HOW MOUNTAIN SNOWMOBILERS ADJUST THEIR RIDING PREFERENCES IN RESPONSE TO AVALANCHE HAZARD INFORMATION AVAILABLE AT DIFFERENT STAGES OF BACKCOUNTRY TRIPS

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ABSTRACT: Over the last five winters, mountain snowmobilers accounted for 53% (41 of 77) of all recreational avalanche fatalities in Canada, which is a significant increase from the 28% (18 of 64) during the previous five winters. This trend clearly highlights the need for the Canadian avalanche community to improve avalanche awareness among this user group. Creating an in-depth understanding of the perspectives, needs and challenges of mountain snowmobilers is an important first step in the development of more appropriate risk communication and prevention strategies. This paper presents preliminary results from an extensive online survey on mountain snowmobiling and avalanche awareness that was conducted in British Columbia during the 2011/2012 winter season. The survey included a series of discrete choice experiments, a stated preference technique, to examine how snowmobilers adjust their riding preferences as new avalanche hazard information becomes available during different stages of typical backcountry trips. The analysis revealed that participating snowmobilers interpret danger ratings on a linear scale and that the presence of a persistent avalanche problem does not affect their riding choices. Furthermore, under increasing avalanche danger, snowmobilers first gravitate towards areas with higher snowmobile traffic before they avoid complex and challenging avalanche terrain. The analysis also showed that instability observations (i.e..whumpfs) affect riding choices more than other relevant observations. The results of this study can help to develop evidence-based avalanche safety initiatives that effectively target existing weaknesses in the avalanche safety behavior of mountain snowmobilers.

KEYWORDS: Mountain snowmobiling, avalanche hazard information, decision making, terrain choices, discrete choice experiment.

1. INTRODUCTION

A detailed understanding of the attitudes and behavioral preferences of your target audience is critical for developing effective risk communications and prevention initiatives (Lundgren and McMakin, 2009). Traditionally, avalanche safety research has mainly focused on improving the physical understanding of the avalanche phenomenon, but over the last decade, an increasing number of social science projects have aimed to better understand the human dimension of avalanche safety (e.g., Tase, 2004; Silverton, 2006; Björk, 2007; Sole, 2008; McCammon, 2009; Bright, 2010; Gunn, 2010; Haegeli et al., 2010).

Initial studies in this area primarily focused on examining the general character of backcountry users with respect to their basic avalanche safety practices and sociodemographics (e.g., Tase, 2004; Silverton, 2006). More recent studies have employed established theories and models from psychology and health behavior to better tie avalanche safety research to the comprehensive body of work existing in prevention sciences. Examples include the examination of the theory of risk homeostasis (Wilde, 1982) by Sole (2008) and the use of the precaution adoption process model (Weinstein and Sandman, 2002) by McCammon (2009).

Despite these theoretical advances, relating the characteristics of backcountry users to their behavior has remained a challenge. Field monitoring campaigns and intercept surveys are generally ineffective for methodically collecting behavioral data as backcountry activities are pursued by relatively few people over large areas. Furthermore, the spatial and temporal variability of avalanche hazard complicates the systematic collection of information across the range of possible conditions. To overcome this challenge, Haegeli et al. (2010) and Gunn (2010) included discrete choice experiments (DCE; Louviere et al., 2000), a stated preference technique, in their surveys to systemat-

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ically collect information on personal travelling preferences in avalanche terrain across a wide range of conditions. In a DCE, survey participants are presented with a series of hypothetical, but realistic decision situations where they have to make a choice among two or more alternatives. Each alternative is characterized by a common set of attributes, whose values are manipulated according to an underlying statistical design.

Matching the hypothetical decision situation as closely to reality as possible is crucial for deriving meaningful results from a DCE. A possible weakness of existing DCEs in avalanche safety studies is that they portray the decision situation of backcountry travelers as a single 'go/no-go' choice. While this approach seems reasonable for the often spontaneous choices made in out-of-bounds skiing (Gunn, 2010), the decision process in other backcountry activities—traditional backcountry skiing and snowmobile riding—is much more gradual and occurs in stages. Backcountry outings for these activities are typically planned in advance and may require overnight travel before engaging in the activity. As different types of avalanche hazard information becomes available during these trip stages, best practices suggest that trip objectives should be adjusted accordingly.

The goal of the present study is to explicitly model the gradual process of avalanche safety decision making and to examine how snowmobilers adjust their riding preferences as avalanche hazard information becomes increasingly available.

2. METHOD

For the present study, we will use the data from an online survey that was conducted as part of a large-scale initiative by the Canadian Avalanche Centre (CAC) to improve avalanche safety among mountain snowmobilers in Canada. The extensive online survey included detailed questions about participants' snowmobile riding preferences, the character of their typical riding partners, their attitude towards avalanche hazard and common avalanche safety practices. Most importantly, the survey included three consecutive DCEs that aimed to emulate the gradually progressing nature of the decision process that is typical among backcountry travelers.

2.1 <u>Design of DCE</u>

The goal of the first DCE was to examine participants' riding preferences independent of any avalanche hazard information. Survey participants were presented with a potential snowmobile area that consisted of three separate riding zones (Fig. 1a), each characterized by two attributes:

- Terrain character photo: *Simple*, *Challenging* or *Complex* (Fig 2) according to avalanche terrain exposure scale (Statham, McMahon, & Tomm, 2006)
- Typical snowmobile traffic: *Rarely visited*, *Regularly visited* or *High traffic zone*

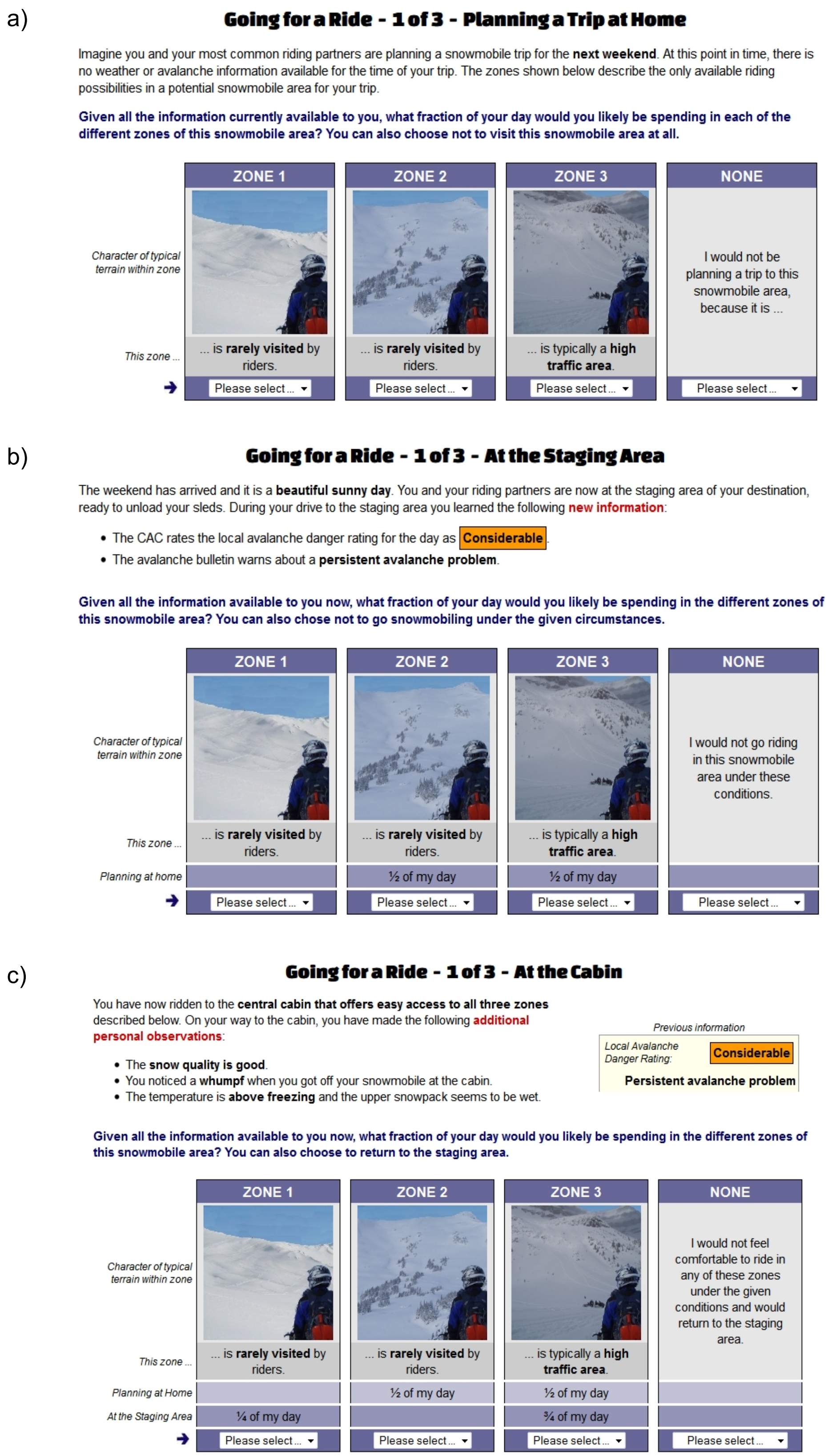
The task of survey participants was to specify how much of their day they would most likely spend in the three different zones with their typical riding group. The response options included *"None of my day"*, *"1/4 of my day"*, *"1/2 of my day"*, *"3/4 of my day"* and *"All of my day".* Their selection(s) had to sum to a complete day. Participants were also able to choose not to ride at all if the selection of riding zones as a whole seemed too advanced or too boring.

Participants who chose to ride in the given snowmobile area were presented with a second DCE that emulated the decision situation at the staging area prior to riding (Fig. 1b). While the basic choice task remained the same as in the first DCE, survey participants were now introduced to large-scale avalanche hazard information typically included in public avalanche bulletins or reported by mainstream media. This information included:

- Avalanche Danger Rating: *Moderate*, *Considerable* or *High*
- Persistent avalanche problem: *"The avalanche bulletin warns about a persistent avalanche problem."*
- Recent avalanche fatality: *"The local radio station reports that there was an avalanche fatality in the general region yesterday."*

When the statistical design required the binary attributes (persistent avalanche problem, recent avalanche fatality) to be absent, the attributed were completely omitted from the decision scenario (see Fig. 1b for example). The goal of this second DCE was to examine how snowmobilers adjust their riding preferences according to large-scale information on avalanche conditions.

Survey participants who chose to ride in the second DCE were presented with a third final DCE (Fig. 1c). For this decision situation, participants had ridden to a central cabin in the snowmobile area that offered equal access to all three riding zones. During their ride, they were exposed to a maximum of five personal observations about the local conditions:


a)
Going for a Ride - 1 of 3 - Planning a Trip at Home
Imagine you and your most common riding partners are planning a snowmobile trip for the next weekend. At this point in time, there is no weather or avalanche information available for the time of your trip. The zones shown below describe the only available riding possibilities in a potential snowmobile area for your trip.
Given all the information currently available to you, what fraction of your day would you likely be spending in each of the different zones of this snowmobile area? You can also choose not to visit this snowmobile area at all.
ZONE 1
ZONE 2
ZONE 3
NONE
Character of typical terrain within zone
I would not be planning a trip to this snowmobile area, because it is ...
This zone ...
... is rarely visited by riders.
... is rarely visited by riders.
... is typically a high traffic area.
Please select ...
b)
Going for a Ride - 1 of 3 - At the Staging Area
The weekend has arrived and it is a beautiful sunny day. You and your riding partners are now at the staging area of your destination, ready to unload your sleds. During your drive to the staging area you learned the following new information:
• The CAC rates the local avalanche danger rating for the day as Considerable.
• The avalanche bulletin warns about a persistent avalanche problem.
Given all the information available to you now, what fraction of your day would you likely be spending in the different zones of this snowmobile area? You can also chose not to go snowmobiling under the given circumstances.
ZONE 1
ZONE 2
ZONE 3
NONE
Character of typical terrain within zone
I would not go riding in this snowmobile area under these conditions.
This zone ...
... is rarely visited by riders.
... is rarely visited by riders.
... is typically a high traffic area.
Planning at home
½ of my day
½ of my day
Please select ...
c)
Going for a Ride - 1 of 3 - At the Cabin
You have now ridden to the central cabin that offers easy access to all three zones described below. On your way to the cabin, you have made the following additional personal observations:
• The snow quality is good.
• You noticed a whumpf when you got off your snowmobile at the cabin.
• The temperature is above freezing and the upper snowpack seems to be wet.
Previous information
Local Avalanche Danger Rating:
Considerable
Persistent avalanche problem
Given all the information available to you now, what fraction of your day would you likely be spending in the different zones of this snowmobile area? You can also choose to return to the staging area.
ZONE 1
ZONE 2
ZONE 3
NONE
Character of typical terrain within zone
I would not feel comfortable to ride in any of these zones under the given conditions and would return to the staging area.
This zone ...
... is rarely visited by riders.
... is rarely visited by riders.
... is typically a high traffic area.
Planning at Home
½ of my day
½ of my day
At the Staging Area
¼ of my day
¾ of my day
Please select ...

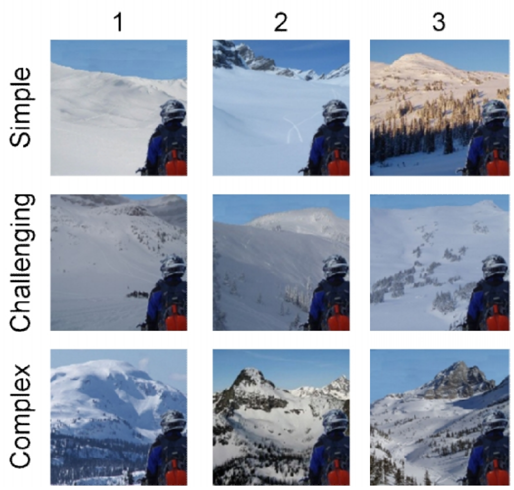


Figure 2: Matrix of terrain photo used in DCE.

- Snow quality: *"The snow quality is good."*
- Avalanche observations: *"Signs of a slab avalanche that occurred today or yesterday."*
- Recent loading: *"Approximately 50 cm of new snow that fell within the last 48 hours."*
- Signs of instability: *"You noticed a whumpf when you got off your snowmobile at the cabin."*
- Critical warming: *"The temperature is above freezing and the upper snowpack seems to be wet."*

While snow quality was good in all scenarios, the presence/absence of the avalanche hazard related observations was varied according to the statistical design. The avalanche danger rating and the persistent avalanche problem introduced in the second DCE, along with the four avalanche hazard related observations of the third DCE represent the six avalanche condition warning signs promoted in the Avaluator V2.0 decision aid for backcountry travelers (Haegeli, 2010).

The response task for survey participants was the same as in the previous two DCEs. The goal of this DCE was to examine how snowmobilers adjust their riding preferences in response to small-scale hazard information.

2.2 Survey sample

The sample for the survey was recruited using a variety of methods. Personalized links for the online survey were emailed to individuals who had provided their email addresses during intercept surveys that were conducted at staging areas in popular snowmobile destinations in British Columbia during the 2011/12 winter season. To further increase the sample size, the online survey was also promoted on popular snowmobile websites (e.g., snowandmud.com; snowest.com), through western Canadian snowmobile clubs, popular snowmobile movie producers (e.g., Slednecks, Team Thunderstruck) and prominent avalanche course providers. The survey was launched on April 9, 2012 and was continuously open for participation until May 31, 2012, when the sample for the present analysis was drawn.

2.3 Survey analysis

The theoretical basis for DCEs lies in random utility theory (McFadden, 1974), which is well documented. An in-depth technical description of the method is beyond the scope of this manuscript, but choice data are generally modeled using a multinomial logit models. The resulting estimates for the regression coefficients—commonly referred to as part-worth utility (PWU) coefficients—describe the relative preference (positive coefficient) or dislike (negative coefficient) of the sample population for each attribute level included in the design of the DCE. Curious readers are referred to Louviere et al. (2000) and Train (2009) for comprehensive descriptions of the method.

Two aspects of the present analysis require a more detailed description. To explicitly examine how snowmobilers adjust their riding choices as new avalanche hazard information becomes available, the preference pattern identified in the first DCE needs to be included in the analysis of the second DCE. Similarly, the preference patterns from the first and second DCE need to be included in the analysis of the third DCE. Analytically, this forward progression of preferences is achieved by summing the PWU estimates from the preceding DCE for each alternative and including them as additional constants in the multinomial logit model of the subsequent DCE. This approach basically locks the preference structure from the former DCE into the analysis of the latter DCE. The PWU estimates for the latter DCE therefore explicitly represent the change in preferences in response to the new avalanche hazard information.

In the present analysis, latent class logit models (Boxall and Adamowicz 2002; Train 2009) were used to examine the riding preferences for each of the three DCEs. The latent class approach—a model-based, probabilistic clustering technique (Vermunt & Magidson, 2002)—offers additional insights into the choice preferences of the sample population as it tests for latent heterogeneity in the choice data and clusters survey participants into a finite number of classes, each characterized by a relatively homogeneous preference pattern that differs significantly from other classes. The latent class approach is increasingly used in prevention science as it offers an effective method for identifying and characterizing distinct subpopulations within larger target audiences of prevention initiatives. Gunn (2010) was the first study to use a latent class approach in avalanche safety research.

3. RESULTS AND DISCUSSION

After eliminating records of survey participants who did not complete the survey, or had particularly unrealistic response patterns, the complete survey sample for the present study consisted of 660 individuals. The majority of the sample was male (93%), the most common age categories were 25 to 34 years old (28%) and 35 to 44 years old (31%), and the vast majority of survey participants were from Canada (81%). The median category for mountain snowmobile riding experience was 6-9 years and the interquartile range ranged from the 1-2 years to the 15-19 years categories. Fifty percent of the sample had started or completed an introductory formal avalanche course (e.g., Canadian AST Level 1).

Survey participants were presented with up to six different snowmobile areas for the first DCE until they decided to go snowmobile riding at least three times. Together, the 660 survey participants completed a total of 2222 DCE sequences.

3.1 DCE1: Riding preferences independent of avalanche conditions

The analysis of the first DCE classified survey participants into three latent classes according to their riding preferences. Eighty-nine percent of the sample were grouped into a class with a strong overall preference for going riding and moderately variable preferences for the different terrain photos. Six percent of the sample (41 of 660) were combined into a class with more conservative riding preferences. This class was more likely to choose the 'Too advanced' based alternative and had a significant dislike for most challenging and complex terrain photos. The remaining 5% exhibited more aggressive riding preferences. This group selected the base alternative 'Too boring' more frequently and exhibited significant preferences for all complex terrain photos. None of the three groups showed any significant preferences with respect to the amount of snowmobile traffic in the different riding zones.

3.2 DCE2: Response to information from avalanche bulletin and mass media

The analysis of the second DCE grouped the survey participants into two separate classes. The only parameter separating the two classes was their preference for the base alternative 'I don't go riding under the given conditions'. While the majority of survey participants (89%) exhibited a general preference for riding, a smaller group of more conservative riders (11%) showed a preference for not riding. The PWU coefficients for all other attributes presented in this DCE did not differ significant between the two classes.

The main effect for danger rating exhibited the expected pattern with strongly decreasing riding preferences being associated with increasing danger rating levels. The linear pattern of danger rating PWU, however, is inconsistent with the opinion of avalanche experts who generally agree that the odds of triggering an avalanche increases exponentially with the danger scale (Jamieson, 2009) This observation highlights the limited understanding of the danger scale by the survey sample.

The presence of a persistent avalanche problem did not have a significant impact on the riding choices of survey participants. For two reasons, this observation is not a complete surprise. First, information on avalanche problems has only recently been included in Canadian avalanche bulletins in a consistent fashion. Second, even though the presence of a persistent avalanche problem is one of the warning signs included in the Avaluator V2.0, it is a more advanced avalanche hazard concept. The radio report of a recent avalanche fatality in the general area did have a significant negative effect on participants' choice to ride. However, the effect was an order of magnitude smaller than the overall effect of the danger rating.

Of all possible interaction effects between the avalanche hazard context variables and alternative-specific attributes, only two emerged as having a significant effect on riding preferences. At a danger rating of Considerable, survey participants exhibited a significant preference for riding zones with regular or high snowmobile traffic. The preference pattern was exactly the same under a High avalanche danger rating, indicating that the additional increase in avalanche danger did not further enhance this compensation behavior. The second significant interaction effect was between the avalanche danger rating and the avalanche terrain exposure scale classification of the terrain photos.

While there was no detectable shift in terrain preferences under a Considerable danger rating, a significant preference for simple terrain was observed for High danger ratings.

Together, the two interaction effects provide interesting insight about how survey participants choosing to ride under elevated avalanche danger adjusted their riding preferences. As the danger level increased from Moderate to Considerable, they first moved to riding zones with higher traffic and only once the danger level increased to High, they moved into simple terrain. This behavioral pattern is troubling for two reasons. First, possible compaction from snowmobile traffic is not a reliable indicator for locally low avalanche hazard and second, using the presence of other riders as a clue for decision making in avalanche terrain is frequently mentioned as a negative human factor in the avalanche safety literature (e.g., Tremper, 2008).

3.3 *DCE3: Response to additional personal avalanche hazard related observations*

A single-class model emerged as the most appropriate model for the third DCE. When analyzing the impact of the individual avalanche hazard related observations, an interaction effect between the individual observations and the danger rating level emerged. The impact of individual observations on the choice to ride was highest under Moderate danger ratings and decreased linearly with increasing avalanche danger ratings. While the observations for avalanches, loading and warming, were weighted equally, the impact of the instability observation (whumpf) was significantly higher at all danger rating levels. At the danger rating level High, the instability clue was only observation with a significant impact on the choice to ride. The analysis also revealed that the impact of the avalanche hazard indicators decreased as the number of indicators present in a scenario increased. This weakening effect was most pronounced under Moderate danger ratings. While the effect was less evident under Considerable, the effect disappeared under High danger ratings. Both the variable weighing of avalanche hazard relevant observations and the decreasing impact of multiple observations are inconsistent with the decision approach promoted by the Avaluator V2.0, which assigns equal importance to all warning signs under all conditions.

Only two alternative-specific interaction effects emerged as having a significant impact on participant's riding preferences in the third DCE. Both of them were only present when the decision scenario featured two avalanche hazard indicators. Similar to the choice pattern observed in the second DCE, there was a significant preference for regular or high traffic riding zones. In addition, the analysis revealed a significant preference for the terrain photos Simple-3 and Complex-1 (Fig. 2). While this preference pattern could not be explained with the avalanche terrain exposure scale ratings of these images, an examination of the general character of the terrain photos indicated that the revealed preference might be related to the amount of riding options in forested terrain available in these images.

The fact that no attribute-specific interaction effects were detected at other numbers of avalanche hazard indicators reveals that the presence of two indicators represented a critical transition in the riding preferences of survey participants. Under conditions with less than two indicators, survey participants did not feel that any terrain adjustments were necessary. At two indicators, they adjusted their terrain choices as described by the two interaction effects. When more indicators were present, the likelihood of survey participants choosing to stop riding increased considerably making terrain adjustments less prevalent.

4. CONCLUSION

The present study used three consecutive DCEs to systematically examine how snowmobilers adjust their riding preferences as avalanche hazard related information becomes available before and during their backcountry outings. For the promotion of avalanche safety among snowmobilers, the study provides the following important insights:

- The avalanche danger ratings were interpreted on a linear scale.
- The concept of persistent avalanche problems was not well understood.
- As the danger rating increases, snowmobilers first gravitate towards zones with higher snowmobile traffic before they adjust their riding preferences towards less serious avalanche terrain.
- Instability observations (e.g., whumpfs) are interpreted significantly more seriously than the other hazard indicators.
- Under Moderate and Considerable danger ratings, the additional impact of avalanche hazard related observations decreases as the number of present observations increases.

Results from avalanche safety surveys should always be examined critically. First, voluntary surveys about avalanche safety issues have the inherent potential to primarily attract participants who already have a special interest in avalanche safety and the context of a safety survey can further cause participants to provide answers that are biased towards more conservative behavior (i.e., social compliance). Preliminary comparisons between the samples of the present online survey and the complementary intercept survey indicates that participants in the online survey were significantly more experienced and avalanche-trained than the general mountain snowmobile population in British Columbia. The results of this comparison make the conclusions of our analysis even more concerning as they reflect the existing decision making weaknesses of a more advanced mountain snowmobiling sample.

We acknowledge that decision situations presented in online surveys are unable to fully capture the physical complexity and emotional involvement experienced when planning for and during real backcountry trips. However, the high degree of realism in the survey results indicates that careful sequencing of survey questions and the multi-attribute nature of the DCE are able to alleviate some of these concerns.

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