ORIGINAL RESEARCH

Epidemiology of Wilderness Search and Rescue in New Hampshire, 1999–2001

Gretchen K. Ela, MD

From the University of Pennsylvania School of Medicine, Philadelphia, PA, and the Lahey Clinic, Burlington, MA.

Objective.—To describe the epidemiology of wilderness search and rescue in a region with easily accessible, heavily used wilderness areas.

Methods.—We conducted a retrospective review of New Hampshire Fish and Game Department wilderness search-and-rescue reports between January 1999 and December 2001. The study group consisted of all the subjects of the New Hampshire Fish and Game Department search and rescue in the state of New Hampshire during the study period. Demographics, types of incidents, type and location of injuries, environmental factors, fatalities, and use of medical services for all the subjects were analyzed.

Results.—Three hundred twenty-one incidents involving 457 subjects were analyzed. The mean age of the subjects in the incidents was 35.6 years, with 64.5% men and 35.4% women; 73% of the subjects resided in New Hampshire and Massachusetts. At the time of the incident, 57.3% of the subjects were hiking. Injuries precipitated 39.3% of the rescues, whereas lost and missing persons accounted for 41.4%. Fractures accounted for 33.7% of the reported injuries; 49.7% of the injuries were to the lower extremities. Sixty-four of the subjects (14%) died; 32.8% drowned, and 23.4% died from cardiac events. Volunteers were used in 53.3% of the rescues, a rescuer was injured in 2.5% of the incidents, and at least 36.4% of the subjects were transported to a hospital.

Conclusions.—The most prevalent demographic group requiring search-and-rescue efforts in New Hampshire was men aged 30 to 40 years who were hiking and who resided within a 4-hour drive of the area where they encountered difficulty. To decrease the number of people involved in most search and rescue, efforts should be focused on preventing wilderness users from getting lost and preventing lower extremity musculoskeletal injuries. Wilderness deaths may be prevented by focusing attention on cardiac health in wilderness users older than 50 years and on water safety.

Key words: wilderness, search and rescue, New Hampshire, hiking

Introduction

Very few data have been published in the medical literature about incidents that lead to wilderness search and rescue. Yet the popularity of wilderness activities is growing rapidly, making wilderness issues relevant to an ever-larger demographic group. According to the National Survey on Recreation and the Environment, the number of Americans who hike increased 46% between 1994 and 2002 from 47.8 million to 69.7 million.^{1,2} As the number of wilderness users grows, it becomes increasingly important to quantify the problems they en-

counter so that these problems can be prevented in the future. Search and rescues are a particularly important subset of wilderness problems to investigate because these incidents expose rescuers to potentially dangerous conditions. Decreasing the need for search and rescue would therefore have 3 main benefits: 1) a reduction in the morbidity and mortality of wilderness users, 2) a decrease in the expense of search and rescue, and 3) a reduction in the risk to which rescuers are exposed.

To our knowledge, no published studies have examined search-and-rescue incidents in easily accessible, heavily visited wilderness areas used by a broad cross section of the population. Moreover, very few studies have gathered data on wilderness incidents in the eastern United States^{3,4}—the vast majority of data on US wilderness injuries originate from the western states. Rela-

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Corresponding author: Gretchen K. Ela, 12 Revolutionary Ridge Rd, Bedford, MA 01730 (e-mail: ela@post.harvard.edu).

tively few papers examine search and rescue involving mountaineering expeditions—one paper on incidents on Denali, another on rescues in Switzerland, and a third on incidents around Mount Hood.^{5–7} Several other papers investigate morbidity and mortality in western US wilderness areas but do not exclusively focus on search and rescue. One paper analyzed morbidity and mortality in California National Parks; another examined wilderness mortality in Arizona; and a third investigated morbidity among participants of National Outdoor Leadership School courses, where the vast majority of the population was younger than 30 years.^{8–11}

The state of New Hampshire, which includes the largest portion of White Mountain National Forest, was chosen as the study area for this project because it contains a number of easily accessible, heavily visited wilderness areas used by a broad cross section of the population. With 2.7 million visits during 2000, White Mountain National Forest is one of the most heavily visited wilderness areas in the United States, similar to Yosemite National Park (3.4 million visits) and Yellowstone National Park (2.8 million visits).¹²

Predictable patterns of conditions may exist for incidents resulting in wilderness search and rescue. Specifically, the following patterns are hypothesized:

- The most frequent subjects of search and rescue are 20- to 25-year-old men, who may be likely to engage in risk-taking behavior, and 50- to 60-year-old men, who may be likely to overestimate their physical capabilities.
- Hiking is the most frequent activity associated with search and rescue.
- The most common injuries are musculoskeletal injuries to the extremities.
- People who die in the wilderness are older than the average person requiring search and rescue.

By systematically and quantitatively compiling data from incidents during several consecutive years, demographic groups, activities, types of injuries, and environmental factors that are predominantly involved in wilderness search and rescue may be identified. Because New Hampshire's wilderness areas are popular and easily accessible to a wide variety of users, the pattern of conditions leading to search and rescue in New Hampshire may provide useful information regarding search and rescue in popular wilderness areas in general.

Methods

This study is a retrospective analysis of New Hampshire Fish and Game Department search-and-rescue records for 1999–2001. The New Hampshire Fish and Game De-

Table 1. Reason for exclusion

<i>Reason for exclusion</i>	<i>Count</i>	<i>Count (%)</i>
False report	17	25.0
Suicide	14	20.6
Runaway/Walkaway	12	17.6
Child lost	11	16.2
Cognitively impaired	11	16.2
Helicopter/Airplane crash	2	2.9
Other	1	1.5
Total	68	100.0

partment has overarching responsibility for wilderness search and rescue within New Hampshire under state statute RSA 206:26. Officers of the New Hampshire Fish and Game Department complete a standardized report for every search-and-rescue incident in which they are involved. This report includes demographic information and 20 coded fields that record information about the incident as well as a narrative description of most cases.

The subjects of this study were users of New Hampshire wilderness areas for whom a search and rescue was initiated and the New Hampshire Fish and Game Department was involved. All New Hampshire Fish and Game Department search-and-rescue reports between January 1, 1999, and December 31, 2001, were reviewed. The incidents were selected for analysis according to 1) inclusion criteria, and 2) exclusion criteria.

Search-and-rescue incidents that met the criteria for inclusion in the study involved people who were intentionally engaged in one of the following wilderness activities: hiking, walking, climbing, cross-country skiing, backcountry downhill skiing, hunting, snowmobiling, all-terrain vehicle use, boating, canoeing, or fishing.

Exclusion criteria were defined as incidents in which the subject was not intentionally engaged in a wilderness activity (see also Table 1):

- A child who became lost when not engaged in an intentional wilderness activity (ie, a small child wandered out of his or her own backyard).
- A person suffering from dementia or who was otherwise cognitively impaired and became lost when he or she originated from his or her place of residence.
- A person who committed suicide and happened to have done so outside.
- A runaway—defined as an individual who intentionally disappeared for a time.
- A helicopter or airplane crash.
- A false report with no individual in need of assistance.

Figure 1. Age distribution of the subjects of search and rescue.

Incident data were entered in a Microsoft Access database. The following variables were recorded for each incident: age of the subject(s), sex, state of residence, date and time of the incident, temperature at the time of the incident, weather and light conditions, location of incident, type of incident, activity performed before the incident, medical history, deaths, cause of death, injuries, human factors that contributed to the incident, environmental factors that contributed to the incident, volunteer use, volunteer injury, method of recovery of the subject, special skills that rescue teams used, transport of the subject to a hospital, cell phone use, and number of people in the subject's party. When a disparity existed between the information recorded in the coded fields and the narrative report, the information recorded in the narrative was used in the analysis. The data were then analyzed by JMP IN statistical program version 4.0 (SAS Institute Inc, Pacific Grove, CA) to create histograms and calculate means and confidence intervals. Percents were rounded to 1 decimal place. Hence, totals do not all equal 100%.

This study was approved by the institutional review board at the University of Pennsylvania as a study exempt from full review, because the project involved the collection of existing data and documents that were publicly available.

Results

The New Hampshire Fish and Game Department conducted 389 wilderness search and rescues between January 1, 1999, and December 31, 2001, involving 526 subjects. Three hundred twenty-one incidents involving 457 subjects met the inclusion criteria for this study. Sixty-eight incidents involving 69 subjects were excluded according to the aforementioned criteria.

Table 2. Type of incident

Type of incident	Count	Count (%)
Injury	126	39.3
Lost person	88	27.4
Missing person	45	14.0
Medical problems	29	9.0
Drowning	29	9.0
Relay	1	0.3
Not recorded	3	0.9
Total	321	99.9

DEMOGRAPHICS

The age was recorded for 89% (409 of 457) of the subjects. The mean age was 35.6 years (SD, 17.9; 95% CI, 33.8–37.3), and the median was 35 years (Figure 1). The sex of the subject was recorded for 96.3% of the subjects. Nearly twice as many subjects were men as women: 64.5% were men and 35.4% were women.

The state of residence was recorded for 90.8% of the subjects. Seventy-three percent of the subjects were from New Hampshire (41%) and Massachusetts (32%). Eighty-six percent of the subjects resided in 1 of the 6 New England states (Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, or Connecticut). Canadians accounted for 2.2% of the subjects, whereas 1.7% of the subjects were from countries other than the United States and Canada.

INCIDENTS AND INJURIES

The type of incident was recorded for 99% of all incidents (Table 2). Injuries precipitated 39.3% of the rescues, whereas lost and missing persons accounted for 41.4%. A primary medical problem—such as a myocardial infarction, seizure, or dehydration—initiated 9.0% of the rescues. The activity engaged in at the time of the incident was recorded for 99.4% of the incidents (Table 3). Hiking was by far the most common activity (57.3%), involving 5 times as many subjects as the next most common activity, operation of an off-highway recreational vehicle such as a snowmobile or an all-terrain vehicle (11.5%).

In 51.1% (164 of 321) of the incidents, an injury to the subject of the rescue was recorded. In 17 of these 164 incidents, a second injury was recorded, for a total of 181 separate injuries. No injuries were sustained in 45.2% of the incidents, and in 3.7%, the presence or absence of an injury was not recorded.

The most common type of injury reported in this se-

Table 3. Type of activity

<i>Type of activity</i>	<i>Count</i>	<i>Count (%)</i>
Hiking	184	57.3
OHRV*	37	11.5
Boating/Canoeing	18	5.6
Climbing	17	5.3
Other	15	4.7
Hunting	14	4.4
Walking	11	3.4
Fishing	10	3.1
Swimming	10	3.1
Cross-country skiing	3	0.9
Not recorded	2	0.9
Total	321	99.9

*OHRV indicates an off-highway recreational vehicle such as a snowmobile or an all-terrain vehicle.

ries was a fracture, accounting for 33.7% of the injuries (Table 4). The next most common types of injuries were sprains and cuts/bruises, with each accounting for 18.2%. There may be some disparity between the percentage of fractures and sprains recorded and a radiographic diagnosis, because not all diagnoses were based on follow-up with the treating hospital. In 42.1% (69 of 164) of the cases in which a subject sustained an injury, New Hampshire Fish and Game Department officials contacted the hospital at which the subject was treated or contacted the subject after the incident to determine the final diagnosis. Head injuries were not systematically recorded; however, in 6 incidents, the presence of a head injury was specifically noted.

In 49.5% (159 of 321) of the incidents, the location of an injury was recorded. Second and third locations of injury were recorded in 5.3% and 1.6% of the incidents, respectively. In 50.5% of the incidents, no injury occurred, or the location of the injury was not recorded.

Table 4. Type of injury

<i>Type of injury</i>	<i>Count</i>	<i>Count (%)</i>
Fractures	61	33.7
Sprains	33	18.2
Cut/Bruises	33	18.2
Hypothermia	18	9.9
Frostbite	6	3.3
Head injuries	6	3.3
Other	24	13.3
Total	181	99.9

Table 5. Location of injury

<i>Location</i>	<i>Count</i>	<i>Count (%)</i>
Leg	57	31.5
Foot	33	18.2
Head	25	13.8
Entire body	23	12.7
Trunk/Torso	23	12.7
Arm	9	5.0
Neck	7	3.9
Hand	4	2.2
Total	181	100.0

In this case series, ankle injuries were sometimes recorded as “leg” and, at other times, as “foot,” hence creating an overlap between these 2 categories. Together, injuries to the leg/foot were most common, accounting for 49.7% of the injuries (Table 5).

ENVIRONMENTAL AND HUMAN ELEMENTS

The date of the incident was recorded for 99.7% of the incidents, and the time the incident occurred was recorded for 97.8% of the incidents. A greater number of search and rescues were conducted during the summer and fall seasons (June through October) than during the winter and spring seasons (Figure 2). Incidents leading to the need for search and rescue also tended to occur more often in the afternoon: 54.8% of the incidents occurred between noon and 6:00 PM, 31.5% occurred between 6:00 PM and midnight, and only 10.5% occurred between 6:00 AM and noon.

The weather conditions at the time of the incident were recorded for 99.4% of the incidents. The weather was clear in 54.6% of the cases, cloudy/overcast in 21.2% of the cases, and windy in 7.6% of the cases. Rain, snow, or fog was recorded in 16.5% of the cases.

Figure 2. Distribution of search and rescue by month.

Table 6. Cause of death

<i>Cause of death</i>	<i>Count</i>	<i>Count (%)</i>
Drowning	21	32.8
Not recorded	16	25.0
Cardiovascular	15	23.4
Blunt trauma	8	12.5
Hypothermia	2	3.1
Avalanche	1	1.6
Penetrating trauma	1	1.6
Total	64	100.0

The most common environmental factor reported as contributing to the need for search and rescue was darkness, which was cited in 26.8% of the cases. The next most common element was inclement weather, which was cited in 11.2% of the cases. The 2 most common human factors contributing to the need for search and rescue were fall/injury (30.1%) and poor judgment (19.9%). Intoxication/drugs were believed to have contributed to 4.5% of the incidents.

FATALITIES

Fourteen percent (64 of 457) of the people requiring search and rescue died. Drowning was the most common cause of death (32.8%) (Table 6). Cardiovascular causes accounted for 23.4% of the deaths. The cause of death recorded in the search-and-rescue reports was based on medical examiner or autopsy results in 42.2% (27 of 64) of the cases. In suspected cardiovascular deaths, the cause of death in 66.7% (10 of 15) of the cases was based on medical examiner or autopsy data. In the other cases, the cause of death reported in the search-and-rescue report either was presumed or was based on unidentified sources of information. Hiking was the most common activity of people involved in fatal incidents (25% of the incidents), but the proportion of deaths for people involved in fishing, boating/canoeing, and swimming was greater (Table 7).

In fatal incidents, the ages of 62 of 64 of the subjects were recorded. The mean age of the people who died in the wilderness was 46.4 years (SD, 17.8; 95% CI, 41.8–50.9) (Figure 3). In nonfatal incidents, the ages of 347 of 393 of the subjects were recorded, with a mean age of 33.6 years (SD, 17.3; 95% CI, 31.8–35.5). Therefore, the mean age of the people who died in the wilderness was 12.8 years older than that of the people who required search and rescue and did not die ($P < .0001$, Student's t test). The mean age for cardiac deaths was

Table 7. Type of activity in fatalities

<i>Type of activity</i>	<i>Count</i>	<i>Count (%)</i>
Hiking	16	25.0
Other	9	14.1
Fishing	8	12.5
Boating/Canoeing	8	12.5
Swimming	8	12.5
OHRV*	7	10.9
Hunting	3	4.7
Not recorded	2	3.1
Cross-country skiing	1	1.6
Climbing	1	1.6
Walking	1	1.6
Total	64	100.1

*OHRV indicates an off-highway recreational vehicle such as a snowmobile or an all-terrain vehicle.

56.5 years (SD, 11.0; 95% CI, 50.4–62.6). Men accounted for 85.9% of the people who died in the wilderness, whereas 10.9% were women. The sex of the subject was unknown in 3.1% of the fatal incidents because the remains were badly decomposed.

IMPACT ON MEDICAL SERVICES

In 41.7% of the cases, the subject had to be carried out, a recovery method requiring tremendous manpower. The subject was airlifted by helicopter in 2.5% of the cases and recovered by divers in 3.4% of the cases. In 36.4% of the incidents, the name of the hospital to which the subject was transported was specifically stated in the narrative. Transport to a hospital was not specifically mentioned in 48.3% of the incidents, whereas in 13.7%, the subject was already dead at the time of recovery.

Figure 3. Age distribution of the subjects who died.

Therefore, at least a third of search-and-rescue subjects in this series was transported to a hospital, utilizing local ambulance and hospital resources in addition to search-and-rescue resources. Volunteers were used in more than half of the incidents (53.3%). Injuries were sustained by 8 rescuers—by 1 New Hampshire Fish and Game Department officer, by 1 New Hampshire Army National Guard member, and the rest by volunteers. Rescuers were injured in 4.7% of the incidents in which volunteers were used, or 2.5% of all incidents. Injuries generally consisted of lacerations and sprained ankles and knees; however, in one instance, a rescuer fell out of a helicopter. Cell phone use was not systematically recorded, but in 15.6% of the cases, the narrative specifically noted that the subject, the subject's party, or a passerby used a cell phone to request assistance.

Discussion

The mean age of search-and-rescue subjects, 35.6 years, was older than hypothesized. It was anticipated that people in their mid-to-late 30s would take fewer risks yet still have a high level of fitness, whereas people in their early 20s would more likely engage in risk-taking behavior leading to search and rescue. A second peak among 50- to 60-year-old individuals who overestimated their physical capabilities was also predicted. However, the data do not suggest a bimodal distribution as hypothesized.

The gender breakdown observed in this study, 64.5% men and 35.4% women, is very similar to the gender breakdown in the National Visitor Use Monitoring Results: White Mountain National Forest study, which found that 65% of the visitors to the White Mountains were men and that 35% were woman.¹² The proportion of men and women requiring search and rescue in New Hampshire appears to reflect the overall population visiting New Hampshire wilderness areas, the largest of which is White Mountain National Forest. This gender distribution differs from that observed by Montalvo et al.⁸ in California, where 47.3% of the people presenting to the National Park Service for medical attention were women. The difference may in part be attributable to different subpopulations in the 2 studies—search and rescue only in this study vs all medical incidents observed by Montalvo et al. However, it may also reflect a difference in the proportion of women visiting wilderness areas in California vs New Hampshire.

Seventy-three percent of the people requiring a search and rescue resided in New Hampshire or neighboring Massachusetts. Hence, the vast majority of the subjects resided within a 4-hour drive from the wilderness area where they encountered difficulty. This predominance of local populations was also observed by Goodman et al.,⁹

who found that 97% of the people who died in the wilderness in Pima County, AZ, resided in Arizona. Most visitors to New Hampshire wilderness areas presumably live locally, and local populations might be expected to be more familiar with the environment and hence less likely to encounter difficulty. However, local populations may also be more likely to take risks than are people who have traveled a greater distance and are less familiar with the region. Given that most people requiring search and rescue live in or near New Hampshire, perhaps education and prevention efforts should be concentrated on local populations.

The largest proportion of search and rescue was initiated for lost or missing persons. These rescues are potentially preventable if wilderness users plan ahead and use detailed maps. Education on wilderness preparedness and map use may be a means of preventing 42% of search and rescue. In addition, educating people to notify others of their planned route may be a helpful means of shortening search and rescue.

As anticipated, most people requiring search and rescue were hiking at the time of the incident, suggesting that education and prevention efforts should focus on hikers. Hikers may be a difficult population to reach, however, as no opportunity to uniformly reach hikers exists. In contrast, many of the other activities included in this study—such as boating, snowmobiling, hunting, and fishing—require a license or permit, which represents a distinct opportunity when safety information may be conveyed or safety courses encouraged.

As hypothesized, the most common site of injury in subjects of wilderness search-and-rescue incidents was the extremities, with 49.7% of all injuries to the lower extremities alone. This predominance of lower extremity injuries is similar to the findings in other wilderness injury studies, which found that 38.3% of the injuries in California National Parks and 56% of the injuries in National Outdoor Leadership School courses were to the lower extremities.^{8,10} Likewise, musculoskeletal injuries predominated; 51.9% of all injuries were sprains and fractures.

Distinct seasonal and diurnal variation in the number of search and rescues was observed. The peak in search and rescue from June to October likely reflects an increase in overall visitors to New Hampshire wilderness areas during these months. The afternoon peak in incidents may be partially attributable to fatigue later in the day, which may make people more prone to injuring themselves. People also may not consider themselves lost until the afternoon or evening when daylight begins to fade.

As anticipated, the mean age of the people who died in the wilderness, 46.4 years, was significantly older than that of the people who survived rescue in the wilderness. Nearly one fourth of the people died from car-

diac causes, and they had a mean age of 56.5 years, highlighting the importance of cardiac health in this age group. Drowning, however, was the most common cause of death in the wilderness, reinforcing the need for further work to promote water safety. Cardiac events and drowning were also the most common causes of death in a study of California National Parks.⁸

Finally, wilderness search and rescues have a substantial impact on local resources. Volunteers were used in more than half of the incidents, manpower-intensive carryouts were necessary in 42%, one third of the subjects required transportation to a hospital, and a rescuer sustained an injury in 2.5% of all incidents. All of these factors highlight the need to decrease search and rescue because of the impact on rescuers and local resources.

LIMITATIONS

This study is limited by the use of retrospective data. In addition, some wilderness search and rescues are conducted in New Hampshire without the involvement of the New Hampshire Fish and Game Department and hence are not included in this series. Notably, from December 1 to June 1, the US Forest Service leads winter search and rescues on the east side of Mount Washington and may notify the New Hampshire Fish and Game Department only if additional resources are needed. This area includes Tuckerman's Ravine, a popular backcountry downhill skiing location. Therefore, this study likely underestimates injuries from backcountry skiing. The Appalachian Mountain Club (AMC) generally aids in search and rescue under the direction of the New Hampshire Fish and Game Department but may handle some search and rescue in the vicinity of AMC backcountry huts primarily. Likewise, the Department of Resources and Economic Development handles primarily some incidents occurring on Mount Monadnock, a heavily visited mountain near the New Hampshire-Massachusetts border. Therefore, events around AMC huts and Mount Monadnock are also likely underestimated. Because the AMC, the Department of Resources and Economic Development, and the US Forest Service snow rangers might contact the New Hampshire Fish and Game Department for more complex or severe incidents, this series may be skewed toward incidents with more severe injuries or deaths.

CONCLUSIONS

The results of this study provide quantitative information on wilderness search and rescue in New Hampshire from which we may attempt to tailor education and prevention efforts. The most prevalent demographic group requiring

search and rescue in New Hampshire can be reached by targeting men aged 30 to 40 years who reside in New England and engage in hiking. To decrease the major precipitants of search and rescue, the focus should be on preventing wilderness users from getting lost and on preventing lower extremity musculoskeletal injuries. Wilderness deaths may be prevented by focusing attention on cardiac health in wilderness users older than 50 years and on water safety.

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