DO TRENDS IN FORECASTED AVALANCHE DANGER AFFECT OUR PERCEPTION OF THE CURRENT AVALANCHE HAZARD
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Finn K. Hovem[1]*, Andrea Mannberg[2, 3], and Jens A. Terum[1]

[1] *Department of Engineering and Safety, University of Tromsø, Tromsø, Norway*
[2] *School of Business and Economics, University of Tromsø, Tromsø, Norway*
[3] *Center for Avalanche Research and Education, Tromsø, Norway*

ABSTRACT: Avalanche forecasts are useful for both professional and recreational backcountry travelers seeking to mitigate avalanche risk. In this paper, we analyze if and how trends in forecasted avalanche danger affect the perception of present danger. To do this, we randomly placed 63 individuals, who work in an environment exposed to avalanches, into two groups. Each group answered questions in response to two different scenarios: one scenario with an increasing trend in forecasted avalanche danger (from level 2 to level 3), the other scenario with a decreasing trend in forecasted avalanche danger (from level 4 to level 3). To identify the effect of trends in forecasted avalanche danger, we compared the mean difference in perceived danger between scenarios. Our results show that participants on average perceive the avalanche hazard to be higher if the forecasted danger goes from level 4 to level 3, than if it goes from level 2 to level 3. The amount of avalanche information presented does not affect the results. In order to improve risk communication and understanding of decision making in regard to avalanche hazards, the observed effect needs to be further understood.

KEYWORDS: Select 3-6 keywords.

1. INTRODUCTION

Previous research suggest that an overwhelming majority of avalanche accidents are caused by the victims or someone in the victims' group (Tschirky, Brabec & Kern 2000). Some of these accidents can be attributed to lack of avalanche knowledge (Adams, 2004). However, in many cases, the victims were knowledgeable about the avalanche danger at hand, and had training. Instead, it appears that cognitive and emotional biases are at the cause of the poor decisions leading up to the accidents (e.g., Atkins, 2000; McCammon, 2002; Furman et al, 2010). To prevent future avalanche incidents, it is therefore important that we not only understand the physical, but also the human processes that lead to avalanche incidents.

The main purpose of avalanche warning services (AWS) is to inform travelers in avalanche terrain about the current and forecasted avalanche danger, and thereby aid decision-making. Previous research suggest that AWS fulfil this purpose. For example, in a study of American backcountry skiers, Furman et al (2010) found that the avalanche forecast constituted the most important factor for deciding on whether or not to ski a slope. However, some psychological studies suggest that the interpretation of the avalanche forecasts may be affected by irrelevant trend factors. For example, in a study on the perceived danger of landslides, Hohle and Teigen (2015) found that participants perceived a situation corresponding to a danger level 2 as more dangerous, when the trend was positive (increasing from a level 1) than if it was negative (falling from a level 3), even though the current danger was described identically in both scenarios.

In this study, we use survey data to analyze if trends in the avalanche forecast affect perceived avalanche danger. Our study contributes to the literature in several ways. First, though landslide and avalanche forecasts both feature categorical danger levels that are based upon likelihood and destructive potential of an event, AWS have a much broader target audience who use the forecast for different purposes (Bjørdal et al, 2017). Among individuals using AWS to inform voluntary recreational activity Hallandvik et al. (2017) report that experts and non-experts value different parts of the avalanche bulletin. Non-experts find the avalanche danger rating most useful, while experts are more concerned with the information about the type of avalanche.

Second, in contrast to Hohle and Teigen (2015), who asked students to evaluate landslide danger, we use a sample of individuals who work in an environment where they at times are exposed to avalanches. As a consequence, our sample belongs to the population of individuals that AWS tries to reach.

2. METHOD

This study is based on the hypothesis that our perception of avalanche danger is influenced by trends in the forecasted avalanche danger level.

We also suspect that level of knowledge about avalanches influence how trends affect our perception of hazard. For example, that experts and novices will perceive a change in forecasted danger level differently, or that individuals who have access to a more detailed avalanche forecast will evaluate scenarios differently. However interesting, the investigation of these effects is subsidiary to our investigation of our hypothesis.

To test our hypothesis, we developed three research questions for the basis of our survey.

- Does a change in forecasted avalanche danger level from the previous day affect how the current avalanche hazard is perceived?
- How does contextual information with regard to forecasted avalanche danger level affect perception of the current avalanche hazard?
- What effect does the level of knowledge about avalanches have on how forecasted avalanche danger is perceived?

2.1 Survey participants

As the majority of individuals involved in avalanche incidents have some form of avalanche knowledge and expose themselves to avalanche hazard voluntarily (McCammon, 2002; 2004) we decided to target individuals who make decisions in, or regards to, avalanche terrain.

We sent our online questionnaire to selected employees and associates of a Norwegian company who work in areas exposed to avalanche hazards. Though the selected employees and associates are not necessarily avalanche experts, they all work in fields related to avalanches and have some degree of standardized avalanche training required by their workplace.

63 individuals participated in the survey. Of these, 83 percent were male. 18 percent were 34 years or younger at the time of the survey, 48 percent were in the age 35-49, and 35 percent were 50 years old or older. Concerning avalanche training and experience, 35 percent had no formal avalanche training at the time of the survey, 46 percent had basic training (two or more days), and 19 percent had advanced training. 43 percent of the sample had spent at least five days in avalanche terrain per year during the past five years.

2.2 Measurement instruments

The main outcome variable in our analysis is perceived avalanche danger. We operationalized this concept via two hypothetical scenarios were the respondents were told about the avalanche danger in the area, and asked the question: “Think about the avalanche danger that the group of skiers are exposing themselves to, how dangerous do you think that it is to travel in this area at the moment?”. The respondents answered on a scale from 1 (not dangerous at all) to 7 (Very dangerous).

Since perceived hazard is not an objective measure that has a standardized value, but rather is an individual perception that is subject to each individual’s biases, we exposed each respondent to positive and negative trends. The difference in perceived hazard between scenarios indicate what effect trends in forecasted avalanche danger have on how current avalanche hazard is perceived.

We designed the study to measure the effect of three independent variables corresponding with our research questions: trend in avalanche danger, amount of contextual information, and avalanche training of the respondent. We define a “trend” as a change in the forecasted avalanche danger from the previous day. More specifically, we say that the trend is “positive” (upward) if the avalanche danger goes from a level 2 yesterday, to a level 3 today, and “negative” (downward) if the danger goes from a level 4 to a level 3.

Half of the participants were shown scenarios that included only the avalanche danger level (figure 1), while the other half received scenarios including the avalanche danger level, the avalanche problem type, and travel advice (figure 2). Finally, we categorized the respondents avalanche knowledge by recording their self-reported level of avalanche training, and the average number of days in they spent in avalanche terrain during the past five years.

* *Corresponding author address:*
Finn K. Hovem, Tromsø, Norway
+47 911 54 532 finnkhovem@me.com

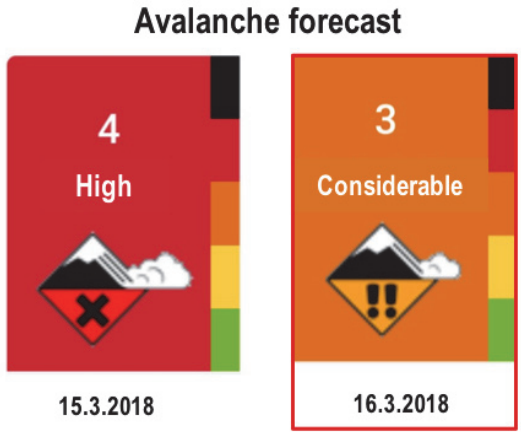

Figure 1 Low information-negative trend scenario. (adapted from varsom.no)

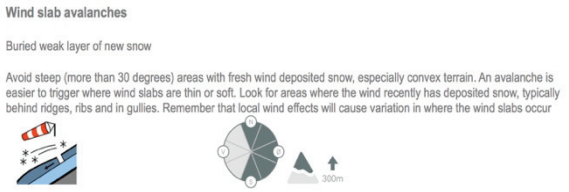

Figure 2. High information-negative trend scenario (adapted from varsom.no)

2.3 Survey structure

We presented each participant with two scenarios (March 16th and March 22nd) with a corresponding set of questions. Each scenario asked the participant to imagine the following situation:

"You are driving your car through mountainous terrain. The sky is overcast and the date is 16th of March. You can see two parked cars on a trailhead next to the road, and skin tracks on the mountainside above. The tracks are on an eastern aspect of the mountain. You know that this mountain has several sections with slope above 30°. Based on the number of cars at the trailhead, you can presume that there is at least one group of skiers on the mountain, but you have no information on their skill level or other characteristics. You can see snow drift from the west on the mountain. You have access to the following avalanche advisory on your mobile phone"

Except for the date, this description was identical for all scenarios. In the second scenario, we presented a reversed trend in the avalanche forecast.

Fig. 3 illustrates the survey flow used to test for the independent variables. Half of the participants, randomly selected, received information about the avalanche problem type (wind slab) and travel advice in addition to the avalanche danger level. In order to control for an effect of viewing order, we randomized the survey so that approximately half of the respondents were shown a scenario with an increasing trend first, while the other half viewed a decreasing trend first. All of the scenarios forecasted danger level 3. In the decreasing trend scenarios, the avalanche danger was forecasted to decrease from level 4 to level 3, while in the increasing trend scenarios, it was forecasted to increase from level 2 to level 3.

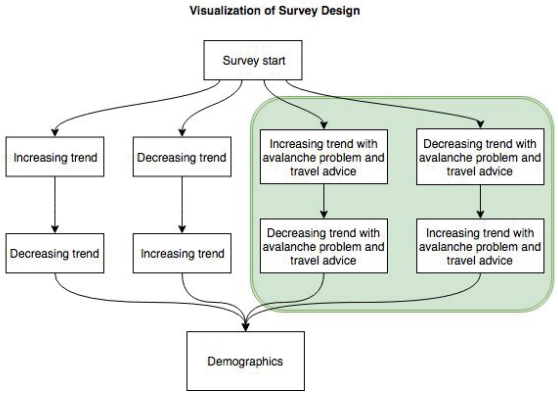

Figure 3 Flow chart illustrating survey randomization and structure

3. RESULTS

Our empirical analysis suggests that the recent trend in avalanche danger has a statistically significant effect on perceived current danger. As can be seen in Fig. 4, participants in our sample perceive the avalanche danger in the area to be higher when the avalanche danger goes from level 4 to 3, than when it goes from level 2 to 3. The effect is small, but significant (N=63, paired t-test: t =-3.52, p = 0.002, Wilcoxon signed rank-test: z =-3.084, p = 0.002). Note that the description of the avalanche danger was identical for the upward and downward trend scenarios.

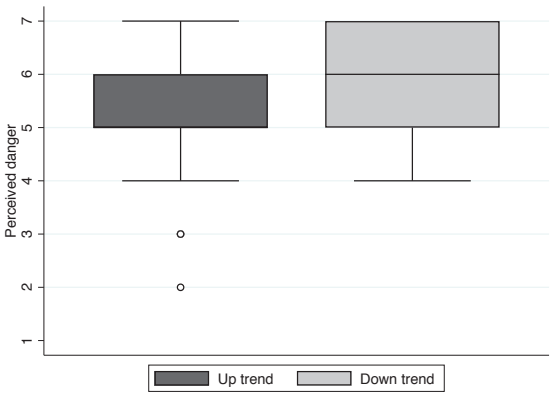

Figure 4. Perceived avalanche danger in area

Avalanche danger is on a subjective and ordinal scale rather than objective and cardinal scale. As a consequence, one individual's perception of a point 5, on a scale from 1 to 7, likely differs from another individuals' perception of the same number. For the same reason, the answers to danger scenario 1 may be relatively imprecise, i.e., an individual may perceive the situation to be either relatively dangerous or non-dangerous rather than exactly at point "5". When faced with a new danger scenario, the first scenario is likely used as a point of reference, i.e., is the new situation less dangerous, equally dangerous, or more dangerous than the first? As a consequence, the most adequate metric to analyze is the *change* in perceived danger between the two scenarios. If no trend effect is present, this difference should be zero. As can be seen in Fig. 5 below, individuals who saw a scenario with a downward trend for March 22nd (and an upward trend for March 16th) on average perceive a small increase in danger, while individuals who saw an upward trend perceive a small reduction in danger. The difference between the two groups is significant (N=63, t-test: t = 3.023, p = 0.004, Mann-Whitney U-test: z = -3.019, p = 0.003).

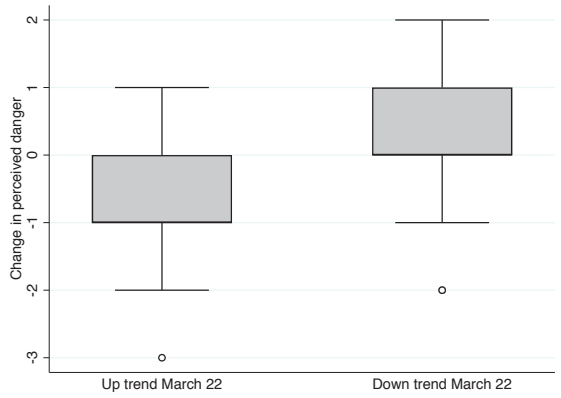

Figure 5. Difference in perceived danger between scenario 1 and 2.

To evaluate potential effects of the amount of avlanche information provided, avalanche training and experience, and socio-demographics, we run a linear regression model (ordinary least squares), in which we control for these factors. The results are presented in Table 1, below. Given the limited sample size, we test for the factors individually, but the results are robust to including all factors in one model.

Table 1. OLS regression coefficients. Heteroscedasticity-robust standard errors in parentheses.

	Model I	Model II	Model III
Down trend 22 March	0.738**	0.746**	0.727**
	(0.245)	(0.251)	(0.245)
Low information	-0.114		
	(0.234)		
Avalanche training			
Basic		-0.124	
		(0.287)	
Advanced		-0.164	
		(0.263)	
Experience			-0.228
			(0.249)
N	63	63	63
Adjusted r2	0.104	0.090	0.114
F-value	4.542	3.051	5.043

* p < 0.1 ** p < 0.05 *** p < 0.001

As can be seen in Table 1, we find no effects of information, avalanche training, or experience. We neither find any effects of gender or age (results not shown). We have also analyzed a panel regression model, in which we evaluate effects of information, avalanche training and experience, and socio-demographics, on the *level* of perceived danger. The results of that analysis (available upon request) confirms the results in Table 1.

4. DISCUSSION

Our results suggest that our participants on average perceive a situation to be more dangerous when the trend is decreasing from level 4 to level 3, than when it is increasing from level 2 to level 3. We further find that the trend effect is present regardless of the training and experience of the participant, and that more detailed information about the avalanche problem does not eliminate the effect.

The direction of the trend effect in our study is opposite to the observed effect by Teigen and Hohle (2015), who found that perceived danger was higher under an increasing trend than under a decreasing trend. The inability of our study to replicate the same effect could be explained by some of the differences between these studies regarding the ecological validity of how the danger ratings were presented and how the experimental designs were structured.

Our results hold implications for policy and raise important questions. If a situation that is identical

in terms of hazard is perceived differently solely due to the recent change in avalanche danger, we may expect that decisions related to avalanche hazard will also depend on how these trends influence our perception. This implies that trends may distort decisions related to avalanche risk, unless the trends hold information about the current hazard. The question then becomes, how can avalanche forecasters mitigate these distortions, and how serious are the consequences of trend dependency?

Reassuringly our initial data suggests that this effect could lead to more conservative decision making under uncertainty, as the scenario that had previously been level 4 was considered more dangerous than the scenario where the danger increased. This is positive in terms preventing avalanche incidents, though McClung (2002) provides examples such as delays in opening closed roads or failure to remove avalanche warnings as examples of how conservatism can be viewed as an error. It is relevant to consider that in the scenarios used in this study there were no rewards presented for risk taking behavior, could this have primed more conservative decision making?

Our study does not answer these questions, and we therefore call for further research. We would also like to linger around some methodological limitations with our research. The small sample size implies a risk of both attenuated effects, and extreme values. It is therefore important to replicate the study on a larger sample. A perhaps even more important caveat is that the trend in avalanche hazard may hold information about the current situation. This is mainly so because a level 3 is not always the same, it can be a strong or a weak level 3.

5. CONCLUSION

The purpose of this study was to investigate if a change in forecasted avalanche danger affects the perception of current avalanche danger. Our results suggest that it does, though more research is needed with greater sample sizes to see if this effect is consistent under different circumstances. In order to improve risk communication and understanding of decision making in regard to avalanche hazards, this effect needs to be further understood.

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