AVALANCHE RISK IN WINTER BACKCOUNTRY TOURING: STATUS AND RECENT TRENDS IN SWITZERLAND

Kurt Winkler[1]*, Adrian Fischer[2] and Frank Techel[1]

[1]WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland
[2] Lamprecht & Stamm Sozialforschung und Beratung AG, Zürich, Switzerland

ABSTRACT: Avalanches are the major cause of accidental death while recreating in the mountains during winter. Up to now the calculation of the statistical risk of death was difficult, mostly due to the lack of reliable data concerning touring activity. However, between 1999 and 2013 three surveys on the type and frequency of sports activities were conducted in Switzerland ("Sport Schweiz") with a total of 23'000 participants. In 2013, 3.9% of the Swiss residents between the age of 15 and 74 years were active winter backcountry users. This corresponds to 240'000 people, and is three times more than in 1999. The comparison of this backcountry touring activity with statistics on avalanche fatalities allows to calculate the absolute risk of death. Not considering exposure time, the risk of an active backcountry user to die in an avalanche was about 4.4×10^{-5} per year, and thus very similar to the risk to die in a traffic accident. From 1999 to 2010, the risk per touring day decreased by nearly half. The main reason for this reduction was the increase in the proportion of snowshoe hikers, a user-group which had an about six times smaller mortality risk due to avalanches per touring day than other users of the winter backcountry. Our results help to identify high-risk user groups and allow to develop avalanche prevention measures targeted to these groups.

KEYWORDS: avalanche risk, backcountry touring, snowshoe hiking, mortality rate

1. INTRODUCTION

Avalanches are the major cause of accidental death while recreating in the Swiss mountains during winter (Winkler et al., 2012). In the last two decades on average 23 people died in avalanches per year in Switzerland alone, the huge majority in uncontrolled avalanche terrain. The number of fatalities varies strongly from year to year, with a not significant increase in uncontrolled terrain since the 1990s (Techel et al., 2016).

Winter recreation activities in the backcountry have strongly increased in the last decades. Several studies support this view; e.g. Zweifel and Wäger (2008) estimated a yearly increase in the backcountry touring activity of 1.5% for the time period from 1989 to 2008. Furthermore, a repeated survey on the Swiss avalanche report showed that the number of touring days per respondent increased from 2008 to 2014 (Winkler and Techel, 2014).

Considerably higher activity with a nearly stable number of fatalities led to a decrease of the avalanche risk. This positive trend was already described and mostly attributed to improved prevention measures and faster and more efficient rescues (e.g. Etter et al., 2008; Kristensen et al., 2012; Techel and Zweifel, 2013).

Knowledge about avalanche risk is important for insurances, but also for recreationists themselves and for organizations focusing on prevention measures. Thus, several attempts have been undertaken to calculate the avalanche risk in backcountry terrain, all of them struggling with the challenge of getting reliable data on exposure.

Already in the 1980s, Valla (1984) estimated the mortality risk per backcountry skiing day due to avalanches in France to be 0.6×10^{-5}. Munter (1997) calculated a markedly higher risk for the 1980s. Later on, he introduced his famous "Reduction method" with the goal of reducing this risk to 1.0×10^{-5}. Grímsdóttir and McClung (2006) used data from a large heli-skiing operator. They calculated the risk of accidentally triggering an avalanche, but the dataset was too small to determine a mortality risk.

In a Swiss study, backcountry tourers and out-of-bounds skiers were counted during two winter seasons in some representative locations in the Davos area by direct observation, registration lists and light barriers. By extrapolating the counts to the Swiss Alps and comparing them with the ava-

* *Corresponding author address:*
Kurt Winkler, SLF, Flüelastrasse 11, 7260 Davos Platz, Switzerland.
email: winkler@slf.ch

lanche accidents, Zweifel et al. (2006) calculated a mean risk to die in an avalanche of about 1.3×10^{-5} per touring day.

Based on surveys about the sport behavior of Swiss residents and the members of the Swiss Alpine Club, Mosimann (2014) estimated not the touring days, but the number of active backcountry skiers. He calculated their annual risk to die in an avalanche to 4×10^{-5}.

An overview of previously reported risk values can be found in the Discussion section together with our results.

Having for the first time reliable data concerning backcountry touring activity, with this study we address the following questions:

1) How high is the avalanche risk in backcountry touring? How is it compared to other risks of daily life?
2) Has this avalanche risk changed over time?
3) Can we identify backcountry user groups with higher risks and target specific prevention measures accordingly?

2. DATA AND METHODS

We defined (avalanche or mortality) risk as the number of avalanche fatalities per year divided by either the yearly backcountry touring days or the total number of active backcountry tourers. Risk was used as a statistical value, valid for Swiss residents. The individual risk normally differs from this value, as it is strongly influenced by the personal behavior.

2.1 Touring activity

Type and frequency of sport activities of Swiss residents were determined with three representative surveys conducted in 1999, 2007 and 2013 ("Sport Schweiz") with a total of 23'000 participants (Table 1). All studies were done in a very similar way and used largely identical questions (Lamprecht et al., 2000, 2008 and 2014). The surveys were performed in German, French and Italian language and were thus limited to language-assimilated Swiss residents. The results were weighted by age and geographic area to represent the Swiss population.

The persons to be interviewed were selected randomly out of the sampling frame of the Swiss National Statistical Office. The selected persons were asked about their sports behavior in a computer-aided telephone interview (CATI). This interview was followed-up by a written survey in 1999 and an online survey (CAWI) in 2013. The survey was conducted by specially trained interviewers by the market research institute LINK.

Along many other sport activities, the activities backcountry skiing, backcountry snowboarding and snowshoe hiking were recorded. As the number of snowboarders was too small for an individual analysis, we added them to the ski tourers. Out-of-bounds skiing, ice climbing and other winter activities away from controlled ski runs were not recorded and were thus not part of this analysis.

When asked about the number of touring days per year, participants tend to provide the number of days they wish to be in the backcountry, rather than the frequency they really were there. As recommended by Lamprecht et al. (2014), we took this assumed over-reporting into account by replacing the (mathematically correct) mean value of the reported touring days with the median, separately for the two groups of backcountry skiers and snowshoe tourers. This corresponds to a reduction of one third of the touring days, compared to the answers given in the survey.

2.2 Time periods

The number of avalanche fatalities varies from year to year, depending on weather and avalanche conditions, but also single multi-fatality events having a large influence. To get robust data, we analyzed two eleven-year periods:

- Time period 2010, including avalanche fatalities from winter 2004/05 to 2014/15. Unless noted otherwise, risk was calculated using the fatalities in this period and the touring activity as the mean of the two large surveys in the years 2007 and 2013.
- Time period 1999, including avalanche fatalities from winter 1993/94 to 2003/04. The touring activity was taken from the smaller 1999 survey and is thus less reliable. We used this period only to calculate the change of risk over time.

2.3 Avalanche fatalities

Avalanche fatality data were extracted from SLF's avalanche accident database containing all reported accidents that occurred in Switzerland. To match the accidents and the usage data, we considered only accidents of Swiss residents from 15 to 74 years old, which occurred during backcountry touring activities using ski, snowboard or snowshoes.

The country of residence was known for all avalanche victims in the time period 1999 and for 80% of them in the 2010 period. For the unknown 28 fatalities we assumed the same proportion of Swiss residents as for the other fatalities in the 2010 period.

The country of residence of accidents with less serious consequences we rarely knew, and in the few cases it was known, a bias towards Swiss residents was noted. Therefore, it was impossible to allocate less severe accidents correctly to the resident country and we restricted our analysis to fatal avalanche accidents.

For avalanche fatalities of Swiss residents in foreign countries, we used data from the Swiss Council for Accident Prevention (bfu, 2016). This information may not be fully complete, but we consider it a good approximation. As these data were only available since the year 2000, we calculated the annual mean for the years from 2000 to 2015, and added them to every winter (Table 2).

2.4 Population and age

The number of language-assimilated Swiss residents from 15 to 74 years old increased from 5.5 million in 1999 and 5.7 million in 2007 to 6.1 million in 2013 (Lamprecht et al., 2000, 2008 and 2014). To calculate the mortality risk in traffic, we used the number of people living in Switzerland from the Swiss Federal Statistical Office: 7.6 million in 2007 and 8.1 million in 2013.

To analyze the influence of age on risk, we used four 15-year classes (15 to 29, 30 to 44, 45 to 59 and 60 to 74 years).

2.5 Statistics

The confidence interval for the touring activity was calculated with the unweighted sample size. Populations were compared for differences using the Mann-Whitney U-test. For contingency tables the chi-square statistic was used. We considered results with a level of significance $p<0.05$ as significant.

3. RESULTS

3.1 Touring activity

3.9% of the Swiss residents at the age of 15 to 74 years were active winter backcountry users in 2013. This corresponds to 240'000 people, and thus three times more than in 1999 (Table 1). While the number of backcountry skiers did not change significantly between the surveys, there was a large increase in snowshoe tourers (14 % of 69'000 in 1999 vs. 67% of 241000 in 2013).

The days spent in the backcountry showed a similar picture, with the cumulated yearly number of touring days rising from 0.7 million in 1999 to 2.2 million in 2013 (Fig. 1). As a consequence of the considerably higher ratio of snow shoe tourers, the increase in the number of days was mostly due to snowshoe hikers.

Tbl. 1: Active backcountry users and their touring days per year by sports device and gender. Bold = significant change since the last survey.

year	*Sports device*	*active backcountry tourers*		*touring days per year*	
(participants)		*proportion in population [%]: all (women, men)*	*persons [x 1000]*	*each tourer [median]*	*total [x 1000]*
2013 (10'652)	all*)	**3.9 (4.2, 3.7)**	**241**	(10)°)	**2150**
	ski	1.4 (1.1, 1.7)	85	10	850
	snowshoe	**2.7 (3.3, 2.0)**	**162**	8	**1300**
2007 (10'262)	all*)	**2.7** (2.8, 2.6)	**154**	(10)°)	**1380**
	ski	1.5 (1.2, 1.8)	84	10	780
	snowshoe	**1.3** (1.7, 1.0)	**76**	8	**610**
1999 (2'064)	all*)	1.3	69	(10)°)	710
	ski	1.2	63	10	630
	snowshoe	0.2	10	8	80

*) who uses ski/snowboard AND snowshoes is counted as 1 person.

°) value not used. The total touring days were calculated with the median for skiers and the median for snowshoe tourers separately.

Tbl. 2: Avalanche fatalities of Swiss residents, per year

	winter 1993/94 to 2003/04			*winter2004/05 to 2014/15*		
	ski[*)]	*snowshoe*	*all*	*ski*[*)]	*snowshoe*	*all*
women	0.9	0.3	1.2	1.1	0.5	1.6
men	4.9	0.3	5.3	6.0	0.9	7.0
all	5.9	0.6	6.5	7.1	1.5	8.6
thereof in foreign countries	0.4	0.4	0.8	0.4	0.4	0.8

*) including snowboard

3.2 *Avalanche fatalities*

The avalanche fatalities of Swiss residents while backcountry touring increased by about one third from 6.5 up to 8.6 per year between the 1999 and the 2010 time period (Fig. 1). However, this trend was not statistically significant (p=0.21).

3.3 *Avalanche risk of active backcountry users among Swiss residents*

Based on the number of people and the avalanche fatalities in the backcountry, the mortality risk was about 4.4×10^{-5} per year in the 2010 period.

During the same time period, the mortality risk was slightly lower than 0.5×10^{-5} per backcountry touring day. However, differences became evident when exploring user groups by the different types of sports devices, age groups or gender (Fig. 2 and Table 3).

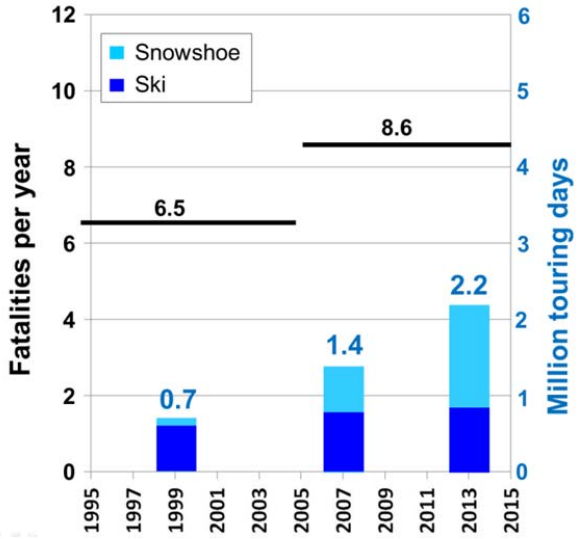

Fig. 1: Touring days per year (blue, right axis) and avalanche fatalities per year (black lines) of Swiss residents.

Snow sports devices

The mortality risk per backcountry skiing day was 0.87×10^{-5} and thus six times higher than on a snowshoe day with 0.15×10^{-5}.

Gender

Men had a more than three times higher mortality risk per touring day than women (7 vs. 2 fatalities per million touring days, respectively). Women had a higher proportion of snowshoe hikers, but this did not explain the difference: the same factor was found when considering only the ski touring group (11 vs. 3.3 fatalities per million touring days, respectively). For snowshoes hikers, the difference was somewhat smaller (2.1 vs. 1.1 fatalities per million touring days).

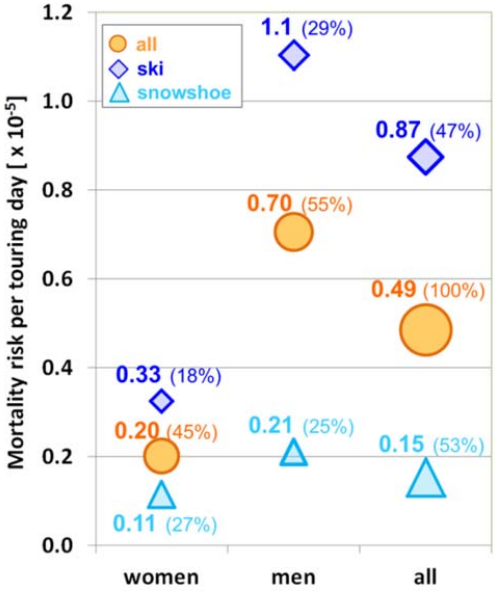

Fig. 2: Mortality risk per backcountry day for different user groups and in brackets the proportion of touring days undertaken by this group.

Age

People from 30 to 44 and from 45 to 59 years old were the most active backcountry users, and also had the most fatalities (Fig. 3). If we consider the reported touring activity to be correct, the risk per touring day was highest for the 30 to 59 years old. The 15 to 29 years old and the 60 to 74 years old both had a lower mortality risk (p = 0.04 and 0.03, respectively).

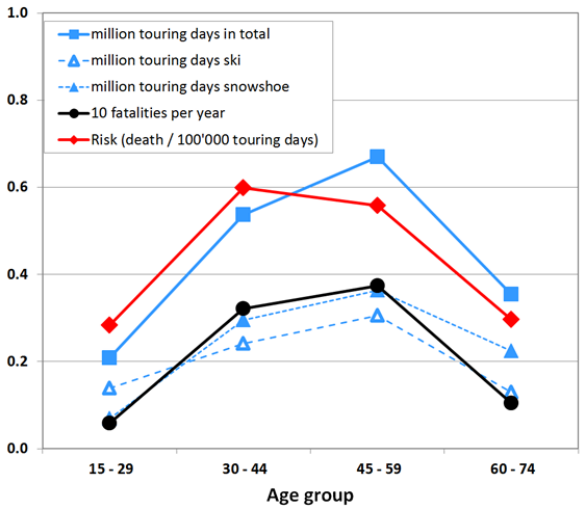

Fig. 3: Backcountry activity, avalanche victims and mortality risk for different age groups.

Trend

In the 2010 period, Swiss residents accumulated 1.8 million touring days per year and thus 2.5 times as many as in the 1999 period. Because the number of avalanche fatalities increased only by one third during this time, the mortality risk was reduced by almost half, from 9.2 to 4.9 fatalities per million touring days. For skiers alone, no significant reduction of the risk was noted (from 0.94×10^{-5} to 0.87×10^{-5} fatalities per million days).

4. DISCUSSION

Taking into account the uncertain assumptions in various studies, the mortality risk values found in our study reflect those from previous mortality risk literature. Also Munter's target value of less than 1 fatality per 100'000 backcountry skiing days was achieved, albeit marginally (Table 3). However, in previous studies there was no clear distinction between backcountry user groups according to their different snow sports equipment.

The annual mortality risk of backcountry tourers due to avalanches (4.4×10^{-5} in the 2010 time period) was equal to the annual mortality risk in traffic accidents (4.2×10^{-5} as mean of the years 2007 and 2013; ASTRA, 2015). As during a year likely more time was spent in traffic than in the backcountry, one hour of touring was more dangerous than one hour of driving on a street or walking on a sidewalk.

The annual mortality risk of an active backcountry tourer and the risk per touring day sharply decreased from 1999 to 2010. However, this risk reduction was not caused by faster rescue, better avalanche education or a more stable snowpack due to increasing ski compaction in highly frequented backcountry touring areas. In fact, our study indicates that this reduction was mainly due to the much greater number and proportion of snowshoe tours undertaken, a user group which was at a considerably lower risk than backcountry skiers. The fact, that the risk per touring day among ski touring has hardly changed, supports this interpretation. The change in risk per snowshoe day could not be compared, because both the touring activity and the number of fatalities were too low in the first period, and thus not sufficient for a statistically meaningful evaluation.

If we consider all reported avalanche accidents in the SLF accident database, and if we assume that the reporting rate of less severe incidents is similar for accidents involving backcountry ski tourers and snowshoe hikers, we can compare the number of fatalities of these two groups with the respective number of people caught in avalanches. It then becomes evident that the mortality rate of a person caught by an avalanche is much higher for snowshoe hikers than for ski tourers (34% and 10%, respectively; $p<0.0005$; Fig. 4). This finding corresponds to the results by Procter et al. (2013) who found that snowshoe tourers are less informed and equipped than backcountry ski tourers.

Tbl. 3: Mortality risk by avalanches in backcountry touring

Study	*mortality risk [x 10^{-5}]*	
Valla (1984)	0.6	per ski touring day
Munter (2003), for the 1980s	2.8	per ski touring day
Zweifel et al. (2006)	1.3	per touring day
this study	0.5	per touring day
	0.9	per ski touring day
	0.15	per snowshoe day
Mosimann (2014)	4	annual risk of a backcountry skier
this study	4.4	annual risk of backcountry tourers
	8.4	annual risk of a backcountry skier
	1.2	annual risk of a snowshoe hiker

Even snowshoe hikers have a higher mortality rate than skiers in case of being caught by an avalanche, they have a considerably lower mortality risk per touring day compared to the skiers. Since snowshoe hikers may be disadvantaged compared to the skiers concerning additional load (more punctual application of the load) and escape chances in case of an avalanche, we explain their lower risk due to the assumption that they more often use gentle terrain at lower elevations and therefore are less exposed to avalanches.

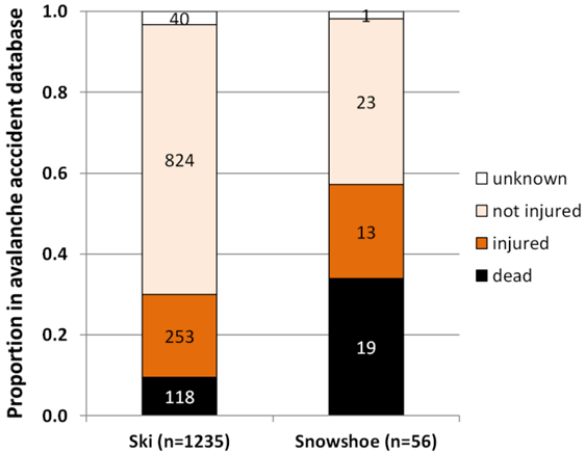

Fig. 4: Backcountry users caught by avalanches in Switzerland. All reported accidents with known sports device during the 2010 time period.

According to Brugger et al. (2010) and Winkler and Techel (2014), the medium-aged were the most active backcountry users and they had the highest mortality risk too. Surprisingly, "the wild young ones" had a lower mortality risk. This may be different if we include the out-of-bounds skiers with their higher number of young victims (Zweifel, 2012). But without reliable data concerning the out-of-bounds activity, we cannot calculate their risk. The higher risk for the 30 to 59 years old backcountry tourers raises the question, whether experience really reduces avalanche risk, or whether experience is mainly used for selecting more challenging routes – according to the theory of risk homeostasis (Wilde, 1994) – rather than for more safety on the same tour. Nevertheless, those over 59 years old had a lower risk. However, this is not necessarily proof that experience is contributing to safety, it may purely be due to less ambitious tour destinations of this age group.

Our work suggests that specific prevention measures should be developed for the following user groups:

- Men on skis contribute to 30% of the total touring days, but to 70% of the fatalities. They are thus the major risk group with a mortality risk per backcountry day of 1.1×10^{-5}, and maybe even more if aged between 30 and 59. These users should be encouraged to use extra caution.
- Snowshoe hikers are rarely involved in an avalanche accident. However, in case of an involvement they have a significantly higher mortality than skiers. We recommend them to carry safety equipment and to attend avalanche rescue courses.

5. CONCLUSIONS

We calculated the statistical risk to die in an avalanche while backcountry touring. Not considering exposure time, the risk of an active backcountry user to die in an avalanche was about 4.4×10^{-5} per year, and thus very similar to the risk to die in a traffic accident during a year.

Even if the mortality risk per backcountry touring day due to avalanches has clearly decreased from 1999 to 2010 to 0.5×10^{-5}, we cannot confirm the often heard statement that ski touring is becoming safer. Based on our data, the decrease was caused by a markedly higher proportion of snowshoe hikers, which were less frequently caught by avalanches than ski tourers. A higher risk of men and young tourers is widely assumed. Our data confirms the first, but disproves the second assumption.

ACKNOWLEDGEMENTS

We thank the Swiss Council for Accident Prevention (bfu) for data about fatalities of Swiss residents in foreign countries. We are additionally grateful to Chris Pielmeier, Benjamin Zweifel and Jürg Schweizer for their valuable feedback on the manuscript.

REFERENCES

ASTRA, 2015. Unfallstatistik 2014. ASTRA – Bundesamt für Strassen, Ittigen, Switzerland.

bfu, 2016. Statistik der tödlichen Sportunfälle. Database query 4th of April 2016.

Brugger H., H. Staffler, A. Aberer, L. Castlunger and G. Strapazzon. 2010. Vollerhebung Skitourengeher in Südtirol. Bergundsteigen. Österreichischer Alpenverein, Innsbruck, Austria, 10 (4): 58-61.

Etter, H.J., T. Stucki, B. Zweifel. and C. Pielmeier. 2008. Developments in avalanche forecasting and other prevention measures and their potential effects on avalanche fatalities. Proceedings ISSW 2012. International Snow Science Workshop. Whistler, Canada: 628-635.

Grímsdóttir, H. and D. McClung. 2006. Avalanche risk during backcountry skiing – An analysis of risk factors. Natural Hazards, 39 (1): 127-153.

Kristensen K., W. Munter W. and M. Genswein. 2012. Perception of Risk in Avalanche Terrain. In: Proceedings ISSW 2012. International Snow Science Workshop, Anchorage, U.S.A.: 501-505.

Lamprecht, M., A. Fischer and H.P. Stamm. 2014. Sport Schweiz 2014 - Sportaktivität und Sportinteresse der Schweizer Bevölkerung. Bundesamt für Sport BASPO, Magglingen, Switzerland.

Lamprecht, M., A. Fischer and H.P. Stamm. 2008. Sport Schweiz, 2008 - Das Sportverhalten der Schweizer Bevölkerung. Bundesamt für Sport BASPO, Magglingen, Switzerland.

Lamprecht, M. and H.P. Stamm. 2000. Sport Schweiz 2000 - Sportaktivität und Sportkonsum der Schweizer Bevölkerung. STG/SOV/LSSFB, Basel/Bern/Zürich, Switzerland

Mosimann, U. 2014. Wie gefährlich ist Bergsteigen? Die Alpen, SAC, Bern, Switzerland: 2014 (6): 48-49.

Munter, W., 1997: 3x3 Lawinen - Risikomanagement im Wintersport. Pohl und Schellhammer, Garmisch Partenkirchen, Germany.

Procter, E., G. Strapazzon, T. Dal Cappello, L. Castlunger, H. P. Staffler and H. Brugger. 2013. Adherence of backcountry winter recreationists to avalanche prevention and safety practices in northern Italy. Scandinavian Journal of Medicine & Science in Sports 24 (5).

Techel, F., F. Jarry, G. Kronthaler, S. Mitterer, P. Nairz, M. Pavšek, M. Valt and G. Darms. 2016. Avalanche fatalities in the European Alps: long-term trends and statistics. Geographica Helvetica, 71: 147-159.

Techel, F. and B. Zweifel. 2013. Recreational avalanche accidents in Switzerland: Trends and patterns with an emphasis on burial, rescue methods and avalanche danger. Proceedings ISSW 2013. International Snow Science Workshop, Grenoble, France: 1106-1112.

Valla F. 1984. The French experience in avalanche education for skiers. In: Proceedings ISSW 1984. International Snow Science Workshop, Aspen CO, U.S.A.: 70-77.

Wilde, G.J.S., 1994. Target Risk. Dealing with danger of death, disease and damage in everyday decisions. Toronto: PDE Publications, 234 pp.

Winkler, K. and F. Techel. 2014. Users' Rating of the Swiss Avalanche Forecast. Proceedings ISSW 2014. International Snow Science Workshop, Banff, U.S.A.: 437-444.

Winkler, K., H.P. Brehm and J. Haltmeier. 2012. Bergsport Sommer. SAC Verlag, Bern, Switzerland.

Zweifel, B. 2012. Jung & wild vs erfahren. Bergundsteigen. Österreichischer Alpenverein, Innsbruck, Austria, 4/12: 78-82.

Zweifel, B. and P. Wäger. 2008. mal10hoch-5. Bergundsteigen. Österreichischer Alpenverein, Innsbruck, Austria, 17 (1): 40-44.

Zweifel, B., A. Raez and T. Stucki. 2006. Avalanche risk for recreationists in backcountry and in off-piste area: surveying methods and pilot study at Davos, Switzerland. Proceedings ISSW 2006. International Snow Science Workshop, Telluride, U.S.A.: 733-741.