

TEN YEARS OF AVALANCHE DEATHS IN THE UNITED STATES, 1999/00 TO 2008/09

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ABSTRACT: After reaching a twenty-year low in the late 1980s avalanche deaths in the United States soared during the 1990s and spiked in 2007/08 with 36 deaths, the highest number killed in the modern era (post 1950). During the 10-year study period 281 people died in 237 fatal avalanche accidents. (In the previous 10 years—1989/90 to 1998/99 avalanches killed 220, an increase of 27 percent.) Data from these accidents have been compiled to draw a profile of the modern avalanche victim. The mean age for all victims is 33 (median, 31); however, the average age varies significantly by gender. The average age for men is 34, while the average age for women is 38 (M-W, $P < 0.0001$). Ninety percent of the victims are men but only ten percent are women. For males the 20–29 age group suffered the most deaths; however, for females, surprisingly it is the 40–49 age group. Recreationists account for 96% of the avalanche deaths. Snowmobilers account for 40% of avalanche deaths—largest single category; however, the combined totals of all skiers and snowboarders is very close at 39%. January, February, and March are the most deadly months. Colorado experienced 19% of the fatalities in the last 10 years (down from 28% during the 1990s); however, Alaska's fatality rate per population is nearly six times greater than Colorado's. Additional data and information are presented regarding US avalanche fatalities by month, state, activity, and the shifting profile of the typical victim.

KEYWORDS: avalanche, avalanche accident, avalanche fatalities, United States

1. INTRODUCTION

This report summarizes avalanche deaths in the United States. The information comes from the Colorado Avalanche Information Center (CAIC), Westwide Avalanche Network (avalanche.org), Cyberspace Snow and Avalanche Center (csac.org), individual avalanche information and forecast centers, and the author. Sources included official and unofficial accident reports, news media, and first-hand accounts. Avalanche accident information is typically presented by the hydrological year (October 1 to September 30) as the majority of avalanche accidents occur in the winter season.

Avalanches have posed a serious threat to people who have lived, worked, and traveled in the United States. There are no known records of avalanche accidents in the country's pre- and early history; however, a few avalanche deaths likely occurred but any records have been lost. Not until middle of the nineteenth century when prospectors and miners swarmed the western territories and followed by towns with newspapers did reliable written records begin. Since the mid-1800s more than 1600 avalanche deaths have been recorded, and 17% of those deaths have occurred in the past 10 years.

US avalanche deaths reached a twenty-year low in the late 1980s but soared during the 1990s (Figure 1). Avalanche deaths spiked in 2007/08 (and again in 2009/10) with 36 deaths, the highest number killed in the modern era (post 1950). Figure 1 also presents the five-year moving average that smoothes the data considerably. Since the end of the 1980s the average number of fatalities per winter rose from 11 to 30 but decreased slightly in the mid 2000s; however, in recent years the five-year average has started to edge back upwards to 27 deaths per winter. As more people head into the winter backcountry avalanches continue to be deadly. In the United States since 1950 avalanches have claimed 855 lives, and 33% (281) of those victims died during the last 10 winters.

2. AVALANCHE DATA

In the last 20 years the formal reporting of avalanche incidents has decreased dramatically despite a dramatic increases in backcountry recreation, backcountry fatalities, and anecdotal reports of accidents. However, the majority of incidents where people are caught, partly buried, and even buried are not reported, much less, documented. However, serious accidents – those with significant injuries and deaths – tend to be reported.

A word of caution about the following accident statistics is necessary. Despite the diligent efforts of the CAIC and other agencies to collect accident information, the combinations of slim budgets, full

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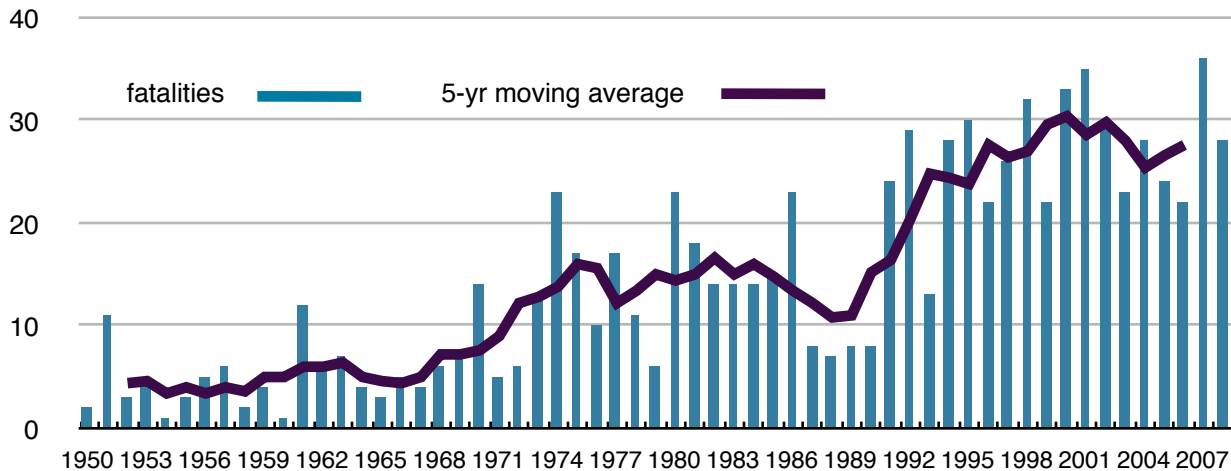


Figure 1. US avalanche fatalities by hydrologic year from 1950/51 to 2008/09.

workloads and a serious under-reporting of avalanche accidents have resulted in the accident data set to become increasingly biased towards avalanche fatalities. With that said, most of the statistics and information presented in this paper come from fatal avalanche accidents.

Before presenting this information, here is an attempt to put the US avalanche problem into perspective. The following estimates are extrapolated from accident data collected by the Colorado, Utah, and Gallatin avalanche centers.

For the past 10 years, each winter an estimated 350 people are caught; 90, partly buried; 40 buried; 40, injured; and 28, known killed. The known median yearly loss to property are reported at \$265,000, though property losses varies significantly from year to year. Losses in the last 10 years ranged from a low of about \$30 thousand

to a high of \$16.5 million in 2007/08. (Nearly all was the result of the destruction of a power line outside Juneau, AK).

2. AVALANCHE ACCIDENTS

From 1999/00 to 2008/09 it is known that 281 people died in 237 fatal avalanche accidents. Recreational activities accounted for 227 accidents killing 270 (96 percent) people. Non-recreational activities involved only 10 accidents.

Table 1 shows that 20% (48 [40+6+2] of 237) of accidents involved more than one death; however, these accidents (65+14+7) accounted for 30% of the deaths. In the backcountry, had the simple rule of exposing only one person at a time to the hazard been followed, avalanche deaths could have been reduced by 31%.

number buried	number of accidents	number of accidents				victims killed
		1 killed	2 killed	3 killed	4 killed	
0	19	15	3	1	0	24
1	170	169	1*	0	0	171
2	40	15	25	–	–	65
3	6	1	2	3	–	14
4	2	0	0	1	1	7
totals	237	200	31	5	1	281

Table 1. Reported burials and deaths, 1999/00 to 2008/09. (*One victim was buried and one was not buried.)

A total of 439 people were reported caught in avalanches that killed at least one member of the party, meaning that on average 1.85 people were caught per fatal avalanche.

2.1 Multiple Burial Accidents

If considering only the bottom row of Table 1, 16% (37 of 237 accidents) killed more than one victim. However, the mortality rate climbs to 20% (48 of 237 when comparing the number of buried victims per numbers of accidents. Again, a

word of caution about these values is necessary because reporting bias results in the reporting of serious accidents, which multiple burials tend to be. These values should only be interpreted to mean that in fatal accidents, multiple burials occurred one in five times. But, when the large unknown value of all avalanche accidents is considered, multiple burials accidents are likely infrequent.

A sobering conclusion can be reached by comparing the number buried and the number of accidents with the number of victims killed in Table 1. The sad fact is that when more than one person is buried, people die! Of the 40 accidents that had 2 people buried, 65 (81%) died. In the 2 accidents where 4 people were buried, 7 (88%) died.

skiers and snowboarders whose better gear, than a decade ago, enables more skiers and riders to venture in to complex terrain. Compounding the situation is the spatial variability of snow stability at the slope scale. Basically, compared to just a decade ago, today more triggers are venturing into complex terrain where absolute safety cannot be guaranteed.

Some activities incurred more fatalities per accident than other activities. Table 3 shows that *climbers* had the highest rate of multiple deaths per accident, followed closely by *backcountry snowboarders*. It is not surprising that climbers lead the list as climbers are often roped together or climbing in narrow gullies.

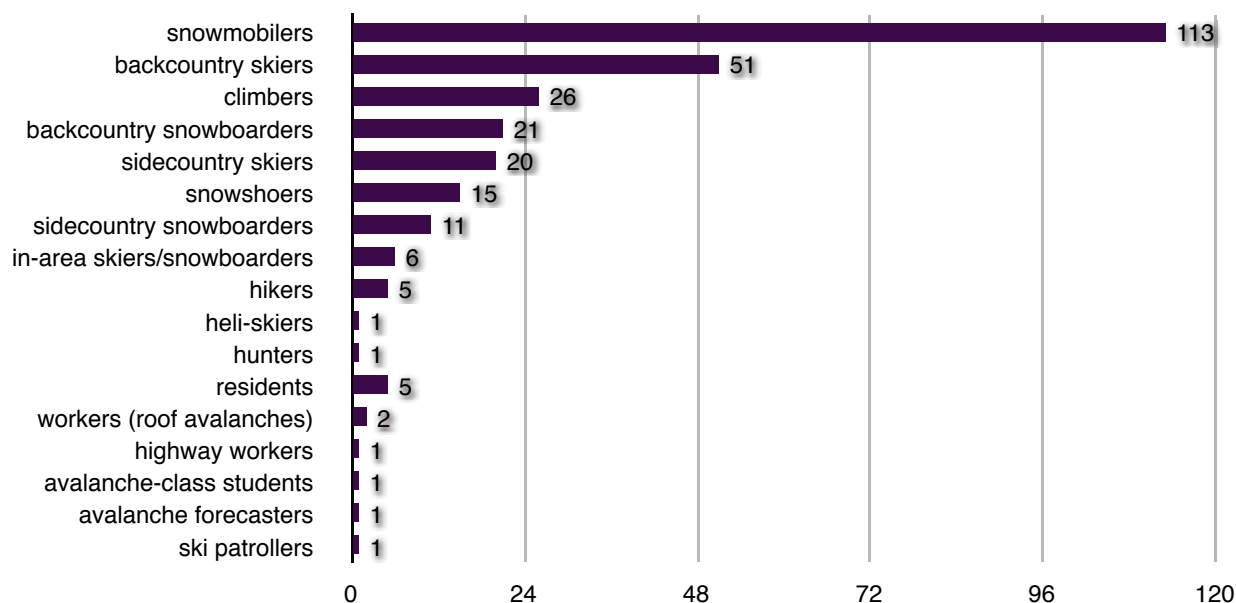


Figure 2. Avalanche fatalities by activity, 1999/00 to 2008/09.

2.2 Accidents By Activities

When looking at avalanche accidents by activity, snowmobilers seem to dominate the number of deaths. Figure 2 provides the traditional view of avalanche fatalities by activity. However, when the skiing and snowboarding categories are combined (Table 2) the total killed nearly equals the number of snowmobilers killed (110 versus 113). Perhaps the only surprise in this 10-year list are the 6 in-area skier/snowboarder deaths. In the previous 10-year period only 1 death was recorded on open terrain within ski resorts. The reasons for the sudden increase in deaths likely reflects new attitudes and actions by today's more aggressive

activity	killed (%)
snowmobilers	113 (40%)
all skiers and snowboarders	110 (39%)
climbers	26 (9%)
snowshoers	15 (5%)
hikers	5 (2%)
hunters	1 (<1%)
non-recreational	11 (4%)
TOTAL	281 (100%)

Table 2. Avalanche fatalities by composit ski and snowboard catagories, 1999/00 to 2008/09.

Table 3 compares the number of accidents with two or more deaths by activity. Public perceptions point at snowmobilers as the activity that has a serious problems with multiple fatalities. This perception is likely a media-reporting bias because of the frequency of snowmobile deaths. However,

activity	fatal accidents with 2+ deaths	total fatal accidents	%
climbers	7	17	41%
backcountry snowboarders	4	16	25%
snowmobilers	15	94	16%
snowshoers	2	13	15%
sidecountry skiers	2	20	10%
sidecountry snowboarders	1	10	10%
backcountry skiers	3	46	7%

Table 3. Comparison of avalanche fatalities by activity group for activities with more than 10 fatal avalanche accidents, 1999/00 to 2008/09.

climbers (41%) and *backcountry snowboarders* (25%) have much higher percentage of multiple deaths per accident than snowmobilers (16%). *Backcountry skiers* (7%) have the fewest accidents with multiple deaths.

2.3 Accidents By Months

month	killed (%)
October	3 (1%)
November	7 (2%)
December	60 (21%)
January	68 (24%)
February	57 (20%)
March	45 (16%)
April	32 (11%)
May	5 (2%)
June	3 (1%)
July	1 (<0.4%)
August	0
September	0
TOTAL	281 (100%)

Table 4. Avalanche fatalities by month, 1999/00 to 2008/09.

Most avalanche victims are killed in the wintertime. January, February, and March are the most deadly months, however, in the past 10 years fatal accidents were reported in all months but August and September. From a historical perspective, of the 855 killed since 1950, US avalanche deaths in August (8) are uncommon and September deaths (1) are rare.

2.4 Avalanche Fatalities by State

Table 5 shows that 14 states experienced avalanche deaths in the past 10 years, and Colorado experienced the most with 19% (52) of the fatalities. However, when the state's population is considered Alaska is followed closely by Wyoming and Idaho. Colorado's ranking drops to sixth, behind Idaho and Utah.

For the first time an avalanche death was reported in North Dakota, which involved a shoveler clearing snow from a roof top. Also, three states reported no fatalities in past 10 years (but have reported fatalities previously: Arizona (1994/95); New Mexico (1995/96), and Maine (1983/84).

month	fatalities (rank)	fatality rate per million population (rank)
CO	52 (1)	1.035 (6)
AK	42 (T2)	6.013 (1)
MT	42 (T2)	4.308 (3)
UT	38 (4)	1.365 (5)
WY	30 (5)	5.512 (2)
WA	28 (6)	0.420 (7)
ID	23 (7)	1.488 (4)
CA	16 (8)	0.043 (12)
NH	4 (9)	0.302 (8)
NV	2 (10)	0.076 (11)
OR	1 (T11)	0.026 (13)
NY	1 (T11)	0.005 (14)
VT	1 (T11)	0.161 (9)
ND	1 (T11)	0.155 (10)
TOTAL	281	—

Table 5. Avalanche fatalities by month and by fatality rate/million population, 1999/00 to 2008/09.

3. AVALANCHE ATTRIBUTES

In just over half of fatal accidents, physical attributes of the avalanche were reported. Table 6 summarizes the dimensions of fatal accidents.

	starting zone angle (degrees) n=116	fracture line depth (m) n=154	fracture line width (m) n=149	vertical fall (m) n=157
mean	39	0.91	141	225
stdv	4	0.52	161	210
median	39	0.76	91	165
maximum	50	3.66	914	1219
minimum	28	0.30	3	12

Table 6. Summary statistics of fatal avalanches, 1999/00 to 2008/09.

3.1 Starting Zone Slope Angle

Figure 3 presents the number of fatal avalanches by starting zone slope angle, and nearly two-thirds of avalanches occurred on slopes of 36 to 40 degrees (62%, 72 of 116). Both the mean and median averages were 39 degrees with a relatively tight standard deviation of ± 4 degrees.

Though not reliably recorded some avalanches were triggered on shallow and even flat slopes, and the fractures propagated upslope to steeper slopes releasing the avalanche.

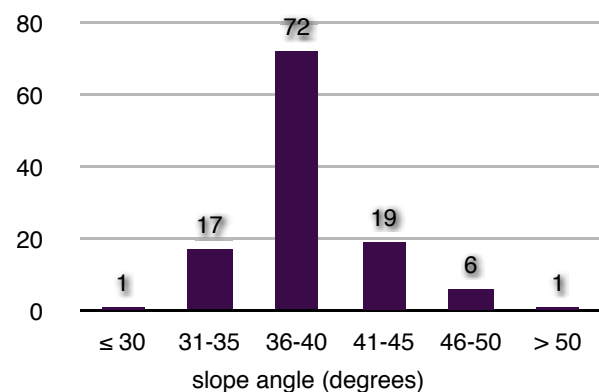


Figure 3. Starting zone slope angles of fatal avalanches, 1999/00 to 2008/09.

3.2 Fracture Line Depth

Almost three-quarters of fatal avalanches released less than 1 meter deep (Table 7). Only three

percent of avalanche fractures were deeper than two meters; however, these avalanche were almost certainly triggered in areas where the slab was less thick.

3.3 Fracture Line Width

The majority of avalanche deaths occurred in

fracture line depth (m)	accidents (%)
≤ 0.50	23 (15%)
0.51 – 1.00	90 (58%)
1.01 – 1.50	20 (13%)
1.51 – 2.00	15 (10%)
2.01 – 2.50	3 (2%)
2.51 – 3.00	0 (0%)
3.01 – 3.51	1 (1%)

Table 7. Frequency of fatal accidents by fracture line depth, 1999/00 to 2008/09.

avalanches less than 100 meters wide (Table 8), however, nearly one-third (31%) of all fatal avalanches were less than 50 meters wide. Five avalanches (3.8%) were less than 20 meters wide.

fracture line width (m)	accidents (%)
≤ 50	48 (32%)
51 – 100	41 (28%)
101 – 200	28 (19%)
201 – 300	16 (11%)
301 – 400	5 (3%)
401 – 500	4 (3%)
> 500	7 (4%)

Table 8. Frequency of fatal accidents by fracture line width, 1999/00 to 2008/09.

3.4 Vertical Fall

From Table 6 the median vertical fall was 168 meters, however, avalanches need not travel far to result in deaths. Table 9 shows that nearly two-thirds of deaths occurred in avalanches that fell less than 200 meters. A closer inspection of those fatal accidents falling less than 200 meters reveals that nearly one-in-four deaths (26.8%) occurred in avalanches that fell less than 100 meters. Even small avalanches turned deadly as one-in-ten (9.2%) fatal avalanches fell less than 50 meters, and the minimum was only 12 meters.

vertical fall (m)	accidents (%)
≤ 50	17 (11%)
51 – 100	26 (17%)
101 – 200	56 (36%)
201 – 400	31 (19%)
401 – 600	15 (10%)
601 – 800	8 (5%)
801 – 1000	2 (1%)
> 1000	2 (1%)

Table 9. Frequency of fatal accidents by vertical fall 1999/00 to 2008/09.

3.5 *Avalanche Type*

Most fatal avalanches (95%) involved slab avalanches (Table 10). The data also show that most killer avalanches were small to medium in size, and usually result in one fatality. Of the 237 avalanche accidents, 200 (86%) claimed one life; 31, two lives; 5, three lives; and 1, four lives. The worst accident in the modern era (post 1950) occurred on Mount Rainier where 11 died in an ice avalanche on June 21, 1981.

Also, the data show that nearly half of the fatal avalanches in Utah and Colorado were hard slabs. This percentage is much greater than experienced in other states (Figure 4).

type of avalanche	fatal accidents number (%)
soft slab	134 (62%)
hard slab	69 (32%)
wet slab	5 (2%)
loose	2 (1%)
wet loose	2 (1%)
roof	4 (2%)
Totals	216 (100%)

Table 10. Type of avalanche reported in fatal avalanche accidents, 1999/00 to 2008/09.

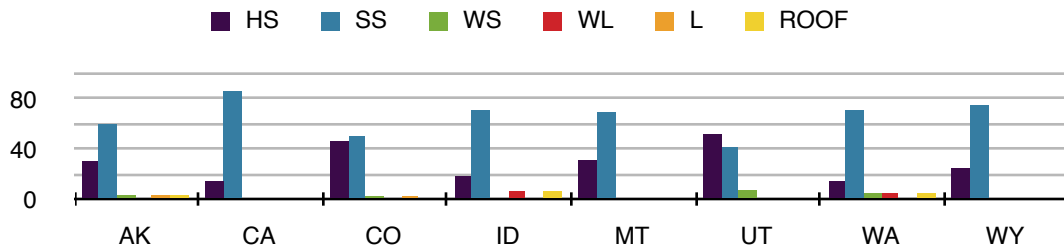


Figure 4. Percent of fatal avalanches by class and state, 1999/2000 to 2008/09.

3.6 *Slope Aspect*

Of the 237 fatal accidents the starting zone slope aspect was reported for 148 avalanches. Fatal avalanches occurred most frequently on north- to east-facing terrain (Table 11).

aspect	accidents (%)
N	32 (22%)
NE	27 (18%)
E	29 (20%)
SE	12 (8%)
S	18 (12%)
SW	4 (3%)
W	11 (7%)
NW	15 (10%)
Totals	148 (100%)

Table 11. Fatal accidents by aspect, 1999/00 to 2008/09.

Table 12 shows a relatively even distribution of accidents occur on north- and south-facing terrain. The fewest fatal accidents occurred on west and southwest aspects. Northerly and easterly aspects offer the most attractive snow conditions for winter recreationists. However, those same aspects are prone to weaker layers and greater wind loading.

quadrant	accidents %
NW-N-NE	36%
NE-E-SE	33%
SE-S-SW	17%
SW-W-NW	14%

Table 12. Fatal accidents by quadrant, 1999/00 to 2008/09.

4. AVALANCHE VICTIMS

Data from the 237 accidents and 281 deaths have been compiled to draw a profile of the modern avalanche victim.

4.1 Age and Gender

Of the 281 avalanche fatalities the mean age for all victims is 31 (median 33); however, the mean age varies significantly by gender. The average age for men is 34, while the average age for women is 38 (M-W, $P < 0.0001$).

Ninety percent of the victims are men and only ten percent are women. Ages for all genders range from 13 to 85; however, both the 77 and 88 year olds (Table 13) died by roof avalanches. (The youngest person to survive an avalanche burial in the past ten years was a three year old, buried by a roof avalanche.) Figure 5 shows the age range of 20–29 claims the most men (35%); however, for women, surprisingly it is the 40–49 age group (33%). A possible reason for this difference is that women may take up these activities later in life.

The data also shows (Table 13) that all *snowboarders* and *climbers* have younger average ages and less spread around the average age. This likely indicates less experience and perhaps less avalanche knowledge than sportspeople in the other categories.

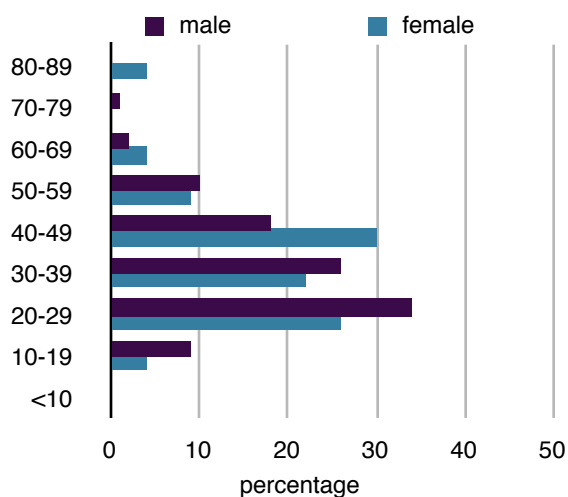


Figure 5. Percentage of fatalities by age group and gender, 1999/00 to 2008/09.

	n	mean	stdv	median	min	max
all	244	31	12.4	34	13	85
male	221	34	11.9	31	13	77
female	23	38	15.9	39	13	85
in-area skiers	6	29	13.4	28	13	53
sidecountry skiers	20	36	13.5	36	17	67
sidecountry snowboarders	9	25	4.8	27	18	31
backcountry skiers	40	36	10.8	32	21	63
backcountry snowboarders	20	27	6.8	26	18	41
snowmobilers	80	35	11.6	34	15	63
climbers	21	28	8.7	26	15	47

Table 13. Age and gender statistics for avalanche fatalities, 1999/00 to 2008/09.

5. CONCLUSIONS

In the past 10 years US avalanche fatalities have increased 27% compared to the previous 10-year period, and today an average of 28 deaths die each winter season. While this rate of increase is significant, it is much less than the dramatic but unmeasured increase of winter recreation. The increased availability of avalanche information from forecasting and education programs are likely reasons the fatality rate is not greater.

Review of the fatal avalanche accidents in the past 10 years shows the physical terrain and avalanche attributes remain unchanged. Most fatal avalanches involved slabs less one meter thick, that release from steep slopes on north to east aspects. Also, small avalanches can be just as deadly as large slides. However, the data show fatal avalanches tend to be remarkably large events, especially when compared to the small areas in that educators teach and individuals practice rescue drills. People should at least practice occasionally simulated search and rescue drills in large areas, 50 x 100 m would be a minimum.

Avalanches tend to be indiscriminate killers of winter enthusiasts of all ages who live, work, and recreate in snow country. A trend in victim's ages reveals that all snowboarders and climbers tend to be younger than others, and thus tend to likely have less experience. Experience teaches the exceptions to the rules learned in education, and experience can only be gained over many years.

A person in their mid 20s is not and should not be thought of as experienced, even if they are avid winter recreators. Avalanche educators may want to urge extra restraint to these groups and to all younger people because they have “not seen it all.” (Likewise, someone in their 40s or 50s has not seen it all, too.)

Despite increasing avalanche awareness by mountain travelers, the data still shows many avalanches involve more than one person caught. If more than one person is buried, the statistics are sobering: most buried victims will die!

While Colorado still leads in total avalanche deaths, other states experience significantly higher death rates when considering their populations. Weak layers are danger and deadly in any snowpack.

Lastly, avalanche professionals, educators and recreators are urged to report all avalanche incidents to their local avalanche center. The more detailed data reported, the better the information to be shared. Report forms can be found in the American Avalanche Association’s *Snow, Weather, and Avalanches: Observation Guidelines for Avalanche Programs in the United States*.

7. REFERENCES

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8. POTENTIAL CONFLICT OF INTEREST DISCLOSURE

I, Dale Atkins, provide services to and receive compensation from RECCO AB.