

Adherence of backcountry winter recreationists to avalanche prevention and safety practices in northern Italy

E. Procter¹, G. Strapazzon^{1,2}, T. Dal Cappello¹, L. Castlunger³, H. P. Staffler⁴, H. Brugger^{1,2}

¹Institute of Mountain Emergency Medicine, EURAC research, Bolzano, Italy, ²International Commission for Mountain Emergency Medicine ICAR MEDCOM, Bolzano, Italy, ³Institute of Statistics, Autonomous Province of Bolzano, Bolzano, Italy, ⁴Department of Fire and Civil Protection, Autonomous Province of Bolzano, Bolzano, Italy

Corresponding author: Giacomo Strapazzon, MD, Institute of Mountain Emergency Medicine, EURAC research, Viale Druso 1, I-39100 Bozen/Bolzano, Italy. Tel: +39 0471 055 543, Fax: +39 0471 055 549, E-mail: giacomo.strapazzon@eurac.edu

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Backcountry recreationists account for a high percentage of avalanche fatalities, but the total number of recreationists and relative percentage of different recreation types are unknown. The aim of this study was to collect the first comprehensive survey of backcountry skiers and snowshoers in a region in the European Alps to quantify adherence to basic prevention and safety practices. Over a 1-week period in February 2011 in South Tyrol, Italy, 5576 individuals (77.7% skiers, 22.3% snowshoers) in 1927 groups were surveyed. Significantly more skiers than snowshoers could report the avalanche danger level (52.5% vs 28.0% of groups) and carried standard rescue equipment (transceiver, probe, and shovel) (80.6% vs

13.7% of individuals). Complete adherence to minimum advisable practices (i.e., an individual being in a group with one member correctly informed about the danger level and carrying personal standard rescue equipment) was 41.5%, but was significantly higher in skiers (51.1% vs 8.7% snowshoers) and in individuals who were younger, reported more tours per season, traveled in larger groups, and started earlier. A transnational survey over a complete winter season would be required to obtain total participation prevalence, detect regional differences, and assess the influence of prevention and safety practices on relative reduction in mortality.

Backcountry recreationists account for approximately 47% of all annual avalanche fatalities in European alpine countries¹ (Etter, 2011). The total number of participants in different backcountry activities and the associated mortality remain unknown. Despite the ever-increasing popularity of backcountry winter recreation, the annual number of avalanche fatalities in Europe and North America between 1984 and 2010 was stable (Etter, 2011), although an increase in the proportion of accidents involving snowshoers has been reported in Switzerland (Harvey & Zweifel, 2008).

In response to increased participation and emerging recreation activities (e.g., snowshoeing), many efforts have been invested in avalanche education and awareness. The publication of avalanche bulletins, for example, is a method to convey avalanche hazard information to backcountry users by reporting a numerical danger scale (Supporting Information Fig. S1). Reading the avalanche bulletin in detail is considered part of routine prevention practices (i.e., strategies that reduce the chance of involvement in an avalanche) for recre-

ationists entering avalanche terrain. Even though recreationists often focus on the danger rating, it is only intended to provide an overview of the existing hazard (Statham, 2008) and a more in-depth understanding of the bulletin text is important for risk management in the field. Similarly, carrying safety equipment and being trained in its proper use is considered part of routine safety practices (i.e., strategies that increase the chance of survival in an involvement; Brugger et al., 2007). Avalanche safety devices function by (a) reducing the duration of burial (avalanche transceivers), (b) reducing the chance of complete burial (e.g., floatation devices), or (c) prolonging survival in the case of complete burial (e.g., AvaLung™; Black Diamond Equipment Ltd., Salt Lake City, UT, USA). Asphyxia is the leading cause of death from avalanches, and extrication within 10–20 min of complete burial is essential for survival (Brugger et al., 2009; Haegeli et al., 2011). Survival analyses have shown that grade of burial is the most determinant factor of survival, followed by duration of burial, patency of the airways, and mechanical injuries (Brugger et al., 2013). In a sample of avalanche accidents in Switzerland ($n = 1296$) and Austria ($n = 208$), duration of burial and mortality rate were significantly lower if an avalanche transceiver was used for locating the victim, and the

¹Backcountry recreation refers here to any type of backcountry touring except snowmobiling and snowshoeing, which are included in the remaining 53% of fatalities along with on- or off-piste recreation, mountaineering, and fatalities on traffic routes or in buildings.



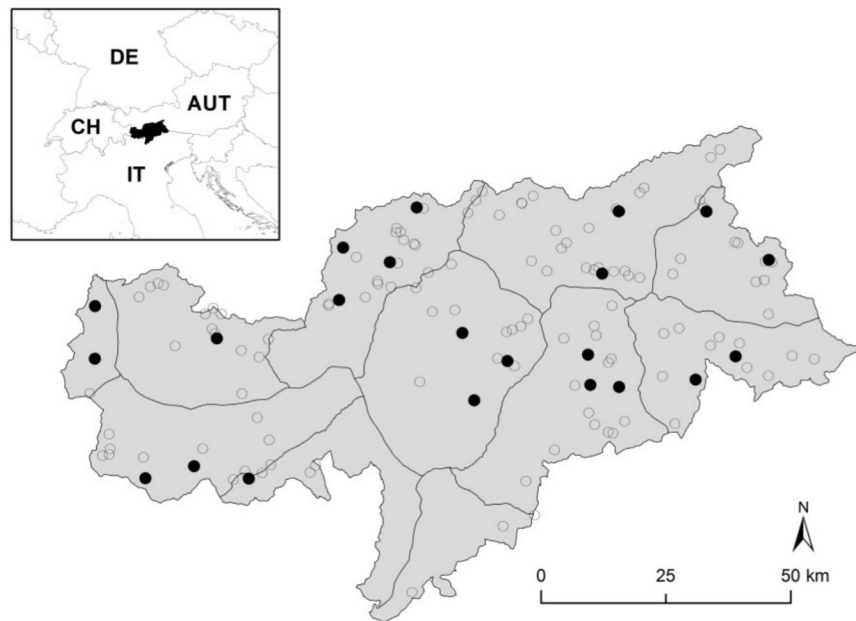


Fig. 1. Distribution of surveyed starting points (●, $n = 22$) and starting points from a pilot study (○, $n = 143$). AUT, Austria; CH, Switzerland; DE, Germany; and IT, Italy.

relative risk of mortality was significantly lower for users of floatation devices compared with nonusers (Brugger et al., 2007).

Despite continued advancements in prevention and safety technology, accidents and fatalities continue to occur. Subjective aspects, or “human factors,” are an undeniably important contributor to risk-taking behavior and avalanche accidents (McCammon, 2009). While this has been targeted in recent online surveys (Sole & Emery, 2008; Haegeli et al., 2012a, b), prospective, in-field studies are logistically more challenging and less common (Zweifel et al., 2006; Silverton et al., 2007, 2009), and as such many aspects of prevention and safety practices have not been fully investigated. The aim of this study was to collect the first comprehensive in-field survey of backcountry skiers and snowshoers in a region in the European Alps to quantify adherence to basic prevention and safety practices.

Materials and methods

A questionnaire was administered at 22 tour starting points (parking lot, trail head, etc.) over a 1-week period in February 2011 in South Tyrol, Italy (Fig. 1). The starting points were selected based on the most frequented locations in a 1-day pilot survey at 143 starting points in 2010 (Brugger et al., 2010).

All skiers and snowshoers departing on a backcountry tour between 7:00 h and 13:00 h were included. Backcountry snowboarders, off-piste recreationists (skiers or snowboarders in non-controlled areas outside but close to the ski area boundary primarily using ski lifts and/or short hikes for access; also known as out-of-bounds skiers), and other variations of recreationists were not included. Age, gender, estimated number of tours per season, group size, and tour start time were collected for every participant (the complete survey form is available as Supporting Information Table S1). One self-selected participant per group responded to

whether they had read the avalanche bulletin pertaining to the tour area and day, and if so whether they could indicate the corresponding avalanche danger level, which is reported using the European 5-scale system (1 low, 2 moderate, 3 considerable, 4 high, 5 very high; Supporting Information Fig. S1). Additionally, the presence of standard rescue equipment (i.e., transceiver, probe, and shovel) and other safety devices (floatation devices, AvaLung™) was recorded for every participant. Minimum advisable prevention and safety practices for an individual were defined as being in a group with one member correctly informed about the avalanche danger level (prevention practice) and carrying personal standard rescue equipment (safety practice). Level of adherence was defined as complete (adherence to both), partial (adherence to one), or none.

Mosaic plots were used to visualize the associations between categorical variables. Factors associated with correct prevention and safety practices were analyzed in a logistic regression analysis. Pearson chi-squared test was used for testing equality of proportions and association between categorical variables; multiple comparisons were tested using z -tests with Bonferroni corrections. All calculations were performed with the statistical software SPSS 19.0 (SPSS Inc., Chicago, Illinois, USA) or R 2.9.2 (R Development Core Team, Vienna, Austria). Tests were two tailed and $P < 0.05$ was considered significant.

Results

Characterization of surveyed individuals and groups

In total, 5576 individuals (77.7% skiers, 22.3% snowshoers) in 1927 groups were surveyed (complete data are shown in Table 1). Seventy-nine percent of groups included only skiers, 17.2% only snowshoers, and 3.8% had skiers and snowshoers. The mean age of the sample was 44 ± 12 years (range 4–95 years). The majority of individuals were in groups with three to five persons, but smaller groups were more common for skiers and groups of six or more persons were more common for snowshoers ($P < 0.001$; Table 1, Fig. 2). Significantly more snowshoers than skiers reported ≤ 10 tours per season



Table 1. Individual and group characteristics by sport type

		Skiers		Snowshoers		Total		P-value
Gender	Male	2961	69.6%	633	52.1%	3594	65.7%	< 0.001
	Female	1293	30.4%	581	47.9%	1874	34.3%	< 0.001
	Total	4254	100.0%	1214	100.0%	5468	100.0%	-
Age (years)	< 18	30	0.7%	43	3.5%	73	1.3%	< 0.001
	18–34	912	21.3%	188	15.4%	1100	20.0%	< 0.001
	35–49	2012	46.9%	444	36.4%	2456	44.6%	< 0.001
	≥ 50	1335	31.1%	545	44.7%	1880	34.1%	< 0.001
	Total	4289	100.0%	1220	100.0%	5509	100.0%	-
Tours per season (n)	≤ 10	849	19.7%	692	57.3%	1541	27.9%	< 0.001
	11–30	1955	45.2%	398	33.0%	2353	42.5%	< 0.001
	> 30	1518	35.1%	117	9.7%	1635	29.6%	< 0.001
	Total	4322	100.0%	1207	100.0%	5529	100.0%	-
Group size (n)	1	363	8.4%	58	4.7%	421	7.6%	< 0.001
	2	1266	29.2%	346	27.8%	1612	28.9%	0.344
	3–5	1634	37.7%	363	29.2%	1997	35.8%	< 0.001
	≥ 6	1070	24.7%	476	38.3%	1546	27.7%	< 0.001
	Total	4333	100.0%	1243	100.0%	5576	100.0%	-
Tour start time	Before 8:00 h	482	11.2%	16	1.3%	498	9.0%	< 0.001
	8:00–9:00 h	1489	34.6%	112	9.0%	1601	28.9%	< 0.001
	9:00–10:00 h	1391	32.3%	450	36.3%	1841	33.2%	0.007
	10:00–12:00 h	835	19.4%	568	45.8%	1403	25.3%	< 0.001
	After 12:00 h	105	2.5%	95	7.6%	200	3.6%	< 0.001
	Total	4302	100.0%	1241	100.0%	5543	100.0%	-

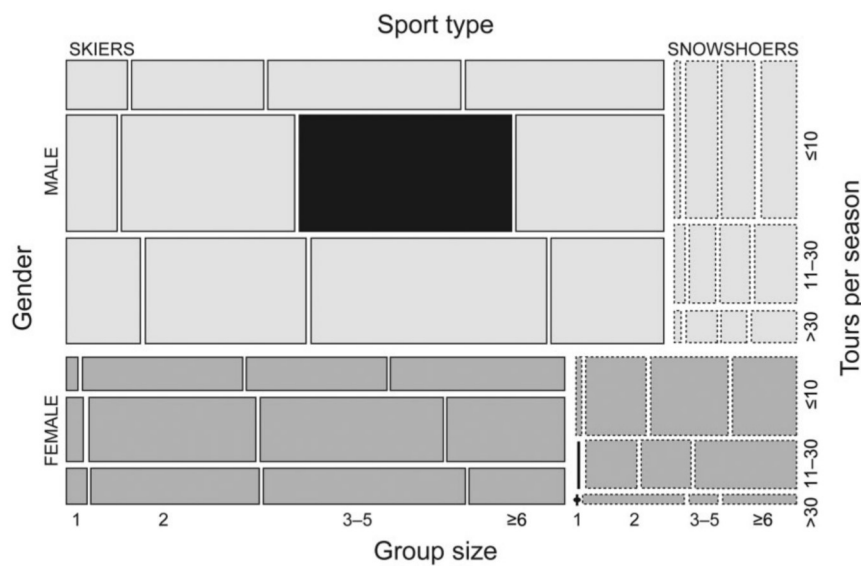


Fig. 2. Mosaic plot of sport type, gender, group size, and tours per season ($n = 5275$). Box size represents the relative percentage within the sample and provides a visualization of cluster distribution across variables: skiers (solid lines), snowshoers (dotted lines); males (light gray), females (dark gray); group size (increasing from left to right per subcategory); and tours per season (increasing from top to bottom per subcategory). The largest and smallest clusters in the sample are shown as black boxes.

($P < 0.001$), and skiers generally had an earlier start time than snowshoers (78.1% vs 46.6% before 10:00 h; $P < 0.001$). The sample contained more males than females, but relatively more female snowshoers than male snowshoers (Fig. 2). The largest cluster in the sample ($n = 5275$) was male skiers traveling in a group of three to five persons and reporting 11–30 tours per season ($n = 455$, 8.6%); the smallest cluster was female snowshoers traveling alone and reporting > 30 tours per season ($n = 0$) or 11–30 tours per season ($n = 4$, 0.08%).

Group knowledge of the avalanche bulletin and danger level

In total, 72.8% of groups had at least one informed person who had read the avalanche bulletin, but only 48.4% of groups could also indicate the correct danger level (referred to hereafter as “correctly informed”). Significantly more skier-only groups than snowshoer-only groups had read the bulletin (78.4% vs 47.0%; $P < 0.001$) and were correctly informed (52.5% vs 28.0%;



Table 2. Factors associated with group knowledge of the avalanche bulletin for skier-only groups ($n = 1213$)

Variable	Reference level	Other levels	Avalanche bulletin knowledge*		
			OR	95% CI	P-value
Mean age (years)	< 35	35–49	0.88	(0.62–1.26)	< 0.001
		≥ 50	0.29	(0.18–0.46)	0.481
Group size (n)	≥ 6	1	0.48	(0.26–0.88)	< 0.001
		2	0.73	(0.42–1.26)	0.017
		3–5	0.93	(0.53–1.64)	0.261
			0.49	(0.37–0.65)	0.811
Tour start time	Before 10:00 h	After 10:00 h	0.49	(0.37–0.65)	< 0.001
Gender × age	Males and females, < 35 years	Only males, 35–49 years	0.80	(0.56–1.15)	< 0.001
		Only males, ≥ 50 years	1.87	(1.12–3.13)	0.230
		Only females, 35–49 years	0.26	(0.12–0.55)	0.016
		Only females, ≥ 50 years	0.87	(0.16–4.56)	< 0.001

Values in bold show significant differences compared with the reference level. * Indicates reading the avalanche bulletin and correctly reporting the danger level. CI, confidence interval; OR, odds ratio.

$P < 0.001$). In total, 8.3% of groups overestimated the danger level and 22.4% underestimated the level.

In a logistic regression analysis, correct knowledge of the danger level was not associated with any factor for snowshoer-only groups, whereas significant associations were found for skier-only groups in group size ($P = 0.003$), tour start time ($P < 0.001$), mean age ($P < 0.001$), and the interaction of gender with mean age ($P < 0.001$; Table 2). Skier-only groups that were correctly informed were larger, started earlier, and had a younger mean age. For example, single-person groups were 0.48 times (95% CI, 0.26–0.88) as likely (i.e., less likely) to be informed about the avalanche bulletin as groups with six or more persons (Table 2). For both skiers and snowshoers, single-person groups had the lowest percentage of correctly informed responses of all group sizes; 62.2% reported having read the avalanche bulletin and 38.4% could indicate the correct danger level. While the likelihood of being correctly informed decreased with increasing mean age (main effect), the interaction effect of gender and mean age shows that the decrease is (a) least pronounced in male groups with mean age ≥ 50 years and (b) more pronounced in female groups, whereby a significant decrease is already present in groups with mean age 35–49 years.

Prevalence of rescue equipment and other safety devices

Avalanche transceivers (75.1%) were the most common item of rescue equipment, and standard equipment (transceiver, probe, and shovel) was carried by 65.7% of individuals. Avalanche floatation devices were carried by 3.6% of individuals and AvaLung™ by 0.4%. The prevalence of rescue equipment and safety devices was significantly higher in skiers compared with snowshoers (Fig. 3).

In a logistic regression analysis, presence of standard rescue equipment was significantly associated with sport

type, age, number of tours per season, group size, tour start time, and the interaction of gender with number of tours per season for skiers and snowshoers ($P < 0.001$ for all comparisons; Table 3). (The logistic regression was also done stratifying by sport type but as the results were similar this variable was again treated as a factor.) Individuals who were significantly more likely to have standard rescue equipment were younger, traveled in larger groups, started earlier, and reported more tours per season. For example, individuals reporting > 30 tours per season were 5.15 times (95% CI, 4.09–6.49) as likely to have standard rescue equipment than individuals reporting ≤ 10 tours (Table 3). While the likelihood of having standard rescue equipment increased with increasing numbers of tours (main effect), the interaction effect of gender with number of tours per season shows that the increase was less pronounced for females, particularly those reporting 11–30 tours.

Adherence to minimum advisable prevention and safety practices

In total, 41.5% of individuals showed complete adherence, 36.5% partial adherence, and 21.9% no adherence. Complete adherence was significantly more common in skiers compared with snowshoers ($P < 0.001$; Fig. 4). Complete adherence was also significantly more common in males (45.6%) compared with females (35.6%); individuals aged < 35 years (47.3%) or 35–49 years (45.8%) compared with ≥ 50 years (33.2%); individuals reporting > 30 tours per season (52.4%) compared with 11–30 tours (47.2%) or ≤ 10 tours (21.9%); individuals traveling in groups with three to five persons (46.1%) or six or more persons (44.4%) compared with single-person (29.9%) or two-person (37.7%) groups; and individuals starting before 10:00 h (49.2%) compared with after 10:00 h (23.1%; complete results are provided in Supporting Information Table S2).



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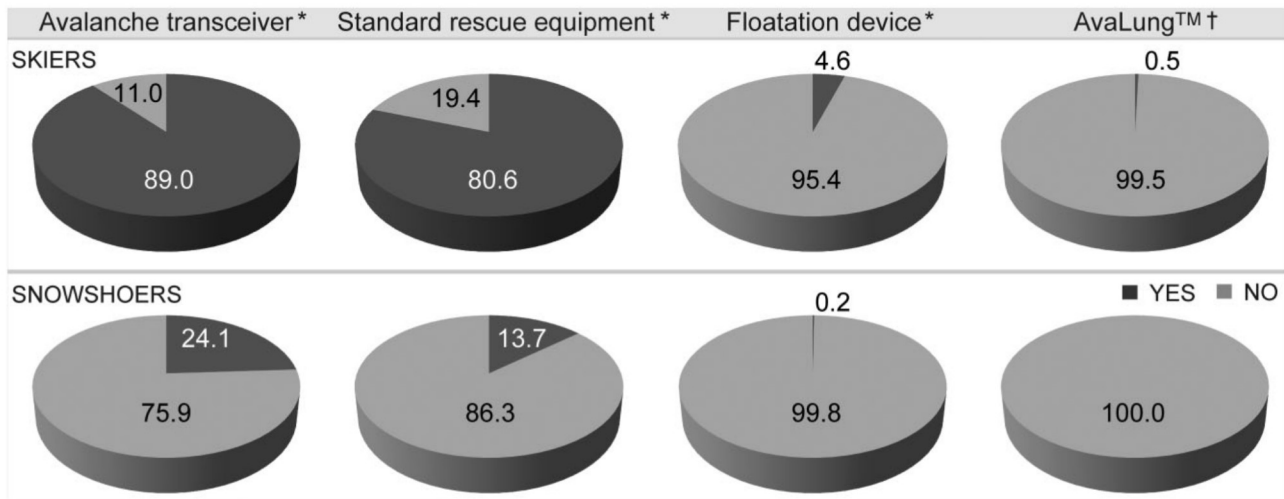


Fig. 3. Prevalence of rescue equipment and other safety devices. Differences between skiers and snowshoers are significant at a level of $P < 0.001$ (*) and $P = 0.014$ (†).

Table 3. Factors associated with presence of standard rescue equipment for skiers and snowshoers ($n = 5244$)

Variable	Reference level	Other levels	Standard rescue equipment*		
			OR	95% CI	P-value
Sport type	Skiers	Snowshoers	0.06	(0.04–0.07)	< 0.001
Age (years)	< 35	35–49	0.84	(0.68–1.03)	0.088
		≥ 50	0.56	(0.45–0.69)	< 0.001
Tours per season (n)	≤ 10	11–30	4.72	(3.82–5.83)	< 0.001
		> 30	5.15	(4.09–6.49)	< 0.001
Group size (n)	≥ 6	1	0.26	(0.19–0.36)	< 0.001
		2	0.50	(0.40–0.62)	< 0.001
		3–5	0.74	(0.59–0.91)	0.005
Tour start time	Before 10:00 h	After 10:00 h	0.35	(0.30–0.41)	< 0.001
Gender × tours per season	Male, < 10 tours	Female, 11–30 tours	0.56	(0.44–0.71)	< 0.001
		Female, > 30 tours	0.70	(0.50–1.00)	0.048

Values in bold show significant differences compared with the reference level. *Indicates complete set of transceiver, probe, and shovel. CI, confidence interval; OR, odds ratio.

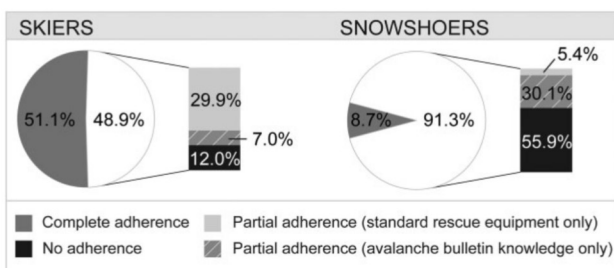


Fig. 4. Adherence to minimum advisable prevention and safety practices in skiers and snowshoers. Level of adherence was defined as complete (knowledge of the avalanche danger level and standard rescue equipment), partial (knowledge of the avalanche danger level or standard rescue equipment), or none.

Discussion

This study reports the first prospective, comprehensive survey of backcountry skiers and snowshoers in Europe,

and highlights the large discrepancies between these recreation groups in adherence to basic prevention and safety practices. Sport type was the most significant factor associated with overall adherence to minimum practices in this sample. Snowshoer-only groups generally had low knowledge of the avalanche bulletin and this was not dependent on other factors, whereas presence of safety equipment was dependent on individual and group factors for skiers and snowshoers. Similarly, in a survey of backcountry users in the 2005–2006 winter season in the Wasatch and Uinta mountains in Utah, USA, snowshoers were least likely of all backcountry recreation groups to carry an avalanche transceiver, probe, or shovel; have taken an avalanche safety course; or travel with a partner (Silverton et al., 2007). Snowshoers ($n = 56$) were 7.11 times (95% CI, 2.95–17.11) more likely than backcountry skiers ($n = 105$) to underestimate the avalanche danger level and this



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difference remained when data were adjusted for participation in an avalanche safety course (Silverton et al., 2009). Although data on previous avalanche education and training were not collected in the present survey, variables that could be assumed to reflect a basic level of experience (more tours per season) and good backcountry travel choices (earlier start time, traveling in a group) were associated with a higher level of adherence.

The influence of avalanche training on involvement in avalanche accidents is not well understood and some studies suggest that it may adversely affect risk perception and risk-taking behaviors (Burtscher & Nachbauer, 1999), although this may partially reflect higher absolute exposure time in avalanche terrain of advanced recreationists (Sole & Emery, 2008). Decision making is a complex process influenced by training, experience, and individual human factors; amateur recreationists in Western Canada (backcountry skiers, out-of-bounds skiers, and snowmobile riders) showed differences compared with professional mountain guides in the level of complexity of decisions and the weighting of importance of safety factors (Haegeli et al., 2010). Investigations are lacking for this region of Italy about users' ability to interpret and apply bulletin information, and further research would be helpful to detect possible deficiencies in risk communication strategies in this region and allow comparison with other regions.

It should also be noted that having rescue equipment does not reflect whether or not the user is skilled in its use. Furthermore, effective companion rescue is only possible if all individuals in a group are equipped with standard rescue equipment and are trained in rescue techniques (Hohlrieder et al., 2005). Because questionnaires are not sufficient to reliably evaluate users' proficiency with rescue equipment or rescue techniques, surveys of this kind have to rely on self-reported proficiency or prevalence of equipment. Silverton et al. (2007) reported a higher percentage of skiers (98%) and lower percentage of snowshoers (16%) carrying an avalanche transceiver compared to the current survey (89% and 24%, respectively), but did not report the presence of standard rescue equipment. Analyses of avalanche accidents reported transceiver use in 68.7% of victims in a sample in Austria (Hohlrieder et al., 2005) and 57.1% in a sample of completely buried victims in Austria and Switzerland (Brugger et al., 2007). Despite evidence that floatation devices significantly reduce chance of burial and mortality (Brugger et al., 2007) and AvaLung™ increases the duration of adequate oxygenation during burial (Grissom et al., 2000), the prevalence of these additional safety devices remains low compared with standard personal rescue equipment (Brugger et al., 2007; Silverton et al., 2007), although absolute prevalence likely differs between recreation types and regions.

In the winter season 2010–2011, a total of 56 avalanche accidents with 16 fatalities were reported in Italy, including 11 accidents with 16 involved persons and 2

fatalities in South Tyrol (one fatality occurred during the collection period). Over one-third of involved persons were injured and 50% of complete burials involved fatalities. The fatalities occurred in single- or two-person groups. In an analysis of trends in recreational avalanche accidents between 1977 and 2006 in Switzerland, Harvey and Zweifel (2008) found an increase in the proportion of accidents involving snowshoers, a significant decrease in the mean group size of involved persons, and a significant decrease in the number of accidents in guided groups. In the period 1970–2010, the majority of accidents (33%, $n = 1663$) involved persons traveling in two-person groups and persons in non-guided groups (73%, $n = 1205$) (Zweifel et al., 2012). A longer data collection period that contains more accident statistics would be required to make conclusive statements about incidence of avalanche involvements in backcountry skiers or snowshoers in this region.

Limitations

One limitation of this study is that the sample may not be representative of all backcountry recreationists nor of a complete winter season. Many survey points were located where multiple tours are possible and because the destination of participants was not recorded, analysis of other tour characteristics such as exposure or terrain difficulty was not possible. Because the survey was administered orally to groups, it was only possible for one person to provide an answer for the question regarding knowledge of the avalanche bulletin and danger level. This does not necessarily reflect the level of knowledge of all group members and some groups may have been guided. Nevertheless, minimum advisable practice was defined as having at least one informed person per group, as is common with formally or informally guided groups (Zweifel et al., 2012). Under this definition, it was necessary to use the group answer for each group member for the statistical analysis of adherence. Finally, the questionnaire used in this study was not intended to encompass all prevention measures or test proficiency in the use of safety equipment and rescue techniques, thus we acknowledge that it is not possible to infer adequate prevention and safety practices from the knowledge of the bulletin or presence of equipment alone.

Perspectives

While the empirical support for safety devices in reducing mortality and the widespread marketing of these devices have led to higher awareness concerning avalanche safety in backcountry recreation, prevalence of use remains insufficient in some recreation groups. This survey provides the first description of individual and group factors associated with low adherence to prevention and safety practices, but a transnational survey over a complete winter season would be required to obtain total participa-



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tion prevalence, detect regional differences, and assess the influence of prevention and safety practices on relative reduction in mortality. Furthermore, it would be important to determine participants' perceived value of equipment (e.g., safety devices) compared with perceived value of self-initiated prevention practices (e.g., applying avalanche bulletin information to tour and route planning), as this may define targets for avalanche education.

Key words: avalanche danger scale, avalanche safety equipment, avalanche transceiver, backcountry skiing, snowshoeing.

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Figure S1 European Avalanche Danger Scale.

Table S1 Questionnaire form for collection of individual and group data.

Table S2 Level of adherence to minimum advisable prevention and safety practices.

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