

DO AVALANCHE AIRBAGS LEAD TO RISKIER CHOICES IN THE BACKCOUNTRY?

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ABSTRACT: While the effectiveness of airbags for reducing mortality in avalanche involvements has been examined in various studies, the nagging question of whether the added safety benefit might actually lead to increased risk-taking – a phenomenon referred to as risk compensation or risk homeostasis – has only been tackled by a few. Building on the existing research on airbags, risk compensation and stated terrain preferences in winter backcountry recreation, we developed an extensive online survey to approach the topic of avalanche airbags and risk compensation from multiple directions. In the spring of 2017, 155 airbag owners and 237 non-owners mainly from Switzerland, Germany and Austria participated in our study. While our analysis of the survey responses indicates that risk compensation behavior in response to airbags is likely among recreational backcountry travelers, the discrete choice experiment included in our survey failed to provide conclusive empirical evidence. To allow backcountry users to make informed choices about airbag use, we recommend the topic of risk compensation to be included in avalanche safety courses and airbag user manuals.

KEYWORDS: Risk compensation, risk propensity, terrain preferences, avalanche safety equipment.

1. INTRODUCTION

The effectiveness of airbags is supported by various scientific studies including simulations, field experiments and statistical evaluations of accident records. The most recent study, a retrospective analysis of avalanche accidents involving multiple victims with at least one wearing an airbag by Haegeli et al. (2014), shows that inflated avalanche airbags reduced absolute mortality among victims from 22% to 11%. Hence, international organizations like the Wilderness Medical Society (Van Tilburg et al. 2017) and national avalanche safety organizations (e.g., Avalanche Canada) officially recommend the use of avalanche airbags in addition to standard avalanche safety gear.

Despite the proven effectiveness of avalanche airbags, there is persistent concern that the positive effect of airbags could be nullified or even reversed by their unintentional negative influence on users' risk perception and risk-taking (Wolken et al. 2014). The thought is that the added sense of security provided by the airbag would lead to riskier choices when travelling in the backcountry and thereby increase the potential for serious injury or even death. The introduction of new safety equipment is commonly accompanied by these types of concerns,

which are grounded in the theory of risk homeostasis or risk compensation (Wilde 2001). This theory posits that people are not trying to minimize their risk, but rather optimize it by maintaining an acceptable target level of risk in the context of the expected benefits and costs of both the risky behavior and the added safety equipment.

Only few studies have explicitly tackled the airbag risk compensation question. Since field experiments examining backcountry users' behavior with and without airbags are not feasible, studies have to resort to indirect measures to explore the issue. Wolken et al. (2014) conducted an online survey where participants had to assess the avalanche risk in a series of avalanche situations and specify their willingness to ski the presented slope. While their comparison of regular users of airbags and non-users did not reveal any differences in risk perception, but airbag users were significantly more likely to ski the slope. Furthermore, 18% of their sample of airbag users indicated having skied a slope they would not have without an airbag at least once. Also using an online survey, Margeno et al. (2016) showed a positive correlation between airbag ownership and personal avalanche involvements. While these types of studies offer some insight, these comparisons of users and non-users of avalanche airbags are unable to identify risk compensation behavior since the observed pattern might be completely explained by the fact that skiers with a higher personal risk propensity might be more likely to buy an avalanche airbag.

To isolate the risk compensation effect properly, it is critical to examine skiers' risk propensities with and without airbags. This approach was pursued in the survey study of Eyland and Thibeault (2016), where participants were presented with a single slope-scale

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skiing scenario and had to specify their acceptable threshold level of danger for skiing the slope under different circumstances. Their comparison of the base scenario with the scenario where participants were given an airbag and an AvaLung showed that about one quarter of the survey sample indicated a higher acceptable danger threshold with the added safety equipment. While this result offers indirect evidence that risk compensation in response to airbags is possible, the power of the study to draw general conclusions seems limited as participants only assessed a single scenario.

The objective of the present study is to provide a comprehensive perspective on the topic of risk compensation and avalanche airbags among backcountry/out-of-bounds skiers by simultaneously examining the topic from multiple perspectives. Building on existing research in risk compensation and backcountry terrain preferences, we aim to a) examine general perceptions of the effect of airbags on risk-taking, b) look at differences in attitudes towards risk-taking between users and non-users of airbags, c) identify common reasons for or against purchasing an avalanche airbag, and d) explore changes in stated backcountry terrain preferences related to airbag ownership and use.

2. METHODS

2.1 *Survey design and deployment*

We designed a comprehensive online survey to examine the effect of avalanche airbags on risk taking in avalanche terrain that included questions targeting the following areas:

- Engagement and skill level in backcountry and out-of-bounds skiing
- Personal backcountry risk attitude
- Avalanche awareness level
- Use of avalanche safety gear
- Airbag use and ownership
- Personal opinion on risk compensation with airbags

The core of the survey was a discrete choice experiment (DCE; Louviere et al. 2000), a stated preference technique that offers an attractive alternative for systematically collecting information on personal preferences when direct observations are impossible. The present study reused a DCE that was designed by Haegeli et al. (2012) to examine risk-taking behavior among out-of-bounds skiers. In this DCE, participants were asked to specify which of two backcountry ski run options they would prefer to ski under a given avalanche danger rating (Fig. 1). Each of the included backcountry run was characterized by a set of terrain attributes including character (open, treed, chute), size (small, medium, large), slope steepness (blue, red, black; following the European ski run classification), frequency of use

(regularly, occasionally, rarely) and number of tracks present (several, two, none). To make the decision situations as realistic as possible, slope character, size and steepness were presented in a single annotated photograph. Participants also had the option to stay within the ski area if they do not like either of the two offered options.

Each survey participant was presented with six different choice sets with varying attribute combinations and avalanche danger ratings. To examine the effect of airbags on terrain preferences, the choice situations were framed as follows. In the first half of the choice situations, participants were asked to select their preferred run imagining their normal setup (i.e., owners with their airbags and non-owners without them). In the second half, owners were told that their airbag was not available to them, while non-owners were given an airbag for these choices. This experimental setup offers insight into risk compensation behavior by allowing comparisons of terrain preferences with and without airbags within both the owner and non-owner subgroups as well as between the groups.

Because it is extremely difficult to recruit a representative random sample of backcountry skiers, we used a convenience sample for this study. We elicited survey participants from Switzerland, Austria and Germany by promoting our study on the websites of the Swiss, Austrian and German Alpine Clubs, the Swiss Council for Accident Prevention (bfu) and Bächli Sport, a prominent provider of outdoor equipment in Switzerland. In addition, the research team used their personal network to promote the survey. The survey was open for participation from March 21 to May 1, 2017, when the final sample for the analysis was drawn.

2.2 *Statistical analysis*

We used general descriptive statistics to describe the nature of the dataset. Responses to the backcountry risk propensity questions were examined with 'princals' (De Leeuw and Mair 2009), a non-linear equivalent to classic principle component analysis, and survey participants were subsequently classified using hierarchical clustering. Differences between risk propensity group as well as owners and non-owners of airbags were examined with Pearson's chi-squared tests, Wilcoxon rank-sum tests and Kruskal-Wallis tests depending on the nature of the data. We only considered differences with a p-value < 0.05 to be significant.

We analyzed the DCE data by estimating a single multinomial logit model with four known classes: a) non-owners without airbags, b) owners with airbags, c) non-owners with airbags, and d) owners without airbags. Model selection involved the assessment of absolute model fit, model parsimony and class interpretability. Wald statistics (Hausman

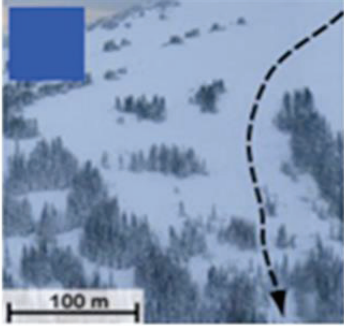
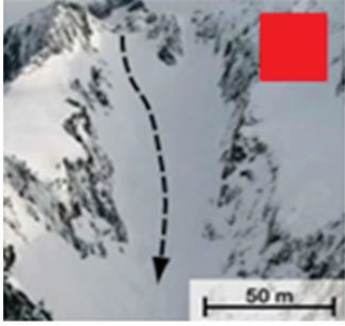
Which run would you ride under presented conditions?		
Avalanche equipment	Avalanche transceiver, probe, shovel, avalanche airbag	
Local avalanche danger rating	 Considerable	
	Run A	Run B
Blue square = moderate steep (less than 30°) Red square = steep (30° to 35°) Black square = very steep (more than 35°)		
Slope use 	Regularly	Regularly
Existing tracks 	Two tracks	Several tracks
Your choice	☐ Run A	☐ Run B ☐ None of these slope, I stay within the ski area.

Fig. 1: Example choice set (translated from German)

and McFadden 1984) were used to identify statistically significant differences in attribute preferences between models.

3. RESULTS

The following paragraphs only provide a brief overview of the main results of our study without statistical details. A manuscript that describes the results in full detail is currently in preparation for publication in a peer-reviewed journal.

3.1 Characteristic of survey sample

Our final analysis dataset consisted on 392 participants. Seventy percent of the sample was male and while we had participants from all age categories, the central 50% were in the '25-34' and '35-44' categories. Three quarters of participants were from Switzerland and 20% from Germany.

Our sample was highly experienced in both backcountry and out-of-bounds skiing with 37% and 42% of participants having pursued these activities for more than 10 years. Thirty-nine percent indicated that backcountry skiing is their preferred skiing activity, while 54% prefer skiing out-of-bounds (with and without short hikes) and 7% prefer skiing short slopes between groomed runs. Eighty percent of participants rated their skiing skills as advanced or expert. Fifty-seven percent of participants indicated that they had formal avalanche safety training and an

additional 16% stated that they work as professional guides.

Our analysis of the backcountry risk propensity questions revealed three distinct groups: thrill-seekers (26% of participants), conscientious seekers of fresh tracks (31%) and conservative skiers (43%). We did not find significant differences in the proportions of backcountry and out-of-bounds skiers among these clusters.

3.2 Airbag ownership

Forty percent of survey participants (155 of 392) indicated that they owned an avalanche airbag at the time of the survey. Owners were significantly more likely to be male but did not differ in age. The proportion of owners was significantly higher among committed out-of-bounds skiers that enjoy doing short hike to reach their run. Overall, owners were more experienced and more committed to the sport. However, we did not detect a significant difference in their avalanche involvements or their backcountry risk attitude group membership.

3.3 Airbag attitude and use

Overall, 87% of participants agreed with the statement that avalanche airbags have the potential to result in risk compensation behavior at least to some degree. However, airbag owners rated the potential significantly lower than non-owners.

The most highly rated reasons for the purchase of an airbag was *"I am generally interested in increasing my safety"* and *"Statistics show higher chance of survival"*. Less than 10% rated *"So that I can go by myself"*, *"To ski steeper slopes"*, and *"I would like to expose myself to higher hazard"* as important or very important.

Of the 32 airbag owners reporting personal avalanche involvements, 56% bought their airbag after their involvement, while 44% had the involvement after they had purchased the airbag. While the proportion of owners with after-purchase involvements is substantially higher in the conservative and fresh track seeking groups than the thrill-seeking cluster (68% and 60% versus 25%), the sample was too small for the contrast to be statistically significant (Pearson's chi-squared test: $p\text{-value} = 0.10$).

Among the non-owners, the most highly rated reasons for not purchasing an airbag was purchase cost and the additional weight.

3.4 Terrain preference

After exploring different model configurations, our final model included main effects for all attributes as well as interaction effects for danger rating and slope steepness. We only summarize the most relevant results of our analysis since a complete description is beyond the scope of this paper.

The only significant difference in terrain preferences that emerged in the comparison between owners with airbags and non-owners without airbags was that the dislike for steep slopes (black) was slightly more pronounced among non-owners than owners. While there were other small differences in their preference, none of them were statistically significant.

The terrain preferences of the non-owners with airbag generally mirrored their preferences without airbags. However, there were a few notable differences. Once non-owners were given an airbag, their preference for blue runs at danger level moderate disappeared and substantially weakened at danger level considerable. Surprisingly, however, they also suddenly showed a significant preference for blue runs and a dislike for red runs at danger level low.

The two models for owners of airbags (with and without airbags) only differed significantly with respect to one attribute. While the base model with airbags did not reveal any significant preferences for slopes of different sizes, owners of airbags suddenly showed significant preferences for medium sized slopes once the airbag had been taken away from them.

4. DISCUSSION

Overall, survey participants agreed that avalanche airbags have the potential to result in risk compensation behavior. Even among owners, 82% agreed that airbags can lead to increased risk-taking.

Our comparison between non-owners and owners of airbags suggests that airbags are generally purchased by more committed skiers that are aware that they might be exposing themselves to higher levels of risk. Wolken et al.'s (2014) result that owners of airbags were more likely to choose skiing in their scenarios and the fact that Margeno et al.'s (2016) sample of airbag owners reported higher life-long avalanche involvement rates can likely be explained by the identified differences between owners and non-owners of airbags. However, using these observations to conclude that airbags directly lead to risk compensation is incorrect. Nevertheless, understanding the motivations for pursuing backcountry skiing is key for assessing the potential for risk compensation (Hedlund 2000). Skiers interested in challenging skiing are fundamentally more susceptible to risk compensation as their objective inherently conflicts more with safety than the one of skiers primarily interested in enjoying nature.

Non-owners' reasons for not purchasing an airbag offer additional insight on the potential for risk compensation. Hedlund (2000) argues that the likelihood for risk compensation is much larger for safety devices that are clearly visible than invisible ones. While avalanche transceivers might quickly fade from users' awareness because they only need to be turned on once in the morning, this is clearly not the case for airbags, where the weight penalty, the handling of the leg loop and the prominent trigger handle constantly remind users of the additional safety device and negatively affect their backcountry experience. Hence, it seems reasonable that users might be tempted to increase their exposure to avalanche hazard to compensate for the constant nuisance.

Hedlund (2000) further states that risk compensation can only occur if individuals are able to change their behavior. Recreational backcountry travelers have complete freedom to adjust their behavior. Our DCE aimed to provide direct empirical evidence on whether airbags lead to risk compensation, but the results are mixed. While some of the observed patterns indicate that there might be some risk compensation (e.g., significant decrease in preference for blue runs at moderate and considerable danger ratings among non-owners with airbags), other patterns seem to indicate the opposite. Hence, the results do not provide conclusive evidence for or against the presence of risk compensation related to airbag use.

While DCE have been able to provide meaningful insights into backcountry terrain preferences in previous studies (e.g., Haegeli et al., 2010; Haegeli et al., 2012; Haegeli and Strong-Cvetich, 2018), we attribute the somewhat inconclusive results of this study to the fact risk compensation is mainly an emotional response that depends on subtle situational cues that are difficult to recreate in hypothetical decision situations in an online survey. Furthermore, the intervention of taking airbags away from owners and giving airbags to non-owners might have not been sufficiently salient to cause survey participants to change their terrain preferences.

5. CONCLUSION

The results of our survey offer considerable evidence that risk compensation due to airbags is likely. Avalanche airbags align with all four conditions promoting risk compensation outlined by Hedlund (2000): a) they are blatantly obvious; b) they negatively affect one's backcountry experience due to their constant need for management and the weight penalty; c) users interested in skiing challenging slopes have reason to change their behavior to satisfy their desire; and d) recreationists have complete freedom to change their behavior. However, this does not mean that every airbag owner will increase their exposure to avalanche hazard.

If risk compensation is likely, the important next question is 'Does it matter?'. Winter backcountry recreation is a personal choice that is associated with inherent risks that are impossible to eliminate completely. While the implied goal of the avalanche safety community is to increase safety overall, avalanche awareness courses and avalanche safety devices primarily enable recreationists to pursue their backcountry activity of choice in an informed and skilled fashion. However, to allow recreationists to make informed choices and ensure they do not overcompensate, it is critical to properly inform them about the benefits, limitations and potential risks of avalanche airbags. We therefore reiterate Haegeli et al's (2014) recommendation to encourage national avalanche safety agencies, international bodies and airbag manufacturers to develop standardized data collection protocols and reporting guidelines to support continued research on the effectiveness of avalanche safety devices. Furthermore, we recommend the topic of risk compensation to be discussed in avalanche safety courses and included in user manuals of avalanche airbags.

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