HUMAN FACTORS IN AVALANCHE ACCIDENTS

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ABSTRACT: A review of fatal United States avalanche accidents in the 1990s shows terrain, weather, and snow pack conditions are generally contributory factors to fatal avalanche accidents; human factors are the primary factor. Human errors are made in terms of judgement, skills, and knowledge. This paper discusses the human factors and errors that might mitigate decision-making errors. The relevant information for this study came from 10 years of accident reports, media reports, and interviews collected and compiled by the Colorado Avalanche Information Center. By identifying and understanding the dynamics of human errors perhaps new or improved pedagogical tools and/or procedures can be developed in improve the safety of people in avalanche terrain.

KEYWORDS: Human factors, human errors, avalanche fatalities, avalanche accidents, naturalistic decision making.

1. INTRODUCTION

"Life is short, the art long,
opportunities fleeting, experience
treacherous, judgment difficult."
— Hippocrates

On January 22,1999 a 45 year-old Aspen, Colorado man was buried and killed in a very small avalanche he triggered outside of the Aspen Highlands Ski Area. The night before the accident the victim and a friend spoke about skiing the backcountry outside of the ski area but agreed the avalanche conditions were too dangerous. The backcountry avalanche danger was rated "high" and a warning issued by the Colorado Avalanche Information Center was in effect. They decided to leave their transceivers and shovels at home. The next day the lure of fresh powder led the victim to venture outside the ski area. He completed two runs and experienced extensive instability with shooting cracks and collapsing snow. For his third run his friend (from the night before) joined him. Neither man carried avalanche rescue year. After leaving the ski area boundary both men experienced shooting cracks and collapsing snow. They triggered a small soft slab avalanche that buried the victim. With no rescue gear it took almost an hour to find the man. Twelve days earlier the victim had been caught skiing in a closed avalanche area. Four days before his death the local newspaper published a "public apology" written by the victim. Regarding skiing in a closed avalanche area, he wrote:

"This was inappropriate and irresponsible behavior...it was dangerous to myself and others."

This accident and others during the 1990s highlight a troubling trend where knowledgeable (avalanche aware) people made decisions that ended in a negative outcome. In fact this accident shares many common themes (steep slopes, fresh snow, signs of instability, no rescue gear, etc.) with other avalanche accidents. Every year these same themes reoccur. Only the names of the victims change. It has been said in aviation that there are no new accidents, only variations upon reoccurring themes (Braithwatie, 1999). This same statement can be said about avalanche accidents.

It is well established that avalanche victims are generally their own worst enemy. Nine-in-ten avalanche victims (or someone in their group) trigger their own avalanche (McCammon, 2000; Atkins, 1994; Logan and Atkins, 1996). The same mistakes are being made repeatly (Fesler, 1980; Fesler and Fredston. 1984; Atkins, 1994). Most avalanche accidents can be prevented (Fesler and Fredston, 1984; Logan and Atkins, 1994). Because the same mistakes are being repeated this implies there are no new avalanche accidents, only variations upon recurring themes.

McCammon (personal communication, 2000) recently reviewed avalanche accidents in the United States (1980 to 1986) and in Canada (1984 to 1996). He found "In recreational accidents where the group had prior avalanche training, a stunning 89% had evidence the danger was high." Furthermore he found a disturbing statistic: "Only 46% of these groups

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with prior avalanche training took pre-cautions...."

Another clue supporting human factors comes from the results of a recent survey by Jamieson and Geldsetzer (1999). The pair surveyed experienced avalanche workers about unexpected skier-triggered avalanches implies weather and snowpack are not necessarily primary factors in avalanche incidents.

The literature and basic research shows avalanche accidents are not a terrain, weather, or snowpack problem; avalanche accidents are a human problem.

Since avalanche accidents are a human problem it begs the question of not "How" but "Why do avalanche-aware people let themselves have avalanche accidents." This question is not necessarily new. Fesler (1980) asked a similar question; his solution focused on route selection. The differences between how and why may seem minor, or unimportant, but how and why are not synonymous. How refers to the manner or cause, e.g., "How did the airplane crash?" The airplane flew into the ground, or "What caused the avalanche?" The victim traversed onto a steep, wind-loaded slope. Why refers to the purpose or reason: Why did the pilot fly into the ground, or why did the skier enter the steep, wind-loaded slope? The answer can likely be found in the cognitive skills (information processing) of the victims.

2. DISCUSSION

2.1 *Naturalistic Decision Making*

To determine the nature of decision-making errors in avalanche country by avalanche-aware victims I have considered that avalanche decision-making is a type of "naturalistic decision making" (Klein, 1998; Orasanu and Martin, 1998).

In naturalistic decision making (NDM) an individual has some level of domain expertise in real world context. Their context involves limited time, dynamically changing conditions, goal conflicts, and information sources of varying reliability. NDM usually involves recognizing a problem, evaluating the situation to define the nature of the problem, and determining a solution. Additional options may be considered but their evaluation is typically not exhaustive (Orasanu and Martin, 1998; Klein, 1998).

Naturalistic decision-makers tend to "satisfice," or chose a solution that meets their needs (Simon, 1956; Orasanu and Martin, 1998). These decision makers act according to their understanding of the situation, and the source of error is the decision maker's knowledge base or in the process of reaching a decision (Orasanu and Martin, 1998)."

2.2 *Potential Problems and Caveats*

For the accident evaluator identifying errors in naturalistic contexts can be difficult for two reasons (Orasanu and Martin, 1998). First there is often not a single "correct" or "best" solution, e.g., mountain climbers choosing to move or not move during a storm. Second, outcomes are not always reliable indicators of the quality of the decision. In some situations even the best situation will be overwhelmed by conditions the decision-maker has no control. Besides the difficulty of recognizing errors there some caveats about the following results that must be told.

Avalanche accidents are infrequent; follow up investigations and reporting are even less frequent. The sample size of avalanche accident reports is very small. Accidents if investigated are investigated differently in different regions, and avalanche accidents are usually investigated by an individual rather than by a committee. Personal biases can creep into single-investigator reports. There are no checks and balances for the interpretation of the data. Also there are no clear working definitions for the concepts of human factors in avalanche accidents, so some latitude must be considered when examining these results.

3. RESULTS

During the 1990s there were 190 reported fatal avalanches that killed 234 people. Of those killed varying amounts of demographic and personal information were known on 217 victims. Of these victims some information about the skill level and avalanche awareness level of 82 victims was also known. Of these victims avalanche-aware victims were involved in only 41 fatal accidents.

> "Good judgment comes from experience, and experience comes from bad judgment."
>
> — Barry LePatner

3.1 *Skills and Knowledge*

Table 1 shows that 73 percent of the victims killed during the 1990s had at least some avalanche awareness training, and many victims had a considerable amount of avalanche awareness training. This is consistent with the 70 percent of backcountry victims found by McCammon (2000) to have possessed at least some avalanche awareness training.

For the purpose of this study I defined "some" as having attended at least one evening-type awareness program and/or having some informal training with friends while traveling in the backcountry. Books or videos sometimes supported this training. The "advanced" level required at least three seasons of recreating or working in avalanche terrain along with the attendance of several awareness-type programs or the attendance of at least one multi-day training program. Again books or videos sometimes supported this training. It is important to point out that using these criteria does not imply competency at the "advanced" level. In some fields (medicine, engineering, chess, music, etc.) an individual with only three or four years of experience is often considered a novice Myer,1992).

Avalanche Awareness Training	novice	intermediate	advanced
advanced	0%	0%	40%
some	0%	1%	32%
none	9%	5%	12%

Activity Skill Level

Table 1. Relationship between avalanche-awareness training and activity skill-level of backcountry travelers, U.S. avalanche fatalities, 1990/91 to 1999/00 (n=82).

3.2 *Human Factors and Errors*

A review of fatal avalanche accidents involving avalanche-aware victims in the 1990s shows that human factors are not just a contributor to accidents but are the primary factor in fatal accidents (figure 1).

Figure 2 shows judgment is the most common human error made in avalanche accidents involving these avalanche-aware victims. The pattern and values are similar to those found in the aviation industry. (It can be assumed that untrained victims would have a reversed trend with knowledge as the significant human error followed by skills and judgment.)

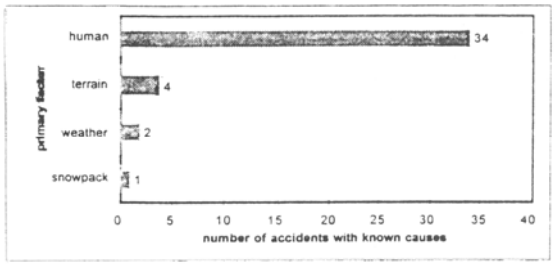

Figure 1. Primary factors causing fatal avalanches, 1990/91 to 1999/00 n=41).

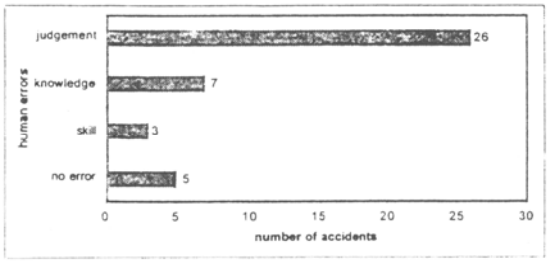

Figure 2. Human errors in fatal avalanche accidents, 1990/91 to 1999/00 (n=41).

Working definitions for these human error types were taken from Webster*s Dictionary:

- Judgement: the ability to come to opinions of things.
- Knowledge: all that has been perceived or grasped by the mind: understanding.
- Skills: ability in such an art, craft, or science

It is important to note from figure 2 that in five cases there was no apparent error. In other words the victims (or groups) were making necessary and appropriate decisions and precautions and still got into trouble. These five groups were the four involved in terrain-caused accidents (climbers on technical routes in Alaska) and one group of skiers in a snowpack-caused accident (see figure 1). Dealing with avalanches is dealing with uncertainty and

sometimes accidents will happen to the best trained.

The role of human factors in avalanche accidents is not new. Fesler and Fredston (1994) introduced the concept and now many avalanche awareness educators include mention of human factors in their training. Fredston and Fesler noted 15 different human factors (table 2) that were major contributors to avalanche accidents:

• attitude	• laziness
• money	• money considerations
• ego	• poor planning
• denial	• tunnel vision
• indecision	• peer pressure
• haste	• poor communication
• complacency	• fatigue
• summit fever	

Table 2. Human factors, Fredston and Fesler, 1994.

A review of the 41 fatal accidents involving avalanche-aware people during the 1990s produced a smaller list (figure 3) presents a simplified list of human. Several factors identified by Fredston and Fesler (e.g., ego, denial, haste, and summit fever) are actually the result or consequence of attitude. The category of *attitude* can be further sub-divided into three subclasses: (a) anti-authority, (2) impulsivity, and (c) invulnerability.

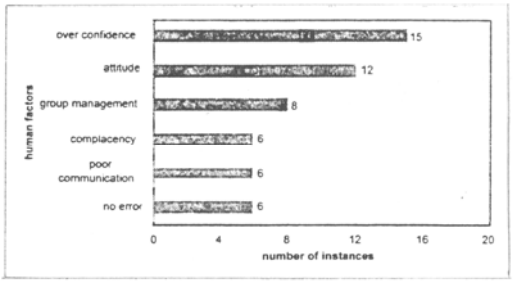

Figure 3. Frequency of human factors identified in avalanche accidents involving victims with some or advanced levels of avalanche awareness training. (n=41. Responses total more than sample size due to some accidents having multiple factors.)

3.2 *Group Size*

Larger groups are more difficult to manage in the mountains and group size may be important to the safety of individuals. Figure 5 shows the number of fatal accidents increases when group size consists of seven or more members. It should not be construed that small groups (2 or 3 individuals) are the most dangerous. Groups of 2 or 3 are probably the most common size for groups heading into the backcountry.

Research in risk taking show that small groups of 2 or 3 are more cautious than an individual (Wilde, personal communication). However, large groups are more risk accepting—known as the "risky shift" (Stoner, 1968) or less risk-aware resulting in greater danger to the group.

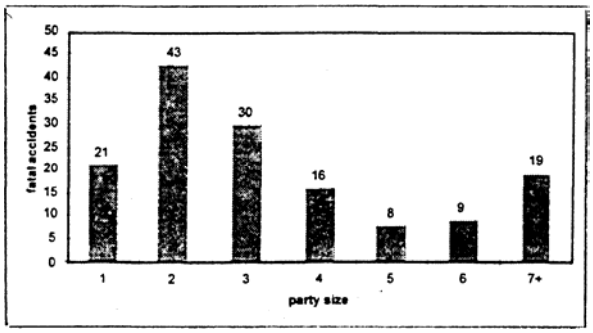

Figure 4. Frequency of fatal accidents compared to party size, 1990/91 to 1999/00(n=146).

Lastly, from figure 4 one might infer that when small groups (2 or 3 people) have an accident and one person is buried there are too few people to effect an efficient rescue.

4. CONCLUSION

Human factors are the cause of most avalanche accidents involving avalanche-aware people. Staying alive is not as simple as being able to recognize avalanche hazards. The problem is seldom a lack of information regarding terrain, weather, and snowpack. The problem is how that information is processed. However, sometimes even the best decision or solution will be overwhelmed by conditions beyond human control.

To prevent avalanche accidents and to save lives there needs to be a better understanding of the dynamics of human errors and how they lead to accidents. To achieve this knowledge we need to improve accident investigation and evaluation methods and techniques.

When investigating avalanche accidents the most consequential question is not one of slope angles, snowfall, winds or weak layers, but one about the victim's cognitive skills: "What

interfered with the person's judgement at the crucial moment." Australian aviation accidents' expert Graham Braithwaite suggests the need to discover:

• What do people know?
• What do people think?
• What do people do?

It will take time to learn more about human factors in avalanche accidents, but fortunately there are already several techniques used by the aviation industry, fire fighting and military that we can adopt to mitigate human factors and errors in avalanche accidents.

One is to increase experience and situational awareness by training to recognize human-error trends so to prevent an accident from occurring (Orasanu and Martin, 1998). Another technique is to use mental simulations so decision makers learn to consider options, the disadvantages of their selected outcomes, and the likelihood of various outcomes (Orasanu and Martin, 1998; Klein, 1998). This requires more role-playing or small-group exercises in avalanche education. These exercises should even be included in the most basic awareness talks.

Lastly, overconfidence is a major human error in avalanche accidents (figure 4). People generally over estimate their ability to recognize risks, or they over estimate their ability to handle problems if an accident should occur. Fortunately teaching people to reduce their overconfidence is easy, but it is seldom done in avalanche education. Instructing individuals or groups to stop and consider reasons why one's judgement might be wrong can reduce overconfidence. (Plous, 1993; Koriat, Lichtenstein, Fischoff, 1980)

By identifying and understanding the dynamics of human factors perhaps new or improved pedagogical tools and/or procedures can be developed in improve the safety of people in avalanche terrain.

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