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Outbreak of Wilderness/Backcountry/Travelers' Diarrhea at a Himalayan Base Camp at 4000 m/13,125 ft

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Abstract

Introduction: Wilderness or backcountry diarrhea is a type of travelers' diarrhea commonly caused by *Cryptosporidium* and *Giardia*, which can survive freezing temperatures. Campsites pose additional risks worldwide, irrespective of developing or developed regions, due to inadequate hygiene.

Methods: In a first of its kind, an outbreak of wilderness diarrhea at a semi-permanent Himalayan Base Camp at 4000 m/13,125 ft in Uttarkashi, India, was investigated and managed by empirical antimicrobials. Return of normal bowel function was considered as primary outcome, and return to routine training at Base Camp was considered secondary outcome.

Results: Sixty-two personnel presented with wilderness diarrhea of 5.58 days mean duration with onset after mean stay of 10.26 days, despite provisions for adequate camp hygiene and sanitation. Both primary and secondary outcomes were reached by all except three students who were evacuated on foot to the district referral hospital 56 km downhill from Base Camp. Hygiene was compromised due to cold weather/water. Epidemiological surveillance was not contributory.

Conclusion: Wilderness diarrhea can present in outbreak proportions from formerly safe water sources due to variable microbial contamination. On-site diagnostics and management are required to control outbreaks of wilderness diarrhea. Traveler risk management strategies and traveler awareness/education can be a targeted mandatory intervention to enhance preparedness and resilience capital in outdoor and mountain environments.

Keywords: Diarrhea, Travelers' Diarrhea, Wilderness Diarrhea, Outbreak, Himalayas, High Altitude

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Introduction

Wilderness or backcountry diarrhea is a type of travelers' diarrhea affecting backpackers, trekkers, campers, hikers, soldiers, wilderness and outdoor enthusiasts. *Giardia* and *Cryptosporidium* are the most common pathogens causing wilderness diarrhea followed by bacteria (*Campylobacter, Shigella*, enterotoxigenic *Escherichia coli*, *E. coli* O157:H7, *Yersinia enterocolitica*, *Aeromonas hydrophila*) and viruses (hepatitis A virus, hepatitis E virus). *Giardia* and *Cryptosporidum* cysts, *Salmonella Typhi*, *Shigella*, and the hepatitis A virus can survive freezing temperatures in mountain streams and lakes. Furthermore, protozoal cysts have a low infective dose of 10-25 cysts compared to bacteria which have higher infective doses of 10^6-10^8 colony-forming units/ml of water.[1,2]

Campsites, wilderness, and mountain environments pose additional risks worldwide irrespective of developing or developed regions. Wilderness and outdoor environments restrict the maintenance of adequate culinary hygiene, washing hygiene, and hand hygiene due to limitations in

the availability of water, food, fuel, and soap; the ambient cold or heat, exertion, and winds; and the lack of awareness and motivation. Opportunistic diarrheagenic pathogens are transmitted from contaminated food, water, or hands and cause acute water diarrhea, which is secretory in nature.[3]

The incidence of wilderness diarrhea varies from 3%-74% among travelers to wilderness areas. Incidence is 1 per 5000 person-field days and 0.26 per 1000 program days under strict hygiene and sanitation protocols.[4-8] Incidence fluctuates with seasonal, geographical, climbing schedule, and hygiene variations.

Outbreaks of wilderness or backcountry diarrhea have not yet been described in scientific research literature. In the first of its kind, this paper describes an outbreak of wilderness diarrhea among mountaineering students at a Himalayan Base Camp at 4000 m/13,125 ft in Uttarkashi, India.

Methods

Outbreak investigation for acute watery diarrhea was conducted as a prospective cross-sectional study keeping the entire strength of 126 personnel (46 male students, 34 female students, 10 mountain instructors, 16 ancillary staff, and 20 porters) under surveillance after consent was obtained from each participant and ethical approval was obtained from the Nehru Institute of Mountaineering, Uttarkashi, India.

A preliminary survey of the Base Camp siting, layout, hygiene practices, and duration of occupation was done. Suspected patients of wilderness or backcountry diarrhea were assessed within the general context of intestinal complaints. Oral rehydration was given along with a combination of ciprofloxacin-tinidazole/ofloxacin-ornidazole for 3-6 days. Return of normal bowel function was considered as primary outcome, and return to routine training at Base Camp was considered secondary outcome. All patients were followed up for the entire duration of camping, mountain training, and climbing activities at Base Camp.

The epidemiological surveillance at the district referral hospital targeted patients of diarrhea; laboratory surveillance for diarrheagenic pathogens were attempted around the outbreak period and the past 10 years. Clinicodemographic, surveillance, management, and evacuation profiles were correlated for descriptive statistics, including frequency, percentages, and 95% CI utilizing Microsoft Excel 2010.

Results

The outbreak occurred at a semi-permanent Base Camp located at the snout of Dokrani Glacier at an altitude of 4000 m/13,125 ft, above tree-line. The Base Camp was approximately 24 km from the roadhead, 22 km from the nearest civilization, and 2 km from high-altitude meadows and animal rearing areas. The 24-km distance from the roadhead to Base Camp was reached via 2 overnight stays at 2 intermediate camps. The Dokrani Glacier, formed by 2 cirques originating from 2 peaks namely Jaonli and Draupadi-ka-Danda, feeds the Bhagirathi river system which reaches the nearest city through the roadhead. For more than a decade, the Base Camp location has been occupied five times per year for 28 days each time for the purpose of camping, mountain training, and climbing endeavors by aspiring mountaineers at Nehru Institute of Mountaineering, Uttarkashi, India.

Provisions for camp hygiene and sanitation included well-spaced 10-person tents, a cooking and dining area, and an activity area. Water for cooking and cleaning was sourced upstream from the campsite, while separate yellow-flag defecation areas for men and women were located downstream from the campsite, away from bodies of water. Lectures on camp hygiene and sanitation were given on the first day of briefing at Base Camp. Mountain trainers and kitchen staff were experienced and trained for safe practices in the handling, storage, preparation, and serving of food and water. Boiled drinking water was provisioned at Base Camp. Waste disposal areas were marked for collection followed by deep burial. The weather was sunny and warm during the daytime and colder at night.

A total of 62 personnel presented with wilderness diarrhea with onset after a mean stay of 10.26 ± 2.53 days (95% CI 10.06-10.45 days, range 5-14 days) at Base Camp. The mean age of patients was 29.48 ± 5.91 years (95% CI 29.21-29.75 years, range 18-41 years) (Table 1). Fifty-four amateur mountaineers (31 males and 23 females), 2 mountain instructors, 3 ancillary staff, 2 porters, and an investigating officer presented with acute watery diarrhea. The mean duration of wilderness diarrhea was 5.58 ± 2.11 days (95% CI 5.36-5.80 days, range 2-12 days) (Figure 1).

Altered appetite was reported by all patients. Fever, nausea, vomiting, abdominal cramps, bloating, malaise, blood or mucus in stools were not presented. Prescribed oral rehydration and empiric antimicrobials were found to be effective for clinical relief and allaying fear among the mountaineering students. A total of 6/62 (9.68%) patients presented with mild to moderate dehydration and required monitored oral rehydration. Both primary and secondary outcomes were reached in 51 students for the remaining duration of training. Three patients aged 22, 26, and 28 years could not cope with their illness and were referred to the district referral hospital 56 km downhill from Base Camp. They were evacuated by foot as walking patients for 24 km to the roadhead and had 2 overnight stays in intermediate camps. By the time patients reached downhill, they had recovered completely and never reported to the referral hospital.

No patients or any non-affected participants were immunized for diarrheal diseases such as cholera or typhoid, nor were any of them on any prophylactic antimicrobials or probiotic-prebiotic combinations.

Personal hygiene, washing hygiene, and hand hygiene were compromised among students owing to discomfort with the cold weather and the cold water for washing. Preventive hygiene measures for culinary, water, washing,

Table 1. Clinicodemographic profile of patients of Wilderness/Backcountry diarrhea (n = 54)

Age	Males	Females	Cumulative Percentage	95% CI
<20 years	0	3	4.84	1.26-14.38
21-30 years	18	16	54.84	41.76-67.32
>30 years	18	7	40.32	28.3-53.54

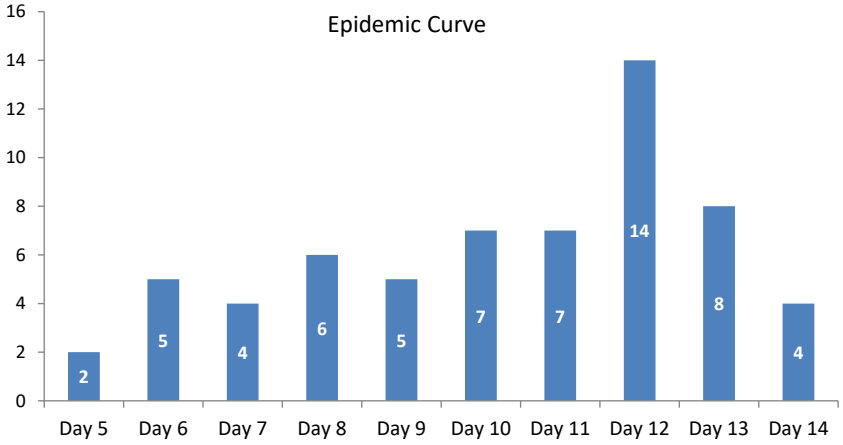

Figure 1. Epidemic Curve of Wilderness/Backcountry Diarrhea (n = 54)

and hand hygiene; maintenance of hydration and nutrition; and moral encouragement were advocated in Base Camp. Epidemiological and laboratory surveillance for diarrhea at the district referral hospital around the outbreak period were not contributory. A long-term retrospective surveillance of 10 years and a seven-year prospective surveillance revealed no similar incidence or outbreak of wilderness diarrhea.

Discussion

Untreated surface streams may be the only source of running water for drinking, cooking, and washing purposes. Other sources of stagnant water such as lakes may be far, few, and contaminated by endemic opportunistic diarrheagenic pathogens from human, livestock, and wild animal excretions in the watershed, getting washed from higher reaches to lower bodies of water.[9]

Frequent human activities of cooking, washing and open-air cat-hole defecation in campsites also lead to fecal contamination of water bodies following precipitation. Semi-permanent campsites in developed nations may have primitive or no sanitation facilities, rendering backpackers at risk of a higher concentration of diarrheagenic pathogens similar to tropical developing countries. The ubiquity of pathogens in the wilderness, overcrowding in camps, and interpersonal contact and sharing of food and water during camp activities facilitate feco-oral transmission.[10]

It is a common practice of both mountain residents and backpackers in India to use untreated water from mountain streams. Minor gastrointestinal disturbances are followed by immunity. The Base Camp had a proven track record of safe water, and there have been no incidents of diarrheal disease among mountaineering students or trainers in the past. Furthermore, boiled water made available to mountaineering students effectively neutralizes bacteria, parasites, and viruses. Mountaineering students form a heterogeneous population from various parts of the country, and they may have varied ideologies and practices toward culinary and overall hygiene.[11] The outbreak was likely a result of transient contamination or pulse contamination, wherein there may be brief periods of high parasitic cysts concentrations consequent to fecal contamination. However, in the high-altitude Himalayan wilderness located far away from civilization, laboratory-confirmed etiological diagnoses could not be established.

Non-infectious diarrhea in the wilderness can occur for 2-3 days because of changes in food and environment. The incubation period of protozoal and bacterial pathogens is seven days and seven hours on average and may, accordingly, present during or after return from the wilderness. The incubation periods of *Cryptosporidium* and *Giardia* are seven and 14 days, respectively. The onset of outbreak was after a minimum of five days at Base Camp, and a limited response was achieved with the combination of ciprofloxacin-tinidazole/ofloxacin-ornidazole. *Cryptosporidium* and *Giardia* are the most common diarrheagenic pathogens in wilderness diarrhea. In the absence of any other evidence, the likely etiology was *Cryptosporidium*, as its incubation period is seven days; *Giardia* would have responded to tinidazole or ornidazole, and nitazoxanide is the treatment for *Cryptosporidium*, which was not given. An etiological study of wilderness diarrhea at Grand Teton National Park found 23% of cases were *Campylobacter*, 8% were *Giardia,* and 69% remained unidentified. The duration of symptoms can extend for a week in 10% of patients.[12,13]

Hypoxia-induced altered physiology at a high altitude and untreated water can affect bowel habits, creating confounders in the frequency of bowel evacuation. First-time travelers to mountains may lack a general sense of well-being and an adequate appetite due to hypoxia. Mountain environments have intraday variations of both cold and hot weather, leading to improper judgments regarding perspiration losses and required amounts of water intake, which then lead to dehydration and/or constipation. Both constipation and wilderness/backcountry diarrhea may exist in different backpackers in a camp, thus delaying reporting to healthcare authorities.[14] High altitude-induced lassitude and indifference lead to outdoor inactivity and negligence. Fear of expulsion or a false sense of bravado may also preclude reporting to medical authorities. Travelers climbing ahead of Base Camp may find the medical establishment inaccessible because of distance, terrain, weather, or the lack of real-time communication.[15,16]

Expedition-style mountain climbing includes resource provisions to cater to prolonged mountain activities. Teams

having the privilege of being accompanied by a paramedic or a doctor have the advantages of rapid assessment, treatment, monitoring, descent/evacuation, and outbreak response. The presence of a doctor at Base Camp facilitates early reversal to routine activities at high altitude, thus enhancing the contingency and resilience capital of the expedition. Evacuation is limited by the availability of collection, personnel, terrain, distance, logistics, and weather considerations, and are largely not feasible in the vast expanse of the Himalayan terrain. Diagnosis, prognosis, and management are dependent on clinical acumen due to the inaccessibility of referrals. On-site management at Base Camp far away from the hospital set-up may be restricted by the unavailability of diagnostic and treatment modalities. Since the current study was conducted at Base Camp, detailed etiological, serological, and epidemiological aspects could not be explored, and this constitutes a limitation of the study.[17,18]

All patients being Indians were not on any prophylactic antimicrobials or probiotics as they are not recommended for travel within India.[19,20] Travelers are expected to have immunity to endemic pathogens, although they may not have been exposed to pathogens from wilderness environments as India is a vast and geographically diverse country.

Diarrheagenic diseases may appear to be spontaneously resolving, self-limiting disease entities; however, they have the potential to disrupt social and community health security in its entirety. One ongoing example is the cholera epidemic in Yemen by *Vibrio cholera* O1 Ogawa serotype, continuing since October 2016 amidst civil war, regional conflict, and the consequent decay of the public health infrastructure, water, sewerage, and sanitation systems in both urban and rural settings. Yemen has witnessed extremely high morbidity with 862 858 confirmed patients, 959 810 suspected patients, and mortality reaching 2219 patients. Approximately 50% morbidity and 25% mortality has occurred among children. The national attack rate is 348.51 per 10 000 population. The case-fatality rate is 0.7% overall and 3.2% in patients above 60 years of age owing to dehydration, malnutrition, and no access to healthcare.[21-23]

Outbreaks of wilderness diarrhea in camps can amplify the protozoal population, thereby increasing the shedding of cysts by patients, convalescents, and carriers in water bodies. Resident communities and livestock using contaminated water downhill can be affected, continuing the vicious cycle of amplification of outbreaks into epidemic proportions until the water is treated prior to consumption.[24] Most rural agrarian resident communities in developing countries have no means of treating water and consider untreated water safe for consumption.

The challenges faced at high altitudes in diagnosing, treating, and overall management of an outbreak cannot be over-emphasized.[25] The origin of the outbreak, source/reservoir, exposure dynamics, mode of transmission, index-case, asymptomatic carrier state, appropriate diagnosis and therapy may not be discerned. Specific epidemiological studies are restricted by unpredictability and non-reproducibility due to fewer patients, the unavailability of a matched control group, the unavailability of screening modalities, variable disease dynamics, and prognosis to empirical therapy.

Outbreaks of diarrheal disease may potentially paralyze local public health systems as an outbreak may not be controlled until a safe source of potable water is made available. Water security remains a concern in many parts of the world today, which poses an imminent danger following inadvertent or deliberate contamination. It is predicted that by 2025, 2 thirds of the world's population will be under water-stress. Water sustainability mandates aquifer replenishment, infrastructure development, distribution networks, risk and resource management aligned with sustainable development goals. Minimization of wastewater recycling and reuse are required to improve the availability of water for human, agricultural, and industrial consumption.[26,27]

Outbreak surveillance systems need to be strengthened from a travel medicine perspective, as most incidents go unreported. An outbreak of wilderness diarrhea has not been reported in scientific research literature so far. To the best of the authors' knowledge, this outbreak investigation of wilderness diarrhea at a Base Camp located in a high-altitude wilderness on the Indian Himalayas and affecting 62 personnel, including the investigating officer, is rare, unique, and a first of its kind. Medical doctors, clinical microbiologists, and public health epidemiologists may not be available in the wilderness or in mountain terrain to ascertain risks, identify etiology, diagnose, treat, or evacuate patients. Travelers are likely to self-medicate while camping and are likely to report to healthcare providers on return from the wilderness only if they continue to be symptomatic.[28] Most backpacking individuals or teams may not appreciate the importance of identifying outbreaks and reporting systems limiting surveillance initiatives. Small disease clusters may not be noticed, reported, or appreciated and can turn into epidemic proportions.[16] Reporting and ascertaining bias along with confounding can limit explicit, evidence-based surveillance. Barriers to communication and grapevine communication may confabulate real-time outbreak surveillance.[29] Core competencies for rapid diagnosis and on-site management are necessary to overcome existing limitations and further concept development and capacity building in travel medicine, wilderness medicine, and tropical medicine.[10,17,18,30-32]

Conclusion

Wilderness diarrhea can present in outbreak proportions from formerly safe water sources due to variable microbial contamination. On-site diagnostics and management are required to control outbreaks of wilderness diarrhea. Astute planning which incorporates traveler risk management strategies and traveler awareness/education can be a targeted mandatory intervention to enhance preparedness and resilience capital in outdoor and mountain environments beyond the means and reaches of hospitals and community public health systems.

Authors' Contributions

The first author investigating the outbreak was the expedition doctor cum instructional mountain-training officer for the mountaineering team. Other authors contributed equally

Research Highlights

What Is Already Known?

Wilderness or backcountry diarrhea is a type of travelers' diarrhea encountered in outdoors and mountain environments. Campsites in the wilderness pose additional risks for wilderness diarrhea worldwide, irrespective of developing or developed regions.

What This Study Adds?

1. In a first of its kind, an outbreak of wilderness diarrhea at a semi-permanent Himalayan Base Camp at 4000 m/13 125 ft in Uttarkashi, India, was investigated and managed by empirical antimicrobials.
2. Wilderness diarrhea can present in outbreak proportions from previously safe water sources due to variable microbial contamination. On-site management and traveler education can be a targeted mandatory intervention to enhance preparedness and resilience capital in outdoor and mountain environments.

toward the final preparation of the manuscript.

Conflicts of Interest Disclosures

None.

Ethical Approval

Ethical approval was covered by the Institutional Committee.

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