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RESEARCH REPORT

Avalanche Risk Perception in a Sample of Backcountry Recreationists: Relationships with Individual Characteristics and Behaviors in Avalanche Country

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1. INTRODUCTION

The involvement in fatal avalanche accidents represent a severe, if relatively infrequent, outcome of winter recreational activities performed in the alpine backcountry, such as alpine skiing and ski mountaineering (Schweizer & Lütschg, 2001). In contrast to what usually observed with other natural hazards, such as floods, hurricane and earthquakes, most avalanche-related deaths are caused by events triggered by the victims themselves (McClung & Schaerer, 1993; McClung, 2002). Indeed, literature and basic research indicate that while recreational avalanche accidents result from a combination of environmental and human factors, the latter largely outweigh the former in terms of predictive power (Atkins, 2000). The inability to assess environmental risk correctly represents the prevalent source of decision-making errors in avalanche territory and result from the interaction between individual and contextual characteristics (McClung, 2002). In particular, findings indicate that when faced with potential avalanche danger and limited time, backcountry recreationists tend to resort to simple cognitive heuristics that may disrupt the accuracy of their judgement, thus ultimately favoring their involvement in avalanche-related injuries and fatalities (McCammon, 2004).

Specific terrain cues, such as slope familiarity and attractiveness, have been shown to increase risk-taking behaviors in avalanche territory (Furman, Shooter & Schumann, 2010). Similarly, the availability of safety equipment (e.g., avalanche beacon), low forecasted avalanche danger and the presence of an expert in the party have been linked to a decrease of precautionary behaviors (Furman et al., 2010; Chamarro, et al., 2013). Additionally, psychosocial characteristics, such as risk-taking propensity, novelty and sensation seeking traits, have been shown to decrease of the adoption of safety practices (Furman et al., 2010; Thomson & Carlson, 2015) and increase the

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likelihood of accident involvement (Sole & Emery, 2008) due to recreationists' voluntary exposure to avalanche risk. Findings indicate that previous exposure to avalanche accidents may increase personal avalanche awareness (Leiter, 2011). Perception of avalanche risk among winter recreationists has also been shown to vary based on performed activity, skiers reporting the highest level of perceived personal risk (Leiter, 2011), adherence to prevention practices and use of safety equipment while in avalanche territory (Procter, et al., 2014).

However, in spite of the growing evidence concerning the importance of human perception bias in shaping recreational avalanche accidents, the literature investigating avalanche risk perception and its relationship with actual avalanche risk exposure and both preventive and safety behaviors is still scarce (Leiter, 2011).

Aims of the report

In light of previous considerations, the present report aims to provide additional evidences concerning the links between perception of avalanche risk, psychological characteristics, adoption of preventive and safety practices and decision-making in avalanche country. The report include the results of three separate studies conducted on data collected on a sample of winter recreationists. In a first study, we investigate the role of participants' demographic characteristics, attitude toward risk (risk-taking propensity, sensation seeking) and personal exposure to avalanche danger and accidents as predictors of both cognitive and affective facets of avalanche risk perception. In the second study, we evaluate the role of participants' perception of personal avalanche risk, as well as attitude toward risk, on the adoption of preventive behaviors (e.g., consultation of avalanche forecast bulletin) and use of safety equipment (e.g., avalanche beacon, probe and shovel), while controlling for previous avalanche exposure and backcountry activity. In the third and final study,

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we employ a methodology based on simulated scenarios to explore recreationists' decision-making in avalanche country. Specifically, we evaluate the role of slope characteristics (i.e., familiarity, scarcity of conditions, inclination), forecasted avalanche danger, use of safety gear and participants' attitude toward risk taking behaviors on the decision to ski a backcountry slope in avalanche country. The results of the three studies are presented separately, while a general discussion and is presented in the final section.

2. METHODS

2.1 Sampling design

The study involved a convenience sample of 613 adults from North Italy. Participants were recruited by posting the link to an online questionnaire on the Facebook fan page of Fondazione Montagna sicura. Incentive for participation in the research was the opportunity to enter an online competition, the prize consisting in a one-day visit to the Mont Blanc glacier. Questionnaires were administered online using the website SurveyMonkey.com. All participants gave informed consent before participating. Inclusion criteria were the following: Age $\geq$ 18 and experience in backcountry sports during the last winter season. After exclusions of individuals not meeting the recruitment criteria, 522 participants remained (83% male; age: M = 41.86, SD = 11.32).

2.2 Instruments

2.2.1 Demographic variables

Demographic variables were assessed and included gender, age, educational level (see Table 1) and occupational status (see Table 2). Further, participants were asked to report about their involvement

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in snow-related professions: 15.9 % of participants reported involvement during the last winter season. Half of the sample (50.4 %) reported at most the upper-secondary level of education while the rest reported at least graduate level education (50%). The majority of participants work as employee (51.1%), 11.5% are self-employed and 18.9% work as professionals. The remaining 19.5% of participants reported being currently unemployed, student, retired or reported other forms of professional employment.

Table 1.

Educational level	Percent
Primary	0.4
Lower-secondary	6.3
Upper-secondary	42.7
Graduate	37.0
Post-graduate	13.0
Other	0.6
Total	100.0

Educational level in the sample

Tab2. Occupational status in the sample

Occupational status	Percent
Unemployed	3.3
Student	6.7
Employee	51.1
Self-employed	11.5
Professional	18.0
Retired	4.0
Other	5.4
Total	100.0

2.2.2 Involvement in backcountry activities

We asked participants to indicate how long they have been practicing activities in backcountry areas (number of years) and to report about the frequency of engagement in the following recreational activities during the last winter season (number of tours): freeride skiing/snowboarding, ski mountaineering (ski/snowboard), cross-country skiing, snowshoeing. Frequency of involvement in backcountry activities is reported in table 4. The majority of participants (56%) reported at most 15

years of backcountry experience. Moreover, based on the reported number of tours per activity, a dichotomic indicator was defined to distinguish between participants who have been mainly practicing activities involving alpine skiing (free riders and ski mountaineers) and excursionist (cross-country skiers and snowshoers): 77.2% participants showed prevalent involvement in activities involving alpine skiing, while excursionists accounted for 22.8% of the sample.

Table 4. Percentage of individuals per years of overall backcountry experience and number of tours per recreational activity during the last winter season (N=522)

Years of backcountry experience	**1-5**	**5-10**	**11-15**	**16-20**	**21-25**	**Over 25**	
	35.2	24.8	12.0	8.5	4.4	15.1	
Number of tours in the last season	**None**	**1-4**	**5-9**	**10-15**	**16-20**	**21-30**	**Over 30**
Freeride	44.6	22.4	10.7	10.2	5.6	2.7	3.8
Ski mountaineering	19.7	17.0	20.3	16.5	10.2	8.2	8.0
Cross-country skiing	91.4	5.0	1.9	1.3	0.4	0.0	0.0
Snowshoeing	61.3	23.6	8.8	4.0	1.3	0.2	0.8

2.2.3 Adoption of prevention practices

Participant's adoption of prevention practices were investigated and included: Previous participation in snow sciences and avalanche safety courses (Responses coded as: Yes/No); participants were also asked to report how frequently they checked the avalanche forecasts bulletin prior to each backcountry tour (Responses coded as: Never/Occasionally/Always). Additionally, participants were asked to indicate how frequently they read the three different sections of the avalanche forecast bulletin (i.e., avalanche danger maps; textual descriptions of snow conditions; table with snow condition information; se figure 1). Results are reported in table 5. The majority of participants reported previous involvement in snow science (60.7 %) and avalanche safety (80.1%)

courses. Use of avalanche bulletin in the sample was found to be a widely common practice (92.1% checked the bulletin prior to each backcountry tour), while only 64.9% participants read all sections of the bulletin before each tour. In general, participants indicated reading the danger map section of the bulletin more frequently than the other sections.

Table 5. Participants' involvement in prevention practices (N=522)

Prevention practices	**Yes**	**No**
Participation in snow sciences courses	60.7	39.2
Participation in avalanche safety courses	80.1	19.9
	Always	**Never /Occasionally**
Checked avalanche bulletin prior to each tour	92.1	7.9
Read all sections of the avalanche bulletin	64.9	35.1
Read avalanche danger map	90.7	9.3
Read text	78.8	21.2
Read snow condition table	76.0	24.0

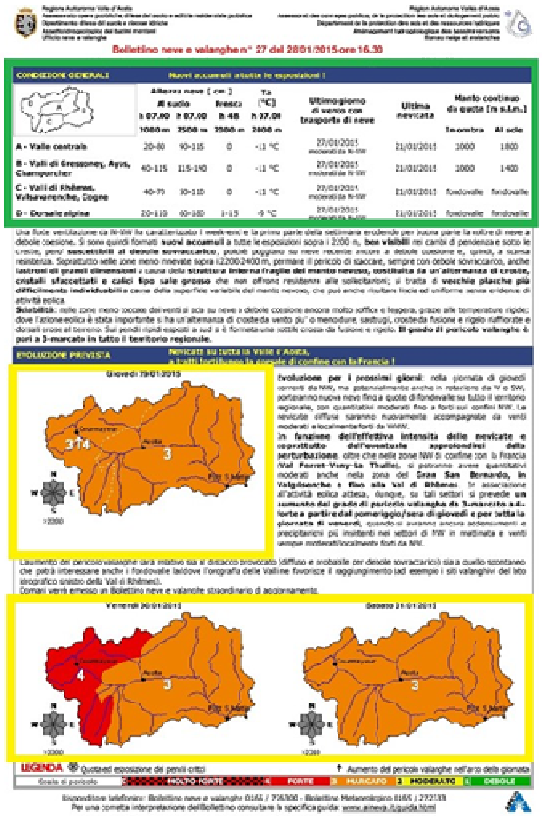

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Figure 1. Example of avalanche forecast bulletin

Danger level	Icon	Snowpack stability	Avalanche triggering probability
5 - Very high		The snowpack is poorly bonded and largely unstable in general.	Numerous large-sized and often very large-sized natural avalanches can be expected, even in moderately steep terrain.
4 - High		The snowpack is poorly bonded on most steep slopes.	Triggering is likely even from low additional loads** on many steep slopes. In some cases, numerous medium-sized and often large-sized natural avalanches can be expected.
3 - Considerable		The snowpack is moderately to poorly bonded on many steep slopes*.	Triggering is possible, even from low additional loads** particularly on the indicated steep slopes*. In some cases medium-sized, in isolated cases large-sized natural avalanches are possible.
2 - Moderate		The snowpack is only moderately well bonded on some steep slopes*, otherwise well bonded in general.	Triggering is possible primarily from high additional loads**, particularly on the indicated steep slopes*. Large-sized natural avalanches are unlikely.
1 - Low		The snowpack is well bonded and stable in general.	Triggering is generally possible only from high additional loads** in isolated areas of very steep, extreme terrain. Only sluffs and small-sized natural avalanches are possible.

Figure 2. The European Avalanche Danger Scale

2.2.4 Use of safety equipment

Participants were asked to report the frequency of use of the following safety equipment tools while involved in backcountry activities during the last winter season: Avalanche beacon (ARTVA), shovel and probe, floatation (Airbag) and Avalung devices. Frequency of use of safety equipment in the sample is reported in table 7. Use of standard equipment was prevalent in the sample (77.6%), while only a minority of participants reported using airbags (8.4%) and the Avalung (4.9%) devices.

Table 7. Percentage of participants reporting use of safety equipment during each tour (N=491)

Equipment	Percent
Beacon (ARTVA)	84.1
Probe	78.0
Shovel	80.1
Standard equipment (Beacon + Probe + Shovel)	*77.6*
Floatation device (Airbag)	8.4
Avalung	4.9

2.2.5 Exposure to avalanche danger

Using the European Avalanche Danger as a reference (Figure 2), which distinguish among 5 levels of increasing avalanche danger (1-Low; 2-Moderate; 3-Considerable; 4-High; 5-Very High), participants were also asked to indicate both the most frequent and the highest level of avalanche danger they entered into while during the last winter season. Results are reported figure 3 and 4. Almost half of the participants reported the 2-Considerable category as the most frequent level of forecasted avalanche danger (49.1%), 43.7% reported entering the 3-Considerable level and only 0.6 % reported the 4-High level as the most frequent level of avalanche danger exposure. On the other side, a large majority of participants reported the 3-Considerable level as the highest level of avalanche danger exposure during the last winter season, 26.2% reported the 4-High level and only 1.6 reported entering the 5-Very High level of danger exposure.

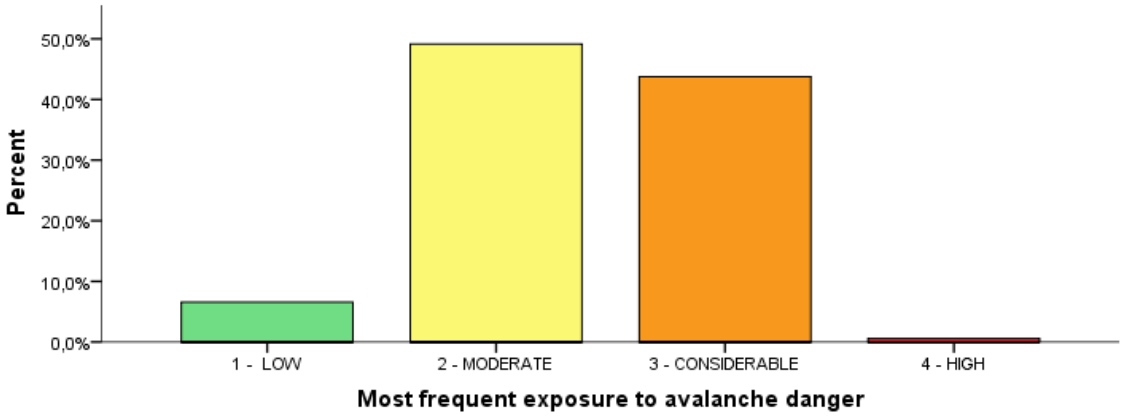

Figure 3. Participants' most frequent level of avalanche danger exposure during the last winter season

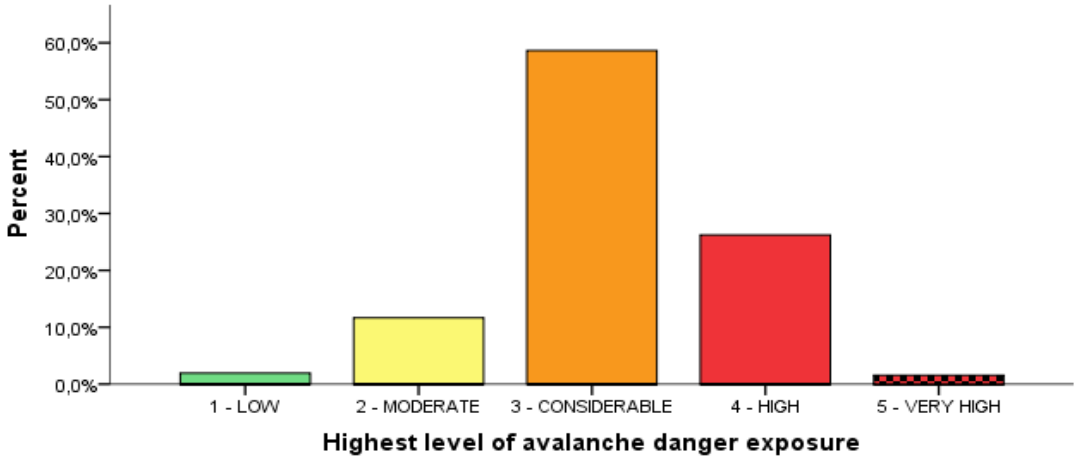

Figure 4. Participants' highest level of avalanche danger exposure during the last winter season

2.2.7 Involvement in avalanche accidents

Table 8 reports information about involvement in avalanche accidents in the sample. Participants reported about the frequency of their involvement in avalanche incidents while involved in backcountry activities with their party. Individuals reporting previous involvement in avalanche

accidents were also asked to indicate the frequency of their involvement in the following five avalanche-related situations (Coded: Never/1 time/2 times/More than 2 times): avalanche accident resulting in complete burial (self/other person in the party), injuries (self/other person in the party) or death (other person in the party). Approximately one third of the sample reported previous involvement in an avalanche accident (34.8%). Only few participants reported personal involvement involving complete burial (2.2%) and injuries (2.6%). Participants' involvement in accident resulting in consequences for other persons in their party was relatively more frequent: 8.1% reported witnessing one or more avalanche accidents resulting in complete burial (), injury () or death for a person in their party. In order to obtain a single score summarizing participants' involvement in avalanche accidents, responses to the 5 items were summed to produce a total score, which showed adequate internal consistency (α =.71)

Table 8. Participants' involvement in avalanche accidents (N=463)

	Percent	
Have you ever witnessed/being involved in an avalanche accident?	**Yes**	**No**
	34.8	65.2
Consequences: Self	**Never**	**1 or more times**
Completely buried	97.8	2.2
Injured	97.4	2.6
Consequences: Other persons in the party		
Completely buried	90.9	8.1
Injured	90.1	8.9
Death	94.2	5.8

2.2.8 Avalanche risk perception

We administered a newly devised questionnaire addressing participants' perceptions concerning the risk of being involved in avalanche accidents while performing backcountry activities. The questionnaire consisted of 8 statements describing avalanche accidents resulting in varying degrees of outcome severity (see Table 9). Using a 5-point Likert scale ranging from low to high, participants were asked to rate the probability of their involvement in each event, as well as the fear they experienced while thinking about it, over the course of their future backcountry tours. The items showed strong internal consistency: Probability ($\alpha = 0.91$), Fear ($\alpha = 0.89$).

Table 9. Statements included in the Avalanche Risk Perception scale

Being involved in an avalanche accident resulting in severe physical damage
Being involved in an avalanche accident resulting in moderate physical damage
Being involved in an avalanche accident resulting in mild physical damage
Being completely buried in an avalanche and unconscious
Being completely buried in an avalanche and conscious
Being partially buried in an avalanche
Triggering an avalanche resulting in damage to other persons
Witnessing an avalanche accident and being required to perform early rescue operations

2.2.9 Sensation seeking: skiing and snowboarding

Participants' seeking sensation-seeking behaviors related to alpine skiing and snowboarding were measured using an adapted version of the Contextual Sensation Seeking Questionnaire – Skiing and Snowboarding (Thomson et al., 2012). Due to its content, which mainly relates to slope skiing, the scale was only administered to participants reporting involvement in freeride and ski-mountaineering activities. CSSQ-S scores have been shown to correlate with self-report sport-related

injury data (Thomson et al., 2012); gene association studies have provided evidence for the criterion validity of the CSSQ-S (Thomson, Hanna, Carlson, and Rupert, 2013). The scale contains 10 items scored on a 5-point Likert Scale. Example items: ‘‘I like to ski/ride fast’’ and ‘‘I like to go down runs that I have never been down before.’’ In the present study, the items exhibited moderate internal consistency ($\alpha = 0.78$).

2.2.10 General risk taking propensity

Participants’ risk taking propensity was assessed by administering an adapted version of the Stimulating Risk Inventory (SRI), part of a two dimensional measure known as the Stimulation-Instrumental Risk Inventory (SIRI) (Zaleskiewicz, 2001). The SRI was chosen for its foundation in heuristic-based decision making, ease of administration, and because it is related to the preference for recreational risks [among others].The SRI is associated with personality features connected with arousal seeking, impulsivity, and strong sensation seeking (Zaleskiewicz, 2001). These conditions may be similar to those encountered in a backcountry context. The administered version included 5 items reporting moderate internal consistency ($\alpha = 0.79$). Example items are: “I am attracted by different dangerous activities”; “I make risky decisions without an unnecessary waste of time”.

2.2.11 Backcountry slope scenarios

In study 3, a randomized factorial survey design was used to determine the impact of forecasted avalanche danger, slope characteristics and use of safety gear (avalanche beacon), along with participants’ attitude (sensation seeking, risk-taking propensity) and demographics (age, gender), on the decision to ski a backcountry slope. Factorial survey designs are appropriate for studying

problems in which decisions must be made and are often used in situations where field-based experiments would be impractical, unsafe, or unrealistic (Ludwick, Wright, Zeller, Dowding, Lauder, & Winchell, 2004; Shooter & Galloway, in press; Taylor, 2006). Similar to conjoint analysis, factorial surveys present a number of varied factors and then ask participants to make a decision based on the presentation of those factors. A distinct feature of factorial survey designs is the presentation of the factors within hypothetical but realistic scenarios. In the case of the present study, the scenarios communicated hypothetical situations that a group of backcountry skiers or snowboarders might encounter while on a backcountry tour. In the present study, participants read four scenarios and responded by indicating how likely they would be to ski a slope based on the combination of factors presented. The factors in the scenarios were *forecasted avalanche danger* (low, moderate, considerable, and high), *availability of avalanche beacon*, *slope familiarity* (yes,no), *slope scarcity* (untracked/tracked slope) and *inclination* (less than 30°, between 30° and 35°, between 35° and 40°, more than 40°).

A sample scenario is:

> You are part of a group that is out for a day of backcountry skiing and you have just reached the slope you intended to ski. The avalanche forecast bulletin states that the avalanche hazard for the area is HIGH. You plan to ski a slope that YOU HAVE NEVER SKIED BEFORE. You plan to ski an UNtracked slope. Inclination of the slope is BETWEEN 35 AND 40 DEGREES. You HAVE an avalanche beacon as part of your equipment.

In this scenario, the seven variables (capitalized), in order of appearance, are: avalanche forecast, familiarity, scarcity, slope inclination and availability of safety equipment. The dependent variable

was *likelihood to ski*, and participants responded to each scenario by indicating the likelihood that they would ski a slope (on a scale of 1–7).

2.3 Data analysis

In order to perform a preliminary investigation of the relationships between the study measures, correlation coefficients (Pearson's for continuous variables; bi-serial correlation for continuous vs. dichotomous variables; tetrachoric correlations for dichotomous only variables) and χ^2 tests (for categorical variables) were computed. A set of t-tests (for continuous variables) and z-tests (for percentages) were employed to evaluate the presence of differences among participants on the study measures when grouped according to their prevalent recreational activity (alpine skiers/excursionists).

Study 1 tests the role of participants' demographic characteristics, prevalent recreational activity performed, attitude toward risk (risk-taking propensity, sensation seeking) and personal exposure to avalanche danger and accident as predictors of both cognitive and affective facets of avalanche risk perception. Analyses were performed implementing two separate multiple linear regression models, one for each facet of avalanche risk perception, and including the same set of predictors.

Study 2 evaluates the role of participants' perception of personal avalanche risk, as well as attitude toward risk, on the adoption of preventive behaviors (e.g., frequency and accuracy of consultation of avalanche forecast bulletin) and use of safety equipment (e.g., avalanche beacon, probe and shovel), while controlling for previous avalanche exposure, participants' demographic characteristics and prevalent recreational activity performed. Analyses were performed

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implementing four logistic regression models, one for each dependent variable, including the same set of predictors.

Finally, study 3 evaluates the role of slope characteristics (i.e., familiarity, scarcity of conditions, inclination), forecasted avalanche danger, use of safety gear and attitude toward risk on participants' decision to ski a backcountry slope in avalanche country, while controlling for participants' characteristics. Given the methodology employed, which involve the assessment of four distinct probability scores for each participant (one for each presented scenario), analyses were performed implementing a two-level multilevel linear model. More specifically, we implemented a random intercept model using the id of each participant as a random intercept effect in order to control for the clusterization present in the data. Slope characteristics, forecasted avalanche danger and beacon use were treated in the analysis as level 1 variables, while the other predictors were included in the model as level 2 variables in a second model estimation.

3. RESULTS

3.1 Preliminary analyses: Correlations

Results of the correlation analyses are reported in table 10. We found several significant correlation between both the cognitive (accident probability) and affective (fear) facets of avalanche risk perception and the other study measures. Participant's fear of being involved in an avalanche accident showed a positive, yet weak, correlation with their perceived probability of personal involvement in an accident (r = .11). Participants' fear of being involved in an accident also showed a weak negative correlation with sensation seeking (r=-.12), while the probability score showed a weak positive correlation with the general risk taking measure (r=.13). Participants' perceived

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probability of personal involvement in an accident was also positively correlated with their exposure to avalanche danger during the last season (r=.12) and previous avalanche involvement (r=.13). Being male was found to be negatively, yet weakly, related with participants' perceived probability of involvement in (-.09) and fear of (-.13) avalanche accidents. No significant correlations were found between the cognitive and affective facets of avalanche risk perception and both bulletin use (frequency and accuracy of use) and adoption of equipment (both beacon and full standard equipment).

A moderate positive correlation was found between the sensation seeking and general risk taking measures (r=.43). Moreover, sensation seeking negatively correlated with both bulletin use (frequency: r=-.16; accuracy of use: r=-.16) and adoption of safety equipment (beacon use: r=-.11; standard equipment use: r=-.11), while the general risk-taking measure was only found to correlate with bulletin use (frequency: r=-.11; accuracy of use: r=-.11).

The frequency of bulletin reading was also positively correlated with age (r=.11), being male (r=.12), bulletin reading accuracy (r=.24) and with the adoption of safety equipment (beacon use: r=.22; standard equipment use: r=.24).

		1	2	3	4	5	6	7	8	9	10	11
1	Age											
2	Gender (Male=1; Female=0)	.08										
3	Avalanche risk perception: Accident probability	-.08	**-.09**									
4	Avalanche risk perception: Fear	-.08	**-.13**	**.11**								
5	Sensation seeking (CSSQ-S)	**-.35**	.07	-.02	**-.12**							
6	General Risk Taking (SRI)	**-.24**	**.11**	**.13**	-.08	**.43**						
7	Avalanche Danger Exposure (Danger level ≥ 3=1; else = 0)	-.06	.00	**.12**	.00	**.18**	**.13**					
8	Avalanche accidents involvement	**.12**	.03	**.13**	-.09	.02	-.01	**.12**				
9	Use of ARTVA device (Always=1; else=0)	.06	.03	.08	.05	**-.13**	.00	**.21**	.01			
10	Use of standard equipment (Always=1; else=0)	.02	.00	.08	.05	**-.10**	-.04	**.17**	-.01	**.81**		

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11	Read avalanche bulletin (Always=1; else=0)	**.11**	**.12**	.01	.03	**-.16**	**-.11**	.08	.00	**.22**	**.24**	
12	Read all sections of avalanche bulletin (Always=1; else=0)	.07	**.18**	-.01	.06	**-.16**	**-.11**	.02	.02	.06	.09	**.24**

*Significant correlation are in bold (p<.05)

Table 10. Correlation among the study variables*

3.2 Preliminary analyses: Participants' characteristics by type of recreational activities

Table 11 shows the results of the analyses aimed at evaluating the presence of statistical differences in the characteristics of participants when grouped according to their prevalent recreational activity. In general, participants' were found to be significantly younger among alpine skiers than in the excursionists' group; no gender differences emerged across the groups.

When compared to excursionists, alpine skiers showed a significantly higher level of avalanche danger exposure during the last winter season. They also reported significantly higher frequency of adoption of avalanche beacon, standard equipment (beacon, shovel, probe) and airbag device during their backcountry tours. No significant differences emerged across groups in use of the Avalung device and both bulletin reading frequency and accuracy.

Perception of avalanche risk was higher among alpine skiers, albeit only concerning the degree of fear they reported when thinking about their potential involvement in avalanche accidents. As expected, risk-taking propensity was higher among alpine skiers than in the excursionists' group; still, no differences emerged concerning their previous involvement in avalanche-related accidents.

Table 11. Participants' characteristics by recreational activity

Variables	Levels	Alpine Skiers (%)	Excursionists (%)	p
Gender	Male	83.4	79.8	n.s.
	Female	16.6	2.2	n.s.
Most frequent level of avalanche danger exposure	1-Low	2.20	21.20	<.0001
	2-Moderate	47.10	55.90	n.s.

	3-Considerable	50.10	22.00	<.0001
	4-High	0.50	0.80	n.s.
Use of avalanche beacon (ARTVA)	Always	93.50	51.40	<.0001
	Never/Occasionally	6.50	48.60	<.0001
Use of standard equipment (ARTVA, shovel, probe)	Always	86.9	45.00	<.0001
	Never/Occasionally	13.10	55.00	<.0001
Use of airbag device	Always	9.90	2.80	<.05
	Never/Occasionally	9.10	97.20	<.05
Use of Avalung device	Always	5.80	1.80	n.s.
	Never/Occasionally	94.20	98.20	n.s.
Read avalanche forecast bulletin prior to tours	Always	92.90	89.00	n.s.
	Never/Occasionally	7.10	11.0	n.s.
Read all sections of avalanche forecast bulletin	Always	64.10	67.70	n.s.
	Never/Occasionally	36.90	32.30	n.s.

	Alpine Skiers (M)	**Escursionists (M)**	**p**
Age	41.18	44.18	<.05
Avalanche risk perception: Accident probability	18.10	18.25	n.s.
Avalanche risk perception: Fear	32.36	3.70	<.05
Avalanche accidents involvement	5.39	5.50	n.s.
General risk-taking propensity (SRI)	1.40	9.50	<.05

3.3 STUDY 1: Predictors of avalanche risk perception

The results of the multiple regression models implemented to investigate the role of demographic variables, avalanche exposure and involvement, sensation seeking and risk-taking propensity in predicting avalanche risk perception showed some significant effects, albeit only when predicting the cognitive facets of avalanche risk perception. Table 12 reports the result of the model on participants' perceived probability of personal involvement in avalanche accidents: being male was found to be a

positive predictor (Beta = -0.11), while the age effect was not significant. Participants' perceived probability of being involved in future accidents was positively predicted by both their degree of previous involvement in avalanche accidents (Beta=0.19) and the general risk-taking measure

(Beta=0.18). On the contrary, participants' scores on the sensation seeking scale was found to be a negative predictor. Finally, participants' avalanche danger exposure during the last winter season was only marginally, yet positively, related to their perceived probability of being involved in future accidents.

Table 12. Multiple regression: Probability of avalanche accident on demographic variables, avalanche exposure and involvement, sensation seeking and risk-taking propensity

Dependent variable: Perceived probability of avalanche accident (R^2 = .09)	B	S.E.	Beta	t	p
Gender (Male=1;Female=0)	-1.96	0.86	-0.11	-2.27	0.02
Age	-0.03	0.03	-0.06	-1.07	0.28
Avalanche accidents involvement	1.01	0.26	0.19	3.95	0.00
Sensation seeking (CSSQ-S)	-0.16	0.07	-0.13	-2.31	0.02
General risk-taking (SRI)	0.31	0.09	0.18	3.45	0.00
Avalanche Danger Exposure (Danger level ≥ 3=1; else = 0)	1.10	0.64	0.08	1.72	0.09

Table 13. Multiple regression: Fear of avalanche accident on demographic variables, avalanche exposure and involvement, sensation seeking and risk-taking propensity

Dependent variable: Fear of avalanche accident (R^2 = .03)	B	S.E.	Beta	t	p
Gender (Male=1;Female=0)	-1.62	0.86	-0.09	-1.89	0.06
Age	-0.03	0.03	-0.05	-1.01	0.32
Avalanche accidents involvement	-0.12	0.25	-0.02	-0.46	0.64
Sensation seeking (CSSQ-S)	-0.13	0.07	-0.11	-1.90	0.06
General risk-taking (SRI)	-0.09	0.09	-0.05	-0.97	0.33
Avalanche Danger Exposure (Danger level ≥ 3=1; else = 0)	0.44	0.63	0.04	0.69	0.49

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3.4 STUDY 2: Avalanche risk perception as predictor of adoption of prevention and safety behaviors

The results of the logistic regression analyses investigating the role of avalanche risk perception in predicting avalanche prevention and safety behaviors, while controlling for the effect demographic variables, avalanche danger, accident involvement and prevalent recreational activity, are reported in tables 13-15. The models predicting the use of the ARTVA device and of the standard avalanche safety equipment showed moderate fit (.25 ≤ Nagelkerke's R^2 ≤ .36). Some significant effects emerged: both behaviors were positively predicted by participants' perceived probability of their potential involvement in avalanche accidents, while fear showed no significant effect. Furthermore, participants' level of avalanche danger exposure and the involvement in alpine skiing positively predicted the use of both the ARTVA device and standard safety equipment, while age showed only a positive effect on the frequency of use of the ARTVA device.

Table 13. Logistic regression: Use of avalanche beacon (ARTVA) on demographic variables, avalanche danger and accident exposure, prevalent recreational activity and avalanche risk perception

Model fit: R^2 Nagelkerke = .36					
Predictors	**Levels**	**B**	**E.S.**	**Wald**	**OR**
Age		0.04**	0.01	7.19	1.04
Gender (Reference: Female)	Male	0.13	0.40	0.11	1.14
Prevalent recreational activity (Reference: Excursionists)	Alpine skiers	2.70**	0.32	70.30	14.83
Avalanche accidents involvement		-0.03	0.12	0.06	0.97
Avalanche risk perception: Accident probability		0.05*	0.03	3.83	1.05
Avalanche risk perception: Fear		0.00	0.02	0.00	1.00
Avalanche danger exposure (Reference: Danger level ≤ 2)	Danger level ≥ 3	0.89**	0.35	6.38	2.44

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Table 14. Logistic regression: Use of standard equipment (ARTVA + shovel + probe) on demographic variables, avalanche danger and accident exposure, prevalent recreational activity and avalanche risk perception

Model fit: R^2 Nagelkerke = .25					
Predictors	**Levels**	**B**	**E.S.**	**Wald**	**OR**
Age		0.02	0.01	2.57	1.02
Gender (Reference: Female)	Male	-0.10	0.35	0.08	0.91
Prevalent recreational activity (Reference: Excursionists)	Alpine skiers	2.11**	0.27	61.22	8.28
Avalanche accidents involvement		-0.07*	0.10	0.45	0.94
Avalanche risk perception: Accident probability		0.03*	0.02	2.82	1.03
Avalanche risk perception: Fear		0.00	0.02	0.03	1.00
Avalanche danger exposure (Reference: Danger level ≤ 2)	Danger level ≥ 3	0.60**	0.27	4.73	1.82

The results of the logistic regression models predicting the frequency and accuracy of use of the avalanche forecast bulletin showed some significant result, although model fit was generally quite low (.06 ≤ Nagelkerke's R^2 ≤ .08). Participant's gender (i.e., being male) predicted both the frequency and accuracy of reading of the avalanche bulletin. Participants' fear of being involved in an avalanche accident positively predicted their reported degree of accuracy in reading the bulletin. No other significant effect emerged.

Table 14. Logistic regression: Frequency of use avalanche forecast bulletin on demographic variables, avalanche danger and accident exposure, prevalent recreational activity and avalanche risk perception

Model fit: R^2 Nagelkerke = .08					
Predictors	**Levels**	**B**	**E.S.**	**Wald**	**OR**
Age		0.04	0.02	5.47	1.04
Gender (Reference: Female)	Male	1.00**	0.41	6.08	2.72
Prevalent recreational activity (Reference: Excursionists)	Alpine skiers	0.32	0.42	0.59	1.37
Avalanche accidents involvement		-0.08	0.13	0.39	0.92
Avalanche risk perception: Accident probability		0.01	0.03	0.05	1.01

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Avalanche risk perception: Fear		0.02	0.03	0.79	1.02
Avalanche danger exposure (Reference: Danger level ≤ 2)	Danger level ≥ 3	0.58	0.40	2.07	1.78

Table 15. Logistic regression: Use of standard equipment (ARTVA + shovel + probe) on demographic variables, avalanche danger and accident exposure, prevalent recreational activity and avalanche risk perception

Model fit: R^2 Nagelkerke = .06					
Predictors	**Levels**	**B**	**E.S.**	**Wald**	**OR**
Age		0.01	0.01	1.37	1.01
Gender (Reference: Female)	Male	1.04*	0.28	13.76	2.82
Prevalent recreational activity (Reference: Excursionists)	Alpine skiers	-0.23	0.28	0.69	0.79
Avalanche accidents involvement		0.03	0.08	0.11	1.03
Avalanche risk perception: Accident probability		0.00	0.02	0.04	1.00
Avalanche risk perception: Fear		0.03*	0.02	4.17	1.04
Avalanche danger exposure (Reference: Danger level ≤ 2)	Danger level ≥ 3	0.12	0.23	0.27	1.13

3.5 STUDY 3: Predictors of participants' decision-making on a backcountry slope

The results of the analyses investigating the role of slope characteristics, availability of the ARTVA device, and forecasted avalanche danger on participants' probability of skiing a backcountry slope are reported in table 16. All scenario variables were found to have significant effects on the partipants' reported likelihood of deciding to ski the slopes. Overall, the forecasted avalanche danger level for the slope area was found to be the strongest predictor: an increase of the forecasted avalanche danger was found to predict a significant decrease of participants' likelihood of deciding to ski the slopes. Moreover, the significance of the differences in predicted likelihood across forecasted danger levels was examined by means of post-hoc comparison analyses using

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Bonferroni's correction: the predicted likelihood values were found to differ significantly with each other in all possible comparisons. Figure 3 shows the predicted likelihood values at different levels of forecasted avalanche danger.

As expected, slope steepness was also found a major factor influencing participants' decision-making on the slope: a decrease in the steepness of the slope was found to predict a significant decrease in the likelihood of deciding to ski the slopes. Based on multiple comparisons analyses, however, only some comparison reported a significant contrast: no significant differences emerged when comparing respectively the "From 30° to 34°" steepness condition with the "From 35° to 39°" condition, and the latter with highest steepness condition ("More than 40°"); all other comparisons showed significant contrasts. Figure 4 shows the predicted likelihood values at different levels of slope steepness.

The availability of the ARTVA device during a backcountry tour was also found to increase participants' likelihood of deciding to ski a backcountry slope. Similarly, participants' likelihood of deciding to ski the slope was positively predicted by their familiarity with the slope area and by the fact that the slope was already tracked out.

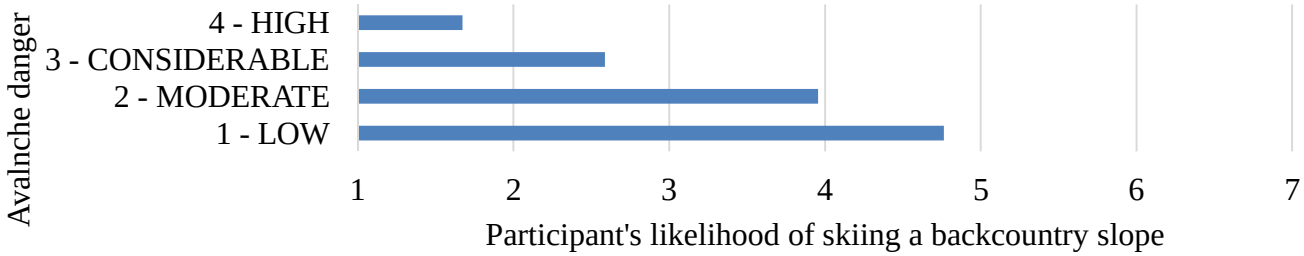

Figure 3. Participants' likelihood of skiing a backcountry slope (1= extremely unlikely; 7= extremely likely) by forecasted avalanche danger

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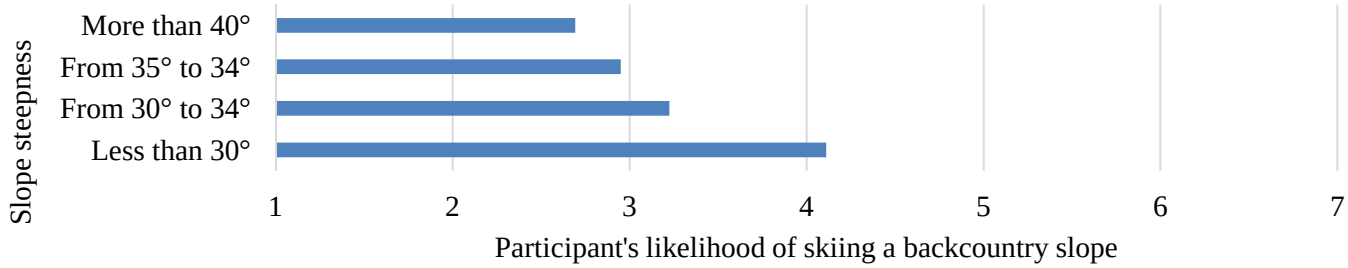

Figure 4. Participants' likelihood of skiing a backcountry slope (1= extremely unlikely; 7= extremely likely) by slope steepness

Table 15 Mixed linear model: Participants' likelihood to ski a backcountry slope on slope characteristics, availability of ARTVA device and forecasted avalanche danger

Effects	Levels	Parameter	SE	t	p
Forecasted avalanche danger					
(Reference: 4-High)	1-Low	3.09	0.10	32.33	0.00
	2-Moderate	2.28	0.10	23.88	0.00
	3-Considerable	0.92	0.10	9.58	0.00
Slope steepness					
(Reference: Higher than 40°)	Lower than 30°	1.42	0.10	13.74	0.00
	From 30° to 34°	0.53	0.10	5.13	0.00
	Lower than 35°-39°	0.26	0.10	2.53	0.01
Slope familiarity					
(Reference = Unfamiliar)	Familiar with slope	0.32	0.07	4.44	0.00
Slope snow condition					
(Reference = Untracked)	Tracked out slope	0.34	0.07	4.59	0.00
Availability of ARTVA device					
(Reference = Unavailable)	ARTVA is available	1.97	0.07	26.91	0.00

Table 16 shows the results of the previous model while including participants' individual characteristics. Results of the present model confirmed all the previous significant effects. Additionally, both the sensation seeking and general risk-taking measures positively predicted participants' likelihood to ski the slope. On the contrary, participants' degree of involvement in avalanche accidents, age and gender did not show significant effects.

Table 16 Mixed linear model: Participants' likelihood to ski a backcountry slope on slope characteristics, availability of ARTVA device and forecasted avalanche danger and individual characteristics

Effects	Levels	Parameter	SE	t	p
Forecasted avalanche danger					
(Reference: 4-High)	1-Low	3.09	0.11	28.91	0.00
	2-Moderate	2.29	0.11	21.37	0.00
	3-Considerable	0.92	0.11	8.57	0.00
Slope steepness					
(Reference: Higher than 40°)	Lower than 30°	1.41	0.11	13.19	0.00
	From 30° to 34°	0.50	0.11	4.65	0.00
	Lower than 35°-39°	0.29	0.10	2.74	0.01
Slope familiarity					
(Reference = Unfamiliar)	Familiar with slope	0.33	0.08	4.36	0.00
Slope snow condition					
(Reference = Untracked)	Tracked out slope	0.38	0.08	5.02	0.00
Availability of ARTVA device					
(Reference = Unavailable)	ARTVA is available	1.97	0.08	25.97	0.00
Individual characteristics					
Avalanche involvement		-0.01	0.03	-0.23	0.82
Sensation seeking (CSSQ-S)		0.04	0.01	4.43	0.00
General risk-taking (SRI)		0.05	0.01	4.69	0.00
Age		0.10	0.10	0.99	0.32
Gender					
(Reference = Female)	Male	0.00	0.00	-0.82	0.41

4. Discussion

Using data collected in a sample of Italian snow recreationists, the present report aimed at providing new evidences concerning the predictors of avalanche risk perception and its connections with avalanche prevention and safety behaviors and decision-making in avalanche territory. Results showed significant but weak connections between recreationists' individual characteristics and avalanche risk perception. Findings from study 1 supported the existence of a significant positive link between participants' degree of personal involvement in avalanche accidents and their

perception of avalanche as a potential hazard. Consistently with previous findings (Leiter, 2011), participants' past involvement in avalanche-related accidents was found to influence their cognitive representation of avalanche-related risks, that is, to increase their perceived probability of involvement in future avalanche accident. Contrary to our expectations, however no significant relationship between avalanche accident involvement with the affective component of avalanche risk perception emerged in our study.

Recreationists' positive attitude toward the involvement in sensation seeking behaviors while skiing or snowboarding was found to be negatively related to their perceived probability of future involvement in avalanche accidents. This is coherent with recent findings indicating sensation seeking as a significant predictor of accident involvement and injury prevalence related to skiing and snowboarding (Thomson, et al., 2012; Thomson & Carlson, 2015). Quite unexpectedly, when controlling for sensation seeking, participants' general attitude toward risk-taking behaviors in every-day life was found to positively predict participants' perception of avalanche risk. Combined with our findings on sensation seeking, this result seems to suggest that while backcountry recreationists may be generally aware of the relationship between risk-taking behaviors and accident involvement, they might ultimately underestimate avalanche danger due to their positive evaluation of the risks connected with performing backcountry sports (Slovic & Peters, 2006).

Findings from study 2 indicate that participants' cognitive representation of avalanche risk may influence adoption of safety behaviors, such as the use of safety equipment, while their affective representation of avalanche risk might be more strongly related to prevention behaviors, such as their propensity to gathering relevant information in preparation of a backcountry tour (e.g., reading the avalanche bulletin). Overall, these findings are coherent with what reported by other authors

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concerning the important role of the affective component of risk perception associated with natural hazards in predicting risk preparedness behaviors (Miceli, Sotgiu & Settanni, 2008). Recreationists' adoption of safety behaviors was also positively related to their involvement in alpine skiing, as opposed to snowshoeing and cross-country skiing (Procter et al., 2014) and the level of avalanche danger they most commonly entered into while in avalanche territory.

In line with what found by many authors (McCammon, 2004; Furman, Shooter & Schumann, 2010; Chamarro, et al., 2013) findings from study 3 provided further evidence on the existence of specific cognitive heuristics influencing, and sometimes disrupting winter recreationists' decision-making in avalanche territory. Coherently with literature (Furman, Shooter & Schumann, 2010), the level of avalanche danger forecasted by the avalanche bulletin for the area of a slope was found the strongest predictor of participants' decision to either ski or avoid the slope. The availability of an avalanche beacon during a backcountry tour was found to be the second strongest predictor of the decision to ski a slope. Overall, findings seems to suggest that the mere presence of an avalanche beacon among the equipment might negatively influence recreationists perception of avalanche risks and leading them to underestimate potential hazards during their tour (Chamarro, et al., 2013). Findings also indicated that recreationists might also be more willing to take risks on a slope that has been already tracked or when they are familiar with the slope area (Mc Cammon, 2004; Furman, Shooter & Schumann, 2010). Slope steepness was also found to be a major predictor of participants' decision-making, with increasing inclination reducing the likelihood of deciding to ski the slope.

As a whole, findings from the present report highlights the relevant role of both individual and contextual characteristics in influencing recreationists' avalanche risk perception and behaviors. In

particular, recreationists' characterized by high levels of sensation seeking might be especially at risk due to their strong desire for both new and exciting experiences while on backcountry slopes, even at the expenses of personal security. Due to their low level of avalanche risk perception, they may also underestimate the importance of the adoption of safety behaviors, such as the use of avalanche safety equipment, putting their party at risk due to their increased inability to perform early rescue operations.

Limitations

The contributions of this report should be understood in light of some limitations. Given that the sample was mainly made up of expert backcountry recreationists, these results would have to be replicated with novice users, given that expertise might influence the way they appraise and combine the information (Ericson et al., 1993). Moreover, the study sample was not representative of the target population; caution should be applied in interpreting and generalizing the results. Finally, due to the cross-sectional nature of collected data, casual relationship could not be established in the studies included in the present report. Future studies should implement longitudinal designs in order to evaluate the influence of snow recreationists' experience in avalanche territory in shaping their perception of avalanche risk and decision-making strategies.

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