsial diseases	Trekking Orienteering Adventure races	Tick avoidance, repellents Frequent tick checks

2.8. Mountain biking/cycling/motor-biking

Accidents, and subsequent injuries obtained when cycling or motorbiking place individuals at risk for infection [112,113]. Skin flora such as *Staphylococcus* spp and *Streptococcus* spp are common causes of infections after accidents. Soil based organisms, both bacteria and fungi are also a concern after biking accidents. There have been cases of *Scedosporium*, *Sporothrix*, *Pseudallescheria* and *Nocardia* in cyclists after accidents [114–117]. Cyclists often compete and train in close proximity increasing the risk for tinea corporis from *Microsporum canis* [118]. The prolonged nature of many bicycle races leaves athletes exposed for prolonged periods of time, increasing the risk of mosquito borne diseases. Stojkovic et al. describe a case of cutaneous leishmaniasis (*L. major*) in a patient who had spent a week biking in Tunisia [119]. Schistosomiasis has been reported in Zimbabwe in a group of triathletes who swam near a fresh water dam. Eighty percent of triathletes had schistosomiasis compared to only 38% of controls from the area [120].

Bikers, are at risk of developing infection with endemic mycosis with the type of fungal infection dependent on location. Cheng et al. report a case of a patient with coccidioidomycosis resulting in endophthalmitis presumed to have been acquired while mountain biking in the Central Valley of California [121]. GI illness in long distance cyclers can occur as access to clean water and good sanitation is sparse. *Cyclospora cayetanensis* has been reported after a prolonged biking trip from Tibet to Nepal. The patient presented with a month long history of watery diarrhea and weight loss. Infections with cyclospora are frequently found in Central and South America and the Indian subcontinent [122]. The use of mudguards possibly reduces the risk of GI illnesses in mountain biking races [123].

3. Conclusion

Adventure travelers are at risk for common travel-related infections including malaria, traveler's diarrhea and arboviral diseases. However, each individual sport predisposes the traveler to a certain subset of infections such as leptospirosis, endemic mycosis, or schistosomiasis. Table 1 provides both education, and prophylactic recommendations that can be offered by practitioners based on infection and adventure travel type. Pre-travel visits should focus on educating the traveler regarding the infectious risk involved as well as appropriate prophylactic medication and vaccines with each specific type of adventure travel. In addition, travel practitioners should be aware of the types of infections associated with each type of adventure travel so they are included in the differential diagnosis of the ill returning adventure traveler.

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