

HUMAN FACTORS IN AVALANCHE AVOIDANCE AND SURVIVAL: CONSEQUENCES OF VIOLATING THE RULES OF SAFE TRAVEL

Bob Uttl¹, Kelly L. Kisinger², Joanna McDouall¹, Christina Mitchell¹, Jan Uttl³

¹Mount Royal University, Calgary, AB, Canada

²University of Calgary, Calgary, AB, Canada

³Avidata.ca, Cochrane, AB, Canada

ABSTRACT: Using hundreds of historical avalanche accident records from USA and Canada, we examined human factors – avalanche victims' behavior prior to, during, and after an avalanche – which may contribute to the occurrence of avalanche accidents and serious adverse outcomes (e.g., injuries and deaths). Each avalanche accident was coded for the presence or absence of human factors influential in avalanche avoidance (e.g., more than one person on the slope, insufficient spacing, standing exposed, travel alone, familiarity with terrain) and survival (e.g., failure to carry beacons, probes, or shovels). In addition, we coded the number of descriptive parameters for each accident including participants (e.g., number of males and females), activity (e.g., skiing, snowmobiling), avalanche safety training level, and number of participants caught, injured, or killed. The results showed that a large proportion of accident victims violated some basic rules of safe travel in avalanche terrain, e.g., more than one person traveling across the slope simultaneously and insufficient spacing between participants. These violations were common in both commercially-led groups and self-guided recreational groups. A substantial number of victims also traveled alone, and therefore, rescuers were unavailable following burial by an avalanche. In sum, our results show that the number of avalanche accident injuries and death can be substantially reduced if avalanche safety training courses focus more attention on highlighting the importance of human factors in causing avalanche accident deaths and reducing survival.

KEYWORDS: human factors, avalanche accidents, avalanche avoidance, avalanche survival

1. INTRODUCTION

On average, avalanches cause approximately 8 recreational accidents and kill 15 people per year in Canada. After an unusually high number of 29 people were killed during the 2002/2003 season, the Canadian avalanche accident reduction strategy has focused almost exclusively on providing recreational users with a simple tool, called the Avaluator Avalanche Accident Prevention Card (Haegeli & McCammon, 2006), designed to help users select appropriate terrain and assess the stability of the snowpack. This tool was meant to reduce the number of recreational accidents in Canada (Haegeli et al., 2006). On the contrary, however, Uttl et al., (2008b, 2009a) showed that the number of recreational avalanche accidents has doubled in the two seasons following the introduction of the Avaluator. One possible reason for this failure is that the Avaluator was developed with poor scientific methodology, and thus, it tends to give users a false sense of

security in the stability of slopes they are about to cross (Uttl et al., 2008a,b; Uttl et al., 2009a,b,c,d; Uttl & Kisinger, 2010). Compounding this problem, the avalanche safety training curriculum administered by the Canadian Avalanche Association was re-designed around the Avaluator, focusing on terrain choices and snowpack evaluation, and relatively little attention has been given to human factors (Canadian Avalanche Centre, 2006).

The importance of human factors in avalanche avoidance is illustrated by the events leading up to the Durand Glacier Avalanche accident on January 20, 2003. This accident involved a commercially guided tour of 21 skiers including two mountain guides from Selkirk Mountain Experience. The guides chose to ascend the La Traviata couloir even though the safer, but longer and slower, route to their objective was available. They split the party into two groups, one ahead of the other ascending the same couloir, both groups traveling in tight configurations and unnecessarily stressing the snowpack. When an avalanche was triggered by the first group (according to the coroner's report), it swept down the bottom group as well as several skiers from the top group. In total, seven people died, buried under several feet

*Corresponding author address: Bob Uttl, Psychology Department, Mount Royal University, 4825 Mt. Royal Gate SW, Calgary, AB, T3E 6K6, Canada; email: uttlbob@gmail.com or buttl@mtroyal.ca; web: www.docbob.ca.

Table 1. *Human factors in avalanche avoidance.*

Trip planning

- Failure to consult avalanche bulletin
- Failure to check weather forecast
- Failure to let someone know where they are going
- Avalanche danger warning effect (considerable, high or extreme)
- Area close due to avalanche danger

Travel technique

- More than one person on the slope (more than one person exposed to avalanche path)
- Herd instinct (travel bunched up, one behind another)
- Insufficient spacing (travel without sufficient spacing)
- Travel above others (while aware of people below)
- Travel below others (while aware of people above)
- Different tracks (when not skiing down)
- Standing/stopping exposed (unnecessary)
- Travel alone
- Poor route choice (safer route exists to achieve objectives)
- Lemming instinct (follows previous tracks where should not)

Physical State

- Fatigue
- Laziness

Communication

- Incomplete sharing of information
- Miscommunication/misunderstanding
- Failure to speak when aware of danger

Motivation

- Goal motivation
- Scarcity/Heading to untracked slopes

Decision Making

- Familiarity with terrain
 - Bravado/Risk taking (takes clearly unnecessary risks)
 - Inertia/Consistency (continuing on despite mounting evidence conditions are dangerous)
 - Confirmation bias (ignores or discounts evidence of danger)
 - Anchoring (interprets all new information in light of the initial information)
 - Authority (group had a clear leader)
 - Social facilitation
 - Peer pressure (at least some participants conformed to peer-pressure)
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Table 2. *Human factors in avalanche survival.*

Rescue Readiness
Failure to carry beacon
Failure to carry probe
Failure to carry shovel
Rescue Ability
Unable to self-rescue (party is unable to clear everyone's airways)
Unable to complete final rescue (others have to come and assist with bringing rescued to safety)
Failure to post avalanche guard(s) (to watch out for further avalanches)
Unnecessary exposure of survivors to further avalanches
Equipment failure (e.g., shovel broke, beacon batteries died)
Inadequate equipment (e.g., mini-shovel that extended the rescue duration)

of snow. Several human factors contributed to this tragedy: poor route choice given the conditions, one group traveling above another group, 21 people on the slope at the same time, and insufficient spacing of the skiers within each group (Penniman & Baumann, 2004).

We investigated the prevalence of human factors in avalanche accident records focusing on two main questions: (1) What are the most common human decision-making errors committed by individuals traveling in the back-country? (2) Are individuals traveling in the back-country prepared for accidents and rescue? Do they carry necessary self-rescue tools such as a beacon, probe, and shovel?

2. METHOD

Accident records were obtained from the following sources: compilations of US avalanche accidents (Williams, 1975; Williams & Armstrong, 1984; Logan & Atkins, 1996); compilations of Canadian avalanche accidents (Stethem & Schaerer, 1979; Stethem & Schaerer, 1980; Jamieson & Geldsetzer, 1996); Avalanche Center (www.avalanche-center.org); Canadian Avalanche Association; American Avalanche Association (www.americanavalancheassociation.org); Westwide Avalanche Network (www.avalanche.org), and other sources (e.g., newspaper reports).

Each avalanche accident record was coded for the presence or absence of human factors potentially influential in avalanche avoidance (Table 1) and avalanche survival (Table 2). The avalanche avoidance factors were divided into trip planning, travel technique, physical state,

communication, motivation, and decision-making factors. The avalanche survival factors were divided into rescue readiness and rescue ability factors.

The presence or absence of each human factor was coded using a 5-point scale: Yes (factor is present), Weak Yes (factor is probably present), Unknown (presence or absence of human factor cannot be established), Weak No (factor is probably absent), and No (factor is absent) (see Uttl et al., 2008b). Preliminary data indicated that the inter-rater coding reliability for coding these individual factors ranges from excellent ($r \geq 0.90$) for most of the Travel Technique factors to merely acceptable for most of the Decision Making factors.

In addition, a number of descriptive parameters were coded for each accident including the time, date, participants (e.g., number of males/females), activity (e.g., skiing, snowmobiling), avalanche safety training level, and number of participants caught, injured, and killed.

Finally, important characteristics of the record were also coded, such as the length (number of words); availability of figures, photos, and diagrams; the source; and the profession of the author(s). These characteristics were used to investigate any possible biases in the reporting of human factors from various sources.

3. RESULTS

As expected, the preliminary analyses revealed that the prevalence of human factors varied with accident report source, length of accident reports (i.e., word count), as well as availability of drawings, photos, and other

schematic information within the reports. Accordingly, due to space limitations, we report only on the prevalence of human factors in recreational accident records described in two volumes of *Snowy Torrents* (Williams & Armstrong, 1984; Logan & Atkins, 1996) and limit the presentation to human factors in avalanche avoidance only.

Figure 1 shows the proportion of accidents with various human factors present (i.e., “Yes” and “Weak Yes” categories in the coding scheme described above). For proper interpretation of these results, it is critical to note that these proportions represent the *minimums or lower*

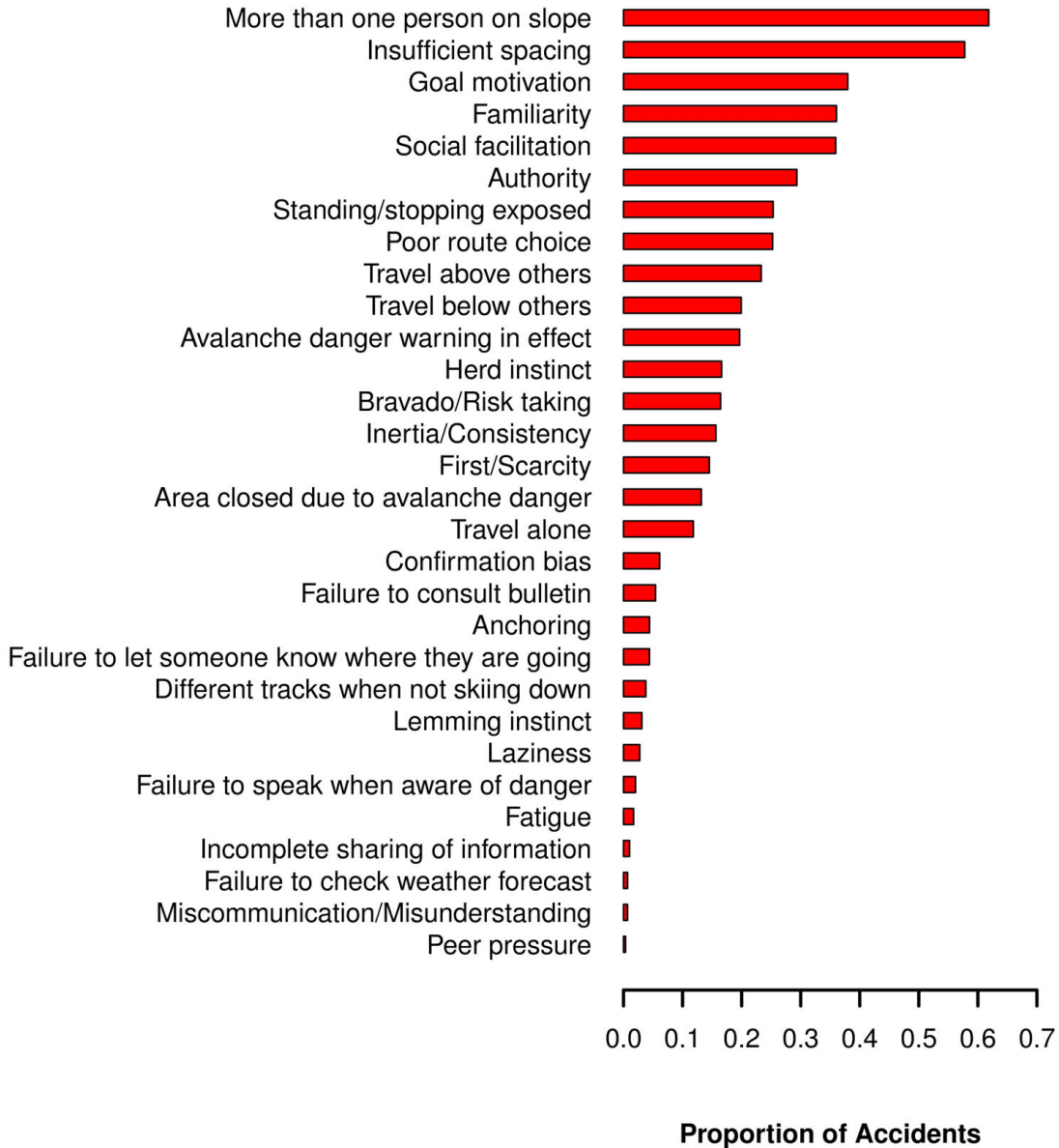


Figure 1. Prevalence of human factors in avalanche accident records. The values represent the lower bound on prevalence because many reports need not be complete and provide sufficiently detailed information to determine whether each factor was present or absent.

bounds on the actual prevalence, as accident records are not necessarily complete.

Surprisingly, the two most prevalent human factors were the presence of more than one person on the slope and insufficient spacing, each of these factors being present in more than 50% of all accidents. Other travel technique factors were also common (i.e., present in >10% of accidents) including standing/stopping exposed, poor route choice, travel above others, travel below others, herd instinct, and traveling alone.

Substantial proportions of accidents also occurred while parties traveled in areas closed due to avalanche danger and traveled under considerable, high, or extreme avalanche conditions. Many accidents happened when parties were motivated to achieve specific goals and/or were heading to untracked slopes. And finally, several decision-making factors were also prevalent: familiarity, social facilitation, authority, bravado/risk taking, and inertia/consistency.

4. DISCUSSION

A word of caution is appropriate when making inferences based on the analyses of accident records. The studies of accident records suffer from several major limitations that must be kept in mind when interpreting the findings. First, the accident records frequently do not mention thought after information and do not allow us to determine whether a specific human factor was involved in an accident or not (see Uttl & Kisinger, 2010, for discussion of this point). Accordingly, the observed values most likely represent a lower bound on accident prevalence. The actual true prevalence of various factors could be much higher. Second, the accident records alone do not allow us to establish that a particular factor is diagnostic of an accident occurring. Thus, it is completely unwarranted to conclude that, for example, familiarity with the terrain causes accidents just because the substantial number of accidents occurred in familiar terrain (DiGiacomo, 2006). Third, the quality of accident records depends on victims', eyewitnesses', rescuers', and investigators' memories as well as on their cognitive biases guiding their interpretation of the information before them.

However, despite these limitations, accident records do allow us to draw some important conclusions from the present study. Most importantly, over half of the accidents involved violations of the basic rules of safe travel in avalanche terrain described in almost every textbook ever written on how to travel safely in

avalanche terrain. It is well known that these violations increase the probability that (1) a slope will avalanche (due to extra mechanical loading), (2) more people get caught (since more of them are on the slope before an avalanche), (d) there will be more than one buried person needing a rescue, and (4) there will be fewer or no people available to rescue the buried individuals. In turn, these data suggest that current education practices may need to increase the focus on discussion of human factors leading to avalanche accidents, injuries, and deaths, rather than focus largely on teaching students how to assess the stability of the snowpack and route selection.

Interpretation of the prevalence of other factors in accident data ranges from relatively easy to impossible. For example, bravado/risk taking is not as clearly interpretable as violations of the rules of safe travel. Yet, it can be identified, coded, and interpreted. In contrast, goal motivation is possible to code relatively reliably but nearly impossible to interpret. Just because a party was motivated to achieve a specific goal does not mean that the party engaged in any poor decisions (see DiGiacomo, 2006, for an excellent discussion of "urban myths" about decision-making in avalanche terrain derived from analyses of accident records).

Finally, there are also accidents where intelligence (also a human factor) or lack of thereof played a key role. To illustrate, on a high hazard day, with many avalanches in an area, two snow rangers proceeded to control avalanche prone slopes. They triggered an avalanche on themselves and were partially buried. They were able to dig themselves out and to continue on their avalanche control route. Next, they arrived under a heavily loaded 45 degree lee slope and decided to toss a charge up the slope in an attempt to trigger an avalanche. Their plan was to hold onto a small tree while the avalanche came down. They tossed the charge up, the avalanche descended, took one of them off the tree and buried him to his neck 50 ft lower (from *Snowy Torrents*). It seems that some accidents may not be preventable.

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