ORIGINAL RESEARCH

Avalanche Safety Practices in Utah

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Objective.—Avalanche fatalities occur on a yearly basis in Utah. The purpose of this study was to assess avalanche safety practices of different backcountry users in Utah and to identify groups that can be targeted for avalanche safety education.

Methods.—We surveyed 353 winter backcountry users to determine the percentage of participants in each group who were traveling with one or more partners; the percentage who were carrying avalanche transceivers, shovels, probes, or AvaLungs; and the percentage who had taken an avalanche safety course. A measure of minimum safe practice was defined as 1) traveling with a partner, 2) carrying an avalanche transceiver, and 3) carrying a shovel. Participants in this study were backcountry skiers, snowboarders, snowshoers, snowmobilers, and out-of-bounds resort skiers/snowboarders traveling in the Wasatch and Uinta Mountains of Utah during the winter of 2005–06.

Results.—The percentage of backcountry recreationists traveling with one or more partners was not significantly different ($P = .0658$) among backcountry skiers, snowboarders, snowshoers, snowmobilers, and out-of-bounds resort skiers/snowboarders. These groups did, however, differ in the percentage who carried avalanche transceivers ($P < .0001$), shovels ($P < .0001$), probes ($P < .0001$), and AvaLungs ($P = .0020$), as well as in the percentage who had taken an avalanche safety course ($P < .0001$) and the percentage who were carrying out minimum safe practices ($P < .0001$). Backcountry skiers showed the highest level of avalanche preparedness, with 98% carrying avalanche transceivers, 98% carrying shovels, 77% carrying probes, 86% having taken an avalanche safety course, and 88% carrying out minimum safe practices. Out of bounds snowboarders were the least prepared with 9% carrying avalanche transceivers, 9% carrying shovels, 7% carrying probes, 33% having taken an avalanche safety course, and 2% carrying out minimum safe practices.

Conclusions.—There are significant differences in the avalanche safety practices of the various groups of backcountry travelers in Utah. Backcountry skiers and snowboarders were the most prepared, while snowmobilers, snowshoers, and out-of-bounds skiers/snowboarders were relatively less prepared.

Key words: avalanche, safety, education, skiing, snowboarding, snowmobiling, snowshoeing

Introduction

Utah has a reputation around the country as a destination for skiing and winter recreation. Aside from the 12 ski resorts, outdoor enthusiasts venture into the backcountry of the Wasatch Mountains to snowshoe, snowmobile, ski, and snowboard. At the ski resorts, patrollers monitor hazardous weather conditions and control the slopes for avalanches. When people venture into the backcountry, however, they assume the responsibility of making safe decisions for themselves in avalanche terrain. Variable

snow conditions make these mountains prone to dangerous avalanches, and because the Wasatch Mountains are so close to Salt Lake City, they are accessible to over a million people. Within an hour's drive of downtown Salt Lake City, there are trailheads that can lead the outdoor enthusiast across potentially life-threatening avalanche paths. Over the last 50 years, avalanche fatalities in the United States have steadily increased.¹ In the winter of 2004–05, there were 28 avalanche fatalities in the United States. Eight of those fatalities occurred in Utah. According to the Utah Avalanche Center, the num-

ber of backcountry users contacting their service has increased by about 600% in the last 5 years.²

Backcountry users can lessen the risk of traveling in avalanche terrain using a number of methods. First, taking an avalanche safety course provides essential awareness and skills for traveling in the backcountry. Second, taking the proper safety equipment is required in order to carry out a rescue should a person get caught in an avalanche. The standard safety equipment for traveling in avalanche terrain is an avalanche transceiver, a probe, and a shovel. It is also important for backcountry travelers to travel in groups, as it is very difficult or impossible for a lone person to extricate himself or herself from an avalanche burial.

The avalanche transceiver (also called a "beacon") is a small device that can be used to locate a person caught and buried in an avalanche. The victim must be located and extricated immediately in order to prevent death by suffocation. Increased burial times decrease the chance of survival such that by the time 35 minutes have passed, 70% of victims will not survive.³ Recently it has been shown that using an avalanche transceiver can reduce the risk of dying in an avalanche because these devices are associated with significantly reduced burial times.⁴ Other avalanche safety devices include the AvaLung (Black Diamond Equipment Co, Salt Lake City, UT), avalanche air bags, and the K2 Avalanche Ball (K2 Sports, Seattle, WA). The AvaLung is a device that diverts expired air away from inhaled air, thereby minimizing the rebreathing of expired air and the formation of an ice mask. This delays hypercapnia, hypoxia, and death from asphyxiation.⁵ The K2 Avalanche Ball is a flotation device designed to buoy to the surface of the snow so that the victim can be easily located. The Avalanche Air Bag System (Mountain Safety Systems, Inc., Whistler, BC, Canada) helps to prevent deep burial by the principle of inverse segregation, whereby larger objects move to the surface during avalanche flow.⁶ This device is designed to decrease the extent of avalanche burial and has been shown to decrease avalanche fatalities from 23% to 2.5% in one study.⁷

Avalanche safety devices can only save lives if backcountry users carry the equipment and know how to use it. Even if avalanche transceivers are used, mortality due to avalanche burial may be greater than 50%.⁴ The best way to be safe in the backcountry is to avoid being caught in an avalanche in the first place. This demonstrates the importance of avalanche awareness and education in the community.

Many of the ski resorts in the Wasatch Mountains allow guests to exit their boundaries and access the backcountry from their facilities. Recently, this type of lift-access backcountry skiing has become very popular in

Utah. Some of the resorts require that the guest carry a beacon and shovel before they will allow the guest to cross the "gate" into the backcountry. Others resorts, however, do not make any such requirements. Potentially dangerous and uncontrolled avalanche slopes are therefore easily accessible to anyone who rides the lift up and walks out the gate. Unfortunately, in recent years there have been a number of tragic deaths in Utah in which "out-of-bounds" resort skiers with little to no avalanche experience ventured onto uncontrolled slopes in dangerous conditions.

Traditionally, avalanche education has been targeted toward backcountry skiers and climbers. Recent efforts by the Utah Avalanche Center and other organizations have been directed toward other backcountry enthusiasts, such as snowmobilers and snowshoers. Avalanche literature describes the physiology of avalanche burial,^{8–10} the types of injuries caused by avalanches,^{11–14} the incidence of avalanche fatalities,¹ and even risk-taking behavior among avalanche victims.^{15,16} To our knowledge, however, there have been no attempts to evaluate either the pervasiveness of avalanche training among backcountry travelers or the degree to which safe practices are utilized in the backcountry. The purpose of this study was to assess avalanche safety practices of different backcountry users in Utah and to identify groups that can be targeted for avalanche safety education.

Methods

We surveyed a convenience sample of backcountry skiers, snowboarders, snowshoers, and snowmobilers to determine what types of avalanche safety equipment they carry with them and what level of avalanche safety training and education they have obtained. Participants in this study were backcountry recreational users traveling in the Wasatch and Uinta Mountains during the prime season for avalanche danger (November–April) in the winter of 2005–06. We hypothesized that there would be a difference in the safety practices of backcountry skiers, backcountry snowboarders, snowmobilers, snowshoers, and out-of-bound resort skiers/snowboarders. Inclusion criteria included those entering the backcountry whose destination involved travel into an area with potential avalanche hazard. Potential avalanche hazard was defined as travel on any slope greater than 25° or that crossed a major slide path.¹⁷ The underlying assumption is that all backcountry travelers should possess some degree of avalanche awareness and should carry appropriate safety equipment if they are entering into avalanche terrain.

We recruited study participants at a variety of trailheads and on a number of ski, snowshoe, and snowmobile trails in the Wasatch and Uinta Mountains. Out-

Table 1. Participant recruitment locations; all locations are in Utah

Big Cottonwood Canyon
Spruces Campground Parking Lot
Mill D Trail
Bear Trap Trail
Guardsman's Road
Cardiff Fork Trail
Great Western Gate, Brighton Ski Resort
9990 Gate, The Canyons Ski Resort
Little Cottonwood Canyon
White Pine Parking Lot
White Pine Trail
Alta Lodge Parking Lot
Telephone Pole Pass Trail
Grizzly Gulch Parking Lot
Albion Basin Parking Lot
Tible Fork Trail Head
Snake Creek Trail Head
Noblett's Trail Head

of-bounds skiers and snowboarders were defined as those exiting a ski resort to travel into backcountry terrain not controlled for avalanches by ski patrol. These participants were recruited for the study at the out-of-bounds exit gates at 2 ski resorts, Brighton and The Canyons. These resorts were selected because access to the backcountry from these areas is easy, unlimited, and very popular. It must be noted that these ski resorts do not restrict access to the backcountry because they are on Forest Service public land. They do, however, make efforts to deter the public from avalanche danger with graphic warning signs at the access gates. The results of the study also may not apply to other resorts that either do not allow backcountry access or that limit access to those who are carrying avalanche safety equipment. For a list of locations in which study participants were recruited, please see Table 1.

The survey was developed by the authors in cooperation with Bruce Tremper, senior avalanche forecaster at the Utah Avalanche Center. The survey included questions about safety equipment as well as avalanche awareness and education. The survey took 3 to 5 minutes to complete. While the participant was filling out the survey, the study team recorded the date, time, location, weather, whether the participant was traveling to or from his destination, and the type of equipment used (skis, snowshoes, etc). (The entire survey and the additional participant information recorded by the study team can be viewed online at <http://www.wemjournal.org>). Participants were screened so that they only completed the survey once. Data were collected in all weather conditions

and at all levels of avalanche hazard. The University of Utah Institutional Review Board approved the study.

The percentage of participants traveling alone was compared across different backcountry user groups, as was the percentage of participants carrying avalanche transceivers, shovels, probes, and other safety equipment. Because an avalanche transceiver will be of no benefit to the victim if he does not have a partner or if that partner is not carrying a transceiver and a shovel, we defined a minimum safe practice that consisted of 1) having a partner, 2) carrying an avalanche transceiver, and 3) carrying a shovel. We also compared the percentage of participants in each group who had taken an avalanche safety course. SPSS 14.0 (SPSS Inc, Chicago, IL) was used for statistical analysis. To determine whether sport is associated with avalanche safety practices we used a Pearson chi-square test or a Fisher exact test. To calculate the likelihood of carrying minimum safety equipment among those who have attended avalanche safety classes, we used the Mantel-Haenszel method of calculating relative risk adjusted for sport as a potential confounder. All statistical tests were 2-sided, with a significance level of $\alpha = .05$.

Results

Three hundred and eighty-eight people were approached to participate in the study. Of these, 35 (9%) declined to participate. Table 2 represents the demographic differences among participants. A total of 275 men and 78 women completed the survey. When the results were compared across the 6 different backcountry sports, we found that there was no statistical difference between the groups in answer to the question "Are you traveling alone or with a partner?" ($P = .0658$; see Figure 1). As for carrying the proper safety equipment into the backcountry, significantly more backcountry skiers and snowboarders carried avalanche transceivers ($P < .0001$), shovels ($P < .0001$), probes ($P < .0001$), and AvaLungs ($P = .0020$) than did snowmobilers, snowshoers, and out-of-bounds resort skier or snowboarders (see Figures 2 through 4). Nonetheless, very few backcountry travelers carried an AvaLung (3.1%). Most backcountry skiers and snowboarders had taken an avalanche safety course, while these numbers were significantly lower among snowmobilers, snowshoers, and out-of-bounds skiers and snowboarders ($P < .0001$; see Figure 5). Similarly, most backcountry skiers and snowboarders engaged in the minimum safe practice ($P < .0001$; see Figure 6). After adjusting for sport, those who had taken an avalanche safety course were 1.4 (95% confidence interval 1.1 to 1.7) times more likely to travel with a partner and to carry the minimum safety equip-

Table 2. Demographics of participants

	<i>No. of Female Participants</i>	<i>No. of Male Participants</i>	<i>Total No. of Participants</i>	<i>Mean Age, y</i>	<i>SD for Age, y</i>
Ski	26	79	105	38	11
Snowboard	2	28	30	32	8
Snowmobile	7	39	46	36	11
Snowshoe	23	33	56	45	13
OOB skier*	14	58	72	28	10
OOB snowboarder	6	38	44	25	8

*OOB indicates out-of-bounds.

ment than those who had not taken an avalanche safety course.

Discussion

Our study demonstrated significant differences in avalanche safety practices among the different groups of backcountry travelers in the Wasatch Mountains. Backcountry skiers and backcountry snowboarders appeared to have the highest level of preparedness, while snowmobilers, snowshoers, out-of-bounds skiers, and out-of-bounds snowboarders were far less prepared. This finding parallels data for recent avalanche fatalities in Utah.

In the past 9 years there have been 36 avalanche fatalities in Utah. Three of these deaths have involved backcountry skiers (8.3%), while 10 have involved snowmobilers (28%), 6 have involved snowshoers (17%), 8 have involved out-of-bounds skiers/snowboarders (22%), and 2 have involved climbers (5.5%).^{2,18–24} Of note, however, is that in the past 9 years, 7 of the avalanche fatalities in Utah have involved backcountry snowboarders (19%),^{2,18–24} a group that we found to be relatively more prepared in our study. The reason for this discrepancy is unclear. Ideally, in order to more accurately assess the avalanche fatality rate for each sport, the number of fatalities should be compared to the num-

Figure 1. Travel with a partner. Ninety-five percent confidence intervals are noted in parentheses. OOB indicates out of bounds.

Figure 2. Travel with an avalanche transceiver. Ninety-five percent confidence intervals are noted in parentheses. OOB indicates out of bounds.

Figure 3. Travel with a shovel. Ninety-five percent confidence intervals are noted in parentheses. OOB indicates out of bounds.

Figure 5. Avalanche safety course participation. Ninety-five percent confidence intervals are noted in parentheses. OOB indicates out of bounds.

Figure 4. Travel with an avalanche probe. Ninety-five percent confidence intervals are noted in parentheses. OOB indicates out of bounds.

Figure 6. Minimum safety practice (traveling with a partner and carrying an avalanche transceiver and shovel). Ninety-five percent confidence intervals are noted in parentheses. OOB indicates out of bounds.

ber of participant-days. While it is true that backcountry skiing, snowboarding, snowshoeing, and snowmobiling are popular sports in Utah, data for the number of participant-days for each sport have not been collected.

In 1999, Page et al¹ published a 45-year analysis of avalanche accidents in the United States and found that 25.5% of avalanche fatalities were climbers, 22.7% were backcountry skiers, and 6.8% were snowmobilers. Recent data, however, from the Utah Avalanche Center 2004–2005 Annual Report indicate that over the past 5 years, snowmobiler fatalities have increased to 40% of all avalanche fatalities in the United States.² The increase in snowmobiler fatalities may be attributable to the fact that the sport has become more popular, and more individuals are therefore putting themselves at risk. Alternatively, the increase in snowmobiler fatalities may be attributable to the fact that snow machines are getting so much more powerful that they can now be found on slopes that are more prone to avalanche. It is possible that the sport has grown so quickly that it has outpaced the spread of avalanche awareness and education.

Recently it has been shown that carrying an avalanche transceiver may decrease the risk of dying in an avalanche.⁴ Of the 3 avalanche fatalities that occurred in Utah during the 2005–06 winter season (the time period in which this study was conducted), none of the victims were wearing avalanche transceivers.²⁵ Intuitively, it seems that avalanche education is important and has the potential to reduce the number of avalanche fatalities, if only because education may increase the use of avalanche transceivers. The exact relationship between avalanche education and the likelihood of dying in an avalanche, however, is still unclear. There have been many experienced skiers, guides, and avalanche experts who have been tragically killed in the mountains by avalanche. Unfortunately, other factors, such as risk-taking behavior and the type of injury incurred in the accident, may be involved as well. McCammon¹⁶ has shown that the level of avalanche training correlates with taking fewer overall risks only through an increase in risk mitigation activities, such as carrying a beacon and shovel, traveling with a partner, and minimizing the number of people exposed to the hazard at any one time. This means that taking an avalanche safety course does not stop the traveler from skiing the steep slope on a high danger day; it just makes the traveler more likely to take precautions while skiing that slope.¹⁶ The data from our study are consistent with this finding in that those who had taken an avalanche safety course were slightly more likely to travel with a partner and to carry the minimum amount of equipment required to carry out an avalanche rescue (an avalanche transceiver and a shovel) than were those who had not taken a course.

The primary limitation of this study was the convenience sample obtained. The study team attempted to sample at multiple trailheads, on multiple days, in all weather conditions, and with varied avalanche conditions throughout the season. The study design, budget, and time constraints were limiting, however, and we may not have captured an absolutely representative sample. Also, 35 of 388 people (9%) that were approached to participate in the study refused to do so. It is possible that those who were less prepared for backcountry travel either refused to participate or avoided participation in the study by other means. If this is true, then our study would overestimate the degree of preparedness of participants.

Conclusions

While more work needs to be done to clarify the relationship between avalanche education and the prevention of avalanche fatalities, the data from our study indicate that there are segments of the backcountry community that are relatively less prepared than others. These groups were snowmobilers, snowshoers, and out-of-bounds resort skiers and out-of-bounds resort snowboarders. These results are consistent with the trend in avalanche fatalities in recent years. We hope that avalanche awareness organizations, backcountry travelers, and the outdoor industry can use these data to target educational programs in the future.

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