ORIGINAL RESEARCH

Avalanche Fatalities in the United States: A Change in Demographics

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Objective.—To describe demographic patterns in avalanche fatalities in the United States during the past 6 decades according to geographic location and preavalanche activity.

Methods.—The Colorado Avalanche Information Center currently manages the National Avalanche Accident Dataset. This dataset describes deidentified avalanche fatalities beginning in 1951. Covariates included age, sex, month, state of occurrence, and preavalanche activity. Both absolute and proportional avalanche fatalities were calculated by year and by each covariate. A linear regression model was used to trend the proportion of avalanche fatalities stratified by covariate.

Results.—There were 925 recorded avalanche fatalities in the United States between 1951 and 2013. There were an average of 15 ± 11 fatalities/y (mean $\pm$ SD; range, 0 to 40 fatalities/y). The mean (+/− SD) age was 29 ± 6.6 years (range, 6–67 years), and 86% were men. Total avalanche fatalities have increased linearly ($R^2 = 0.68$). Despite the highest number of total deaths in Colorado (n = 253), the proportion of avalanche fatalities in Colorado decreased (–5% deaths/decade; $P = .01$). Snowmobilers are now the largest group among fatalities and accounted for 23% of deaths (n = 213). The proportion of snowmobile fatalities has increased (+7% deaths/decade; $P < .01$), as has the proportion of snowboarder fatalities (+2% deaths/decade; $P < .01$).

Conclusions.—Avalanche fatalities have increased. This is most likely related to an overall rise in backcountry utilization. Fatalities have increased among snowmobilers and snowboarders. Despite a rise in backcountry utilization, avalanche fatalities in Colorado are decreasing. A strategy of focused training and education aimed toward at-risk groups could result in lower avalanche fatalities.

Key words: avalanche, trauma, snowmobiler, backcountry skier, backcountry snowboarder

Introduction

In the United States, backcountry winter recreation has become increasingly popular. This trend is evident for both motorized and nonmotorized recreationalists. According to Snowsports Industries America (SIA), the sale of alpine touring boots has doubled since 2012, and sales of backcountry accessories such as avalanche beacons and probes have risen 12%.[1] The SIA also observed a huge growth in splitboard sales, reporting fewer than 500 units sold in 2009, but more than 3000 sold in 2012 (6-fold increase).[1] The Outdoor Industry

Association has reported a 40% increase in the number of telemark skiers since 2006.[2] Snowmobiling has also gained in popularity. According to the International Snowmobile Manufacturers Association, there are now more than 1.3 million snowmobiles registered in the United States, a 40% increase from 1990.[3]

Snow avalanches are a recognized objective risk when participating in backcountry winter recreation. In 1999, Page et al[4] published a study that described more than 4 decades of avalanche fatalities in the United States. At that time, snowmobilers and snowboarders accounted for less than 10% of victims. Clearly there are more people recreating in the backcountry. Have there also been changes in their activities? Given the increased popularity of snowmobiling and splitboards, this is certainly possible.

The purpose of our study was to describe changes in demographic patterns in avalanche fatalities in the United States during the past 6 decades. Given the increase in backcountry recreationalists, we hypothesized that avalanche fatalities have increased. We also hypothesized that there has been a change in the pattern of these fatalities with respect to geographic location and type of preavalanche activity.

Methods

The Colorado Avalanche Information Center (CAIC) currently manages the National Avalanche Accident Dataset[5], which was initiated in 1951. This dataset contains deidentified descriptions of avalanche fatalities. This analysis includes entries from 1951 through 2013. Each entry includes the time, location, and number of fatalities for each reported avalanche. Additional information included the age, sex, preaccident activity, and burial status of the victim. The CAIC estimates the current capture rate for reporting avalanche fatalities in the United States to be >95%. However, this capture rate has not been formally validated, and a capture rate before 2000 is speculative. Colorado population data were obtained from the US Census Bureau.[6] Data on snowmobile registrations were made available from the International Snowmobile Manufacturers Association.[7] Winter recreation utilization data for Vail Pass, Colorado, were made available from the US Forest Service (Vail Pass Winter Recreation Season Report, unpublished data used with permission, 2014). Occupancy data for the 10th Mountain Division Hut System were made available from the 10th Mountain Division Hut Association (B. Dodge, unpublished data used with permission, 2014).

Victim age, sex, month, and state of occurrence were analyzed using descriptive statistics. Victims were characterized as either fully buried (avalanche debris covered the head or there was no exposed part of the victim visible to rescuers) or partially buried (the head remained above the snow surface). Fatalities were classified a priori by preavalanche activity based on the preexisting categorizations within the National Avalanche Accident Dataset. For the purpose of this analysis, victims could be classified exclusively as a snowmobiler, a backcountry skier, a backcountry snowboarder, a climber, an in-bounds skier/snowboarder, a side-country skier/snowboarder (victim rode a ski lift to access out-of-bounds terrain), a hiker/snowshoer, or other. Other included a heterogeneous mix of highway workers, house occupants (those killed by an avalanche while in a home), miners, and motorists, which when taken separately were too underpowered to allow for individual analysis.

The absolute number of avalanche fatalities was categorized by state, activity, age, and sex for each year of the study period (the outcome variables). Next, the proportion of avalanche fatalities was calculated for each outcome variable between 1951 and 2013 (for example, number of snowmobile fatalities in 2010 divided by the total number of avalanche fatalities in 2010). Because validated data on winter backcountry utilization are limited, formal avalanche mortality rates for each outcome variable could not be calculated. However, by calculating the proportion of avalanche fatalities by outcome variable for each year and then trending these proportions with time, modeling of a proxy rate was possible. A bivariate linear regression analysis was performed to model percent change per decade (beta coefficient) in the proportion of avalanche fatalities calculated for each outcome variable. Normality of outcome variables was evaluated. Log transformation and nonparametric methodologies were not required before linear regression. To maximize relevance, the regression model included only the 6 states with the most avalanche fatalities (Alaska, Colorado, Montana, Utah, Washington, and Wyoming). Student's *t* test was used to compare mean age of snowmobile fatalities compared with nonmotorized victims. A two-tailed probability value <.05 was considered significant. Stata 12.1 (StataCorp, College Station, TX) and JMP Pro 11.1 (SAS, Cary, NC) were used for statistical analysis.

Results

Nine hundred twenty-five avalanche fatalities were reported between 1951 and 2013. There were an average of 15 ± 11 fatalities/y (mean ± SD; range, 0–40 fatalities/y). The mean (+/− SD) age was 29 ± 7 years (range, 6–67 years). Eighty-six percent of fatalities were men (n = 795). Although avalanche fatalities occurred in every month of the calendar year, February had the most fatalities at 205 (22%). The burial status was known in 837 (90%) of the victims. Of the 837 fatalities with a recorded burial status, 785 (93%) were fully buried.

Figure 1 illustrates the increasing number of fatalities in the United States during the study period. Colorado accounted for 27% of avalanche fatalities, the most of any state. Taken together, Alaska, Colorado, Montana, Utah, Washington, and Wyoming accounted for 81% of all avalanche deaths. Despite the highest number of total deaths in Colorado, the proportion of avalanche fatalities in Colorado has decreased with time (–5% deaths/decade; *P* = .01). Figure 2 demonstrates the absolute number of avalanche fatalities in Colorado as a function