

## ORIGINAL RESEARCH

# Trends in Skin and Soft Tissue-Related Injuries in NOLS Wilderness Expeditions from 1984 to 2012

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**Objective.**—Wilderness expeditions inevitably involve risk to participants. Understanding of expedition-related illnesses and injuries allows institutions and individuals to develop strategies to mitigate risk. We describe findings and trends in soft tissue injuries, the second-most common type of injury, among participants in the National Outdoor Leadership School expeditions from 1984 to 2012.

**Methods.**—Injuries and illnesses sustained by students and staff have been recorded continuously since 1984 in the extensive National Outdoor Leadership School database. We performed a retrospective analysis of incidence of soft tissue injuries in this population. Data before 1996 were standardized in order to make use of the entire dataset.

**Results.**—Of 9734 total reported incidents, 2151 (22%) were soft tissue related, 707 (33%) of which required evacuation. The sex distribution of incidents was similar to the sex distribution of participants. The largest incidence of soft tissue injuries occurred independent of activity (711 incidents, 33%). The most commonly associated activities were hiking (528 incidents, 25%), camping (301 incidents, 14%), and cooking (205 incidents, 10%). Over the study period, rates of injury declined overall and in every individual category except cooking.

**Conclusions.**—Over this 28-year period, the incidence of soft tissue injuries associated with the most common activities decreased. Incidence of activity-independent injuries did not change significantly, but reported severity decreased. These data provide unique insights to help improve wilderness risk management for institutions and individuals and suggest areas in which educational efforts may further reduce risk.

*Keywords:* expedition medicine, wilderness medicine, infection, injury, illness, evacuation

## Introduction

Annually in the United States, almost 40 million people with varying degrees of experience enjoy outdoor pursuits such as hiking and camping.<sup>1</sup> The National Outdoor Leadership School (NOLS), headquartered in Lander, Wyoming, has been a popular source of outdoor experiential education since its founding in 1965. NOLS teaches technical outdoor leadership skills, environmental ethics, and leadership on multiweek wilderness expeditions on 5 continents, ranging from

sea-level water courses like sea kayaking and sailing to high-altitude mountaineering. NOLS has collected illness and injury data for its expedition participants since 1984, amassing an extensive database that encompasses 3.7 million participant days. Given the wide range of activities and geography and the great size of this database, analysis of these data promises significant potential utility to schools, organizations, and individuals planning outdoor activities. Existing literature on injuries and illnesses sustained while participating in outdoor activities is limited, and most studies are of relatively narrow scope, examining, for example, only skiing,<sup>2</sup> sea kayaking,<sup>3,4</sup> or sailing.<sup>5</sup> One broader study suggests that soft tissue injuries such as contusions and lacerations are the second most common type of wilderness injury after

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athletic injuries such as fractures and sprains.<sup>6</sup> We have therefore focused our analysis on soft tissue injuries, which we hypothesized to be a leading cause of injury among NOLS participants and which would have been positively affected by improved screening and training protocols put into place at NOLS over the past 3 decades.

## Methods

This is a retrospective review of incidents reported by NOLS staff over the years 1984 to 2012, encompassing all NOLS expeditions worldwide during that time period. The term “incident” refers to events directly affecting the health, safety, and welfare of NOLS students and staff. Events may be accidental, intentional, or an outcome of the inherent risks of participating in an outdoor expedition.<sup>7</sup> The term does not indicate severity. Reportable incidents were required to meet one or more of the following criteria: 1) injury requires more than simple first aid, such as applying a clean dressing or supportive elastic bandage; 2) injury needs follow-up care or prescription medications; 3) injury interferes with active participation for a period of 12 hours, beginning the next day; or 4) injury necessitates evacuation. A strong institutional emphasis is placed on accurate and timely reporting of all expedition incidents. Incidents are voluntarily reported by NOLS staff, and a database of incidents is maintained by the risk-management director. Methods to ensure accurate capture of any field injury include a standardized process of precourse briefings before field deployment, required daily field journaling of events by instructors, written accounting of all medication and supply usage, and both written and verbal end-of-course debriefings. The iterative nature of this practice helps ensure accurate data capture.

In this study, we analyzed trends in soft tissue–related incidents at NOLS. Incidents affecting soft tissues include lacerations, puncture wounds, contusions, burns, rashes, infections, and blisters. Incidents are divided into categories by the type of activity (eg, hiking or camping) or type of complaint (eg, cellulitis or ear infection). Because of differences in the number of participants and the lengths of programs over time, rates were calculated per 1000 person days (1 person day is equivalent to 1 person on a course for 1 day).

Data collected from 1984 to 2012 were used for this analysis. NOLS data collection was standardized starting in 1996. Small subsegments of this database (typically over 3 years and drawn from 1996–2012) have been analyzed previously, with recommendations that a larger analysis be pursued. We reviewed the primary records before 1996 and standardized them for consistency with

the more recent data. By expanding the period of time to include these data, over 1 million additional total person days of valid data could be used in our analysis, increasing the database total to just over 3.7 million total person days.

Incidents were summarized by type of activity, and incident rates were calculated as number per 1000 person-years. Poisson regression models were used to test the trends over time. All statistical analyses were conducted using SAS version 9.4 (The SAS Institute, Cary, NC). A 2-sided *P* value of .05 or less was considered as statistically significant.

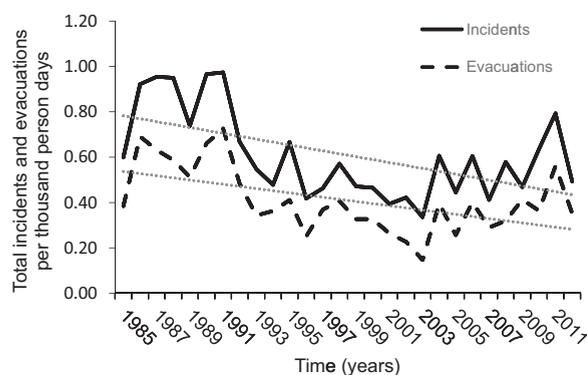
## Results

### GLOBAL TRENDS

From 1984 to 2012, of 9734 total reported incidents, 2151 (22%) were soft tissue related. Of these, 707 (33%) were severe enough to require evacuation. These included 5 bear attacks; many lacerations large enough to require stitches, including one caused by a crocodile bite; and blisters and other infections preventing weight bearing in the affected extremities. In contrast, 2927 (30%) were athletic injuries, which comprised the largest category of incidents. Overall, 1301 (61%) of the soft tissue–related incidents affected male subjects, who also comprised 63% (446) of evacuations. These values closely paralleled the overall sex distribution of course participants. In almost every individual category, with the exception of horseback riding and swimming, incidents involving male subjects were more frequent than those involving female subjects, but distribution by sex within each category was quite similar to the sex distribution of participants overall.

Infections and rashes were the most common type of soft tissue incident reported (711 incidents, 33%). These complaints were not related to the activity during which the injury was sustained. Fungal infections such as *tinea corporis* and *candida*, polymorphic light eruption (commonly known as “sun bumps”), cellulitis, and insect- and plant-related rashes were common examples. Lacerations, punctures, and contusions (528 incidents, 25%) were the second most common injury type, most of which were associated with hiking. Commonly reported injuries included trips over boulders or branches, falls down slopes or into ravines, and accidental blunt trauma to the head or extremities from overhanging branches and rocks.

Analysis of the trends over time reveals a statistically significant decrease in the rates of incidents and evacuations over the past 30 years. The difference in the actual incident rate is small, however, having decreased from



**Figure 1.** Total incidents and evacuations per 1000 person-days over time.

0.60 per 1000 person-days in 1985 to 0.49 per 1000 person-days in 2012 (Figure 1).

#### TRENDS BY ACTIVITY

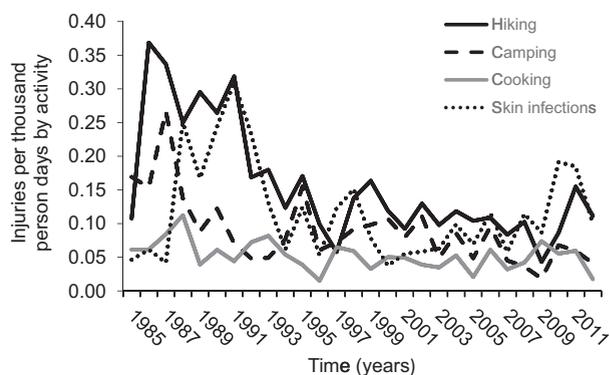
The number and frequency of incidents were categorized according to the activity during which they occurred (Table 1). The most common specific activities associated with soft tissue injuries were hiking (527 incidents, 25%), camping (298 incidents, 14%), cooking (187 incidents, 9%), boating (154 incidents, 7%), and climbing (118 incidents, 6%). Incident rates in the 4 most common categories were trended over time (Figure 2).

Overall, there was a decline in hiking injuries over time. Of all hiking incidents, 435 (83%) were sustained while wearing a pack. Most of these injuries were related

**Table 1.** Total incident numbers by activity

Activity type	Total no. of incidents	Percent of total incidents
Hiking	527	25
Camping	298	14
Cooking	187	9
Boating	154	7
Climbing/Mountaineering	118	6
Swimming	48	2
Game playing	28	1
Skiing	27	1
Caving	19	1
Horseback riding	18	1
Fishing	15	1
Glacier travel	10	1
Independent of activity <sup>a</sup>	702	33

<sup>a</sup> This category includes cellulitis, rashes, insect bites, ingrown toenails, ear infections, sinus infections, and conjunctivitis.



**Figure 2.** Hiking, camping, and cooking injuries and skin infections over time.

to slips and falls (199 incidents among hiking, 305 incidents among total injuries) or accidental contact with branches and rocks (46 incidents, 9%) that was not necessarily accompanied by a fall. Blisters accounted for 94 incidents (18% of hiking injuries). Three reported incidents involved accidental discharge of bear spray, which resulted in skin and eye irritation and, in one case, minor respiratory distress. In comparison, there were, as previously noted, 5 total reported incidents of bear attacks, 4 of which occurred during hiking activities. The fifth occurred while a student was sleeping in camp.

Camping injuries also significantly declined over time ( $P < .001$ ). These mainly consisted of injuries sustained while walking around camp, often barefoot; accidental contact with cacti (8 incidents, 3%); and insect (55 incidents, 18%) and animal (18 incidents, 6%) bites. The reported incidents involving animals included injuries by a mouse, a hyena, 2 wildcats, a dog, a black bear, a quoll (an Australian marsupial), a fox, and a rattlesnake.

Of 187 total cooking incidents, the most frequent type was burns (172 incidents, 84%), very often involving spills of boiling water (113 incidents, 66% of burns), followed by accidental lacerations. Thirty-three (16%) of the cooking incidents were sustained while cutting food with a knife, 12 (36%) of which were specifically while cutting cheese. One memorable incident involved temporary loss of vision from hot butter splashed in the eyes while making a calzone. There was no significant decrease in cooking injuries over time.

#### TRENDS BY INCIDENT TYPE

Incidents were also analyzed by type of injury or illness (Table 2). The most common types of soft tissue-related incidents, comprising nearly one third of the total incidents (702, 33%), were not a direct result of the activity during which they occurred. These included episodes of cellulitis and dermatitis, insect and animal

**Table 2.** Total incident numbers by incident type

<i>Incident type</i>	<i>No. of incidents</i>	<i>Percent of total incidents</i>
Cellulitis/Skin rashes	526	25
Cuts/Lacerations/Punctures	391	18
Burns	195	9
Insect bites	189	9
Blisters	166	8
Bruises/Contusions	137	6
Eye-related incidents (including conjunctivitis and corneal abrasions)	94	4
Ear infections (otitis media and externa)	91	4
Ingrown toenails	31	1
Animal bites	18	1

bites, ear and eye infections, and ingrown toenails. Of these incidents, 526 (75%) were skin infections such as cellulitis, abscesses, and other rashes, of which only 18 (3%) were known to be from poison ivy. The total number of skin infections decreased over the study period.

Lacerations, punctures, and contusions make up the second largest group (528 incidents, 25%). These were categorized as directly related to the activity the participant was pursuing at the time of injury.

## Discussion

Few published studies examine illness and injury rates in wilderness settings. The NOLS dataset has global reach (extended experience on 5 continents), includes a wide range of activities (from sailing to caving to high-altitude mountaineering), and covers an extended time period (28 years) and a wide range of student ages (14 to 66 years). As such, the findings are likely to reflect injuries experienced by a broad range of outdoor enthusiasts. Injury and illness trends extracted from these data will lead to a better understanding of the health-related challenges faced by participants in wilderness expeditions and will support targeted interventions.

Although they are rare and down-trending, this study showed that soft tissue injuries continue to be one of the most common causes of morbidity in the backcountry among NOLS participants, consistent with prior studies of NOLS data<sup>7,8</sup> as well as that of other expedition programs. In one retrospective study of an Arctic expedition program in Alaska with up to 60 participants per year, all participants were given screening physicals, injury and illness-prevention training, and a hands-on

wilderness first aid course by an expedition physician. Over a period of 7 years, only 28 total incidents requiring physician-level care were reported, 11 of which were soft tissue related.<sup>9</sup> In a study of injuries and illness in visitors to 8 California national parks over 3 years, the incident rate was quite low, with only 9.2 people per 100,000 visits affected. Of these, more than 70% were attributed to soft tissue or musculoskeletal injury.<sup>10</sup>

## LONGITUDINAL TRENDS AND TARGETED INTERVENTIONS

Although previously published analyses of smaller subsets of these data spanning shorter time periods indicate some variability in the incidence trends of injury and evacuation over 2- to 3-year periods, this review of almost 30 years of continuous data reveals a significant downward trend in injury and evacuation rates. This decrease occurred despite the constant influx of new, inexperienced students and the unpredictability of wilderness conditions. The decline in injury rates may reflect improvements in pretravel medical screening, field risk mitigation, educational efforts, and equipment. On prior NOLS analyses of limited datasets, the injury rate decreased from 2.3 incidents per 1000 program days in 1984–1989<sup>11</sup> to 1.07 incidents per 1000 program days in 1999–2002.<sup>7</sup> Total evacuations also decreased over time from 1.77 to 1.2 incidents per 1000 program days during the same time period.<sup>7</sup> These decreases occurred after NOLS had introduced significant programmatic changes, including careful review of wilderness course routes to optimize safe travel. NOLS also began providing students with targeted predeparture information encouraging levels of physical fitness commensurate with the anticipated degree of their course's physical demands.

Slips, falls, and accidental contact with plants and other obstacles were among the most common causes of soft tissue injuries during both hiking and camping. This may suggest that heightened awareness of one's surroundings and better protective gear (eg, long-sleeve shirts or closed-toed shoes) might contribute to reducing the number of injuries. These types of injuries are unlikely to be influenced by precourse medical screenings, as are the athletic injuries such as sprains and fractures, but would benefit from careful review of participants' gear, clothing, and shoes to ensure proper fit. There have been many technical improvements to shoes, clothes, packs, and other gear over the past 3 decades, and this may also have contributed to the decline in injuries.

Perhaps the most striking finding is the large number of infections involving skin, ears, and eyes. In prior

NOLS analyzes, wound infection varied from 0.10 per 1000 program days in 1984–1989<sup>11</sup> to 0.02 per 1000 programs days in 1999–2002<sup>7</sup> to 0.04 per 1000 program days in 2002–2005.<sup>8</sup> Although incident severity was imperfectly incorporated into the current data, there was an increase in the reported incidence of cellulitis and a decrease in the severity of reported skin infections by the qualitative assessment of NOLS leadership between 2009 and 2010, when new medical protocols were implemented. These protocols, instituted after several NOLS participants experienced unusually severe skin infections, included increased instructor education in the importance of hygiene and early recognition and treatment of skin infections.

Primary prevention of skin infections may be achieved through targeted education regarding early recognition of “hot spots,” toenail trimming, appropriately fitted and broken-in footwear, and insect bite prevention. Once a wound occurs, education to encourage use of proper hand hygiene when handling the area, proper irrigation, careful removal of any foreign bodies, and appropriate bandaging to maintain wound cleanliness may contribute to decreased infection risk. Although many of these infections may have been inevitable given the rigors of extended expeditionary travel over difficult, remote, technically demanding wilderness terrain, these data suggest that focused educational efforts leading to improved prevention and early interventions likely contributed to a decline in the severity of skin and soft tissue infections. In addition, increased first aid training for participants may be of benefit.

Lacerations and contusions are harder to prevent than infections after skin injury. Trail conditions are notoriously unpredictable. In one study, an individual’s pack weight, anthropometry, and individual characteristics did not affect the risk of musculoskeletal or soft tissue injury while hiking with a backpack.<sup>12</sup> Potential areas in which continued focus may improve outcomes may include well-balanced and fitted packs and properly fitted footwear, as these 2 pieces of equipment may increase the risk of falls if improperly adjusted or sized. Short, practice hikes while wearing the same footwear and pack before setting out on a longer expedition could also help the participant to acclimate to these conditions, potentially lowering the injury risk in the field. Other factors, including increased predeparture fitness and pretrip training, should be examined to determine appropriate strategies to reduce significant musculoskeletal and soft tissue injuries on wilderness expeditions.

There is considerable research on injury surveillance and prevention in athletes and military personnel. This is relevant as these populations may also be exposed to austere, unpredictable environments. Studies of military

personnel suggest that fitness may be a predictor of injury risk,<sup>13</sup> with low cardiopulmonary endurance found to be the most consistent risk factor for injury.<sup>14–17</sup> Introducing a fitness program for recruits has been shown to reduce the rate of injury.<sup>18,19</sup> If fitness is a modifiable risk factor, NOLS may be able to target participants with low fitness and recommend that they meet certain fitness standards (eg, being able to run a mile in a predefined time) before entering the course. In one report of wilderness expeditions in Alaska, as in many expedition courses, although there were no absolute medical criteria for exclusion, participants were still expected to ski, climb rock and ice, travel over glacial and crevassed areas, and weather the Arctic environment.<sup>9</sup> Screening individuals carefully and adjusting endurance requirements may better prepare participants for anticipated physical challenges. Certain NOLS courses are tremendously more physically demanding than others (eg, high-altitude mountaineering as compared to horse-packing trips) and may especially benefit from detailed and demanding preexpedition physical fitness requirements.

## LIMITATIONS

This study has several limitations. This is a retrospective data review open to enrollment and data entry biases. There are no external means of data validation. Calculations use total program days for each activity, rather than accounting for the frequency of each activity. Variation in frequency of each activity, the sex and age distribution of participants, and geographic distribution of expeditions among years may cause inaccuracies.

As described above, data from 1984 to 1996 were gathered before standardization of data forms was implemented. Despite systematic efforts to review the primary data carefully and abstract these data into the same form and standards as post-1996 data, incidence reporting could be affected. Additionally, categorization of incidents is complicated because many of the reported incidents are interrelated. For example, a skin break due to blister may become infected and result in cellulitis. For the purposes of data analysis, incidents were categorized under the initial event (blister) even if they later developed into an infection. The data are not sufficiently granular to allow for subcategorization of incidents (eg, the division of “cellulitis” into caused and not caused by blisters). Although this affected only a very small number of the data points, it might lead to undercounting the incident type that occurred second.

Although they comprise a very large database, these data were drawn from a single organization and so may reflect unique risk mitigation and field supervision

practices. Despite a wide range of student experience before NOLS participation, all students are accompanied by experienced NOLS instructors, and therefore these data may not be generalizable to unsupervised wilderness travelers.

## Conclusion

Limited data exist on injury and illness patterns among participants in outdoor recreational activities, despite the fact that millions of people engage in these activities every year. Institutions and individuals would benefit from greater awareness of large-scale injury surveillance programs,<sup>20</sup> and data from these programs can be used to inform strategies for risk reduction and prevention of injury and illness in the wilderness. This review of extensive data collected by NOLS over the past 3 decades shows that soft tissue injuries comprise the second largest category of injury, with an overall decreasing incidence over time. This may be attributable to increased educational efforts, particularly surrounding early recognition of cellulitis and systematic wound care; targeted physical fitness requirements; and technical improvements in clothing and equipment. Further efforts may be directed at developing fitness guidelines and training programs for each type of outdoor course, as well as screening of gear and clothing for proper fit. By examining trends, patterns of injury and illness among NOLS participants, and successful NOLS interventions, outdoor expedition programs may be able to implement their own initiatives to reduce risk in their participants.

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