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Group dynamics among recreationists traveling in avalanche terrain

Challenges for improving avalanche safety

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Cover photograph: *Ascending groups of recreationists in the region of Davos* © Matthias Gerber / WSL Institute for Snow and Avalanche Research SLF

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Group dynamics among recreationists traveling in avalanche terrain – challenges for improving avalanche safety

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To Nicole, Liselotte and Emil

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Vorwort und Dank

Es war ein thematisches Experiment, mich als gelernter Erdwissenschaftler in psychologische und soziale Themenfelder zu wagen. Die Zeit der Doktorarbeit ist um und ich hoffe, es ist mir gelungen einen nützlichen Forschungsbeitrag im Themenfeld von Gruppendynamik und Lawinenrisiko zu liefern. Für mich persönlich war die Arbeit ein Erfolg; ich konnte nicht nur die Forschungswelt kennenlernen, sondern auch mein selbständiges Arbeiten optimieren und aus verschiedensten Herausforderungen lernen und viele Erfahrungen machen, die mir auch in Zukunft helfen werden.

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Bedanken möchte ich mich bei zahlreichen Wintersportlern, die mit ihren Interviews zur Datengrundlage dieser Arbeit beigetragen haben, aber auch bei den Personen, die an der Fokusgruppendiskussion teilgenommen haben.

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Summary

Group dynamics play an important role in the decision making processes of recreationists who travel in avalanche terrain and therefore have a crucial influence on avalanche safety. This perspective is partly based on personal experience but also on information from high-profile avalanche accidents where groups sometimes made decisions without proper regard for avalanche safety rules. The most interesting aspect in such situations is that no one in the group would have made the same decisions if they had been on their own. Although there is a strong indication of the effect of group dynamics on avalanche safety, research in this field is surprisingly sparse.

As a result of this dissertation, avalanche accident analysis show that groups of two and three are most frequently involved in avalanche accident. However, backcountry usage data indicates that groups of four and more people are more at risk being involved in an avalanche accident than groups of two or people who travel alone. Considering group size is therefore an important factor when planning a trip and group leaders should think about risk reduction measures for large groups. Furthermore, results indicated that the majority of avalanche victims are male and between 20 and 30 years old. However, since it is not clear how many recreationists in this group are really present in winter backcountry, one cannot conclude that men in their twenties are most at risk. Nevertheless, results from the online survey indicate that men have a greater willingness to take risks than women. The survey also indicates that more experienced recreationists take higher risks than beginners.

For the purpose of exploring behaviors and decision strategies of winter backcountry groups, group interviews appeared as a valuable qualitative method. While this study showed that the majority of recreationists who followed behaviors or strategies that are considered recommended in avalanche safety (e.g., traveling with an experienced leader or deciding based on established avalanche safety rules), recreationists also report behaviors which are questionable and probably only appropriate in certain conditions (e.g., following existing tracks or deciding based on intuition) or behaviors which can cause an increased avalanche risk (e.g., traveling in emergent groups or trivializing decisions concerning avalanche risk).

Finally, I proposed a group check tool called SOCIAL, in order to improve the control of group dynamics within winter backcountry groups. SOCIAL recommends checking the Skills, Organization, Communication, Identification, Anomalies and Leadership aspects of the group. This dissertation has improved our understanding of group phenomena in the context of winter backcountry activities, and with its group check tool (SOCIAL) has the potential to improve avalanche safety of recreationists. However, there is plenty of room for future research, such as the investigation of the role of power and conflict in group dynamics as well as the effectiveness of avalanche safety research in terms of implementations in practice.

Zusammenfassung

Bei Entscheidungen von Wintersportlern, die sich im Lawinengelände bewegen, spielen gruppendynamische Aspekte eine wichtige Rolle und beeinflussen massgeblich das Lawinenrisiko. Basierend auf eigenen Erfahrungen aber auch auf Erkenntnissen von grossen Lawinenunfällen realisierte ich, dass Gruppen manchmal Entscheide treffen, die weit weg von gängigen Lawinensicherheitsregeln sind; und ein interessanter Aspekt dabei ist, dass niemand in der Gruppe diesen Entscheid gefällt hätte, wenn er allein entschieden hätte. Obwohl es diese starken Hinweise auf den Einfluss von Gruppendynamik auf die Lawinensicherheit gibt, existiert erstaunlich wenig Forschung auf diesem Gebiet.

Die Ergebnisse der Dissertation zeigten, dass bei den Lawinenopfern 2er und 3er Gruppen am häufigsten sind. Analysen, welche die Begehungszahlen berücksichtigen, deuteten aber darauf hin, dass Gruppen von vier oder mehr Personen ein höheres Lawinenrisiko haben als 2er Gruppen oder Personen, die alleine unterwegs sind. Der Faktor Gruppengrösse sollte jedenfalls bei der Planung berücksichtigt werden und Gruppenleiter sollten sich Massnahmen zur Risikoreduktion bei grossen Gruppen überlegen. Die Ergebnisse zeigten zudem, dass eine Mehrheit von Lawinenopfern Männer zwischen 20 und 30 Jahren alt sind. Da aber nicht klar ist, wie viele Wintersportler in dieser Gruppe effektiv unterwegs sind, kann man aus diesem Ergebnis nicht folgern, dass Männer Mitte zwanzig auch das höchste Risiko haben. Resultate aus der Onlinebefragung zeigten allerdings, dass Männer eine höhere Risikobereitschaft als Frauen haben; und sie zeigten auch, dass erfahrende Tourengeher eine höhere Risikobereitschaft haben als Anfänger.

In der Studie über das Verhalten und über Entscheidungsstrategien von Wintersportlern im Lawinengelände haben sich Gruppeninterviews als wertvolle qualitative Methode gezeigt. Die Studie zeigte, dass die meisten Wintersportler sich entsprechend gängigen Regeln in der Lawinenprävention verhielten (als Beispiel mit einem erfahrenen Gruppenleiter unterwegs zu sein oder entscheiden aufgrund von etablierten Lawinensicherheitsregeln). Wintersportler berichteten aber auch fragliches Verhalten oder Verhalten, dass nur untergewissen Bedingungen angebracht ist (zum Beispiel vorhandenen Spuren zu folgen oder intuitiv zu entscheiden) oder gar Verhalten, das zu

einem erhöhten Lawinenrisiko führen kann (zum Beispiel in zusammengewürfelten, ungeplanten Gruppen unterwegs zu sein oder Entscheidungen zur Lawinengefahr herunter zu spielen).

Schlussendlich habe ich das Gruppenchecktool SOCIAL vorgeschlagen, welches zur Kontrolle kritischer Gruppenfaktoren dienen soll. SOCIAL prüft die Skills, die Organisation, die Kommunikation, Identifikation, Anomalien und die Führung. Eine deutsche Anpassung des Tools ist auf Winter 2014-15 geplant aber zu diesem Zeitpunkt noch ausstehend. Diese Doktorarbeit verbesserte unser Verständnis von Gruppenfaktoren im Zusammenhang mit Wintersport im potentiellen Lawinengelände. Mit dem Gruppenchecktool SOCIAL bringt diese Arbeit eine Anwendung hervor, welche die Lawinensicherheit der Wintersportler erhöhen soll. Die Arbeit hat aber auch gezeigt, dass es noch viele Möglichkeiten für zukünftige Forschung gibt, so zum Beispiel der Einfluss von Macht oder Konflikten auf Entscheidungen aber auch die Erforschung, wie effektiv Empfehlungen und Resultate aus der Forschung in die Praxis einfliessen.

1 Introduction

The influence of group phenomena on the decision making of recreationists traveling in avalanche terrain has been cited in several recent studies (Atkins, 2001; McCammon, 2002, 2004; Bright, 2010). To introduce the topic of group dynamics in avalanche terrain, the following description (adapted from Study III, Appendix A.4.2, Zweifel, 2014a) from a backcountry ski trip examines a case as an example of group dynamics and its possible effects on avalanche safety.

It's a nice January day with blue sky, low avalanche danger and perfect powdery snow conditions. And this time it is not a dream, it is real, I have a day off today. I call my freeride partner, and it is soon clear that he can take the day off to take advantage of these perfect conditions. We make our plans quickly – the Leidbachhorn with its chutes is the perfect trip. We just arrange a meeting point and the planning for this trip is finished. Next morning we meet at Rinerhorn gondola station. We are ready for a new adventure. At the mountain station we meet a friend who also heads towards Leidbachhorn with his colleague. We join them; there is nothing to be said against it.

However, from this point the trip starts to get somehow odd, the speed increases, no one knows from whom in this group. Approaching the summit skis have to be carried and exhausting tracking is needed. We sweat and fight, however, not like in a team but like in a contest. We are in a stage, where everyone wants to be a hero – however, we are not aware of that effect in that moment. Like single fighters, everyone reaches the summit. Just as the last skier arrives, the first one wordlessly dives into a steep dark couloir. The next one quickly follows because there is no space for four fresh tracks in the upper part of the small couloir. Let's go, I also follow. Finally, all skiers arrive at the Sertig valley with the best powdery snow conditions and as it was so splashy, we reran the trip with exactly the same behavior as before.

This is a typical example of group dynamics within groups of young male mountaineers. The group situation got out of control and decisions were made that none of the group members would have made on their own. I only became aware of this type of phenomenon, however, after many years.

1.1 The research problem and its relevance

The discussion of human factors has recently become more prevalent not only in avalanche safety literature (see, e.g., Munter, 1997; Engler, 2001; Tremper, 2008; Fredston & Fesler, 2011; Harvey, Rhyner & Schweizer, 2012) but also in other fields of research. While most studies examine human factors of individuals traveling in avalanche terrain (Tase, 2004; Adams, 2005; Sole, 2008; McCammon, 2009; Gunn, 2010; Haegeli, Haider, Longland, & Beardmore, 2010; Berget, 2012; Haegeli, Gunn, & Haider, 2012; Strong-Cvetich, 2014), studies which explore group related phenomena of winter backcountry recreationists are sparse. However, it is known from observations (Procter et al., 2013) and avalanche accident statistics (Jamieson, Haegeli & Gauthier, 2010) that people usually travel in groups.

The overall goal of this dissertation is therefore to gather more insight into recreational groups traveling in avalanche terrain and their behavior with respect to avalanche safety. This will provide a better understanding of group phenomena when performing recreational activities and will lead to recommendations on how to improve group processes such as decision making, leadership or group planning which, in turn, have a critical potential to reduce avalanche risk.

Since environmental factors, such as weather, snowpack and avalanche formation are highly variable and complex, a fully analytical approach in decision making is not possible. This is why avalanche researchers have attempted to understand behavioral factors of decision making and highlighted typical traps in decision making (e.g. McCammon, 2002, 2004; Tremper, 2008). I intend to go further in this direction by exploring group phenomena in detail. The potential gains in performance due to improvements in group processes has been highlighted in sociology and social psychology (see, e.g., Baron & Kerr, 2003; Kerr & Tindale, 2004; Sexton, 2004) and recently also in outdoor sports (e.g., Lynch, Jonson, & Dibben, 2007; Shooter, Paisley, & Sibthorp, 2009; Leon, Sandal, & Larsen, 2011; Kjærgaard, Leon, & Fink, 2013). However, this has not been explored thus far with regards to winter backcountry activities.

Finally it should be said that the avalanche safety community desires for improvements in the human-factor dimension of the avalanche problem. Avalanche prevention resides in a paradigm shift from a focus on understanding the physical factors of avalanche danger, such as snowpack, weather or terrain, to better comprehend the avalanche formation process,

towards a more general approach that not only includes a physical understanding of the avalanche phenomena but also an understanding of human factors within the decision making process of recreationists. This paradigm shift – which has recently leaded to prominent "human factor"-chapters within the popular avalanche safety literature (e.g., Tremper, 2008; Harvey et al., 2012) – has produced an increased awareness of human factors among avalanche safety practitioners and recreationists. In conclusion, people are waiting for useful instruments which will help gain a better understanding of human factors.

1.2 Research questions

This dissertation adresses the following broad research question: *What are the behavioral patterns of groups traveling in avalanche terrain with respect to avalanche safety?* This is split into three partial research questions which guide the different studies:

(1) *What are the characteristics of groups involved in avalanche accidents?* This research question is addressed in Study I (chapter 4).

(2) *Does group size affect avalanche risk?* This research question is addressed in Study II (chapter 5).

(3) *How do recreational groups that travel in avalanche terrain behave and make decisions?* This research question is addressed in Study III (chapter 6).

The last part of the thesis follows a development objective and combines results, literature and the outcome of an expert workshop to propose a tool to address group dynamics challenges in groups traveling in avalanche terrain. This part is covered in chapter 7 with its own research article.

1.3 Research approach

The empirical part of this thesis follows an exploratory design which aims to provide information, gain knowledge and understand problems of groups traveling in avalanche terrain, and involves three research studies and finally a suggestion for practice in the form of a group-check tool. All studies choose

different research methods in line with the main research objective and the guiding research questions.

Study I characterizes individuals and groups who are involved in avalanche accidents, analyzing avalanche accident statistics from the Swiss avalanche accident database as well as data from an online survey in a *quantitative* approach. In Study II, the risk of recreational groups in avalanche terrain with respect to group size is explored using a *quantitative* approach by comparing the frequency of groups traveling in avalanche terrain with the frequency of such groups within avalanche accident statistics. Study III gains deeper knowledge of groups traveling in avalanche terrain with a *qualitative* analysis of group interviews. Finally, I propose a group-check tool based on the findings of studies I to III, existing relevant research and on an expert workshop, building a bridge to avalanche safety practice (→ fig. 1-a). More details on the methodological design of the dissertation and the single studies can be found in chapter 3.

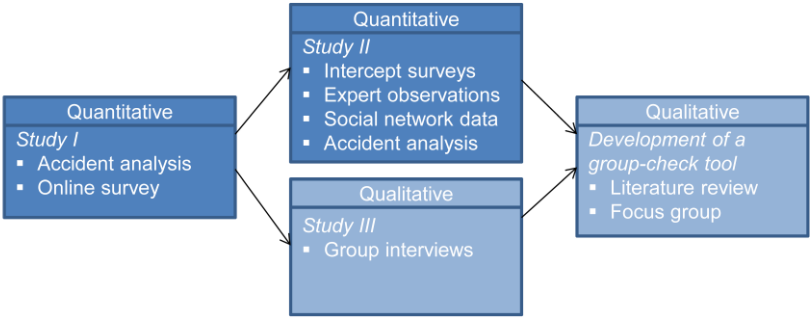

Figure 1-a: Overall design of the dissertation and methodological approaches of the four research studies.

Within this mixed-methods design, relevant theories from sociology and social psychology are integrated and play a crucial role in the guidance of the research questions; an overview on existing concepts from sociology and social psychology can be found in chapter 2.

1.4 Research contribution

This dissertation offers contributions to different fields. Primarily, this project aims to improve avalanche safety of recreationists with a deeper

understanding of group phenomena within backcountry recreation activity in avalanche terrain. Therefore this project contributes to:

- Avalanche education to better address group phenomena in their courses.
- Avalanche researchers to promote group related research and to encourage them to include more social science approaches in their research.
- Recreationists traveling in avalanche terrain to improve avalanche safety with a deeper understanding of group related factors, supported by a group check tool.
- Professional mountain guides and organizations to track group related risks during announcement, trip planning and on tour.

In order to reach relevant readership, findings of this dissertation have been published both in the science orientated journals (e.g., Journal of Outdoor Recreation and Tourism) and in magazines addressing practitioners (e.g., Bergundsteigen). However, in the field of avalanche research, the merging of theory and practice has a long tradition. A good venue to reach both scientists and practitioners is the International Snow Science Workshop which takes place in the United States, in Canada and in Europe on a rotating basis (www.issw.net).

1.5 Structure of the thesis

The present dissertation consists of eight chapters, where the findings are presented as research articles in a cumulative way in chapters 4 to 6. Chapters 1 to 3 and chapter 7 build the conceptual frame of this work.

In *chapter one*, the research topic is presented by showing the relevance of the research problem. I briefly describe the guiding research questions and show how these questions are approached. Finally, I give a short overview on the contribution of this dissertation.

In *chapter two*, relevant literature and the state-of-the-art in this research field is presented in order to understand the basics of avalanche safety research and of group-related research from sociology and social psychology.

In *chapter three*, I lay out the methodological approaches of the research studies in detail and discuss the pros and cons of the chosen methods. This chapter also gives an overview of the datasets as used in this study.

In *chapter four to six*, the results are presented in a cumulative way regarding the three different studies (→ tab. 1-a). The original articles are briefly summarized and it is shown how they contribute to answering the research questions. I further discuss the implications of the articles and the relevance of the chosen publications.

In *chapter seven*, I present the group check tool SOCIAL which combines results shown in this dissertation with literature and the outcome of an expert workshop in form of a tool for practitioners such as backcountry recreationists or mountain guides (→ tab. 1-a).

In *chapter eight*, I sum up the overall findings and implications, and give an overview of potential future research. The overall conclusion finally takes the reader back to the research problem.

The appendix contains the online survey from Study I, the interview guideline from Study III, a participants list of the expert workshop from the development of the group checklist as well as two original German articles.

Table 1-a: Overview of articles included in this dissertation.

Research question	**Publications**	**Chapter (Pages)**
(1) What are the characteristics of groups involved in avalanche accidents?	1) Zweifel, B., Techel, F., & Björk, C. (2012). Who is involved in avalanche accidents? *International Snow Science Workshop 2012, Proceedings* (pp. 234-239). Anchorage, AK.	Chapter 4
	2) Zweifel, B. (2012). jung & wild vs erfahren. *bergundsteigen - Zeitschrift für Risikomanagement im Bergsport.* Oesterreichischer Alpenverein, Innsbruck, Austria, 21(4), 78-82.	Appendix A.4
(2) Does group size affect avalanche risk?	3) Zweifel, B., Procter, E., Techel, F., Strapazzon, G., & Boutellier, R. (submitted). Risk of avalanche involvement in winter backcountry recreation: the advantage of small groups.	Chapter 5
(3) How do recreational groups that travel in avalanche terrain behave and make decisions?	4) Zweifel, B., & Haegeli, P. (2014). A qualitative analysis of group formation, leadership and decision making in recreation groups traveling in avalanche terrain. *Journal of Outdoor Recreation and Tourism, 5-6*, 17-26.	Chapter 6
	5) Zweifel, B. (2014). Gruppendynamik. *bergundsteigen - Zeitschrift für Risikomanagement im Bergsport.* Oesterreichischer Alpenverein, Innsbruck, Austria, 23(1), 46-51.	Appendix A.4
Development objective	6) Zweifel, B. (2014). SOCIAL - A group check tool. *International Snow Science Workshop 2014, Proceedings* (pp. 963-969). Banff, AB.	Chapter 7

2 Literature review and background concepts

The second chapter of this dissertation provides an overview of relevant literature and follows the guiding question: Which group-related concepts exist in avalanche safety research and what can we learn from other disciplines, such as decision making theories or group dynamics concepts as they exist in sociology and social psychology? Due to the interdisciplinary character of this study, it is essential to investigate these different subjects in order to gain a comprehensive picture of relevant knowledge. To provide the necessary background information, I first give a short introduction to recreational winter backcountry activity.

2.1 Recreational winter backcountry activity

2.1.1 Winter backcountry terrain and avalanche danger

Concerning the hazard of avalanches, winter mountainous terrain has been divided into avalanche-controlled areas (e.g. settlements, roads or ski areas) and free terrain where no avalanche control is performed. Due to extensive mitigation measures which could be divided into active protection measures such as snow sheds, dams or supporting structures in starting zones and passive protection measures such as hazard mapping which effectively protect infrastructure and people living therein (McClung & Schaerer, 2006), avalanche accidents in avalanche-controlled areas have decreased significantly (Tschirky, Brabec, & Kern, 2001; Techel & Zweifel, 2013). In contrast, more and more avalanche accidents during recreational activities have been observed. Fatalities in settlements and on transportation routes decreased from an average of 8.3 deaths per year in the1950s, 1960s and 1970s to an average of 2.7 deaths per year in the 1980s, 1990s and 2000s (from the Swiss national avalanche accident database). The effectiveness of avalanche safety measures for settlements and infrastructure has also been shown while comparing the catastrophic avalanche winters 1951 and 1999 (SLF, 2000). This shift from avalanche accidents in settlements and infrastructure areas towards accidents during recreational activity can best be seen in avalanche accident statistics (→

fig. 2-a). It should be noted that the shift from avalanche accidents in infrastructure areas towards recreational accidents can mainly be seen for highly developed mountain areas in North America, Europe or New Zealand. Emerging countries such as Pakistan or India with avalanche prone infrastructure may still have many fatalities in settlement areas or on transportation routes. However, no reliable data of these countries are available (Zweifel, 2011).

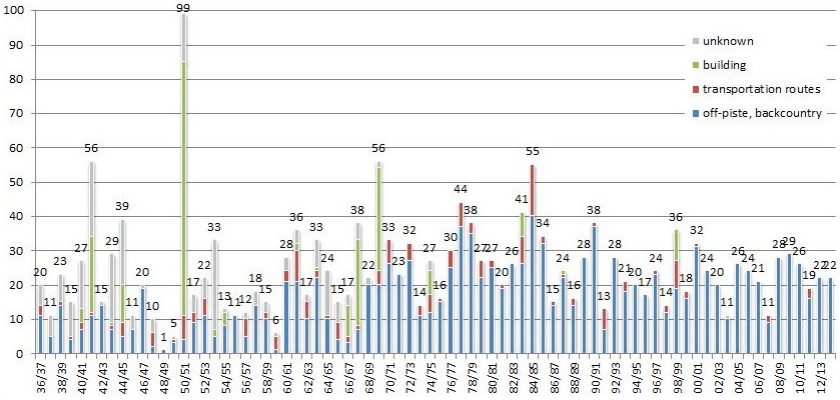

Figure 2-a: Avalanche fatalities in Switzerland from 1936/37 to 2013/14.

In parallel with the development of these extensive safety measures, the population in mountainous terrain has increased, traffic volume on a growing number of infrastructures has increased (SLF, 2000; McClung & Schaerer, 2006) and winter recreation activity as well as the mobility of recreationists have increased considerably. Even if avalanche experts agree on this increase in recreational use, available data on it are sparse (Zweifel, Raez, & Stucki, 2006, Mosimann, 2014). However, nowadays the vast majority of avalanche accidents in western mountain countries happen during recreational activity (Schweizer & Lütschg, 2001; Atkins & Williams, 2001; Jamieson et al., 2010; Jarry, 2011; Techel & Zweifel, 2013; Valt & Pivot, 2013).

It is surprising that avalanche fatalities have not increased in recent decades, at least in Alpine countries such as Switzerland (Harvey & Zweifel, 2008; Techel & Zweifel, 2013), Italy (Valt, Chiambretti, & Zasso, 2009; Valt & Pivot, 2013), France (Jarry, 2011) or Austria (A. Würtele, personal communication, March 26, 2014). Avalanche researchers have highlighted the fact that avalanche fatalities have not increased even though backcountry recreation activity saw a strong increase and attributed this favorable

development to improved avalanche prevention measures such as avalanche forecasting, improved avalanche education (McClung & Schaerer, 2006; Etter, Stucki, Zweifel, & Pielmeier, 2008) as well as improvements in avalanche rescue technology (Brugger et al., 2007; Techel & Zweifel, 2013; Haegeli et al., 2014). In contrast, North America has seen an increase in avalanche fatalities, primarily due to increased snowmobile activity (Atkins & Williams, 2001; Jamieson et al., 2010). Atkins and Williams (2001) mentioned an increase in fatalities amongst snowmobilers from 3.4% in the 1970s to 7.0% in the 1980s and 27.8% in the 1990s in the United States. Consequently, in the 1990s snowmobilers were the largest group within avalanche fatalities amongst the different activities. This trend continued and from 2004/05 to 2013/14 snowmobiles accounted for 35% (101 of 290) of all fatalities in the United States (CAIC, 2015). Overall, it will be an ongoing challenge for avalanche prevention institutions to make increasing numbers of recreationists aware of avalanche danger, to educate them and to give them appropriate avalanche danger information to prevent an increase in avalanche fatalities.

2.1.2 The history of winter sports

The behavior of people who enter winter backcountry terrain changed drastically form historic times until nowadays. In the historic past people tried to avoid winter backcountry terrain, which is prone to avalanches. It was not only dangerous to stay in snowy terrain but also burdensome to move there. People only entered avalanche terrain if it was necessary for their daily live. So, they crossed Alpine passes for example in winter. Consequently large avalanche accidents happened (Bätzing, 2003). In the middle of the 19th century when tourism became popular not only in summer but also in winter, tourists – predominantly wealthy British tourists – began to explore the wintry mountain terrain. It was at the end of the 19th century when several well-known Alpine summits were successfully climbed in winter. However, the real start of winter tourism can be dated to the first half of the 20th century, with milestones such as the first slalom race in Mürren in 1922 or the first winter alpine world championship in 1931, also in Mürren. With the construction of some famous mountain railways (e.g., Corviglia in St. Moritz in 1928 or Parsenn in Davos in 1931) or the first ski lift in Davos in 1934 (Schmoll, 2000) winter mountainous terrain became more accessible (→ fig. 2-b). However, due to bad political and economic conditions, no considerable boom emerged in these years. It was only after the Second World War when winter tourism saw an impressive

boom. Bätzing, a leading expert of Alpine tourism, drew comparisons to the gold rush for the period of 1955 to 1985 (Bätzing, 2003). In this time, a form of mass tourism emerged with more and more people accessing winter backcountry terrain away from the ski areas.

Figure 2-b: First ski lift at Bolgen, Davos in 1934[1].

With this growth in recreationists entering avalanche terrain, recreational avalanche fatalities also experienced a prominent increase from an average of 14.3 fatalities per year in the 1950s, 1960s and 1970s to an average of 21.6 fatalities per year in the 1980s, 1990s and 2000s (→ fig. 2-a). However, it was not only that more people entered winter backcountry; there was also a remarkable change in behavior. While backcountry skiers traditionally mainly skied in spring months with stable snow conditions, nowadays there is considerable skiing activity in all winter months. Furthermore, technical developments and improved skiing skills have allowed recreationists to access much steeper slopes. Even if skiing is the main sport activity done in winter

[1] Picture provided by Archiv Jakob Schuler Skilift & Seilbahnmuseum

backcountry terrain, there has been a remarkable diversification in winter sports with, for example, snowboarding, ice climbing or snowshoeing. All of these activities are mainly done in groups (Procter et al., 2013). This may be due to safety aspects of better chances in rescue situations, but this may also be due to team work aspects of tours, e.g. several recreationists could share the exhausting "work" of "trail breaking".

2.1.3 Characteristics of different winter backcountry activities

Several studies have addressed differences in behavior and risk between different winter backcountry activities. While more traditional activities such as backcountry skiing has shown relatively constant accident frequencies (Techel & Zweifel, 2013), newer activities like snowmobiling or snowshoeing have shown increasing trends in avalanche fatalities (e.g., Atkins & Williams, 2001; Harvey & Zweifel, 2008). However, the real risk of these groups is unclear due to the lack of precise data on frequency of the different backcountry user groups. Approaches to assess this real risk are inconsistent: Zweifel, Raez and Stucki (2006) found off-piste skiers more at risk than backcountry skiers, but Sole (2008) found the opposite result in his study.

Nevertheless, behavior of backcountry skiers has been identified as being different from the behavior of off-piste skiers. While backcountry skiers are more attracted by sporty exercise or summits, off-piste sports are more forced by adrenalin and fun factors (Sole, 2008). It is worth saying that avalanche experts agree that each user group shares a characteristic individual culture and many prevention measures need to be targeted group specific to effectively reach the audience. An off-piste group for example does not usually focus very much on avalanche forecasts due to its limited validity in off-piste terrain. Instead, they focus more on terrain factors or skiing skills. In contrast, backcountry skiers rely heavily on avalanche reports in their planning in order to avoid traveling on dangerous slopes.

The individual character of different recreational groups traveling in avalanche terrain remains a basic challenge for avalanche safety initiatives. They are required to adapt their prevention measures to the needs of these groups. In addition, in order to become accepted in different recreational groups, it is necessary to put oneself in the position of these recreationists and to speak a common language. This implies that prevention messages are better accepted from a peer than from an outsider. That an understanding of the target

public is crucial for effective prevention is an established perspective (see, e.g., Lundgren & McMakin, 2009; Weinstein & Sandman, 1993). In North America, for example, avalanche forecasters who used to travel on skis had to learn to ride a snowmobile in order to become respected within this group and effective with their prevention messages (Staples, Chabot, & Knoff, 2014).

2.2 Recreational avalanche safety initiatives

Activities in winter backcountry imply different risks including avalanche hazard. Recreationists participating in these activities have been seen as voluntary risk takers (Haegeli et al., 2012). Even if most of these recreationists are aware of avalanche danger, some are not (Björk, 2007; Gunn, 2010; Sole, 2008). Avalanche safety initiatives therefore have a two challenges: to make those people aware of avalanche danger who do not expect it, through avalanche forecasts and warnings, and to improve the safety measures of recreationists who do expect it, by focusing on avalanche education, the integration of research findings into practice and avalanche rescue.

2.2.1 Avalanche forecasts and warnings

Switzerland

Avalanche forecasts in Switzerland have a long tradition and go back to the winter of 1936-37 when the Swiss Ski Association published a report of snow conditions for the weekend based on observations of the Commission for Snow and Avalanche Research (SLF, 2013a). Later on, avalanche forecasts were the responsibility of the Swiss army. Only after the Second World War in 1945 did the civil Institute for Snow and Avalanche Research, Davos-Weissfluhjoch become responsible for avalanche forecasts and distributed a report based on 20 observation stations once a week on radio and print media.

Nowadays, the Swiss avalanche forecast is a highly developed report of snow, weather and avalanche conditions in the Swiss mountains. It relies on nearly 200 observers who measure snow and weather parameters, observe snow and avalanche phenomena and provide danger estimates and a multitude of snow profiles (Suter, Dürr, & Harvey, 2010; SLF, 2013b). The report also relies on data from around 170 automated weather stations, detailed weather data from weather models, radar and satellite information, as well as useful feedback from mountain guides, backcountry skiers and rescue organizations (Etter et al., 2008; SLF, 2014). Based on these data, avalanche forecasters judge and weigh the important factors for avalanche formation, such as snow

cover stability, new snow, wind or temperature and make a forecast of avalanche danger for the entire Swiss Alpine area. Avalanche danger is rated using the five-level international avalanche danger level scale (Meister, 1995) for each of the 123 existing warning regions. The danger levels 1 (low), 2 (moderate), 3 (considerable), 4 (high) and 5 (very high) are characterized by specifications on snowpack stability, distribution of avalanche prone locations and size, type and number of expected avalanches. Some countries also add some general recommendations for infrastructure and recreational risk management. For example they recommend having experience in avalanche danger estimation at level 3 or to remain in moderately steep terrain (defined as less than 30 degrees of slope angle) at danger level 4.

As recommended by the European Avalanche Warning Services (EAWS, 2009), avalanche danger is communicated following the information pyramid where important information comes first. The user is guided from the danger level to the danger location (elevation and slope aspect), then the danger description including the typical hazard pattern (Harvey, 2008; Harvey & Nigg, 2009). Further, the forecast gives information on the existing snowpack and its stability, observed avalanche activity, as well as a retrospect and a forecast of relevant snow and weather activity. Finally, the user can also evaluate unchecked raw data (Winkler et al., 2013).

Avalanche reports predict avalanche danger for the next 24 hours twice a day in different languages (Winkler et al., 2013). It is accessible by the public using the internet, smartphones, print media and radio stations. In special situations with expected high risk, the report is also distributed on national television. The avalanche forecasts are provided from November through May depending on the conditions, and for specific days in summer with increased avalanche danger (SLF, 2013b). In addition to avalanche reports, the avalanche warning service also provides snow maps with information on new snow, snow height, relative snow height and snowpack stability, a weekly report on snow and avalanche conditions with considerable background information as well as measured raw data from meteorological stations. Apart from this content, which is publically accessible, the avalanche warning service also provides local safety services, which are responsible for infrastructure safety, with specific information such as early snowfall warnings or specifications of danger for infrastructure at higher danger levels.

Even if nowadays it is impossible to imagine recreational activity in avalanche terrain and safety measures without an avalanche forecast, it has its

limits. The avalanche report cannot answer the "go-no go" question for the individual slope decisions of recreationists. Since the forecast is only a regional general danger estimate, it cannot give evidence of the stability of a particular slope. Furthermore, the predicted avalanche danger level can be wrong, for example, due to unexpected weather changes or locally different snow conditions. Verifications of predicted avalanche danger levels propose a score of around 60% to 80%. However, the verification of avalanche danger is delicate (Föhn & Schweizer, 1995; Schweizer, Kronholm, & Wiesinger, 2003; Jamieson, Campbell, & Jones, 2008). These limitations of avalanche reports require backcountry recreationists to be able to make their own decisions based on local observations, their experience in avalanche danger estimation and their knowledge of avalanche formation.

International

Even if the Swiss avalanche report is very comprehensive, other alpine and North American countries provide reports of similar quality. Their reports are based on the same data sources as described above and also follow the five-level danger scale. In addition, many countries have started to use avalanche danger patterns, whereby the warning service of Tyrol, Austria played a key role in the development of these patterns (Mair & Nairz, 2013). While European countries use the European avalanche danger scale, which was developed in 1993, North America uses a slightly adapted version of this scale (Statham et al., 2010). Aiming to harmonize avalanche reports and use a common language, European avalanche warning services organized as EAWS (Nairz & Kriz, 2013) developed through their regular exchanges a common multilingual glossary on snow and avalanche terms (Stucki et al., 2005). In a similar way North American warning institutions regularly meet for harmonization.

Countries where recreational winter backcountry activities are only increasing nowadays, e.g. eastern European countries or Scandinavian countries, are just beginning to produce avalanche reports (see, e.g. Engeset, 2013; Juras et al., 2013). However, they are developing very quickly since they can benefit from advances existing in countries where avalanche warning has been highly improved over the last decades.

Human factors in avalanche reports

Avalanche forecasts clearly focus on the avalanche hazard and do not include risk factors containing information of usage frequency (e.g.

information on how many people are traveling in the mountains on a specific day). However, some countries have integrated recommendations for backcountry users into the European avalanche danger scale as well as in their daily forecasts. Usually these recommendations advise users to travel only in avalanche terrain if they have considerable experience in avalanche danger estimation. To my knowledge, no group-specific advice has been used in avalanche reports so far.

2.2.2 Avalanche education

In this section I give a short overview of the educational formats that exist for recreationists who travel in avalanche terrain. My focus is not on education for avalanche professionals (e.g. mountain guides or ski patrollers).

Avalanche courses

Generally, avalanche training is organized in many different ways in different countries. While in Canada and in the United States standardized levels of avalanche training exist (AIARE, 2014; CAC, 2014), avalanche training in Europe is organized in different ways in each country. Usually avalanche training in Europe is provided by mountaineering schools or Alpine clubs. Over all, avalanche courses have the goal to teach recreationists skills in avalanche hazard evaluation and safe travel behavior and usually take place in the field. However, they vary from one-hour awareness courses to up to two-week courses with in-depth training.

A main focus of these courses is the understanding of weather, snow properties, avalanche formation and subsequently avalanche hazard interpretation and safe travel behavior. Recently, human factors have gained considerable attention in avalanche training courses.

Avalanche safety literature, leaflets and tools

Another stream of avalanche education provides avalanche safety books, which provide basic knowhow for recreationists (e.g., Munter, 2003; McClung and Schaerer, 2006; Tremper, 2008; Harvey et al., 2012). These works, which are published by experienced avalanche experts, include up-to-date research findings and transfer this knowhow to practitioners, such as recreationists, in an easily understandable way. Some decision aid tools have been based on such works, such as Munter's reduction method (1997) which stands at the forefront, the Stop-or-Go method (Larcher, 1999), the SnowCard (Engler,

2001) and the Avaluator (Haegeli, 2010). More details on these tools are given in paragraph 2.3.6.

Since avalanche knowledge is itself complex and avalanche education teaches recreationists in many varying formats and with a range of content, avalanche prevention institutions have taken the initiative to build a common sense of basic avalanche education content. In Switzerland, the Swiss core training team of Snow Sport Avalanche Accident Prevention (KAT), which includes a plurality of important stakeholders in the avalanche community, published the leaflet "Caution - Avalanches!" (Harvey et al., 2009) to be used as the basis for avalanche education. In a similar way Germany and Austria also make efforts for a common direction for avalanche education.

E-learning

The latest stream of avalanche education types includes e-learning, mobile applications and educational trails. A milestone in e-learning was "WhiteRisk", an interactive learning tool on CD-Rom published by the WSL Institute for Snow and Avalanche Research SLF and the Swiss working insurance company SUVA and authored by the Swiss avalanche expert Stephen Harvey (Harvey, 2006) which rapidly became very popular and nowadays is available in a web-based version in German, French, Italian and English. Initially, e-learning tools mainly addressed a younger public; however, experience shows that users of "WhiteRisk" are in all age classes.

"WhiteRisk" also provides a tour planning tool which can be applied on smartphones in a mobile manner. Beside of this tour planning tool, the WhiteRisk App also provides information on the actual avalanche report and tool to evaluate the danger in the field. Mobile applications have also been used for educational trails where users had the chance to follow a winter backcountry trail with different information points in order to learn avalanche prevention aspects in a combination of field experience and information provided on a smartphone.

2.2.3 The role of research in avalanche safety measures

Avalanche research traditionally focuses on the basic understanding of avalanche formation, including fracture processes related to avalanche release (see e.g., Heierli, Gumbsch, & Zaiser, 2008; van Herwijnen, Schweizer, & Heierli, 2010), spatial variability within the snow cover (for a comprehensive review see Schweizer, Kronholm, Jamieson, & Birkeland, 2008), slab properties for avalanche formation (van Herwijnen & Jamieson, 2007; Gaume,

van Herwijnen, Schweizer, Chambon, & Birkeland, 2014; Schweizer, Reuter, van Herwijinen, Gauthier, & Jamieson, 2014) or investigations of snow stability (Winkler and Schweizer, 2009; Schweizer and Jamieson, 2007).

Although such basic research findings cannot usually be directly applied in practice, the avalanche research community is normally strongly connected with avalanche education, mountain guides or other practitioners. Many basic education instruments such as the e-learning tool White Risk with its "cool tools" (Harvey, 2006; Harvey, Reuter, & Mitterer, 2014) have their origin in avalanche research centers. The best known platform of knowledge sharing between research and practitioners is the International Snow Science Workshop which has exemplified the slogan "A merging of theory and practice" since 1976 and nowadays has up to 1,000 attendees every two years (www.issw.net).

2.3 The decision making process

The human decision making process gained considerable attention in economical and psychological research in recent decades and in neurological science in recent years. Since researchers realized that humans often do not decide fully rationally, behavioral aspect of the decision making process came into reseracher's focus. The decision situation in avalanche terrain is usually complex. From the characterization of a realistic decision making process by Klein (2003) the following elements could be involved in the decision situation in avalanche terrain: time pressure, high risks, limited experience of decision makers, imperfect information, ambiguous goals, an undefined approach to the decision process, influencing environments, dynamic situations with varying conditions or difficulties in team coordination in the decision making process.

The avalanche researcher Ian McCammon analyzed the decision making process of wilderness leaders and recreationists in avalanche terrain. In 2001, he presented a framework of recreationists' decision making strategies which still summarizes very well the way people deal with decisions in an outdoor and risk context. Following his explanation, wilderness leaders follow a mix of heuristics and analysis in their novice stage turning to a mix of analysis and expertise in their expert stage (McCammon, 2001a; → fig. 2-c). I will look at these three strategies in greater detail in the following sections.

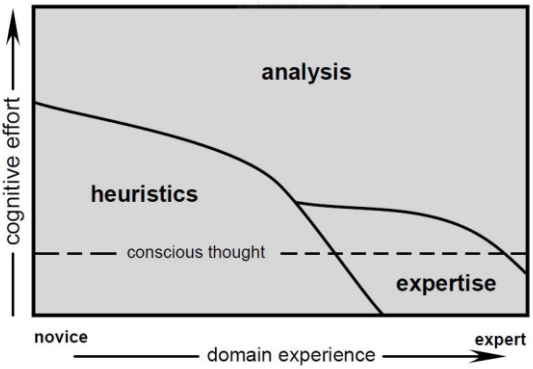

Figure 2-c: Framework of decision making strategies as used by wilderness leaders.[2]

The analysis of decision making as described in this section is focused on individual aspects. Group-specific aspects of the decision making process are described in paragraph 2.4.4.

2.3.1 Analytic decision making

Analytic decision making which can be based on certain or uncertain factors is a way to decide based on facts and calculations. McCammon (2001a) mentioned an example of a route time calculation for the planning of a trip to show how analytic decision making can work. Traditionally, avalanche educators assumed that a better understanding of the avalanche phenomena helps recreationists to make better decisions. However, the avalanche phenomena is of such complexity that it is not possible for most backcountry recreationists to gain such an in-depth understanding of the phenomena in order to apply a knowledge-based decision approach (Haegeli, et al., 2010).

Decisions in avalanche terrain may follow an analytic decision process in simple problems with clear signs. For example, if we are at the base of a steep slope which we have to climb to reach the summit and have had clear danger signs such as cracking or whoumpfing in similar slopes before, it is easy to conclude that the slope ahead should not be entered. However, if we imagine the same situation without the presence of clear danger signs, analytic decision making is no longer possible. We then deal with several factors which all have

[2] From *Decision making for wilderness leaders: Strategies, traps and teaching methods* (p. 9) by McCammon, I., 2001a. Paper presented at the Wilderness risk manager's conference, Lake Geneva, WI. Reprinted with permission from author (see Appendix A.6).

their uncertainties, such as the avalanche danger level from the forecast, the snow stability on the slope or the spatial variability of the snow cover.

Stating that recreationists in avalanche terrain may not follow a fully analytical approach in decision making, researchers have sought alternate solutions for the decision making process.

2.3.2 Heuristic decision making

McCammon (2001a) proposed heuristics as an alternative decision making approach in avalanche terrain. Heuristics refer to simple rules (Gigerenzer, Todd, & ABC Research Group, 1999) based on a few key elements aiming to simplify decisions in a complex environment where not all relevant factors can be taken into account. In general, heuristics work well most of the time and without substantial cognitive effort – which is what makes them so easy to use. However, they may lead into dangerous situations if they are used inappropriately.

Analyzing avalanche accidents, McCammon (2002, 2004) found that heuristics can in fact lead to dangerous situations when used in the wrong context and identified six heuristic traps. (1) The *familiarity* trap is when people tend to rely on the memory of past actions to guide their behavior in familiar settings. This means that they simply behave as they have done before in a setting rather than to go through the trouble of figuring out what is appropriate every time. Most of the time, the familiarity heuristic is reliable. But when the hazard changes and the setting remains familiar, this rule of thumb can become a trap (McCammon, 2004). This heuristic is based on the availability heuristic originally identified by Amos Tversky and Daniel Kahneman (1974). (2) The *acceptance* trap is related to the fact that people want to be accepted and respected by the rest of the group. This means it is often easier to "go along with the crowd than to speak up when we think there's a problem" (Tremper, 2008, p. 287). The acceptance heuristic can lead to problematic decisions in the direction of more risk taking especially in peer groups with mixed genders (Tremper, 2008). (3) The *commitment* trap (also called *consistency* trap) is connected to the fact that people tend to follow an initial decision regardless of changing conditions. It is reliable to use this heuristic most of the time, but if conditions change towards more hazard it can become a trap just to follow an initial decision. The consistency heuristic is especially at hand in the presence of specific goals like summits or "coming back home" and is reinforced when there is time pressure (McCammon, 2004;

Tremper, 2008). (4) The *expert halo* trap describes the effect that we draw conclusions from the known characteristics of a person on unknown characteristics of the same person. In our avalanche related problem, this can mean that we follow the decisions of a person we consider to be an expert who is probably not an expert. The person in question may just be older, the best skier in the group or a social leader. (5) *Social facilitation* describes the effect that humans perform differently in the presence of other people. "In other words, when a person or group is confident in their skills, they will tend to take more risks using those skills when other people are present than they would when others are absent" (McCammon, 2004, p. 5). More details on this trap are given in section 2.4.6. Finally, (6) the *scarcity* trap describes the trend of recreationists to take more risk when they have the opportunity to make the first tracks on a slope. Cialdini (2001) described it as a tendency to value resources or opportunities in proportion to the chance that you may lose them, especially in competitive conditions. The six heuristic traps mentioned by McCammon have been established widely in avalanche safety literature (e.g. Tremper, 2008; Fredston & Fesler, 2011; Harvey et al., 2012).

Since we use many heuristics in daily situations, they often operate in an unconscious manner. This is the reason why it is especially hard to combat such heuristic traps.

2.3.3 The role of training and expertise

Training in avalanche courses and experience are most often cited as very important factors in improving decision making (McClung & Schaerer, 2006; Tremper, 2008; Harvey et al., 2012). In Switzerland, experience is even anchored in the danger level scale as a factor recommended at danger level 3 (SLF, 2013b). However, empirical studies have shown that training per se does not prevent recreationists from being involved in avalanche accidents (Tase, 2004; Sole, 2008). It was the Swiss avalanche expert André Roch who said "remember, the avalanche does not know you are an expert" (Perrin, 2002). In avalanche risk evaluations with respect to training level one should, however, consider that avalanche experts usually spend much more time in the mountains than avalanche novices, an effect which increases overall risk of an avalanche accident for experts. Not only in winter backcountry sports, it is recognized that training changes people's behavior usually in such a way that they try to maximize their benefits from risks they see as acceptable (McCammon, 2004). This effect is called risk homeostasis (Wilde, 1982).

Overall, this means that avalanche training and gaining experience does not make people's avalanche decisions less risky (Tremper, 2008).

That gaining expertise solely by trial and error when traveling in avalanche terrain may somehow be ineffective could be caused by a so-called wicked learning environment (Hogarth, 2001). This means we can ski a slope without triggering an avalanche and then decide that the slope was safe. However, due to the spatial and temporal variability of the snowpack, we cannot conclude a slope is safe in the case of not triggering an avalanche. Due to this more or less meaningless "feedback" on snow cover stability, recreationists traveling in avalanche terrain tend to be systematically overconfident in their decisions. It has been shown that overconfidence is inversely proportional with useful feedback (Russo & Schoemaker, 1992).

2.3.4 Naturalistic decision making (NDM) and the role of patterns in avalanche practice

Avalanche researchers (e.g. McCammon, 2001b; Adams, 2005; Stewart-Patterson, 2008) have noted that more experienced recreationists are particularly characterized by a *Naturalistic Decision Making (NDM)* process (Klein, Orasanu, Calderwood, & Zsambok, 1993), where experts such as mountain guides or ski patrollers try to base their decisions on their experience. Klein (1998) later explained expert decision making with the model of recognition-primed decisions (RPD). This model explains people's ability to make quick and efficient decisions in complex situations. According to RPD, experts are able to intuitively recognize particular situations as typical of a category of situations with familiar characteristics. In contrast to heuristics, experts are able to recognize patterns of key features instead of only situational key features (McCammon, 2001b). Adams (2005) further stated that "In the RPD model, processes of intuition and analysis synthesize. The process of pattern matching is intuitive, and provides the recognition of the situation and an understanding of how to react. The process of mental simulation, (imagining how those reactions will play out), is analytic, and provides the deliberate thinking that enables the decision maker to see if the reaction is going to work (Klein, 2003)" (Adams, 2005, p. 69-70).

In order to understand the complex avalanche formation process, typical avalanche patterns have gained considerable attention in recent years (Atkins, 2005; Harvey et al., 2009; Statham et al., 2010, Lazar, Greene, & Birkeland, 2013; Mair & Nairz, 2013). The decision making approach with defined

patterns and subsequent recommended actions for recreationists is indeed related to the model of RPD, but then applied in a simplified way. One could also relate this approach to heuristic decision making.

While Austrian forecasters have suggested ten different avalanche danger patterns (Mair & Nairz, 2013), and the Canadian avalanche Center *Avalanche Canada* eight patterns (CAC, 2014), the Swiss core training team of Snow Sport Avalanche Accident Prevention (KAT) have agreed on four typical avalanche danger patterns (Harvey et al., 2009) characterized by typical signs and typical distributions of dangerous spots. These are linked with recommendations for recreationists (→ tab. 2-a).

Table 2-a: Avalanche danger patterns summarized from Harvey et al. (2009).

Pattern	Typical signs	Distribution of dangerous spots	Recommendations
New snow	▪ Critical new snow depth ▪ Alarm signs (e.g. recent avalanches)	▪ Dangerous areas cover a wide area	Wait
Wind loading	▪ Snow drifting signs ▪ Cohesive snow ▪ Alarm signs (e.g. recent avalanches, cracking)	▪ Wind shadows (leeside, terrain brakes, gullies) ▪ High elevation and close to ridges ▪ Variation within a small area	Avoid
Wet snow	▪ Rain ▪ Overcast weather ▪ High temperatures, strong solar radiation ▪ Deep ski penetration ▪ Natural avalanches	▪ Varying aspects and elevations depending on the time of year and day	Return early, wait for cooling
Old snow	▪ Weak layer within the snowpack ▪ Alarm signs (Whoumpfing sounds)	▪ Zones with relatively shallow snow cover ▪ Terrain transitions ▪ Rocky outcrops ▪ Often on north facing slopes	Travel defensively

These avalanche patterns or problems nowadays are established in avalanche forecast reports and help recreationists to identify the situation.

2.3.5 The role of intuition

Iain Stewart-Patterson (2008) presented the role of intuition in the decision making process in avalanche terrain at the International Snow Science Workshop in Whistler, 2008. He concluded that the type and characteristics of the environment in which the intuition is formed plays a crucial role and called for more research in that area in order for recreationists to learn how to distinguish between functional and dysfunctional intuitions (Hogarth, 2001).

However, considerable research is needed before recreationists may be able to deal with intuitions in an appropriate way. Nowadays intuition is often used to masquerade poor decisions for good ones, which is, of course, dangerous (Stewart-Patterson, 2008). Munter (1997) plead to follow intuitions only for precautionary measures: follow your intuition in the negative case, that is, when your gut feeling is telling you to turn back. Do not follow your gut feelings when they tell you to go ahead in an ambiguous situation. This comes close to the general precautionary principle where the burden of proof falls on those who want to go ahead.

2.3.6 Decision frameworks and aids

With the appearance of a strategic risk reduction approach in the early 1990s, the decision making process in principle gained attention in avalanche safety research. It was the goal of avalanche prevention initiatives to bring more structure into the decision making process and therewith, facilitate this process for recreationists. Munter (1992) developed a *3-by-3* planning tool which structured the decision making process into three stages – trip planning at home, assessment of the conditions in the terrain and final decisions before entering an individual slope, and into three factors – conditions, terrain and human factors. In Switzerland, the *3-by-3* matrix has been widely included in avalanche safety literature and official leaflets (Harvey et al., 2009). In a similar way, Fredston and Fesler (1994) illustrated an approach for avalanche hazard estimation by centering humans as decision makers in a triangle including snowpack, weather and terrain as avalanche formation factors.

To facilitate the decisions at these three single stages – at home, in the terrain and before entering the slope – Munter (1997) proposed a risk-reduction method (Reduction Method), a formula which calculates a risk factor based on

the degree of danger indicated in the avalanche report, slope angle, slope aspect, elevation and group factors. Out of Munter's Reduction Method, several rule-based decision tools have been developed including the Stop-or-Go Method (Larcher, 1999), the SnowCard (Engler, 2001), the NivoTest (Bolognesi, 2001), the Avaluator (Haegeli, 2010, → fig. 2-d) and the Graphical Reduction Method (GRM, Harvey, 2002). These tools usually rely on a combination of terrain factors (mostly the slope angle) and avalanche conditions (mostly the danger level from the avalanche forecast) leading to a risk level which helps people to decide whether to go or not to go, usually focusing on the single slope decision. Interestingly, human factors played only a secondary role in most of these decision-making aid tools.

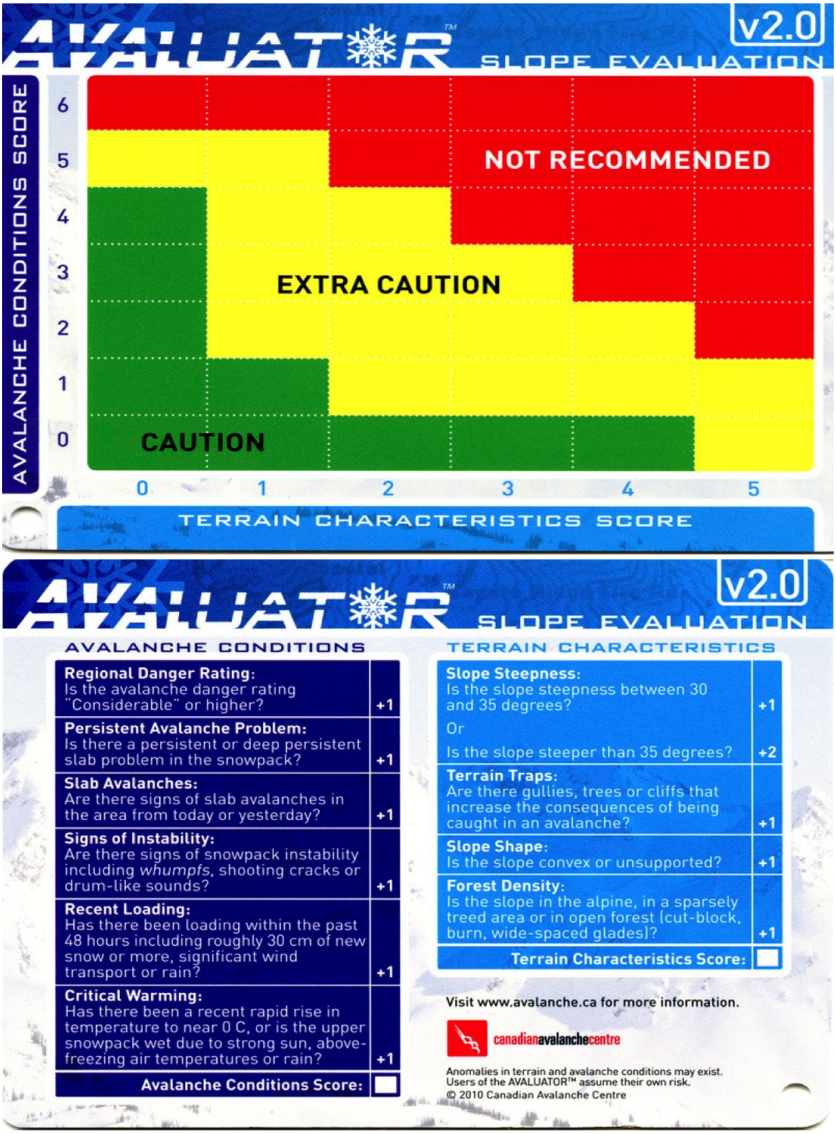

Figure 2-d: Front and backside of Avaluator 2.0: A decision making aid tool for recreationists traveling in avalanche terrain.[3]

[3] Printed with the permission of Canadian Avalanche Centre, the publisher and owner of Avaluator 2.0 (see Appendix A.6).

The potential of decision tools have been demonstrated by analyzing avalanche accidents. McCammon and Haegeli (2007) found that 60% to 92% of accidents could have been prevented if the accident party had used decision aids. Further, Haegeli et al. (2010) compared amateur decisions with and without decision tools and found that decision tools have the potential to steer recreationists towards more avalanche hazard sensitive behavior. However, it remains unclear whether and how recreationists apply decision aids in their decision process.

2.4 Group dynamics concepts

Group dynamics is a relatively young science field merging psychology and sociology and focuses on a diversity of processes which take place in and across groups. Lewin (1951) "described the way groups and individuals act and react to changing circumstances" and "named these processes *group dynamics*" (Forsyth, 2010, p. 14). Modern group dynamics include processes of group formation, group structure, influence, power, leadership, performance, decision making, conflict and intergroup relations (Forsyth, 2010). In the following sections, I focus on group formation and structure, leadership, decision making, communication and intergroup relations which I assume to be key concepts for groups traveling in avalanche terrain.

2.4.1 Group formation

It is an established concept in group dynamics that groups go through different stages over time. Tuckman (Tuckman 1965, Tuckmam & Jensen, 1977), for example, identified the five stages of forming (orientation), storming (conflict), norming (structure), performing (work) and adjourning (dissolution) (Forsyth, 2010). In each of these stages, group members follow different processes and concepts. Accordingly, in each of these stages groups show different problems in behavior and performance. For recreationists who travel in avalanche terrain it would in my opinion be important to be aware of these different group development stages and their characteristics in order to better understand problematic behavior patterns. However, to my knowledge, little attention has been paid to this aspect within groups traveling in avalanche terrain. Therefore I focused on this aspect in study III in the way that I compared group performance of newly formed groups with group performance of well established groups.

2.4.2 Group structure, group size

Group classifications could be seen as a prerequisite for any group related research. As Forsyth (2006) mentioned, "researchers often begin their analyses of group processes by drawing distinctions between the different types of groups they study" (p. 5). Cooley (1909) distinguished between primary groups (e.g. family, friends) whose relationship is direct, intimate and personal, and secondary groups (e.g. work groups, unions) whose relationship is indirect, less intimate, impersonal and formal. In our avalanche context, the distinction between planned and emergent groups (Cartwright & Zander, 1960) should be considered. Lickel and his colleagues (2000) divided groups into intimacy groups (e.g. families, romantic couples or close friends), task groups (e.g. teams, neighborhood associations), weak associations (e.g. crowds, audiences) and social categories (e.g. women, Swiss citizens).

In avalanche awareness research, four traditional group types have been used and are defined based on particular criteria: (1) the method of travel (e.g. skiers, snowboarders, snowmobilers, snowshoers; Harvey & Zweifel, 2008), (2) primary activity (e.g. backcountry skiers who ascend by their own power vs. off-piste skiers who use the help of transportation in ski areas to climb up; Atkins & Williams, 2001; Tschirky, Brabec, & Kern, 2001; Harvey & Zweifel, 2008), (3) whether groups are guided or not (Harvey & Zweifel, 2008) and (4) the level of experience of the groups or individuals (Conger, 2005; Richards & Schimelpfenig, 2012). So far, less attention has been paid to classification schemes from group dynamics concepts. However, I assume there is potential value in investigating these group classifications among recreationists who travel in avalanche terrain, since I believe there may be considerable differences in the approaches used by these groups, for example, a group of friends compared to a family or to a professionally guided group. Therefore I focused on group structure aspects in Study III and distinguished different group types in the qualitative analysis.

Group size has been the most discussed factor among groups that travel in avalanche terrain. As shown in avalanche safety literature, the higher risk of large groups has been explained by the increased load on the snow cover and an increased chance of hitting a weak spot in the snow cover. Schweizer and Camponovo (2001) investigated the zone a skier influences in the snow cover and discussed the chances of triggering an avalanche. They found that the zone of influence of a skier is rather small, well below one square meter and

accordingly “stress peaks of two individual skiers walking right behind each other are not cumulative” (p. 319). With respect to snow cover and weak layer characteristics, Schweizer and Camponovo (2001) suggested that group triggering is rather due to larger weak areas that failed than to local higher stresses. The group situation which Schweizer and Camponovo investigated refers to the ascent situation when backcountry skiers usually walk in a row in the same ski track. However, in the downhill situation, a group of skiers covers a bigger area than a single skier would, since they usually ski in different tracks that are horizontally spaced and therefore, the risk of hitting a weak spot is higher.

In avalanche safety practice, several measures to reduce load on the snowpack have been established, such as keeping distances between skiers in ascent or skiing dangerous slopes downhill one by one (see, e.g., Volken, Schell, & Wheeler, 2007; Tremper, 2008; Harvey et al., 2012). It has also been established to rate single skiers as a low additional load and a group of skiers as a high additional load (EAWS, 2014). These additional loads play an important role in the European avalanche danger scale (Meister, 1995).

I addressed the aspect of group size with respect to avalanche risk in Study II.

2.4.3 Leadership

Regarding groups traveling in avalanche terrain, leaders have been attributed with the function of providing the group with good decisions and subsequently reducing avalanche risk (Adams, 2005; Tremper, 2008). While some studies have found that fatalities in guided groups did decrease (Harvey & Zweifel, 2008), a trend which supports the view that leaders reduce avalanche risk, other studies found a higher risk exposure score within groups with a leader compared to groups without a leader, in particular in groups with a leader without formal avalanche training (McCammon, 2004). However, all of these studies focused on risk factors of leadership and none of this research applied existing theories from sociology.

How leadership affects group performance has been a social research interest for a considerable period of time (see, e.g., Fiedler, 1964; Liden, Sparrowe, & Wayne, 1997; Vroom & Yetton, 1973) and is nowadays the focus of many organizational studies (e.g., Pfeffer & Veiga, 1999; Bruch & Walter, 2007). Forsyth (2010) has noted a handful of theories which explore leadership

effectiveness. I found theories which were more related to team and workplace situations in a professional environment such as the Fiedler's contingency model (Fiedler, 1964), the leadership grid (Blake and Mouton, 1980), the situational leadership theory (Herysey, Blanchard, & Johnson, 2001) or theories from the latest stream of leadership effectiveness research which include concepts such as charismatic (see, e.g. Conger & Kanungo, 1987), transformational (e.g., Burns, 1978) and visionary leadership (Sashkin, 1988) (paraphrased from Walter, 2010) and therefore did not suit very well the recreation situation in my dissertation context. More useful for my context were the participation theories from Lewin, Lippitt, & White (1939) who proposed three main leadership styles: Autocratic, democratic or laissez-faire and in particular the normative model of decision making for groups from Vroom and Yetton (1973). They investigated the influence of leadership on group decisions and developed a normative model. They stated five types of decision making (paraphrased from Forsyth, 2006: p. 339):

- *Autocratic I (AI)*: The leader makes the decision on his own, using the information available to him.
- *Autocratic II (AII)*: The leader collects information from group members and then makes the decision alone. The group members' involvement is just providing information.
- *Consultative I (CI)*: The leader shares problem to relevant followers individually and seeks their ideas and suggestions and makes decision alone. Here followers do not meet each other and the leader's decision may or may not reflect his followers' influence. So, here followers' involvement is at the level of providing alternatives individually.
- *Consultative II (CII)*: The leader shares problem to relevant followers as a group and seeks their ideas and suggestions and makes decision alone. Here followers meet each other, and through discussions they understand other alternatives. But the leader's decision may or may not reflect his followers' influence. So, here followers involvement is at the level of helping as a group in decision-making.
- *Group II (GII)*: The leader discusses problem and situation with followers as a group and seeks their ideas and suggestions through brainstorming. Leader accepts any decision and does not try to force his idea. Decision accepted by the group is the final one.

I used the model of Vroom and Yetton (1973) in study III (chapter 6) to compare and discuss different leadership styles amongst winter backcountry recreationists.

2.4.4 Group decision making and its pitfalls

Although groups have been seen as better decision makers than individuals in general (see, for example, Stasser & Dietz-Uhler, 2001; Zimbardo, Butler, & Wolfe, 2003; Ruscher & Hammer, 2006; Glick, & Staley, 2007), groups are prone to make defective decisions due to group polarization or groupthink (Di Salvo, Nikkel, & Monroe, 1989; Forsyth, 2010).

Group polarization

Group polarization describes the tendency that group decisions are more extreme than individual decisions (Myers & Lamm, 1976). This can be toward a riskier decision, known as risky shift (Stoner, 1961, 1968) or towards a more cautious decision, also known as cautious shift (Wallach, Kogan, & Bem, 1962). Whether a group shifts towards more risk or towards more caution depends on their average initial preferences. Groups whose members are initially on average on the cautious side, shift towards more caution and groups whose members are initially on the risky side, shift towards more risk.

The effect of risky shift has been in the focus of avalanche safety studies for a long time (e.g., Munter, 1992, 1997; Tremper, 2008, Harvey et al., 2012). Following the theory of group polarization (Myers & Lamm, 1976), groups with members who show an above-average risk appetite would be especially susceptible to risk shift. This means that groups with individuals who have been shown to be risk takers, such as men aged between 25 and 29, off-piste skiers, people seeking adventure rather than nature or individuals with long years of expertise (Sole, 2008; Gunn, 2010) would be prone to risky shift and should therefore be aware of a shift towards more risk in their group decisions.

Several studies further addressed the relationship between group size and risky shift. Teger and Pruitt (1967) found an increasing shift with extended group size. However, Bennett, Lindskold, and Bennett (1973), who compared groups of four and groups of eight people, found a risky shift only in groups of four. Barnir (1998) analyzed 14 different studies on the topics of choice shift, risky shift and polarization and concluded that larger groups and groups whose members are not very familiar with each other will shift to risk. This agrees

with existing avalanche safety practice who mentions an increase of risk with larger groups (e.g. Tremper, 2008; Harvey et al., 2012).

Groupthink

A further well-known group decision pitfall is the phenomenon of groupthink, "a mode of thinking that people engage in when they are deeply involved in a cohesive in-group, when the members' striving for unanimity overrides their motivation to realistically appraise alternative courses of action" (Janis, 1982, p. 9). Janis analyzed symptoms of groupthink and finally identified cohesiveness as a prerequisite of groupthink, stating that members in a cohesive group do not speak out against other group members and want to have good relations whatever the costs are (Forsyth, 2010). Janis emphasized that insulations of groups and leadership style may cause groupthink. He found that groups under stress are more likely to make faulty decisions. Kelly's studies, for example, have highlighted the negative influence of time pressure on group performance (Kelly & Loving, 2004; Kelly & Karau, 1999).

A number of research findings have reported decreasing cohesion as group size extends (Bogart & Lundgren, 1974; Fisher, 1953; Seashore, 1954). Following Janis' explanation of groupthink, which sees the attempt to create cohesion as the primary factor of groupthink, one would expect a decrease in groupthink with increasing group size. However, in some recent discussions of Janis' groupthink theory, the role of cohesiveness has become less and less obvious (Mullen, Anthony, Salas, & Driskell, 1994). Instead, Bright (2010) found a significant increase in groupthink as group size increased from two to seven for groups traveling in avalanche terrain. Cohesiveness may be more a function of group development than of group size (Wheelan, 2009).

2.4.5 Communication

Communication skills are regarded as crucial for groups to perform effectively not only in outdoor recreation settings (see, e.g., Priest & Gass, 1997; Raiola, 2003; O'Connell & Cuthbertson, 2009; Kjærgaard et al., 2013) but also in organizational settings (see, e.g., Bambacas & Patrickson, 2008; Mengis & Eppler, 2008; Garicano & Wu, 2012). On the other hand, communication skills have been seen as a main pitfall in group decision making (Di Salvo et al., 1989). The importance of open communication has also been highlighted in avalanche safety literature (Tremper, 2008; Fredston & Fesler, 2011; Harvey et al., 2012). Poor communication has been identified as an important factor causing avalanche accidents (Atkins, 2001). Adams

concluded in her study on avalanche experts that "communication was fundamental to the creation of shared mental models in individuals, teams, organizations, and professional associations in my study. Environments that encouraged effective and open communication resulted in improved judgment and decision actions, and reduced subjective biases that may have been present in an individual decision-maker" (Adams, 2005, p. 213).

Many studies have reported a loss of communication quality when group size increases (e.g., Dunbar, 1996; Burgoon et al., 2002; Lowry, Roberts, Romano, Cheney, & Hightower, 2006). Lowry and his colleagues (2006) attributed process losses due to bigger groups, among other factors, to the social phenomena of evaluation apprehension. Evaluation apprehension is the effect when group members do not speak out their ideas because they are afraid of criticism from other group members (see, e.g., Lamm & Trommsdorff, 1973). Dunbar (1996) found that communication starts to go wrong when group size goes above four people and noted the development of sub-groups. The negative correlation between group size and communication has been confirmed in the context of recreational groups traveling in avalanche terrain by Bright (2010).

2.4.6 Intergroup relations

Very often recreationists travel in winter backcountry in the presence of other groups. McCammon referred to this aspect with the *social facilitation* trap (McCammon, 2002, 2004). For recreationists, it is important to understand whether and how other groups influence the behavior of their own group. While the disposition within a group usually is quite harmonic, the level of *competitiveness* between different groups is usually much higher (Pemberton, Insko, & Schopler, 1996). Competition is not the only problem when traveling in the presence of other groups. Do (2014) effectively describes an example of an avalanche accident, where the group was heavily influenced in their decision by another group that decided to ski on a specific slope in critical avalanche conditions. This other group did not trigger an avalanche and hence the group decided to ski on the slope too. Although it has been mentioned for years that existing ski tracks in a slope do not imply that the slope is stable (see, e.g., McClung & Schaerer, 2006; Tremper, 2008; Harvey et al., 2012), recreationists notice existing tracks and – whether consciously or unconsciously – base their decisions on existing tracks.

A case presented by Zweifel (2012a) shows that there is usually little or no communication between different groups and hence problems in route selection can cause dangerous situations. In addition, in off-piste terrain with much more ski traffic than in backcountry terrain, the problem of several groups in the same potential avalanche slope is omnipresent, and useful concepts to face this problem do not currently exist.

2.5 Discussion of the literature

To approach the avalanche safety challenge holistically, it is necessary to scan different research realms such as avalanche related research, sociology and social psychology, and decision making theories. However, it was not obvious from the beginning which disciplines provide the most useful content for my research question. Research related to the human dimension of the avalanche problem was in fact very important as a base for this dissertation. However, only one study exists addressing explicitly group dynamics aspects (Bright, 2010). Many studies related to social avalanche safety research concentrated on the analysis of human risk factors (e.g., Gunn, 2010; Sole 2008; Haegeli, Gunn, & Haider, 2012; Tase, 2004) or on the decision making process of individuals (e.g., Furman, Shooter, & Tarlen, 2012; Haegeli & Haider, 2008; Haegeli, Haider, Longland, & Beardmore, 2012; McCammon, 2002, 2004, 2009; Stewart-Patterson, 2008). However, the newer avalanche books contain some information on group aspects too (Harvey, Rhyner, & Schweizer, 2012; McClung & Schaerer, 2006; Tremper, 2008). Nevertheless, it was necessary to review other disciplines as well. I found most useful concepts in group dynamics research. While some important basic findings from decision making research already have been applied to avalanche safety research – pioneered by McCammon (e.g., 2001a, 2001b, 2002) but later also by other avalanche researchers (e.g., Haegeli & Haider, 2008; Stewart-Patterson, 2008; Furman, Shooter, & Schumann, 2010) – only little attention has been given to group dynamics research so far. This is why I applied some existing group dynamics concepts (e.g., the normative model of decision making by Vroom and Yetton (1973) or the group development theories of Tuckman (1965)) to my research. Further, group dynamics educational books such as Baron and Kerr (2003) or Forsyth (2010) guided me through the group dynamics research field. Since group dynamics include a plurality of different topics it was necessary to focus on a treatable amount of concepts for this dissertation. I did this focusing process in a two-step process: firstly, I decided

for a selection of topics based on my longtime experience in avalanche safety practice; secondly, I focused on themes which seemed most interesting and promising for this research after the experience from the group interviews. This led me to the three key topics of group formation and structure, the group decision making process and leadership. However, it is clear to say that this is on the one hand only a narrow aspect of the whole group dynamics theories and on the other hand, I cannot provide evidence that these topics are the most important ones for my research question. Figure 2-e gives a generalized overview of key literature as used in the present thesis.

I further have to mention that I did not include findings from medicine and aviation in this dissertation. Even if a pilot or medical crew is faced with high-stakes decisions which have some similarities to decisions in avalanche terrain, the implications are of a fundamentally different character in these two fields as former represent professional environments compared to the recreational environment in winter backcountry activity. Professional institutions can, for example, force flight crews to use checklists; in the recreational field this is not possible. Avalanche safety institutions can only develop recommendations. Whether recreationists use them or not is their own responsibility.

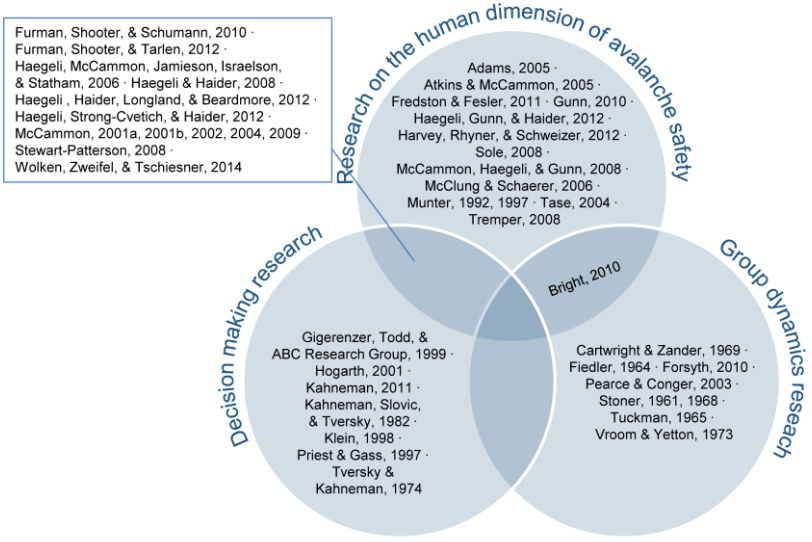

Figure 2-e: Literature map representing relevant concepts for the present thesis.

3 Methods and data

On the one hand, research in this field has mainly used a quantitative approach with surveys (e.g., Sole, 2008; Bright, 2010; Furman, Shooter, & Tarlen, 2012), analysis of accident records (e.g., McCammon, 2002, 2004; McCammon & Hägeli, 2007) or discrete choice experiments (e.g., Haegeli, Haider, Longland, & Beardmore, 2010; Furman, Shooter, & Schumann, 2010; Gunn, 2010). Online surveys are an effective instrument to reach many participants with little effort. However, they have been criticized because they are on a voluntary basis and basically attract recreationists who are already especially interested in avalanche safety issues (Haegeli, Strong-Cvetich, & Haider, 2012). To overcome this bias, intercepting recreationists directly in the field may be a good possibility (e.g., Björk, 2007; Gunn, 2010; Procter et al., 2013; Strong-Cvetich, 2014). However, Haegeli and his colleagues (2012) found "field monitoring campaigns and intercept surveys are generally ineffective for methodically collecting behavioral data as backcountry activities are pursued by relatively few people over large areas" (p. 800). In fact, it is difficult to gain a relevant sample allowing statistical analysis with intercept surveys.

On the other hand, little attention has been given to qualitative approaches to date. Only a few researchers advanced in this direction. Adams (2005) used expert interviews and focus groups to explore decision making among avalanche professionals. McCammon, Haegeli, and Gunn (2008) used a mixed-methods design including intercept surveys and focus groups to assess out-of-bounds avalanche awareness. This rare use of these methods seems surprising since qualitative methods are established for social research realms. This may be due to most researchers in the field of avalanche safety research have a natural science-based background and are most likely not familiar with qualitative research methods. However, qualitative methods have been mentioned as a suitable method to explore people's behavior (Denzin & Lincoln, 1994; Frey & Fontana, 1991) and seemed therefore as a suitable approach for my dissertation. However, overall a mixed-methods design seemed most promising for my research approach, similarly to McCammon, Haegeli, and Gunn (2008).

In the following sections I illuminate the overall methodological design and explain the applied datasets in more detail. In the end of this chapter I explain the publication concept of my dissertation.

3.1 Overall methodological design

To investigate behavior of groups traveling in avalanche terrain a qualitative approach was most obvious. However, to analyze some basic characteristics of groups traveling in avalanche terrain, also quantitative statistical methods seemed suitable. Therefore I choose a mixed-methods design (Creswell, 2003) and organized the dissertation in four different studies. Figure 1-a details the mixed-methods design used in the present study (Creswell, 2003) including quantitative analysis of avalanche accidents, online and intercept surveys, expert observations (Study I and II), qualitative analysis of group interviews (Study III) and a literature review combined with an expert workshop for the final development objective (→ tab. 3-a for an overview of the four studies). While Study I, III and IV were planned and could therefore be adopted within a fixed mixed-methods design (Creswell & Clark, 2011), Study II emerged during the research conducting process.

Study I and II identified individuals and groups who are involved in avalanche accidents and provided inputs for the following research of this dissertation. Study III provided qualitative exploratory data on the behavior of recreational groups and marks the core of my dissertation. With the gained knowledge from Study I, II and III, an additional literature review as well as information from a workshop with avalanche education experts, a group check tool for recreationists traveling in avalanche terrain was developed. This tools brings research findings back into practice. This goal of having practical applications has some tradition in avalanche safety research. In any case, time will tell whether the results of this thesis will become established in avalanche safety recommendations or not.

Table 3-a: Overview on the four studies with content, methods and publications.

	Content	Method	Publications
Study I (Chapter 4)	Basic characterization of avalanche victims (individuals and groups)	*Quantitative:* Accident analysis Online survey	1) Zweifel et al., 2012 2) Zweifel, 2012b
Study II (Chapter 5)	Group size specific risk of avalanche involvement	*Quantitative:* Accident analysis Intercept surveys Social network data	3) Zweifel, Procter, Techel, Strapazzon, & Boutellier, submitted
Study III (Chapter 6)	Investigation of group behavior with respect to avalanche safety	*Qualitative:* Group interviews	4) Zweifel & Haegeli, 2014 5) Zweifel, 2014a
Development objective (Chapter 7)	A group check tool for recreationists who travel in avalanche terrain	*Qualitative:* Literature review Expert workshop	6) Zweifel, 2014b

3.2 Applied datasets and analysis

In the following sections I discuss the applied methods and datasets. However, a complementary explanation of the methodology of each study can also be found in the publications in chapters 4 to 7.

3.2.1 Accident data for Study I and II

Avalanche accident records are a valuable data source to analyze not only avalanche characteristics of skier-triggered avalanches (e.g., Schweizer & Lütschg, 2001) but also the human dimensions of these avalanches (see, e.g., Tschirky, Brabec, & Kern, 2001; Harvey & Zweifel, 2008; Techel & Zweifel, 2013). In Switzerland, avalanche accidents with damage to property, infrastructure or people have been stored systematically since 1936-37 and the database contains nowadays over 15'000 records.

Concerning human-triggered avalanches in uncontrolled avalanche terrain every known avalanche where a person was caught by the avalanche gets registered in the Swiss national avalanche accident database. The reported avalanche accidents contain detailed information concerning the avalanche (location, size, type) but also information on the recreationists involved in the avalanche such as triggering (point of triggering, number of people in the triggering area) or whether the slope was tracked before the avalanche or not. Further, detailed information on the caught person is given such as burial information (burial time and burial depth), how the person was found, the presence of an air pocket and information on injuries or death. Only little information is given concerning the group involved in the accident, namely the number of groups involved, the group size, the type of activity, if the group was guided or not and in some cases gender and age of group members.

The information for the Swiss avalanche accident database stem from a wide range of information sources. Accidents are reported by observers from the WSL Institute for Snow and Avalanche Research SLF, from mountain guides, ski area rescue teams, helicopter rescue and police or from individual backcountry recreationists. It is to say that not only the quality of the reports vary significantly but also the amount of detail of the given reports. Further, with technical developments in communication (mainly Internet based feedback), there was an increase in the reported accidents without serious consequences (full burial, injuries or fatalities) in the mid-1990s (Techel & Zweifel, 2013) which should be taken into consideration when analyzing temporal trends.

For Study I, a 40-year dataset (1970-71 to 2009-10) with 2239 recreational avalanche accidents was analyzed. I investigated human factors, such as age distribution, group size or whether groups were guided or not. In these 2239 accidents, 4619 recreationists were caught and 898 people were killed. The data were divided in four decades in order to find temporal trends. I tested monotonic annual trends using the Mann-Kendall trend test (Hipel and McLeod, 1994; Mann, 1945).

In Study II, a 10-year period (2003-04 to 2012-13) with 446 accidents was applied. In these 446 accidents, 819 recreationists were caught and 101 people were killed. I choose this period since it is in the same time frame as the usage datasets used in this study and therefore fits best for this analysis. For this study, I only analyzed accidents where one group was involved and where the

size of this group was known. To investigate the relative avalanche risk by group size I compared this accident dataset with usage datasets.

Overall, avalanche accident data are a very valuable source for risk analysis. However, avalanche accident records are clearly limited in detail especially concerning group specific information.

3.2.2 Online survey for Study I

Since accident data are usually limited in detail with regard to human factors, I launched a complementary online survey in Study I to address questions on the experience and education of the participants, the characteristics of their typical group, leadership, decision making, risk behavior and motivation.

The survey was posted in German, French and English on different websites related to snow and avalanches and via several email lists from May 2012 to July 2012, and the survey was completed by 570 participants (→ Appendix A 1 for the complete survey sheet).

To survey group information is challenging since you can usually not reach all members of a group in the same survey. I addressed this problem indirectly by asking participants of the survey to give both their personal information and also report for their typical recreational partners in the group. In this way participants answered questions on avalanche specific experience and education, guiding and decision making preferences, risk parameters as well as gender and age information in a first part of the survey. In a second part of the survey participants reported on their behavior concerning motivation and decision making and on the role of human factors in their decision process. Participants rated predefined answers using 5-point Likert scales (Likert, 1932). Further they had the option to give answers in open text fields.

The snow and avalanche related websites where people report their backcountry trips and actual conditions (I used (*www.gipfebuch.ch*, *www.skirando.fr* and *www.camptocamp.org*) revealed as useful platforms to place the survey and generated 60% of all answers. Also suitable was a posting of my personal Facebook account with different links from snow related Facebook websites (Snowboarder Magazine, Snowboarder MBM, Powder Magazine, Downdays, Freeskier Magazine, Snowshoe Magazine and youth of the German Alpine Club) which generated 14% of the answers. The remaining participants (26% of answers) were reached by several email lists (personal friends, workers of WSL Institute for Snow and Avalanche Research SLF,

avalanche accident reporters season 2010-11, snowtrail map buyers and Academic Alpine Club Zürich).

While such a survey is a very suitable way to reach many backcountry recreationists with little effort and to generate a large set of answers which allows statistical analyses one always has to consider representativeness of the data sample. Haegeli and his colleagues (2012) mentioned that these surveys are voluntarily based and may therefore show a bias towards recreationists who show a higher interest in avalanche topics.

3.2.3 Voluntary self-registration boards, Switzerland for Study II

While avalanche accident records go back until the beginning of the 19th century and even in historic time, there is little known about how many people travel in avalanche terrain. However, for risk calculations of avalanche accidents one has to has usage data, which is the denominator for calculating risk. How many people move in winter backcountry and how long are they exposed to avalanche hazard? To answer this question Zweifel et al. (2006) started a pilot project in winter 2004-05 and evaluated diverse methods for counting backcountry recreationists both in real time (light barriers, beacon checkpoints, voluntary self-registration boards, satellite and air photos and direct monitoring) and with historical records (winter overnight stays in alpine huts and sales volume of winter sport equipment such as touring bindings or beacons) (Guggenheim, 2005). The voluntary self-registration boards and the light barriers turned out to be most suitable for our aim of counting backcountry recreationists and have therefore been in operation for two more winters (2005-06 and 2006-07; Zweifel et al., 2006). For Study II I used the data of the voluntary self-registration boards since they provided reliable data on group size. Voluntary self-registration boards have been mentioned as an easy to use and affordable method to count recreationists before (Arnberger, Haider, & Brandenburg, 2005; Cessford & Muhar, 2003).

Three boards have been installed on two starting points for popular ski tours in the region of Davos, one board at Monstein and two boards at Tschuggen. From Montstein backcountry recreationists can reach the peaks of Büelenhorn, Chrachenhorn, Älplihorn or Gletscher Ducan, from Tschuggen tours start to Flüela Wisshorn, Pischahorn, Jörihorn, Gorihorn, Sentischhorn or Baslersch Chopf (→ fig. 3-a).

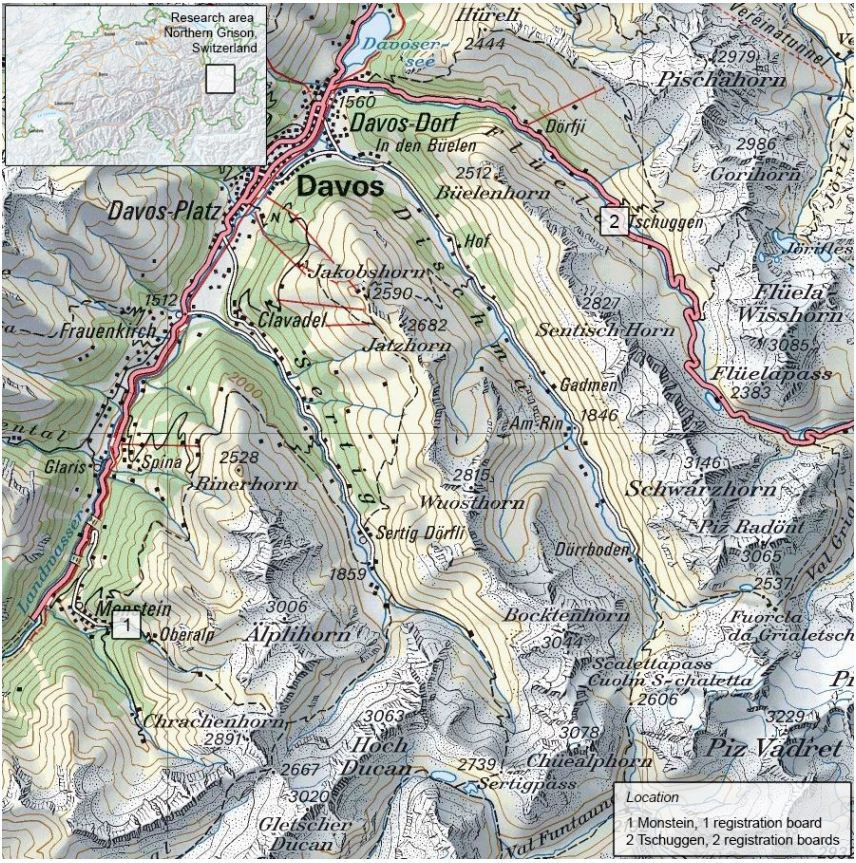

Figure 3-a: Map with locations of voluntary self-registration boards in Northern Grison, Switzerland.

In the 3-year field campaign from 2004-05 to 2006-07 a total of 2299 groups had registered at the boards. Recreationists reported tour date, intended tour, group size and activity type (e.g., skiing, snowboarding, snowshoing) (Zweifel et al., 2006). The data from the registration sheets have been digitalized manually.

The intercept surveys seemed as a valuable method for winter backcountry usage data collection with a low budget. However, the main disadvantage is obvious since recreationists registered on a voluntary base on the boards and the overall registration rate was not clear.

3.2.4 Intercept survey South Tyrol, Italy for Study II

A second dataset from an intercept survey was collected by Italian researchers in February 2011 (Procter et al., 2013). They intercepted backcountry users at 22 tour starting points in South Tyrol. The researchers selected the 22 most frequented starting points from a pilot survey where they evaluated 143 locations in one day (Brugger, Staffler, Aberer, Castlunger, & Strapazzon, 2010) (→ fig. 3-b).

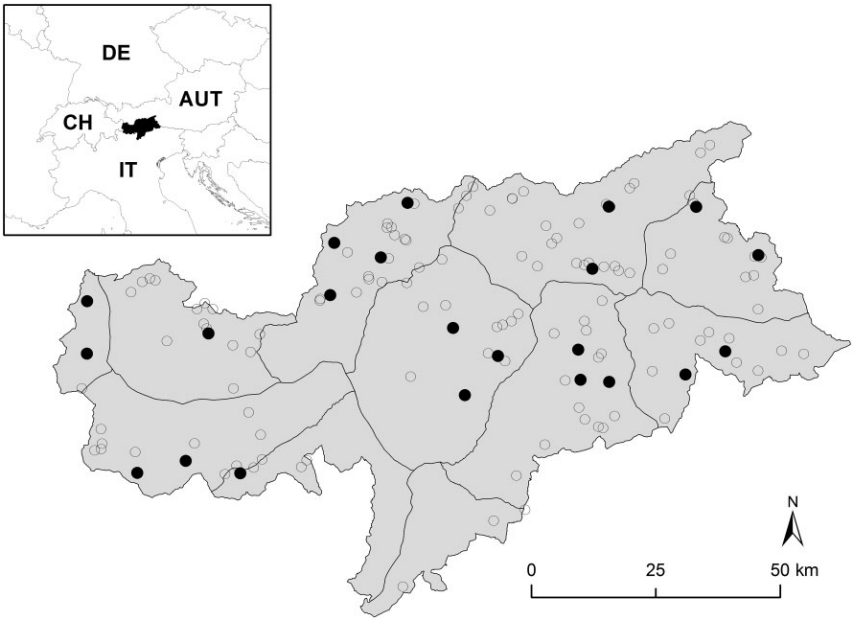

Figure 3-b: Study area of the South Tyrol intercept survey in 2011 located in the northern part of Italy (IT), bordering to Switzerland (CH) and Austria (AUT). 22 starting points (●) were taken from a pilot study at 143 different locations (○).[4]

1927 groups were surveyed in the South Tyrolean study in February 2011 in one week. Apart from group size, which I used in Study II, information on participants' experience, basic socio-demographics, avalanche safety equipment and avalanche knowledge of the group was collected.

[4] Printed with the permission of Emily Procter, the first author of the publication Procter et al. (2013) and with a license from the Publisher *John Wiley and Sons* (see Appendix A.6).

3.2.5 Expert observations Switzerland and Austria for Study II

Further, I used data form an expert observation in winter 2013-14. Expert observations have been seen as another valuable method for recreational monitoring (Cessford & Muhar, 2003). Ten avalanche experts observed groups during their backcountry outings and reported on a total of 238 groups with known group size in 59 different observations. While most observations came from the region of Davos, some information also came from other regions, namely the Tessin and Bergell in Southern Switzerland and two observations from Austria (Arlberg and Wildspitze). The locations and numbers of interviews are shown in the following map (→ fig. 3-c).

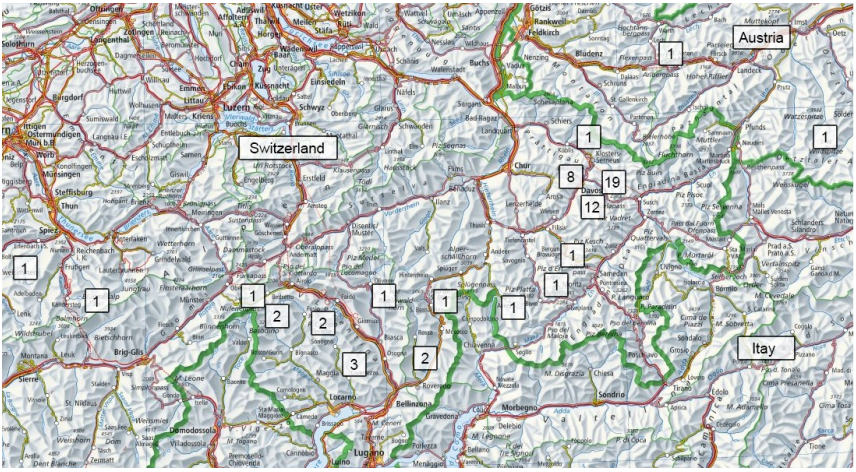

Figure 3-c: Map with locations and numbers of expert observations in Switzerland and Austria.

3.2.6 Social network data for Study II

For Study II I further used an existing dataset from social mountaineering networks (Techel, Zweifel, & Winkler, 2014a). Online social media mountaineering networks such as *bergportal.ch* and *camptocamp.org* are a new data-source which is very valuable for backcountry usage information (Techel, Zweifel, & Winkler, 2014a). On these portals, people report their backcountry experiences to allow other members to be informed on actual conditions. For study II a dataset from *bergportal.ch* with 10310 entries with known group size

was applied, whereby only backcountry activities like skiing, snowboarding or snowshoing were considered. Group size is an actual field in the reporting form of *bergportal.ch*.

3.2.7 Group interviews for Study III

To explore group behavior in more detail, the qualitative method of group interviews was used which has, to my knowledge, not been applied in this context before (Frey & Fontana, 1991). The objective of using this method was this method would provide valuable new ideas and insights, and generate new concepts.

I intercepted groups directly in the backcountry with the goal to reach a variety of different group types (e.g., group of friends, families, couples or guided groups) and different group activities (backcountry skiing and off-piste skiing). While backcountry skiers were interviewed at parking lots or restaurants after their trip, off-piste skiers were interviewed in the ski areas, either at the gondola stations while waiting for the next gondola or at restaurants during their midday break. Davos and the northern Grisons mountain area with its wide selection of backcountry routes and with many ski areas was ideally suited for this study design (→ fig. 3-d).

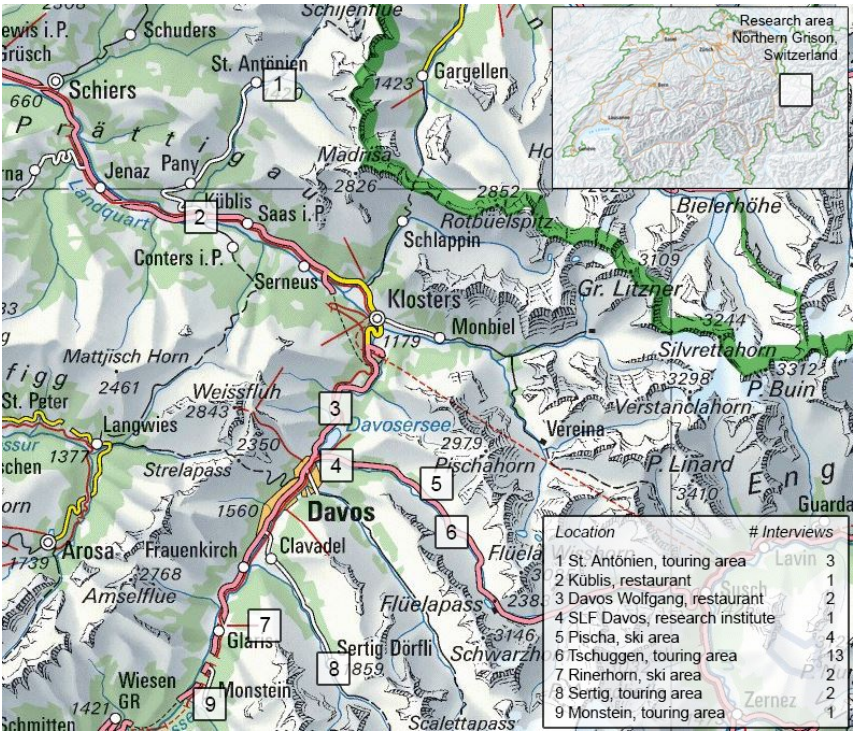

Figure 3-d: Map with locations of group interviews in Northern Grison, Switzerland.

To intercept recreationists during or directly after their trips had the advantage that recreationists still remembered their decisions and discussions of the trip. However, it was necessary to intercept the groups after their trips and not in the morning before their trips to gain compliance for the interviews. To further encourage recreationists to participate and to create a comfortable atmosphere for the interview, I served coffee and cookies and used a van as a shelter during bad weather (→ fig. 3-e).

Figure 3-e: Impression of the field work during the group interviews in winter 2012-13.

The interviews were collected between January 20th and March 22nd 2013 and therewith covered both high winter conditions and spring conditions. An overview on the group interview taken in winter 2012-13 in the region of Davos is given in the following table (→ tab. 3-b).

Table 3-b: Group interviews taken in winter 2012-13.

Nr	Date	Time	Location	Activity	Group size
1	20.01.2013	13:00	Tschuggen, parking lot	Tour	2
2	05.02.2013	14:30	Tschuggen, restaurant	Tour	7
3	06.02.2013	16:00	Davos Wolfgang, gas station	Off-piste	2
4	09.02.2013	13:45	Tschuggen	Tour	2
5	09.02.2013	14:30	Pischa, gondola station	Off-piste	3
6	09.02.2013	15:15	Pischa, gondola station	Off-piste	5
7	09.02.2013	15:30	Pischa, gondola station	Off-piste	2
8	10.02.2013	16:15	Davos Wolfgang, restaurant	Off-piste	6
9	12.02.2013	15:00	Monstein, restaurant	Tour	3

10	13.02.2013	15:30	Tschuggen, parking lot	Tour	2
11	15.02.2013	13:00	Pischa, gondola station	Off-piste	2
12	20.02.2013	14:45	Rinerhorn, gondola	Off-piste	2
13	20.02.2013	15:00	Rinerhorn, restaurant	Off-piste	2
14	21.02.2013	14:15	Tschuggen, parking lot	Tour	2
15	21.02.2013	15:00	Tschuggen, parking lot	Tour	2
16	22.02.2013	13:45	Tschuggen, parking lot	Tour	2
17	22.02.2013	14:15	Tschuggen, parking lot	Tour	2
18	25.02.2013	13:45	St. Antönien, parking lot	Tour	5
19	25.02.2013	14:15	St. Antönien, restaurant	Off-piste /Tour	2
20	26.02.2013	14:45	Sertig, restaurant	Tour	2
21	26.02.2013	15:30	Sertig, restaurant	Tour	14
22	01.03.2013	13:00	SLF Davos, snowlounge	Tour	2
23	04.03.2013	13:45	St. Antönien, parking lot	Tour	2
24	04.03.2013	14:45	Küblis, restaurant	Tour	2
25	22.03.2013	12:30	Tschuggen, parking lot	Tour	2
26	22.03.2013	13:00	Tschuggen, parking lot	Tour	9
27	22.03.2013	13:30	Tschuggen, parking lot	Tour	5
28	22.03.2013	14:00	Tschuggen, parking lot	Tour	2
29	22.03.2013	14:30	Tschuggen, parking lot	Tour	2

In semi-structured interviews I followed an interview guideline which covers the topics of planning, motivation, decision making, leadership, group structure and the risk behavior of the groups (→ Appendix A.2 for the interview guideline). Due to open-ended questions I tried to not restrict the interviewees in their answers and to support an open conversation. Further, I always included all group members in my questions in order to gain a rich and trustworthy perspective of the group opinion.

Even if the group interviews showed up as a valuable method to gain insight knowledge on group behavior they showed its limits by capturing some subtle communication and decision making processes of the groups since group

members had difficulty to remember exactly these processes despite I interviewed them directly after their trips.

3.2.8 Workshop with avalanche education experts for development objective

To include also practitioners' needs and opinions in my proposition for a group check tool, I conducted an expert workshop on 12 May 2014 in Innertkirchen (Switzerland) with 14 members of the Swiss Snow Sport Avalanche Accident Prevention core training team (→ Appendix A.3 for a participant list). This core training team is an umbrella organization with members of different associations and organizations in the realm of snow sports and with members of the WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland with the goal to provide material for avalanche education in a Swiss wide consistent way. The workshop I conducted with this core training team had two goals: (1) to "develop content and the practical requirements of a group check tool" (Zweifel, 2014b, p. 964) and to (2) include key individuals from the avalanche community in order to have their ongoing support for the future promotion of the tool.

3.3 Publication concept

This dissertation follows the concept of a cumulative thesis with several publications. I chose the cumulative format since it makes the research results more easily accessible for other researchers and for the whole avalanche community.

One critical aspect was the selection of the publication language. On the one hand, German would have suited since the research sites and the majority of applied datasets stem from Switzerland and a German speaking environment. On the other hand, the avalanche research community is strongly linked to North America and an English speaking audience. Overall, I decided to work for the broader impact of a thesis in the English language. However, I also published in German outdoor recreation journals.

The thesis is organized into four studies which were published in six articles. The single publications follow the research questions as mentioned in section 1.2. The primary publications are written in English and presented in the result chapters 4 to 7 (→ tab. 1-a). The associated German publications can be found in Appendix A 5.

In addition, I contributed to several other publications while working on the present dissertation. As an introduction to group dynamics I presented a short case study of an accident involving several groups (Zweifel, 2012) just at the beginning of the dissertation project at hand. Further I was involved in several avalanche accident and risk analysis works (Techel & Zweifel, 2013; Techel, Zweifel, & Winkler, 2014a, 2014b; Wolken, Zweifel, & Tschiesner, 2014). Although these publications are also in the field of avalanche safety research, I decided to not include them in more detail in this dissertation since they do not properly fit the research topic and its related research questions.

4 Characterization of groups involved in avalanche accidents (Study I)

I examined the first research question and explored how groups involved in avalanche accidents are characterized in Study I. This is of interest for further studies in group related avalanche research and provided the basis for Study II and III. The original research article can be found in section 4.4. A separate summary and conclusion of this study, the contribution of this study to the thesis and an assessment of an appropriate publication outlet are provided in sections 4.1 to 4.3.

4.1 Summary and conclusion of Study I

Study I explored the basic characteristics of avalanche victims – individuals and groups – based on a 40-year Swiss avalanche accident dataset and an online survey. The examination of the Swiss avalanche accident dataset confirmed previous research and found that 81% of victims are male and only 19% female. As expected, the majority of victims was between 20 and 30 years old. However, a plateau in the victim distribution was also found in the range from 36 to 50. Most accidents involved only one group. However, in 6% of the accidents, more than one group was involved. With increasing backcountry activity I assume that the chance of a multiple group avalanche involvement increases in future. About three-quarters of the accidents happened in non-guided groups. However, accident data records only distinguish between guided groups with a professional guide and non-guided groups. However, these non-guided groups include many groups who travel with an informal guide such as club leaders or just the most experienced recreationist in the group. Groups of two, three and four people were most prominent in accidents.

The survey further showed that males are higher risk takers than females and that the willingness to take risks increases with experience. 95% of the respondents were aware of avalanche risk. This high percentage raised the question of the representativeness of the survey participants sample. Finally, results showed that travel motivations depend on activity type.

4.2 Contribution of Study I to the present dissertation

To know who is involved in avalanche accidents is a prerequisite for avalanche safety studies. While basic socio-demographics were known before and my study can be seen as confirmatory in nature concerning these factors, I investigated group factors for the first time in greater detail. However, accident records are limited in detail for further investigations on group phenomena. Therefore, I additionally implemented an online survey with questions on group aspects and group behavior. Some results of the online survey, however, indicated a sample bias and required different methodological approaches. I applied a new methodological approach in Study II.

Further, I realized that accident analysis is indeed an important start for such studies but is not able to assess real risks of recreational activity in avalanche terrain. For real risk assessments, one also needs to include usage data which was implemented in Study III.

Overall, Study I generated valuable input regarding the methodological aspects of the thesis as well as on the content side and led directly to Study II and III. This means that Study I was particularly useful for the set-up of the further studies for this thesis, more than for generating new results.

4.3 Publication and presentation of study (Study I)

Study I was given as an oral presentation at the International Snow Science Workshop (ISSW) 2012 in Anchorage, AK. This gave me the opportunity to further discuss the organization of the dissertation and related methods. The ISSW is an excellent forum for the community of leading avalanche researchers worldwide and is therefore the best place for the exchange of ideas ideal for the starting phase of a dissertation. The conference format including several social events stimulates discussion. It was at this conference where the opportunity emerged to initiate a half-year fruitful collaboration with Pascal Haegeli at Simon Fraser University in Vancouver, BC.

4.4 Who is involved in avalanche accidents? (original research article)

Zweifel B, Techel F, Björk C. Who is involved in avalanche accidents? International Snow Science Workshop 2012, Proceedings. Anchorage, AK, 2012:234-239.

ABSTRACT: Off-piste and backcountry skiers, snow-shoers, climbers, heli-skiers, hikers, ski patrollers and many more: The range of people who are involved in avalanche accidents is wide—and so are their avalanche knowledge, training and experience. Avalanche hazard information published in avalanche bulletins aim to reach all off-piste and backcountry enthusiasts as well as professionals. However, this can only be done effectively if the characteristics and needs of the target group are known (e.g., language, foreknowledge, the medium of information used and the main interest in the field of snow and avalanches). With that knowledge at hand, forecasters can design avalanche information products that are tailored and more effectively address the needs of the various user groups. In this paper, we investigate a 40-year dataset of the Swiss avalanche accident database and a recent online survey to provide detailed background information on who is involved in avalanche accidents in Switzerland. My results confirm that most individuals involved in avalanches in Switzerland are men between 20 and 30 in non-guided groups of two to four people. Often groups have an informal leader even if they are not professionally organized. My findings demonstrate that men show higher willingness to take a risk than women. Furthermore willingness to take a risk also increased with the self-declared level of experience. Travel motivation factors showed that off-piste skiers are more motivated by adrenalin rush than backcountry travelers who mainly enjoy being outdoors.

4.4.1 Introduction

More than 90% of fatal avalanche accidents (data from Switzerland 1987-88 to 1996-97) occurred during recreational activities in uncontrolled avalanche terrain (Schweizer and Lütschg, 2001). One of the primary goal of the daily avalanche bulletins is to reach recreationists and prevent these accidents. Originally recreational activities in avalanche terrain were dominated by classical mountaineering and backcountry skiing and the avalanche community had a good understanding of their perspectives and needs. Over the last decades, we have seen a general increase in the number of backcountry users (Zweifel et al., 2006) as well as the appearance of numerous new backcountry activities including off-piste skiing, ice climbing, snow-shoeing or speed flying. A detailed understanding of the perspectives and needs of these newer backcountry user groups is critical for the development of

products and services that can reach them effectively and reduce their numbers of accidents and fatalities. However, this information currently does not exist.

The goal of the present study is to provide the foundation to guide future backcountry user group studies by providing an up-to-date perspective on who is involved in avalanche accidents in Switzerland.

4.4.2 Previous research

Previous research has shown that there are common aspects in recreational avalanche accidents. In Europe, the groups most frequently involved in accidents are backcountry skiers, off-piste skiers and mountaineers (Etter et al., 2005; Jarry and Sivardière, 2001; Tschirky et al., 2001; Valt et al., 2009). Snowboarding and snowshoeing increasingly contribute to the number of accidents in Switzerland (Harvey and Zweifel, 2008). In the United States snowmobilers and backcountry skiers account for 79% of all avalanche fatalities between 1999-2000 to 2008-09 (Atkins, 2010). Avalanche accidents typically involve men (90%) with the most important common age range from 20 to 29 year (Atkins and Williams, 2001; Harvey and Signorell, 2002; Irwin and Owens, 2005; Jamieson et al., 2010). The highest number of fatal accidents occurred in groups consisting of two or three people (Atkins and Williams, 2001). In Switzerland, group size in avalanche accidents decreased significantly in recent years (Harvey and Zweifel, 2008). In Switzerland fatalities in guided groups showed a significant decreasing trend (Harvey and Zweifel, 2008).

It is difficult to gain more detailed insight from avalanche statistics as most avalanche databases do not record more details on groups or individuals. Another way to obtain information on group composition and behavior of people moving in avalanche terrain are survey studies, a relatively new area of avalanche safety research (Björk, 2007; Bright, 2010; Gleason et al., 2006; Gunn, 2010; Zgraggen, 2004). Even if the results of these studies are partly different mainly due to different group samples some common findings emerge: most people participating in the surveys were aware of the avalanche risk, informed about danger and used risk mitigation practices. People were equipped with avalanche beacon, shovel, probe and cell phone, only few people used further avalanche safety devices like avalanche airbag backpacks or AvaLung. These results based on self-declaration in online surveys do obviously not agree with what can actually be observed in the field. Percentage of individuals who are aware of the avalanche risk (and therefore also better

equipped with avalanche safety gear) is lower in intercept surveys than in online survey (Björk, 2007; Gunn, 2010).

However, the topic of investigation is prone to fast changing behavior and previous research is partly based on old datasets or does not describe all characteristics of individuals and groups in avalanche accidents. Therefore, we conducted the investigation at hand which will be described in the following section.

4.4.3 Data and Methods

We analyzed a dataset from the Swiss avalanche accident database and used data from an online survey.

Swiss avalanche accidents dataset

The dataset from Swiss avalanche accidents covers a 40-year period from 1970-1971 to 2009-2010 with 8130 avalanches recorded, including 2239 datasets from recreational avalanche accidents. In these 2239 avalanches, 4619 people were caught and 898 were killed. The data from the Swiss avalanche accident database were analyzed by decades. Monotonic trends in annual data were tested using the Mann-Kendall trend test, which is based on the Kendall rank correlation (Hipel and McLeod, 1994; Mann, 1945).

Online survey dataset

The second dataset used in this study was collected using an online survey. The first part of the survey included questions on backcountry experience, avalanche specific education, leading and deciding preferences, risk awareness, willingness to take risk as well as basic socio-demographics. Survey participants were asked to enter their personal information as well as the information for their typical backcountry companions. The second part contained questions on travel motivation, decision making approach during trip planning and during backcountry outings as well as potential human factors affecting the decision process. These questions were asked using 5-point Likert scales (Likert, 1932) with proposed factors as well as open text fields.

The online survey was open for participation between 31 May 2012 to 30 July 2012 and links to the survey were posted on websites giving information on travel conditions in the mountains (www.gipfebuch.ch, www.skirando.fr, www.camptocamp.org), on facebook (personal site of first author, posts on the sites of Snowboarder Magazine, Snowboarder MBM, Powder Magazine, Downdays, Freeskier Magazine, Snowshoe Magazine and youth of the German

Alpine Club). The survey was also promoted via a number of email lists (avalanche accident reporters 2010-11, snowtrail map buyers, Academic Alpine Club Zürich). Despite the survey being posted in early summer, a total of 570 respondents completed the survey. Statistical significance was tested using the non-parametric Wilcoxon rank-sum test (Starnes et al., 2012).

4.4.4 Results

Swiss avalanche accident dataset

An examination of the full dataset of people caught in avalanches shows that 81% (1985 of 2446) of Swiss avalanche victims were male and 19% (461 of 2446) were female with only very small variations over time (less than 3% over the last four decades). The age of avalanche victims ranged from 1 to 80. Thirty-one percent of the individuals (596 of 1937) was between 21 and 30 years old (→ fig. 4-a). Interestingly, the percentage of avalanche accidents involving people younger than 25 decreased significantly over the study period ($p<0.01$).

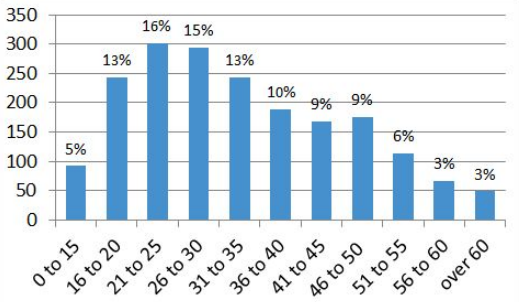

Figure 4-a: People caught in avalanches in Switzerland by age group, 1970-1971 to 2009-2010 (n=1937).

In 94% of the accidents (1713 of 1822) only one group was involved; in 6% two or more groups were involved in the same accident. Thirty-three percent of accidents occurred in groups of two (547 of 1663) and 19% in groups of three people (→ fig. 4-b). Single individuals were involved in 8%, groups of ten or more people accounted for 8% of accidents. The number of accidents reported increased with time as more and more accidents with no serious consequences are reported. The number of accidents with only one individual involved increased with time ($p<0.001$) while accidents with large groups (10+ people) decreased ($p=0.07$). Twenty-seven percent of the accidents involved guided

groups (only accidents with one group, 329 of 1205) and 73% non-guided groups. The proportion of fatalities in guided groups was lowest in the 2000s (→ fig. 4-c). Sixty-three percent (550 of 870) of avalanche fatalities were Swiss nationals and 37% were from other countries with the largest groups from neighboring countries Germany, France, Italy and Austria.

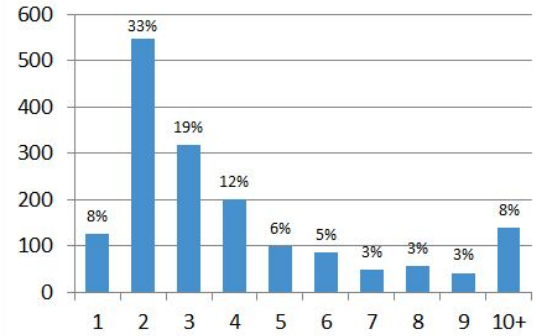

Figure 4-b: Accidents in Switzerland by group size, 1970-1971 to 2009-2010 (n=1663).

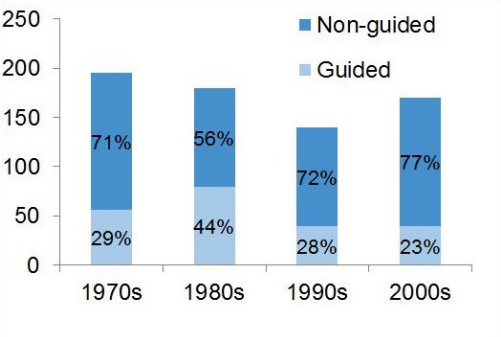

Figure 4-c: Proportion of fatalities in guided and non-guided groups in Switzerland from 1970-1971 to 2009-2010 by decades (n=685).

Online survey dataset

For the first part of the survey analyses were limited to respondents only. Data provided by respondents about other group members were not considered as data quality is uncertain. Eighty-seven percent of respondents were male (473 of 544) and 13% female. Main age groups of respondents was 25 to 35 years and median age was 39. People aged 25 and younger were under-represented in the survey compared to the age distribution found in the avalanche accident statistics. Sixty-five percent of the individuals participating

in the survey reported to travel in groups of two to four people (373 of 570). Generally, these groups were not formally organized although most of them had an informal leader, who had more backcountry experience, was more avalanche trained and preferred to decide (rather than the other group-members).

In the survey people were asked to assess their willingness to take risk on a scale including “high”, “mean” and “low”. Respondents who were prepared to take a higher risk were more often caught in avalanches (41%) than people willing to take a lower risk (21% caught). Men had a higher willingness to take risk than women and were caught in 28% in avalanches, women only in 15%. Willingness to take a risk increased with increasing backcountry experience ($p<0.001$, → fig. 4-d). A considerable proportion of the respondents had been caught at least once in an avalanche during their backcountry outings (26%). This percentage rises significantly ($p<0.01$) with increasing life-time backcountry exposure: from 10% for the 25% of the respondents with the least backcountry days to 43% for the 25% with the most days.

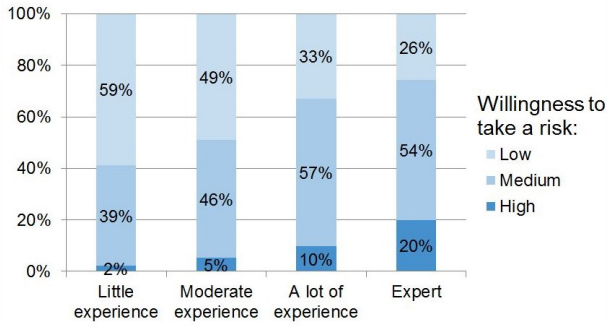

Figure 4-d: Relative willingness to take a risk by experience (n=553).

Ninety-five percent of respondents (543 of 570) were aware of the risk of getting caught in an avalanche. Sixty-three percent (356 of 566) traveled with friends, 17% with a partner, 13% in organized groups, 4% alone and 3% with family members. Table 4-a shows participants' motivation to go on a trip. Off-piste skiers were significantly ($p<0.001$) more motivated by adrenalin rush on the downhill than backcountry skiers, while backcountry skiers put more weight on summit experience than off-piste skiers ($p<0.001$).

Table 4-a: Travel motivation by activity.

	Backcountry	Off-piste
Fitness-exercise	52%	26%
Outdoor recreation	80%	76%
Adrenalin rush on the downhill	21%	53%
Getting away from daily stress	49%	33%
Summit experience	66%	22%
Powder snow	60%	87%

Eighty-five percent of participants (462 of 541) stated that they plan a trip, 13% (with a higher percentage for off-piste skier) decided spontaneously (71 of 541), only 1% hired a guide (6 of 541) and 2 out of 541 went always on the same trip. The three most frequently named factors for trip-planning were related to the expected conditions: avalanche danger level as forecasted in the bulletin (85% of respondents "strongly agreed"), weather (82%) and snow conditions (76%). These were rated significantly ($p<0.001$) more important than characteristics of the planned tour (38-53%) and group-related factors (group-size, -experience, skiing abilities, 35-55%). For decision-making during the backcountry outing, again the condition related factors were most important (77-81%). Additionally, the terrain (71%) as well as the own snow stability assessment (79%) gained importance. The latter ranked similar to the official hazard forecast for both experienced and relatively un-experienced backcountry users. As was the case for the trip planning, these factors were rated more importantly than group-related factors ($p<0.001$). When people were asked what typically leads to poor decisions in their group in avalanche terrain, most often named was a poor assessment of the avalanche hazard ($p<0.001$). However, group dynamics and group pressure were also considered important factors (→ fig. 4-e).

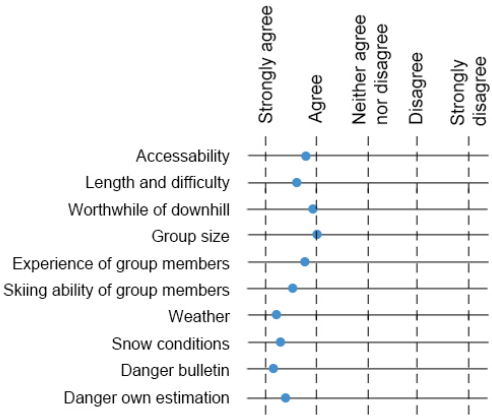

Figure 4-e: Factors for poor decision-making in avalanche terrain (488 respondents).

4.4.5 Discussion

Results on gender and age were not surprising: males in their twenties are the largest age group among avalanche victims in Switzerland. This is in agreement with previous accident statistic studies from Switzerland (Harvey and Signorell, 2002) and also from other countries (Atkins and Williams, 2001; Irwin and Owens, 2005; Jamieson et al., 2010). Accidents with more than one group show up in 6% of cases. This situation may increase with the increasing number of backcountry travelers. An example of such an accident occurred in the Safiental valley-Switzerland during the winter 2009-10 when three different backcountry groups on the same route were hit by an avalanche (Etter et al., 2012). Small groups (two to four people) show up most in avalanche accidents accordingly to Atkins (2010). The decreasing number of accidents with large groups may be a result of avalanche education as in the last decade education has focused on reducing the risk by, for example, forming small groups. Seventy-three percent of accidents happened in groups without a guide with the highest proportion (non-guided vs. guided) in the 2000s. This finding agrees with results of Harvey and Zweifel (2008), who found that the ratio of fatalities in guided and non-guided activities dropped significantly from 40:60 to under 20:80.

Data from the online survey should be interpreted more cautiously than data from the avalanche accident database as we do not know how representative my sample of respondents is. Most groups in the survey that were not under

professional guidance seemed to have an informal leader. Males are willing to take a higher risk than females. Willingness to take risk correlated with avalanche involvement and increased with self-declared level of experience. This is in agreement with (McCammon, 2002) who has shown that experienced individuals are as frequently caught as un-experienced. We attribute this to be a risk-compensation effect (Sole, 2008; Wilde, 1982). Although 95% of survey participants stated that they were aware of the avalanche risk, we can observe many avalanche accidents where people were not aware of the risk and got surprised. Probably people not aware of avalanche risk were not reached by the survey or did not respond. Travel motivation factors showed that off-piste skiers were more motivated by adrenalin rush on the downhill than backcountry skiers, while backcountry skiers put more weight on summit experience than off-piste skiers. That off-piste skier are more forced by fun and adrenalin factors than backcountry skiers was also found in previous research (Sole, 2008). Decision making factors (while planning and in the backcountry) showed that people rated factors related to the expected conditions (e.g., weather, forecast from the bulletin or snow conditions) more importantly than group-related factors (e.g., group-size, -experience, skiing abilities). But differences among groups were very small. Differences in “go or no go”-decisions in terrain that we observed, probably have different reasons. Factors favoring poor decision making were inconclusive.

4.4.6 Conclusions

We explored a 40-years data set of the Swiss avalanche accident database and data from an online survey focusing on groups exposed to avalanche terrain in terms of characterization of individuals by age and gender, groups by size, composition, organization, travel motivation factors, factors considered for decision making and potential factors for poor decisions. Accident data are the most valuable for describing who is involved in avalanche accidents and gives a sound base for further studies in this research field. But since the true number of people venturing off-piste or into the backcountry is not known (Zweifel et al., 2006) assessment of risk of different groups or individuals will be left difficult. And due to limitation in existing avalanche accident records, this approach can only provide limited details on aspects like group composition, group dynamics or decision making. Therefore we should investigate methods to further explore the risk of people exposed to avalanche terrain. To find more insights about group composition, group organization or

decision making online surveys can give interesting results but we should always consider that representativeness of such survey populations is not clear. When we see that decision making in avalanche terrain is very complex, it is hard to gain detailed enough data from online surveys. Probably qualitative methods from social science can give better results in future.

Acknowledgements

We thank Pascal Hägeli, Jürg Schweizer and Stephan Harvey for their helpful reviews. Also, many thanks to Nico Grubert, who implemented the online-survey. And finally, the SLF would like to thank everyone who contributed reports of avalanche accidents over the years.

5 Group size and avalanche risk (Study II)

While the analysis in Study I focused on avalanche accident data only, in Study II I included usage data as well. Consequently Study II aimed to estimate the risk of an avalanche accident with respect to backcountry usage. Section 5.4 contains the original research article. A summary and conclusion of the article can be found in section 5.1. Section 5.2 discusses the contribution of Study II to the dissertation and in Section 5.3 the value of the publication outlet is discussed.

5.1 Summary and conclusion of Study II

In an international study, accident data were compared with usage data from an intercept survey, voluntary self-registration boards and from expert observations to assess the avalanche risk with respect to group size for the first time. Group size is a basic group characteristic and has heavily been discussed in avalanche safety initiatives (e.g., McClung & Schaerer, 2006; Harvey et al., 2012). The results of Study II indicate that the risk generally increases with group size. The lowest risk was found for groups of two and surprisingly for people who travel alone.

While groups of two or three are most prominent in accident data (see Study I), this study showed that groups of two and three do not show the highest risk compared to bigger groups since they are also very frequent backcountry users. Future studies addressing risk factors of winter backcountry recreationists should include usage data. However, appropriate datasets are rare and new observations and in-field surveys are necessary. New technologies (e.g. video monitoring) could improve the performance of such studies.

5.2 Contribution of Study II to the present dissertation

Study II effectively shows how important it is to include usage data in any risk analysis. Although due do the sparse database this was only possible for group size, I successfully implemented a research approach for risk assessments in a realistic setting in an international collaboration. Further, Study II provides direct implementation for practice. Avalanche safety institutions should on the one hand stress risk reduction measures for large

groups since large groups showed higher avalanche risk and on the other hand also re-discuss recommendations for people traveling alone. Up-to-date, avalanche safety institutions generally advice recreationists not to travel alone in avalanche terrain. However, since recreationists who travel alone did not show higher risks, this general recommendation is questionable.

5.3 Publication and presentation of study (Study II)

The interdisciplinary character of Study II represents a challenge for the search for an appropriate journal. As the *Scandinavian Journal of Medicine and Science in Sports (SJMSS)* recently published an article which lies in the same scientific field (Procter et al., 2013) I decided together with my co-authors to choose this journal for publication.

5.4 Group size and avalanche risk (original research article)

Zweifel, B., Procter, E., Techel, F., Strapazzon, G., & Boutellier, R. (submitted). Risk of avalanche involvement in winter backcountry recreation: the advantage of small groups. Scandinavian Journal of Medicine and Science in Sports.

ABSTRACT: Avalanches are the primary hazard for winter backcountry recreationists and cause numerous deaths and injuries annually. While recreationists usually travel in groups there is little empirical knowledge on group related risk factors. This study aims to explore the relative risk of avalanche accidents with respect to group size and to discuss underlying reasons for different risk levels. We compared data from backcountry usage – characterizing groups who travel in avalanche terrain – with avalanche accident data from Switzerland and Italy. We found a higher avalanche risk for groups of four and more people and a lower risk for people traveling alone and in groups of two. These findings are in accordance with avalanche safety recommendations regarding large groups but not people traveling alone in avalanche terrain, which is not recommended and requires great caution. Further studies on backcountry usage are necessary to improve our understanding of human behavior and risk factors. New techniques (e.g. video monitoring) may be useful for acquiring reliable data on backcountry usage.

5.4.1 Introduction

Recreational activity in avalanche terrain such as backcountry skiing[5], off-piste skiing or snowshoeing has increased in recent decades due to higher mobility of recreationists and significant simplifications in equipment. The risk of avalanches during these activities and mortality of avalanche victims are high (Brugger et al., 2001). Based on avalanche accident statistics and user surveys, the majority of recreationists travel in avalanche terrain in groups and only few people travel alone (Zweifel et al., 2012; Procter et al., 2013). Therefore group related risk factors play a crucial role in avalanche risk management.

Characterizing recreation groups by group size has been widely discussed for avalanche risk reduction initiatives. Previous work suggests that the risk of avalanche involvement increases with increasing group size (e.g., McClung & Schaerer, 2006; Volken, Schell, & Wheeler, 2007; Tremper, 2008; Harvey et al., 2012). Accordingly, small groups are considered a risk reduction factor in the Risk Reduction Method of Munter (1992), and traveling in small groups and/or keeping distances between single group members are also risk reduction factors in avalanche decision making tools such as *Stop or Go* (Larcher, 1999) or *Snowcard* (Engler & Mersch, 2000). Larger groups may have higher risk due to higher load on the snow cover or human factors (e.g., decision making or communication) (Harvey et al., 2012). However, these avalanche safety practices are based on avalanche accident statistics (e.g., Atkins, 2001; McCammon, 2002; Zweifel et al., 2012) or surveys examining basic demographics, travel behavior, avalanche expertise or rescue equipment (e.g., Tase, 2004; Sole, 2008; Gunn, 2010; Haegeli, Gunn, & Haider, 2012). However, it is logistically more difficult to directly examine the association between group size and avalanche risk, as this requires reliable data on the total number of recreationists; subsequently, avalanche accidents of a specific group size are compared with the relative frequency of these groups in the field. Direct in-field observations are one method for recreational monitoring (Cessford & Muhar, 2003); two in-field surveys of backcountry recreationists have been reported in Europe (Zweifel et al., 2006; Procter at al., 2013). Social media sources are now frequently used by recreationists to report tours and travel conditions (e.g., the mountaineering website *bergportal.ch*) and are available as a data source (Techel et al., 2014a). The aim of this study is to

[5] The terms ‘skiing’ and ‘skiers’ also includes snowboarding and snowboarders.

estimate the relative risk of avalanche accidents with respect to group size for the first time by comparing the relative frequency of groups in the field with the relative frequency of accidents in these groups.

5.4.2 Materials and methods

We included skiers and snowshoers who traveled in winter backcountry terrain; other recreationists such as off-piste skiers[6], hikers, ice climbers, mountaineers or snowmobilers, and accidents on transportation routes or in buildings were excluded. All datasets included group size and the date of the tour, and other information such as location, socio-demographics of group members and activity.

Recreation groups in the field (usage data)

Swiss usage data (self-registration boards, in-field observations and social network data)

A first usage dataset was collected in a 3-year field campaign (winter 2004/05 to winter 2006/07; each winter from December through April). Voluntary self-registration boards with survey sheets (Cessford & Muhar, 2003) were installed at Tschuggen in the Flüela valley and at Monstein near Davos, Switzerland, two popular starting points for backcountry skiers and snowshoers (Zweifel et al., 2006; → fig. 5-a).

Figure 5-a: Registration board at Tschuggen in the Flüela valley, Davos, Switzerland.

[6] In contrast to backcountry skiers, who ascend by their own means, off-piste skiers use mechanized transportation in ski areas.

A second dataset stems from observations of ten avalanche experts from WSL Institute for Snow and Avalanche Research SLF who counted backcountry skiers and snowshoers in the field between December 2013 and May 2014. A third usage dataset is based on the social network website *bergportal.ch*. We analyzed all entries with known group size from a five-year period (winter 2010 to winter 2014), as also applied in Techel et al. (2014a). Groups larger than five people were merged into two classes (six to ten and more than ten people).

Italian usage data (in-field observation)

In a one-week field campaign in February 2011 a questionnaire was administered to all skiers and snowshoers departing on a backcountry tour at 22 popular tour starting points in South Tyrol, Italy (Procter et al., 2013). The locations were based on the most frequented locations in a 1-day pilot survey at 143 starting points in 2010 (Brugger et al., 2010).

National accident databases (accident data)

In order to have representative datasets we collected accident data over a 10-year period and not only the period of the usage datasets. However, the usage data stems from a period covered by the accident datasets.

Swiss avalanche database

The Swiss avalanche database contains all recorded avalanches in Switzerland that produced a material or economic damage or damage to persons. The reports stem from rescue organizations, mountain guides, SLF observers or backcountry recreationists. We extracted accidents involving backcountry skiers and snowshoers in a 10-year period (winter 2003/04 to winter 2012/13). Accidents involving more than one group were excluded.

Italian avalanche database

The Italian avalanche database contains all recorded avalanches in Italy. Data were collected by the regional avalanche warning services and sent to a central database that is managed by an association (Associazone Interregionale Neve e Valanghe, AINEVA). We included all avalanche accidents involving backcountry skiers and snowshoers in a 10-year period (winter 2004/05 to winter 2013/14) in South Tyrol, Italy.

Data analysis

Avalanche risk is defined as the ratio of the total number of accidents to the total number of exposed individuals. Relative risk refers to the ratio of avalanche risk in two groups being compared. There are currently no available datasets that contain both the number of exposed individuals and the number of accidents for the same individuals; thus we assessed relative risk by comparing group size distributions in usage data with group size distributions in accident data for both countries. When assuming that usage data is a representative sample of backcountry recreationists and that group size has no influence on avalanche risk, then usage and accident datasets should show the same group size distribution. Group sizes were analyzed by comparing six group size classes: groups consisting of 1, 2, 3, 4, 5 and ≥6 people. Large groups were combined in one class as (1) the *Bergportal* data did not contain exact group sizes for larger groups and (2) the absolute number of large groups was low. In a first step we compared group size distribution between the different usage-datasets by applying the non-parametric Wilcoxon rank-sum test (Crawley, 2007). Because differences were found in these datasets, which suggests different sampling schemes, we combined the three Swiss usage datasets by applying equal weights, regardless of their sample size, to create one representative Swiss usage dataset for further analyses. In a second step we compared the group size distribution of usage data with accident data and calculated the relative risk for a specific group size with respect to the most frequent group size (reference group) as $RR_i = \frac{acc_i \cdot usage_{ref}}{acc_{ref} \cdot usage_i}$, where acc_i is the frequency of accidents in group size I, acc_{ref} the frequency of accidents in group size 2, $usage_i$ the frequency of recreationists in group size I and $usage_{ref}$ the frequency of recreationists in group size 2; $RR = 1$ means that the risk of being involved in an accident in the investigated group is similar compared to the reference group, $RR > 1$ indicates that the risk is higher and $RR < 1$ indicates that the risk is lower with respect to the reference group. We used the Pearson Chi-square-test (Boslaugh & Watters, 2008) and results were considered significant if P was < 0.05.

5.4.3 Results

Group size distributions in usage and accident datasets

An overview of the datasets, the mean group size and the group size distribution are shown in Table 5-a and in Figure 5-b. The median group size for usage datasets was 2 for all datasets; median group size in both accident datasets was 3. Group size two was the most frequent in all datasets (22–44%). The frequency of group size one and three was similar; frequency decreased with increasing group size, though was higher in group size 6 or more compared to group size four and five.

Table 5-a. Overview of usage and accident datasets.

Data type	Dataset	N	Median group size (n)	Group size distribution (%)					
				1	2	3	4	5	≥6
Usage	Davos (self-registration boards)	2299	2	17	44	15	10	4	10
	Davos (in-field observation)	238	2	27	41	18	5	2	7
	Bergportal	10310	2	26	39	15	7	4	9
	Combined Swiss	12847	2	23	41	16	8	3	9
	South Tyrol	1927	2	22	42	15	8	5	8
Accident	Swiss national database	446	3	8	35	16	11	7	23
	Italian national database	91	3	18	22	18	16	9	18

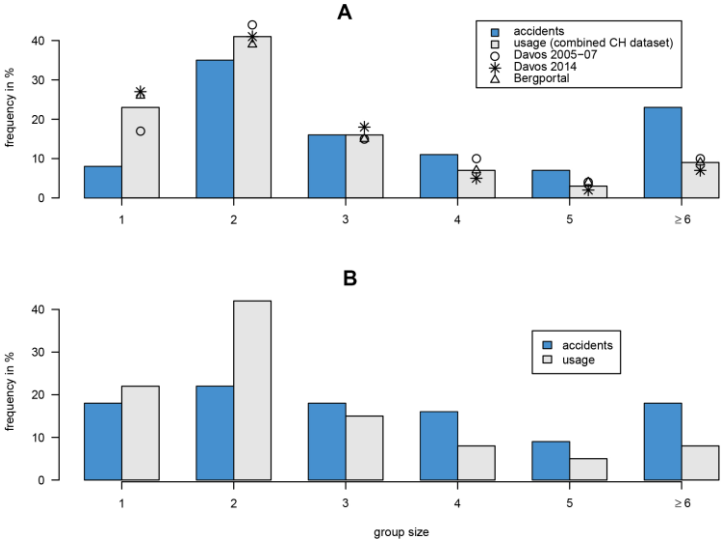

Figure 5-b: Distribution of group size of accident and usage data in the Swiss (A) and Italian (B) datasets. The Swiss data shows the combined usage dataset as grey bars. The single usage datasets are marked with circles (Davos self-registration), stars (Davos in-field observations) and triangles (Bergportal).

We found no difference in group size distribution between usage data from the in-field observations in Davos and the bergportal.ch usage data ($P = 0.220$). However, the group size distribution from the self-registration boards in Davos differed from the Davos in-field observations ($P < 0.001$) and from the bergportal.ch usage data ($P < 0.001$); the Davos self-registration board usage dataset showed relatively fewer people traveling alone. Group size distribution was different in each of the three usage datasets compared to the Swiss avalanche accidents ($P < 0.001$ for all) as well as in the Italian usage dataset compared to the Italian avalanche accidents ($P < 0.001$), but not between the Swiss and Italian accident datasets ($P = 0.584$).

After combining the three Swiss usage datasets we found no difference between the combined Swiss usage dataset and the Italian usage dataset ($P = 0.527$). The combined Swiss usage dataset differed in group size distribution from the Swiss avalanche accidents ($P < 0.001$) and the Italian avalanche accidents ($P < 0.001$). Thus, group size distribution in the usage datasets differed from accident datasets.

In the Swiss datasets we found higher frequency in usage compared to accidents in group size one (23% in the combined usage dataset vs. 8% in the accident dataset) and two (41% vs. 35%, respectively) (→ fig. 5-b). Frequencies of usage and accidents were similar for group size three (16% vs. 16%). Frequency of accidents was higher than usage for group size four (11% accidents vs. 8% usage), five (7% vs. 3%) and six or more (23% vs. 9%).

In the Italian datasets we found higher frequency in usage compared to accidents in group size one (22% usage vs. 18% accidents) and two (43% vs. 22%) (→ fig. 5-b). Frequency of accidents was higher than usage for group size three (18% accidents vs. 15% usage), four (16% vs. 8%), five (9% vs. 5%) and six (18% vs. 8%).

Relative risk of avalanche involvement

RR for all group sizes of the Swiss and Italian datasets are shown in Figure 5-c. In the Swiss datasets group size one had an *RR* of 0.36 (95% confidence interval CI 0.24-0.51), which indicates a lower avalanche risk than the reference group size two ($P < 0.001$). Groups size three had an *RR* of 1.24 (95% CI 0.93-1.64) but was not significantly higher than group size two ($P = 0.141$). Group size four (*RR*=1.54; 95% CI 1.09-2.13; $P = 0.011$), five (*RR*=2.30; 95% CI 1.54-3.35; $P < 0.001$) and six or more people (*RR*=10.60; 95% CI 6.45-16.91; $P < 0.001$) had a higher avalanche risk than the group size two. In the Italian datasets group size one had an *RR* of 1.53 (95% CI 0.77-3.00), which was not higher than the reference group size two ($P = 0.208$). Group size three (*RR*=2.27; 95% CI 1.14-4.46; $P = 0.014$), four (*RR*=3.78; 95% CI 1.86-7.55; $P < 0.001$), five (*RR*=3.22; 95% CI 1.29-7.30; $P = 0.005$) and six or more people (*RR*=4.77; 95% CI 1.50-12.57; $P = 0.001$) had a higher avalanche risk than group size two.

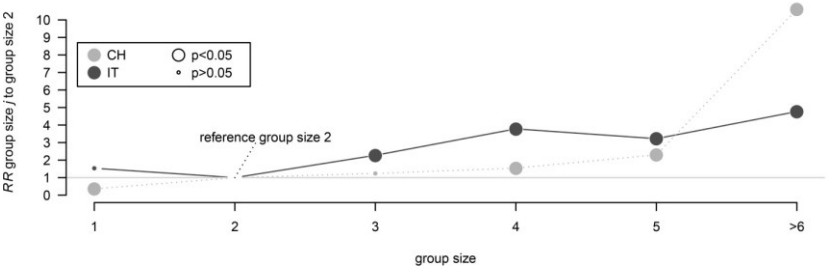

Figure 5-c: Relative risk of group size one, three, four, five and six or more compared to the reference group (size two) for the Swiss (light grey) and Italian (dark grey) dataset. The size of the bullet points indicates the significance level.

5.4.4 Discussion

We calculated the relative risk of avalanche involvement with respect to group size for the first time by comparing accident data with data from in-field usage. The results suggest lower avalanche accident risk for people traveling alone or in groups of two and higher risk for groups of four or more people. The highest risk was found for groups of six or more people in both the Swiss and Italian datasets.

Our findings are in agreement with avalanche safety literature, which emphasizes the increasing risk with increasing group size (e.g., McClung & Schaerer, 2006; Volken et al., 2007; Tremper, 2008; Harvey et al., 2012). Harvey et al. (2012) referred to five causes of increasing risk in large groups: (1) higher load on the snow cover, (2) increased probability to hit a weak spot in the snow cover, (3) a slower decision making process of groups, (4) challenges in communication and (5) high-risk appetite due to an increased but wrong sense of security (related to the risky shift effect [Stoner, 1961]). These factors are absent when someone travels alone in avalanche terrain, which may explain why we did not find higher risk in group size one. However, these results should be considered with caution and do not replace avalanche safety recommendations, which strongly deter recreationists from travelling alone (Ferguson & LaChapelle, 2003) because of the potential consequences of being involved in an accident alone as well as the risk of other injuries, fatigue or getting lost. Companion rescue is imperative for rapid extrication of buried avalanche victims and survival probability is high if the victim is extricated within 18 minutes of burial (Brugger et al., 2001; Mair et al. 2013). Nearly one-quarter of all recreationists in these datasets were traveling alone.

Although the above risk factors may be obvious for large groups there is room for controversy. Group decision-making is a highly complex topic and there is no empirical evidence that groups make better decisions than individuals (Stasser & Dietz-Uhler, 2001) or if group decision-making pitfalls prevail (e.g., Stasser & Titus, 1985; Kerr et al., 1996; Bright, 2010). Communication research has shown that communication quality decreases when group size increases (e.g., Dunbar, 1996; Burgoon et al., 2002; Lowry et al., 2006) and some research found evidence for an increasing risky shift effect with increasing group size (Teger & Pruitt, 1967; Barnir 1998). However, a better understanding of behavior and processes within recreational groups traveling in avalanche terrain is necessary to determine risk factors of larger groups.

Our findings are valuable for understanding avalanche safety related to group size with specific implications: (1) although group size two is the most common in accidents (e.g., Atkins, 2001; McCammon, 2002), considering the relative frequency of users, we found lower risk for groups of two than for larger groups. (2) Our findings support the hypothesis of increased avalanche risk for large groups and we encourage avalanche educators to stress risk reduction measures for large groups. (3) The avalanche safety community should discuss how to advice recreationists who travel alone since the data suggest that many people do travel alone despite the potential consequences and it is unclear how avoiding some of the pitfalls of group dynamics and decision-making may affect risk for these persons. (4) Guided groups are often large and guides should discuss strategies to reduce risk. Finally, (5) our findings show similarities in group size distribution and risk across group sizes between these two regions, but further research may investigate country-specific similarities and differences in more detail.

One limitation of this study is that usage data may not be representative of the total number of recreationists active in a geographic region or during an average winter season. However, obtaining usage data will always be a logistical challenge and to the authors' knowledge this is the first attempt to use data from in-field surveys where possible, which remains the most direct means of estimating the number of recreationists. Another limitation is that the analysis is limited to only those parameters that are comparable between datasets. Group size was defined and collected in the same way in all datasets. Other parameters such as gender or age distributions were not consistently available in all datasets, which prevented additional comparisons. Subsequently, we have no evidence that the combination of the three Swiss datasets with similar weight into one dataset is reasonable. Finally, accident datasets are also prone to reporting bias, for example accidents without serious consequences are underreported. It has been estimated from Swiss data that 20% of avalanche involvements remain unknown (Techel & Zweifel, 2013). However, the accident data included in this study were taken from national databases and all reported accidents with known group size were included for the specified period.

5.4.5 Perspective

For the first time, we quantitatively investigated the effect of group size on avalanche risk by comparing avalanche accident data and backcountry usage

data. The results support previous hypotheses that avalanche risk is higher in larger groups (McClung & Schaerer, 2006). Groups of two are the most common and had lower avalanche risk than larger groups even though they are most frequent in avalanche accidents (Atkins, 2001, McCammon, 2002). Though recreationists who travel alone did not have higher risk than groups, this result is not conclusive and does not replace current avalanche safety recommendations. To overcome the current limitations of risk analyses (i.e. methodological challenges and incomplete data), we recommend that avalanche safety organizations encourage data collection of backcountry recreationists. Video monitoring may be a promising technique in outdoor recreation (Cessford & Muhar, 2003; Arnberger et al., 2005). Future research could integrate other factors into the risk analysis such as gender, age, travel behavior or level of expertise. This would improve our understanding of human factors and avalanche risk and help refine avalanche safety recommendations.

Acknowledgements

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6 Investigation on group behavior (Study III)

In Study I, it became clear that investigations on group behavior require different research approaches. I therefore applied the qualitative method of group interviews to explore the behavior of groups traveling in avalanche terrain is Study III. Section 6.1 to 6.3 provide a separate summary and conclusion of the article and discuss the contribution to the dissertation as well as the value of the publication organ. Section 6.4 contains the original research article.

6.1 Summary and conclusion of Study III

Through 29 group interviews with backcountry and off-piste skiers in winter 2012-13 in Switzerland, the behavior of these recreationists with respect to avalanche safety was analyzed. The analysis focused on the key aspects of group formation, leadership and decision making. Results of the study showed a large number of recommended behaviors, such as the avoidance of risky people in group formations, traveling with an experienced leader or deciding based on established avalanche safety rules. However, also questionable behaviors were found, such as a lack of trust in leadership or deciding based on intuition or even discouraged behaviors, such as traveling in emergent groups or trivializing decisions concerning avalanche risk (Zweifel & Haegeli, 2014).

Overall, group interviews appeared as a valuable approach to exploring behaviors of groups traveling in avalanche terrain and I encourage avalanche safety researchers to do further similar studies. There are numerous interesting group dynamics topics that still remain under-researched such as the investigation of the role of power and conflict in recreationist's decision making or understanding and improving communication issues.

6.2 Contribution of Study III to the present dissertation

Study III could be called the core of this dissertation. It shows a comprehensive overview of different group behaviors as found directly in field investigations. The results of this study provide on the one hand interesting new findings in group phenomena among winter backcountry recreationists

and on the other hand a sound basis for the development of a group check tool (study IV).

6.3 Publication and presentation of study (Study III)

The Journal of Outdoor Recreation and Tourism is a new journal which shows an interest in the application of social science approaches within the realm of outdoor recreation. Hence this journal fits perfectly with the study of the behavior of winter backcountry recreationists. It is worth noting that the Journal of Outdoor Recreation and Tourism recently became more active in the context of avalanches and intended to publish a special issue dedicated to the human dimension of avalanche safety following the International Snow Science Workshop 2014 in Banff.

6.4 Group behavior in avalanche terrain (original research article)

Zweifel B, Haegeli P. A qualitative analysis of group formation, leadership and decision making in recreation groups traveling in avalanche terrain. Journal of Outdoor Recreation and Tourism. 2014: 5-6: 17-26.

ABSTRACT: The popularity of recreational activities in avalanche terrain has increased dramatically in recent years. Venturing into such terrain also increases the personal risk of injury or death. Whereas the majority of recreationists travel in groups, existing research on the human dimension of avalanche safety has primarily focused on individual decision making. This empirical study aims to fill this gap by investigating aspects of group formation, leadership and decision making among winter recreationists with respect to their ability to make safe decisions when traveling in avalanche terrain. We used a qualitative research design and conducted 29 semi-structured group interviews with backcountry skiers and off-piste skiers in Switzerland during the winter of 2013. Our results show that while the majority of the reported behaviors and strategies are effective at reducing avalanche risk (e.g., traveling in well-established groups or deciding on the basis of well-known avalanche safety rules), others are highly problematic (e.g., traveling in emergent groups or trivializing decisions concerning avalanche danger). The identified behavioral patterns offer valuable insight for the development of effective avalanche safety messages to address weaknesses in group dynamics.

MANAGEMENT IMPLICATIONS: Since most recreationists travel in groups when visiting avalanche terrain, group dynamics are a crucial component of avalanche safety, and a better understanding of group behaviors is imperative for safe traveling. We urge avalanche safety educators to put more emphasis on the role of group formation, leadership and decision making for avalanche safety. While strategies known to improve group performance should be encouraged, educators should also highlight the risks associated with the more problematic behaviors explicitly. We propose the development of a group checklist to facilitate the group formation process.

6.4.1 Introduction

Winter recreationists traveling in mountainous terrain, such as backcountry skiers, off-piste riders, snowmobilers and snowshoers, often expose themselves to avalanche hazard. Over the five winters from 2005 to 2010, an average of 183 recreationists died every winter while traveling in avalanche terrain in Europe and North America (ICAR, 2013). Since fatal avalanches are typically triggered by a member of the involved group, a better understanding of their collective behavior is crucial for the prevention of these accidents—a perspective well established in prevention science (Lundgren and McMakin, 2009 and Weinstein and Sandman, 1993).

Traditionally, avalanche safety research has mainly focused on examining the physical aspects of avalanche phenomena such as snow cover, weather conditions and avalanche dynamics. However, the discussion of human factors has recently become more prevalent in the popular avalanche safety literature (see, e.g., Harvey et al., 2012, Munter, 1997 and Tremper, 2008), and the number of studies on the human dimensions of avalanche safety has increased. While existing studies primarily investigated backcountry users′ individual motivations, attitudes and behaviors (e.g., Adams, 2005, Borrie and Roggenbuck, 1995, Gunn, 2010, Haegeli and Haider, 2008, Haegeli et al., 2010, McCammon, 2009, Sole, 2008, Strong-Cvetich, 2014 and Tase, 2004), we know from experience that most people travel in avalanche terrain as groups. Accident investigations clearly document that most accidents involve groups (Jamieson et al., 2010 and Zweifel et al., 2012). Obviously, group dynamics are a critical component affecting the safety of individuals traveling in avalanche terrain. The negative effect of group dynamics on avalanche safety has recently been highlighted in a number of high profile accidents such as the 2007 accident on the Jungfrau in Switzerland (Harvey, Winkler, Techel,

& Marty, 2013), which resulted in six fatalities, and the 2012 Tunnel Creek accident in Washington state, U.S.A. (Branch, 2012) with three fatalities.

Literature

While a wealth of social psychological and sociological research links group phenomena to group performance (e.g., Baron and Kerr, 2003, Kerr and Tindale, 2004 and McGrath, 1984), empirical research on this topic in the context of outdoor and adventure recreation in general, and avalanche safety in particular, is sparse. The most relevant body of literature can be found among expedition studies and outdoor adventure courses, where several researchers have focused on *leadership* issues. Leon, Sandal, & Larsen (2011), for example, examined group phenomena and their influence on group performance in polar environments including polar expeditions, providing a comprehensive overview of relevant social factors, such as decision authority, group size, composition, experience, and leadership issues. Similarly, Cashel (1994) studied leadership issues on mountaineering expeditions. Another relevant research field examines the relationship between *communication* and group performance in outdoor settings. Kjærgaard, Leon, & Fink (2013) emphasized the importance of proper communication for team effectivness from analyzing small military teams on a dogsled journey. Raiola (2003) pointed to the importance of communication in outdoor adventure courses, helping leaders to "address interpersonal and intrapersonal issues as efficiently as possible" (Eys, Ritchie, Little, Slade, & Oddson, 2008: 90). The role of *trust* within recreational outdoor groups has also been studied by various researchers. Motivated by a criminal conviction following a recreational cycling event in New Zealand, Lynch, Jonson, & Dibben (2007) analyzed the role of trust and its influence on freedom in relationships between organizations and participants in adventure recreation. Shooter, Paisley & Sibthorp (2009) analyzed students in outdoor education courses and identified the positive influence of leaders with demonstrated technical abilities, interpersonal ability, kindness and integrity on trust. Other scholars have analyzed *group formation* and group development stages in mountaineering expeditions (e.g., Allison, Duda, & Beuter, 1991). Finally, *group cohesion* has been of interest to researchers of recreational outdoor groups. Eys et al. (2008) examined factors that facilitate cohesion in outdoor expeditions by analyzing behaviors of adventure canoe groups following the approach used by Carron, Colman, Wheeler & Stevens (2002). Their study concluded that cohesion positively influences group performance.

Given the strong link between group performance and personal safety, the lack of studies that relate group phenomena to group performance in the context of recreational activities in avalanche terrain is surprising. While some of the recent studies on human dimensions included questions on group dynamics and the group decision process (Bright, 2010 and Gunn, 2010) or characterized groups in terms of group size, age and gender using accident records (e.g. Atkins and Williams, 2001 and Zweifel et al., 2012), none of these studies used sociological concepts to examine these factors in a more systematic fashion.

Research question

The goal of this study is to provide a first overview of group dynamics affecting recreational groups traveling in avalanche terrain. The concept of group dynamics, which Lewin (1951) defined as the way groups react to changing conditions, describes the salient interpersonal processes that take place within groups and between groups before and during travel in avalanche terrain, such as group formation, leadership, decision making, conflict or motivation (Forsyth, 2006). Following the aforementioned studies on group dynamics in outdoor recreation activities, the present study primarily focuses on (a) the process of *group formation* and development, (b) *leadership* issues within groups and (c) typical strategies used for *decision making*. We analyze reported group behaviors and decision making strategies and discuss their potential effect on avalanche safety. Furthermore, we identify specific behavioral patterns exhibited by certain group types and group activity specific characteristics. More detailed information on the behavioral strengths and weaknesses of different groups traveling in avalanche terrain will provide the avalanche safety community with the necessary background for the development of effective prevention initiatives that aim to address critical aspects of group dynamics.

6.4.2 Background

In the following sections, we will present the sociological concepts of group formation, leadership and group decision making that are examined in the present study. We will also document why they are important in the avalanche context and highlight gaps in existing research.

Group formation

The group development theory of Tuckman (1965) suggests that generally the formation of a group undergoes five different stages, with the first stage being group formation in which group members orient towards each other. At this stage, group members are exposed to uncertainty, dependency and inclusion issues, which make them particularly vulnerable for group dynamics pitfalls like group think or polarization. Since the group formation process sets the stage for all subsequent group interactions, it seems particularly important for accident prevention.

In the avalanche prevention literature, the importance of group formation process was first highlighted in Munter's (1997) 3-by-3 matrix, whereby the three factors conditions, terrain and human factors are evaluated at the three stages trip planning at home, before leaving the trailhead and finally before entering an individual slope. Munter suggested that both the size of the group as well as the skill and experience of group members should be considered during the trip planning stage. Recently, Harvey et al. (2012) further recommended that groups of recreationists should clarify goals and expectations of individual group members prior to a trip.

Leadership

The effect of leadership on group performance has been an active research topic for a long time (see, e.g., Fiedler, 1964 and Liden et al., 1997). Vroom & Yetton (1973) investigated the influence of leadership on group decisions and developed a normative model that describes a number of different leadership styles. The most relevant leadership styles for the present study include the *autocratic style* (leaders make a stand-alone decision, either using information from group members or not, but without sharing the problem with them); the *consultative style* (leaders share the problem with relevant individuals in the group or the group as a whole in search for ideas and suggestions; the stand-alone decision may or may not reflect group members' influence); and the *group style* (leaders discuss the problem and situation with the entire group seeking ideas and suggestions through brainstorming; groups then collaboratively come to a decision and leaders accepts the group decision as final without trying to force a solution on the group) (summarized from Vroom & Yetton, 1973: 67). One should note that in small groups, newly formed or fleeting groups might not exhibit explicit leadership patterns at all (Pearce & Conger, 2003).

In the context of recreational activities in avalanche terrain, the role of leaders is to provide their groups with a pleasurable backcountry experience

and their goal is to make decisions that are appropriate for all members. A leader is regarded as the person whose function is to help the group make better decisions, which includes the reduction of avalanche risk (Tremper, 2008). Accident analyses of Harvey & Zweifel (2008) and Zweifel et al. (2012) support this view as they show a decreasing trend in the proportion of avalanche accidents involving professionally guided groups compared to self-guide groups of recreationists. In contrast, McCammon (2004) found that groups with a leader had higher risk exposure scores than groups without a leader, especially in cases where the identified leader did not have formal avalanche training. Focusing on the performance of groups of avalanche professionals (e.g., mountain guides, avalanche technicians), Adams (2005) concluded that strong leadership skills can overcome common group dynamics pitfalls.

Decision making

The performance of groups in avalanche terrain is not only dependent on leadership, but also on their approach to decision making. Group dynamics research has shown that groups have the ability to make better decisions than individuals (Klein, 1998), but shared information biases, group polarization or 'groupthink' can also lead to suboptimal choices within a group (Forsyth, 2006).

Existing empirical research in avalanche safety has primarily focused on the shortcomings of group decision making. Bright (2010), for example, discussed the role of 'groupthink' in recreational groups in avalanche terrain and McCammon (2002) showed in evidence from accident investigations that so-called heuristic traps might be contributing considerably to avalanche fatalities. In psychology, heuristics refer to simple rules or mental shortcuts that people often use to make decisions in complex situations by focusing on individual aspects of the situation and ignoring others (Gigerenzer, Todd, & ABC Research Group, 1999). Due to cognitive simplicity of heuristics, many decisions in our daily lives rely on this basic approach. However, these rules of thumb can lead to dangerous situations if used in the wrong context. McCammon, 2002 and McCammon, 2004 showed that the inappropriate use of heuristics people commonly employ in their everyday lives can have a detrimental impact on their safety in avalanche terrain.

In the present study, we focus on the heuristic traps most relevant for group dynamics: expert halo, familiarity, social proof and consistency. The *expert halo* effect describes the heuristic where an overall positive impression of the

leader can lead party members to ascribe avalanche skills to that person that they may not actually have (McCammon, 2004). Typical examples of this type of trap are groups led by the best skier or the oldest person, even though these characteristics do not necessarily relate to avalanche safety skills. *Familiarity* refers to the effect when people tend to rely on their memory of past actions to guide their present behavior in familiar settings. This means that they simply tend to behave the same way as they did before in the same setting, rather than going through the entire assessment process again. While the familiarity heuristic is reliable most of the time, it can become a trap when the hazard conditions change considerably. McCammon described *social proof* as the phenomenon that people consider their actions to be appropriate if other people behave similarly (McCammon, 2002). An example of this trap is skiers following existing tracks. McCammon later expanded his list of heuristic traps to include *social facilitation*, which is related to social proof, but more specifically refers to the effect that people perform differently in the presence of others. Groups that are confident in their skills "tend to take more risk using those skills when other people are present than they would when others are absent" (McCammon, 2004: 5). This effect has also been called the 'risky shift' (Stoner, 1961 and Stoner, 1968) and has been observed in groups traveling in avalanche terrain (e.g., Munter, 1997 and Tremper, 2008). The *consistency* trap refers to the fact that people tend to follow an initial decision regardless of changing conditions. In most situations it is reliable to employ this heuristic, but, similar to the familiarity heuristic, it can lead to hazardous situations if conditions change considerably. Groups seem to be particularly susceptible to the consistency heuristic when they are under time pressure, or in the presence of specific goals such as reaching a summit, a hut or completing a trip.

In order to compete with the simplicity of these heuristic traps, avalanche educators have developed simple decision aids that aim to provide an objective platform and assist recreationists in making informed decision (e.g., Haegeli et al., 2012 and Larcher, 1999). While the benefits of these tools have been documented in theory (McCammon and Haegeli, 2007 and Hales and Pronovost, 2006) and among avalanche awareness course participants (Haegeli & Haider, 2008), the prevalence of their use among the general population of recreationists remains unclear.

6.4.3 Methods

Given the exploratory nature of this study, we used a qualitative research design with group interviews to examine reported group behaviors and decision making strategies. Social science researchers have clearly highlighted the insights that qualitative interviews provide on human behavior, opinions, personality characteristics, and life experiences (e.g., Denzin & Lincoln, 1994), which is different and complementary to the insights gained from quantitative studies. Since qualitative interviews attempt to address questions of how and why, instead of how much or how many (Arksey & Knight, 1999), it is especially valuable for exploring relatively new research fields. The potential of qualitative approaches in a recreational context has recently been highlighted by Aas & Onstad (2013), who investigated kayakers′ and anglers′ behavioral strategies to get along with a highly variable river environment.

Sampling design and data gathering

To collect a meaningful sample for this study, we conducted our interviews at locations with a high likelihood of encountering different types of skiing groups (e.g., backcountry skiers[7] and off-piste skiers[8]) and different group structures (e.g., families, couples, groups of friends). Interviews were conducted in the Eastern Swiss Alps (Grisons) between January and March 2013. Backcountry groups were intercepted in parking lots where ski tours start and end, off-piste groups were interviewed in ski areas, either at lift stations, restaurants or at locations, where popular off-piste routes end. Intercepting groups right at the end of their backcountry trips helped to minimize issues with recall, particularly about their thoughts and discussions during their trip. Because the WSL Institute for Snow and Avalanche Research SLF is well known and highly respected for its avalanche safety work, it was easy to obtain compliance and only few groups declined to participate in this study. During bad weather we used a van as a shelter, which provided a comfortable atmosphere for the interviews.

We used a rough interview script for the semi-structured group interviews to ensure we covered the six main themes: planning, motivation, decision making, leadership, group structure and risk taking. However, the open-ended character of our questions allowed interviewees to more openly report on their

[7] For simplification, the terms ‘skiing’ and ‘skiers’ also includes snowboarding and snowboarders.

[8] Also known as free riders or out-of-bounds skiers.

outdoor experience. To ensure an accurate representation of the group dynamics in our study, our interviews always included the entire group of recreationists. This approach offered all group members the opportunity to express their thoughts and opinions, which resulted in a much richer and authentic perspective. Frey & Fontana (1991) regarded field group interviews as an excellent data gathering technique, especially in exploratory studies and in settings where other observation techniques are difficult. They further mentioned group interviews to be "a research technique that takes advantage of group dynamics to produce new and additional data" (Frey & Fontana, 1991: 183). Following the group interview, each interviewee completed a short survey form with background information about basic socio-demographics and avalanche training.

In total, we conducted 29 group interviews with a total of 98 individuals. Thereof, 21 interviews were conducted with groups of backcountry skiers (mean age 54) and the other eight interviews with groups of off-piste skiers (mean age 35). The interviewed groups consisted of two to 14 members each.

Data analysis

After transcribing the interviews, we used a thematic analysis to examine the interview data (Guest, MacQueen, & Namey, 2011). During the exploratory phase of the analysis we developed an initial list of thematic codes using the text analysis software 'MAXQDA' (www.maxqda.com) to examine the interview scripts and identify typical quotes for each of the thematic codes. Subsequently, we summarized thematic codes to build patterns of behavior for each theme and to develop an initial inventory of reported group behaviors regarding group formation, leadership and decision making. The identified patterns were then compared with the concepts from social psychology and avalanche safety research described in the previous section and—to provide the most meaningful insights for the development of future avalanche safety initiatives—classified with respect to their effectiveness for avalanche risk management into three categories:

- *Recommended behaviors:* suggested as best practices in avalanche safety literature and research.
- *Questionable behaviors:* only appropriate under certain conditions and should be used with caution.

- *Discouraged behaviors:* have the potential to considerably increase avalanche risk.

6.4.4 Results and discussion

Group formation

All groups interviewed in this study emphasized the importance of the group formation process as a first step of managing group behavior on their trip and maximizing the quality of their experience. While we found a multitude of strategies and behaviors related to this process, we did not find any evidence of a well-structured approach to group formation similar to how recreationists typically seem to approach the evaluation of the physical aspect of avalanche risk. Table 6-a lists the most prominent observed behavior patterns in group formation process and contains some typical quotes.

Table 6-a: Observed behaviors in group formation with typical quotes.

Group formation	Typical quote
Recommended behavior patterns	
(1) Constant groups over time	*Guiding is awesome when you know the guests and work with the same groups. This allows you to plan differently, also with respect to risk, than when you have a single guy in the group who is always pushing (Mountain guide from backcountry group 2)*
(2) Consider group size	*I think…the bigger the group, the more dangerous it is, because you get a sense of safety and you don't question things the same way as when you are traveling in a group of two (Backcountry skier from couple 15)*
(3) Avoidance of risky people	*I would be way too stressed out if I knew…that they like to push the limit and you cannot talk to them about it. I am just not up for that (Off-piste skier of friends group 7)*
Questionable behavior patterns	
(4) Changes in group structure	*Yeah, I do a lot of different groups too, but mostly with Johan my friend. But often we are bigger groups. But every time there are some others (Backcountry skier from friends group 22)*
(5) Group formation done by organizations	*So last week we were on a four-day trip with the Alpine Club. The trip description said that the tours would include between 900 and 1100 m of elevation gain for people with intermediate levels of fitness. But the weather was so nice…we simply decided to do a 1750 m ski tour on Sunday. But then you think this totally does not match with the original description of the trip (Backcountry skier from couple 17)*
Discouraged behavior patterns	
(6) Emergent groups	*I just really wanted to go out of bounds! And I really wanted to find somebody to come along. I then met him, just by chance,…and he has so much experience (Off-piste skier from emergent group 3)*

Recommended behavior patterns

Many recreationists travel in well-established groups and have been recreating together for a long time:

We have been a couple for seven years and we have been ski touring together since then. We probably do 99% of our ski tours together. This is

super convenient… really for everything: group, organizing,.. (Backcountry skier from couple 1).

People often consciously form groups with individuals they know well and with whom they have previously recreated. Using this strategy, individual and group expectations are well established and avalanche risk can be reduced:

I generally try to go with people I know and where I have a good sense of their willingness to take risk…and I can discuss things with people I know (Off-piste skier from friends group 7).

Proper awareness of the abilities, goals and behaviors of other group members significantly reduces the risk of unexpected group dynamics. Raiola (2003) mentioned that "usually, these issues are addressed before the group embarks on its journey, while you establish individual and group goals, discuss rights and responsibilities, and develop agreements aimed at facilitating a positive educational experience" (p. 51). Eys et al. (2008) highlighted that "understanding the background experiences and characteristics of group members involved in extended outdoor expeditions is important" (p. 91). Cashel (1994) also mentioned that groups that have traveled together before show better performance than newly formed groups.

The group classification scheme of Lickel et al. (2000) distinguishes between intimate groups (e.g., families, romantic couples, close friends) and task groups (e.g., teams, neighborhood associations). In the present study, we found well-established intimate groups, both in self-guided groups (e.g. families, couples, close friends) and in professionally guided groups (e.g. a mountain guide with regular guests).

Most recreationists interviewed in this study considered group size when organizing their group. Most groups tried to keep their numbers small since they view larger groups as more susceptible to negative group effects. Other interviewees, however, preferred large groups because they can be divided into smaller groups in case of disagreements within the group, or to ride different routes that better match the abilities of different members:

And in bigger groups you have the advantage that you can split the group, as we did today (Off-piste skiers from friends group 13).

Keeping groups small is an established strategy for managing avalanche risk (e.g., Tremper, 2008 and Harvey et al., 2012), since larger groups show a higher susceptibility to heuristic traps (McCammon, 2004), and because quality of communication decreases and 'groupthink' increases (Bright, 2010). While McCammon (2004) used avalanche accident records to show that single individuals and larger groups might expose themselves to higher levels of avalanche hazard than small groups, so far no studies have explicitly examined the effect of group size on the group′s ability to manage avalanche hazard effectively. The possible advantages of larger groups have so far not been discussed in avalanche safety literature.

A widespread consideration during group formation is the avoidance of people who are considered a safety hazard. People who have had bad experiences with a participant or a particular group typically avoid including these participants again.

Questionable behavior patterns

Apart from groups that are very constant over time, many groups consist of a core group of members who are occasionally joined by additional participants. These self-organized task groups (e.g., a group of friends with a common goal) exhibited a more active group formation process. They usually have a network of people who they travel with and often try to build groups with consistent goals, skill levels or risk taking attitudes:

We have a common interest in snowboarding and skiing: ski instructor, snowboard instructor, snowboarder; we know each other from home (Off-piste skier of friends group 5).

Harvey et al. (2012) recommended that groups should clarify the goals and expectations of group participants prior to a trip without giving concrete advice regarding the selection of other group members.

Apart from situations where the group formation processes are driven by the group itself, professionally guided task groups are usually formed by third parties (e.g., reservation office of a mountaineering school that offers commercial backcountry trips). This approach can lead to considerable misunderstandings among group members regarding the difficulty of the trip or the expectations of other group members. Harvey et al. (2012) argued that open communication from these schools can considerably reduce group pressure and avalanche risk. However, the potential for conflict with commercial interests

increases as clients are typically expecting exciting outdoor experiences or famous summits. It is the responsibility of professional guides to clarify expectations and desires of their clients beforehand.

Discouraged behavior patterns

Groups that only form for the purpose of skiing and exist only for the duration of their trip should use extreme caution, since their group behavior is highly uncertain due to the looseness of this configuration and the lack of shared prior travel experience:

So, you don't know each other and have never been riding together? Right. In the end all of our friends were working, which just left the two of us (Off-piste skiers from emergent group 3).

Cartwright & Zander (1960) labeled this type of short-lived task group 'emergent groups' in contrast to the more in advance organized 'planned groups'. While we only found a small number of emergent groups in our study, they seemed to exhibit more risky behavior patterns than the planned groups. One of the possible reasons for this difference is the generally limited knowledge of partners' abilities, goals and expectations in emergent groups. A in-depth understanding of partners' perspectives has been highlighted as a key factor for superior group performance (see, e.g., Eys et al., 2008 and Raiola, 2003).

Leadership

In general we found that the level of avalanche expertise was high among leaders, which is an excellent foundation for effective leadership when traveling in avalanche terrain. However, it remains unclear whether these recreationists were also actively developing other important leadership skills, such as communication, personal mastery or leadership capacities (see, e.g., Adams, 2005, Cashel, 1994 and Leon et al., 2011). The primary observed behavior patterns in leadership are summarized in Table 6-b with typical quotes.

Table 6-b: Observed leadership styles with typical quotes.

Leadership behavior	***Typical quote***
Recommended behavior patterns	
(1) Groups with a leader who has considerable avalanche expertise	*Is somebody in this group in more of a leadership role? A: Probably me, because I have more experience. B: Yes (Backcountry skiers from couple 15)*
(2) Task-orientated leadership	*Who in your group normally leads and why? On the downhill, it is always him. On the uphill, I like to lead until I do not know where to go anymore (Backcountry skier from couple 1)*
Questionable behavior patterns	
(3) Lack in trust	*A: It [to go with a professional guide] is totally not a problem anymore. However, just going somewhere, with just any guide just somewhere, hmm. B: I would not like that! A: That would be difficult… there would not be any trust here (Backcountry skiers from family 9)*
(4) Leader with wrong skill set (expert halo heuristic)	*Is somebody in your group in more of a leader role? Daughter: Yes, that would be Dad; And when you make a decision, do you communicate this and everybody just follows your leader or do you openly discuss the situation? Mother: Yes, we do, don't we? We normally check with everybody (Backcountry skiers from family 9). [From the additional questionnaire we have seen that the daughter had considerable more avalanche expertise than the father.]*
Discouraged behavior patterns	
(5) Groups without a leader	*Does anyone guide this group? B: No. So you decide all together? A, C, D and E at the same time: Yes (Off-piste skiers of friends group 6)*
(6) Lack of communication	*You could interpret this [open communication] in two ways: As confidence or as insecurity. A confident person can openly say what they think and feel. That's the pretend confidence you get from guides sometimes, super cool on the surface, but deep down extremely insecure (Mountain guide from backcountry group 2)*

Recommended behavior patterns

Besides the three professionally guided groups interviewed in this study, the majority of the 18 self-guided groups stated that they have a designated leader. This leader was typically the group member most experienced in

assessing and managing avalanche hazard. To have a designated leader has been regarded as a crucial factor to avoid confrontations (Leon et al., 2011) and therefore improves group performance.

Although groups were usually led by a single person at a time, we observed considerable variations in leadership configurations. In some groups, for example, the leader changed depending on the task at hand. Eys et al. (2008) stated that such task oriented leadership behavior improves group performance. Other groups were led by two members at the same time. While this configuration has potential for disagreement between the two leaders, it also has considerable advantages. In the case of problems (e.g., after a fall or in difficult terrain), two leaders offer more resources for assisting inexperienced group members.

We observed that leaders of self-guided groups primarily lead in a consultative manner as described by Vroom & Yetton (1973). Leaders actively incorporated their group in the decision process and groups did not report any cases of conflict, indicating a high level of consensus.

The recreationists interviewed in this study exhibited a high level of trust in their leaders and were generally pleased with their leadership style and decision making:

How would you describe [his leadership style]? *A: So, he is very confident and he knows what he is doing. C: even tempered…and now, at his age, he has become calmer, more rational and very diligent. A: Even tempered and cautious… This is really what one should be looking for, isn't it? (Backcountry skiers from guided group 26)*

Professionally guided groups generally showed autocratic leadership styles (Vroom & Yetton, 1973) reflective of the guide–client relationship. However, our interviews also showed that the extent to which guides rely on their authority to lead their group varies depending on the group and the severity of the avalanche situations:

I try to guide with as little authority as possible, but rather with professionalism. You want to be transparent and openly communicate the options… However, if the situation gets dangerous, I will definitely tell them where to go. I will clearly communicate the boundaries (Mountain guide from backcountry group 2).

Questionable behavior patterns

Interviewed recreationists stated that a bond of trust between members and the leader is crucial for the leadership to be effective. Whereas a bond of trust is generally inherent in intimate groups, the bond of trust is often lacking in task groups or emergent groups:

I was touring in Norway last year…And then…I simply refused to continue once. It just did not feel right. The whole group agreed with me right away. We just needed somebody to vocalize it. The guide totally did not understand [our concerns] and I did not understand [his reaction]. He is getting paid for this and when the group does not want to continue, they do not want to. He then dug a snow profile to prove to us that itwas safe. But I said "I don't care about the profile." It was really a solid profile. He was probably right, but at this point it did not really matter anymore. …And did the guide finally give in? He did, yup. But he was grumbling a bit (Backcountry skier from couple 4).

One should therefore note that the existence of a leader alone does not necessarily imply good leadership and improved group performance. The importance of a bond of trust between the leader and his or her followers for good group performance has also been highlighted by Lynch et al. (2007) and Shooter et al. (2009).

A further concern in leadership behavior of self-guided groups is that the leader is not always the most qualified person with respect to avalanche safety. The leader role often is often rooted in personality traits, age, family structure or athletic skills, but not necessarily related to avalanche expertise. Our study sample included a family, where the father led his family in a consultative manner and a high level of trust even though his daughter was most experienced and had completed two formal avalanche safety courses. While the daughter′s perspectives were certainly included in the family′s decision process, the father was still the primary decision maker despite his lack of formal avalanche training and lower level of experience. This example nicely illustrates the expert halo heuristic trap identified by McCammon (2004).

Discouraged behavior patterns

Eight groups in our sample did not have a designated leader. Groups without an explicit leader are viewed to be at increased risk of negative group

phenomena (e.g., 'groupthink' or group polarization) by social scientists (e.g., Pearce and Conger, 2003 and Forsyth, 2006), avalanche researchers (Bright, 2010) and avalanche safety educators (Tremper, 2008). We observed a general lack of avalanche safety concerns in many of the groups without leaders interviewed in this study:

Did you plan this tour in advance? A: No, we decided to go spontaneously. B: Yes, it was a spontaneous decision (Backcountry skiers from friends group 10).

Consistent with the many scholars who have highlighted the importance of open communication for group performance in the outdoor context (e.g., Di Salvo et al., 1989, Raiola, 2003, Baldoni, 2004 and Kjærgaard et al., 2013), many of the interviewed groups mentioned poor communication as a unfavorable behavior pattern that should be avoided. Even though the importance of open communication was stressed by many of our interviewees, it was difficult to systematically examine this aspect of leadership in our interviews.

Decision making

Decisions made by groups traveling in avalanche terrain can roughly be classified into two main categories: (a) decisions related to avalanche safety and (b) decisions regarding the general well-being and experience of the group (e.g., turning back because of discomfort due to heavy wind). The present analysis focuses exclusively on decisions that explicitly relate to avalanche safety. Table 6-c lists the most prevalent behavior patterns in decision making observed in this study with typical quotes.

Table 6-c: Observed decision making strategies with typical quotes.

Decision behavior	***Typical quote***
Recommended behavior patterns	
(1) Strategies based in avalanche safety rules	*Go through the avalanche bulletin in your head again. Remember that this is a north facing slope. The bulletin mentioned slopes facing west to north and south east, so this slope is within the aspects with elevated hazard (Backcountry skiers from couple 1)*
Questionable behavior patterns	
(2) Familiarity heuristic	*This is the twelfth time we are doing this trip. I have been to Eggberg I don't know how many times. We don't need to plan anything anymore (Backcountry skiers from friends group 18)*
(3) Following existing tracks (social proof heuristic)	*But we knew that there were still holidays and lots of people around. This is a fairly popular route and we expected that there would be a track (Backcountry skiers from friends group 16)*
(4) Deciding based on intuition	*Did you use any decision aids for this decision [to turn around]? A: No. B: No, it is enough to have a gut feeling. At this point, it is best to stop. (Backcount. skier from couple 4)*
(5) Blindly trusting the danger level from the public avalanche bulletin (consistency heuristic)	*How did you plan the tour? Yes. First, we considered the conditions. Is it possible? And the avalanche danger changed from considerable to moderate the evening before (Swiss Alpine Club guide from backcountry group 26)*
(6) Possible over-commitment (consistency heuristic)	*I always try to find peaks that I have not climbed yet (Backcountry skiers from couple 20)*
Discouraged behavior patterns	
(7) Avoiding or trivializing decisions concerning avalanche risk	*Did any of your decisions today specifically relate to avalanche hazard? Nope, because it is pretty flat here (Off-piste skier from friends group 7)*
(8) Deciding spontaneously	*… You just hike up and when you get to the top, the first guy just says "Guys, I am out of here!" We don't really talk about feeling or so. I am actually always surprised about this because all three of us teach this stuff and we exactly know how important it is (Off-piste skier from emergent group 3).*[a]

[a] Statement about the behavior in another off-piste group.

Recommended behavior patterns

Many of the decision making strategies observed in our interviews are well-grounded in established avalanche safety practices and take the form of simple rules that relate to general warning signs about snowpack and avalanche conditions (e.g., signs of instability):

And then we were planning to go to Gfrorenhorn first. But we decided to cancel that, because we heard two whoomphing sounds [9] (Backcountry skiers of friends group 22)

or terrain characteristics (e.g., slope include, aspect, terrain traps):

...we avoided the southeast facing slopes of the Sentischhorn one hundred percent. We followed a route on the left side of the little valley, the safe side of the valley, to avoid the issue of remote triggering. We stuck to this plan one hundred percent: We broke trail ourselves to make sure that we did not blindly follow an existing track (Backcountry skier from guided group 26).

We also observed rules that aim to mitigate the effect of unfavorable human factors, such as:

If we bring people along, beginners or people we do not really know, which also happens once in a while, we adjust our ski tour appropriately (Backcountry skiers of group 29).

These adjustments usually relate to the difficulty and length of a tour. By not overly pushing the limits of the group (e.g., not staying too late on south facing slopes that become more dangerous in the afternoon due to solar radiation), they can considerably improve their margins of safety and reduce the avalanche risk of the group.

While rule-based decision strategies have been seen as best practice with respect to safely travel in avalanche terrain (Haegeli et al., 2010), none of the groups interviewed in this study reported to formally use one of the published

[9] 'Whoomph' is a technical term for the sound of a collapsing snow cover, usually interpreted as a sign of avalanche danger (Tremper, 2008).

decision aids (e.g., Larcher, 1999 and Munter, 1997) even though they were specifically asked about it. However, most groups did use at least some of the decision rules promoted by these tools in the form of simple heuristics.

Questionable behavior patterns

Apart from heuristics which are grounded in avalanche safety practice, we also observed that people relied on common heuristics which are not rooted in avalanche safety and can—under certain circumstances—lead to serious consequences. Twenty out of 29 groups interviewed in our study relied heavily on familiarity and often traveled in areas they already knew (McCammon, 2004). This behavior was common among all types of groups.

Backcountry skiers often seemed to base their decision to go on a particular trip on the existence of an up-track. However, blindly following existing tracks can be dangerous since their presence does not automatically imply that a slope is currently stable. Interviewees explained that existing tracks made them feel more secure and gave them confidence as other groups had safely completed the trip before them. However, avalanche conditions might have changed dramatically since the previous group completed the trip. This behavior nicely illustrates the potential pitfalls of McCammon's (2002) social proof heuristic trap.

Furthermore, winter recreationists often made decisions based on their intuitions—they followed their gut feeling without being able to fully verbalize the factors contributing to their decisions. Klein (1998) described intuitive decision making as a process of knowledge-based decision making that occurs at a subconscious level and is based on years of practical experience. While this approach to decision making works well in many situations of our daily lives, gaining the necessary practical experience for safe decision making in avalanche terrain is challenging because it is a so-called wicked learning environment (Hogarth, 2001). Because of the spatial variability, small scale and transient nature of trigger spots for avalanches, it is possible to ski a slope without triggering an avalanche even under high avalanche hazard when it is not considered safe due to the potentially fatal consequences. Because these judgment errors are generally not apparent to unobservant recreationists, the experience can lead to unjustified confidence in decision skills and ill-calibrated intuition. Avalanche safety educators therefore recommend only using intuition if it appears to warn about the current conditions, but never for justifying an otherwise questionable decision (Harvey et al., 2012).

We also observed that backcountry groups often blindly put their trust into the danger ratings of the public avalanche bulletin without locally verifying it during their trip. Such blind trust can lead to dangerous choices if the danger level of the general forecast is lower than the actual local condition or conditions have changed between the time of publication of the avalanche bulletin and the actual trip (Tremper, 2008).

Other groups had larger, overarching objectives that might conflict with avalanche safety concerns in their decision making process. Some of the interviewed groups expressed to focus on peaks that they had not visited before, whereas others had an explicit list of peaks they wanted to climb over time. Even if this strategy is not directly related to avalanche safety, this focus on a particular goal can significantly influence it. Having a strong desire to climb a particular summit—maybe the last summit on a 'list'—has certainly the potential to make people take more risks than usual. Both of these behavior patterns are examples of McCammon's (2004) consistency heuristic trap.

Discouraged behavior patterns

Some groups, mainly groups of off-piste skiers, simply did not take avalanche hazard into consideration or trivialized avalanche problems:

Did any of your decisions today specifically relate to avalanche hazard? A: *No, not today. First we skied in the trees and now a bit above treeline…a bit of slush, but otherwise pretty good (Off-piste skier from friends group 12).*

Other groups decided very spontaneously with little consideration of avalanche hazard:

Today was totally spontaneous… I thought the weather would turn bad and we would only have a run or two. I was totally fine with just a run or two, but then we said "Let's do another one since it is so nice" and so on. So from this perspective, we really did not plan our day. We planned a little from hour to hour (Off-piste skiers from emergent group 3).

6.4.5 Conclusion

The present study aimed to address a significant gap in the human dimensions research of avalanche safety by systematically examining the formation process, leadership style and decision making strategies of groups

traveling in avalanche terrain and contrasting them to best practices promoted in avalanche safety literature.

While the majority of groups showed favorable behavior patterns that are well rooted in best practices of avalanche safety, some of the observed patterns are causing great concern as they can considerably increase the risk of being involved in an avalanche accident. The *group formation* process of many groups was dominated by favorable behaviors such as traveling in long-standing groups, taking group size into consideration, and avoiding traveling with people who are known to take risks or behave unpredictably. Groups that frequently change in their structure and groups that are formed by third parties (e.g., reservation office of a mountaineering school) are advised to apply extra caution as they are more susceptible to negative group influences. However, the most problematic groups are emergent groups, since safety considerations are often completely absent during their group formation process. Many groups interviewed in this study exhibited favorable *leadership styles*, including single leaders with considerable avalanche expertise or multiple leaders who divided up the leadership responsibilities according to their specific skills. Professionally guided groups put together by third parties should pay special attention to establish a good guide–client relationship as a lack of trust can lead to highly problematic leadership situations. Self-organized and self-guided groups should carefully evaluate whether the leader really possesses relevant avalanche expertise. Groups without a leader and groups with poor communication behavior are most susceptible to negative group influences. Many of the interviewed groups used *decision making strategies* that are based on simple safety rules, such as avoiding the terrain stated in the public avalanche bulletin as being the most dangerous, or responding to the presence of warning signs, which are consistent with best practice. Strategies that should be used only with great caution include the use of heuristics that are not grounded in avalanche safety, intuition, blind trust in the danger level posted in avalanche bulletins and being overly committed to a pre-existing plan. However, the most dangerous strategy is to not to take avalanche hazard into consideration at all, or to trivialize these decisions.

The results of this study provide valuable first insights into the strength and weaknesses of the behaviors of groups traveling in avalanche terrain and help avalanche educators to better highlight the influence of group dynamics on avalanche safety. However, as pointed out by McCammon (2002), merely

making recreationists aware of human factors might not necessarily make them less susceptible to them. McCammon further suggests that in order to make these human factor challenges more tangible, educators need to provide recreationists with simple and viable tools for recognizing and mitigating them. Checklists for error management and performance improvements has proven valuable in many high-risk environments such as aviation, aeronautics, product manufacturing and critical care (Hales & Pronovost, 2006) and checklist-type tools have been introduced to avalanche awareness education to assess snow and avalanche conditions (e.g., Haegeli et al., 2012 and McCammon and Haegeli, 2007), and to highlight the potential for heuristic traps (McCammon, 2004). Even though the recreational and voluntary nature of the activity might make it more difficult to promote the use of such structured decision aids, we suggest that the development of a simple group checklist to enhance the group formation process in the planning stage would be a valuable addition to the existing avalanche safety toolbox. While avalanche educators should highlight behavior patterns that have been identified as questionable or should be discouraged, they should also explicitly promote the benefits of favorable behaviors, such as forming groups with similar goals and skill levels or ensuring that the difficulty of a trip matches the skill level of the weakest members of the group.

The method of qualitative group interviews has proven itself as a valuable tool for exploring this new research field. However, despite being interviewed immediately at the end of their trip, most participants had trouble recalling their communication during the trip in detail. This indicates that communication within backcountry groups is likely quite subtle, involves non-verbal cues and is highly situational. The interview approach used in this study clearly has limitations for capturing these types of influences and direct in-situ observations during backcountry trips would be required to get more meaningful insights into communication processes in backcountry groups. While participant observation has been seen as a valuable approach in the context of outdoor recreation (e.g., Glancy, 1986 and Weber, 2001), we believe that it would be difficult to conduct a study with an explicit observer without inadvertently affecting the behavior of the group. We therefore conclude that technical methods like audio-recorders, as proposed by Fitzpatrick and Boulton (1994) for health care research, or experience-sampling (Berget, 2012 and Christensen et al., 2003), also known as beeper studies, offer promising

alternatives for examining group dynamics and decision making in avalanche terrain in more detail.

To obtain a more comprehensive perspective on group dynamics among backcountry recreationists, future research should also examine other major influences on group behavior mentioned by Forsyth (2006), but not covered in this study: the role of power, motivation and intergroup relations. Furthermore, a quantitative examination of the relationship between the key group behaviors and group performance using either one of the in-situ approaches suggested above or accident avalanche records could provide a valuable perspective on the prevalence and impact of the various identified shortcoming. Even though we did not explicitly examine differences in group behavior among backcountry users groups in the present study, our results provide hints that there are considerable differences between backcountry skiers and off-piste skiers. This observation confirms previous research that showed that motivation for backcountry travel and level of avalanche awareness can vary considerably among user groups (e.g., Hales and Pronovost, 2006 and Zweifel et al., 2012). Future research of group dynamics should therefore examine these differences in more detail as each of the user groups might exhibit different weaknesses and require a tailored prevention approach.

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7 Practical application

Traditionally avalanche research is closely linked with practice and its players. Findings from research usually find their way quickly into practice even if they are not yet verified. Therefore I propose a group checklist for people who travel in avalanche terrain with an own article. The checklist which is defined with the acronym SOCIAL is based on avalanche safety literature and on existing concepts from sociology and social psychology as well as on the findings of Study I, II and III of this dissertation. The goal is to finally have a useful tool for group who travel in avalanche terrain to make them aware on typical problems occurring in groups. The group check tool SOCIAL is presented in the following section with minor adaptations from the original research article as presented at the International Snow Science Workshop in Banff, AB in 2014.

7.1 SOCIAL – A group check tool (original research article)

Zweifel B. SOCIAL - A group check tool. International Snow Science Workshop 2014, Proceedings. Banff, AB, 2014:963-969.

ABSTRACT: Despite the fact that recreationists in avalanche terrain usually travel in groups, empirical research on group phenomena is still sparse. I propose a group check tool based on relevant literature from avalanche safety research but also on existing concepts from sociology and social psychology. Important additional input on content and form of the tool was given by an expert workshop of the *Swiss Snow Sport Avalanche Accident Prevention* core training team. The resulting group check tool SOCIAL summarizes the most important group factors: ***S**kills* of group members should be in accordance with the demand of the trip; ***O**rganization* should set course for basic group characteristics such as group size and roles of group members; ***C**ommunication* is THE instrument enhancing group performance; ***I**dentification* of group members with trip goals, expectations and decisions taken; one should always screen for ***A**nomalies* in group behavior like risky shift or heuristic traps; and finally one should critically question ***L**eadership* issues.

7.1.1 Introduction

Winter backcountry recreationists travel usually in groups (Zweifel et al., 2012). While these groups show a wide variety of size, type, leadership styles or decision making strategies they are all faced with avalanche hazard and therefore have to find a way to deal with it.

The majority of research related to human factors concentrates on decision making strategies and pitfalls (e.g., McCammon, 2002; McCammon et al., 2008; Haegeli et al., 2012) or analysis of human risk factors (e.g., Sole, 2008; Procter et al., 2013) including investigations of safety equipment (e.g., Brugger et al. 2007; Haegeli et al., 2014). While there is surprisingly little empirical research on group phenomena (e.g., Bright, 2010; Zweifel & Haegeli, 2014), there is evidence from high profile avalanche accidents but also from group dynamics concepts for group factors to be crucial while traveling in avalanche terrain.

Examining group interviews that we conducted in winter 2012-2013 Zweifel and Haegeli (2014) found that most groups used a variety of strategies in planning, leadership and decision making, usually with the goal to reduce avalanche risk. However, there was no structured way how groups dealt with group related factors. In contrast, the value of simplified tools for decision making has been indicated theoretically (e.g., Haegeli et al., 2010) and practically with avalanche awareness course attendants (Haegeli & Haider, 2008). Zweifel and Haegeli (2014) found that recreationists usually did not use decision aid tools explicitly, i.e. in the way they were supposed to be used, but that "most groups did use at least some of the decision rules promoted by these tools in the form of simple heuristics" (p. 23). This means that these tools rather have an educational value than that they are a real decision aid. Nevertheless, it is beyond controversy that a structured approach in the decision making process supported by simplified tools and/or checklists is superior to an unstructured approach as often found in practice.

Our goal is therefore to propose a simple group check tool which facilitates the planning and management of group phenomena. The tool should on the one hand include the most important group factors influencing avalanche risk and on the other hand stay as simple as possible in order to not burden recreationists. I followed therefore the two research questions: (1) Which is the most important content of a group check tool and (2) how should such a tool look like in order to be valuable in practice?

7.1.2 Methods

In order to reveal the most important group factors influencing avalanche risk I reviewed avalanche safety literature as well as existing concepts from sociology and social psychology. I framed the factors I found in structural, psychological and communication elements.

To evolve content and practical requirements of a group check tool I conducted an expert workshop with 15 members of the *Swiss Snow Sport Avalanche Accident Prevention* core training team during a workshop on human factors on 12 May 2014 in Innertkirchen, Switzerland (→ Appendix A.3 for a participant list). The expert workshop discussion was taped and additional notes were taken. In a similar manner to our expert workshop focus groups have recently been applied in the avalanche context (Adams, 2005; McCammon et al., 2008). Focus groups have been seen as an interview technique notably useful in studies with exploratory character (Denzin & Lincoln, 1994). A further benefit of this expert workshop was the inclusion of key avalanche community people from the very beginning of the development of the group check tool. Past avalanche safety initiatives have shown the importance of including key avalanche experts in the initial stage of tool development to promote acceptance (e.g., Harvey, 2006; Haegeli, 2010).

Finally, I combined findings from the literature review with results from the expert workshop to develop the SOCIAL group check tool.

7.1.3 Literature review

Group phenomena can be arranged in three main characters: (1) Structural attributes such as group size, skills of group members, organization of leadership or the type of the group (e.g. family, couple, group of friends), (2) psychological attributes such as the decision making process and its difficulties, goals and expectations of group members, the leadership style or the influence of the environment on the group and (3) communication as THE instrument enhancing group performance (e.g., Adams, 2005; Priest & Gass, 1997; Garicano & Wu, 2012).

Structural attributes

Group size has been the most discussed group risk factor with an agreement that large groups have a higher avalanche risk than small groups (Harvey et al. 2012; Zweifel et al., submitted). Harvey et al. (2012) related the higher avalanche risk of large groups on the one hand to snowpack parameters such as

a higher probability of triggering an avalanche and on the other hand to group related parameters such as a slower decision making process or the risky shift effect. In sum the message from an avalanche safety perspective is clear: keep groups small. However, this may be challenging especially for professionally guided groups due to commercial interests.

Leadership is a second crucial factor in group performance. Statistics have shown that groups without a guide produce more accidents than professionally guided groups (Harvey & Zweifel, 2008). However, since these analyses do not include backcountry activity as information on the usage data, a real risk assessment is impossible. Further, accident data distinguish only guided and non-guided groups and no information on informally guided groups is available. However, empirical studies showed that a majority of groups traveling in avalanche terrain is informally guided (Bright, 2010; Zweifel & Haegeli, 2014). In their qualitative study on group dynamics, Zweifel and Haegeli (2014) found that interviewed non-guided groups exhibited unfavorable behavior most frequently, while in informally guided groups the main question is whether the guide is the right person and has appropriate avalanche expertise. Do (2014) also mentioned groups without a leader or moderator as a risk factor in a human factor red flag list. Although guided groups have been seen as the most favorable ones they are not free of any negative group aspects, especially if there is no bond of trust between the guide and the group members.

Moreover, backcountry recreationists are characterized by its *group type*. Regarding activity type, off-piste skiers are generally seen as higher risk takers than backcountry skiers since they are more motivated by adrenalin and risk factors (Sole, 2008; Zweifel et al., 2012). However, there is no evidence from risk examinations from accident and usage data for this effect. Procter et al. (2013) found snowshoers are less aware of avalanche danger than backcountry skiers. Regarding group structure, Tremper (2008) mentioned mixed groups of men and women a dangerous combination, “especially when men are trying to impress woman in the group” (p. 287). Further, it would be interesting whether families and couples behave differently than a group of friends. To our knowledge there are no empirical studies on this topic and additional research is necessary for a meaningful inclusion of group type in a group check tool.

Group members are also characterized by their skills, either skiing *skills*, physical constitution or avalanche expertise. While it has been seen as favorable when the group is homogenous in skiing skills and physical

conditions it is not necessary that all group members have considerable avalanche expertise. However, it is of great importance to choose a tour which does not overburden any group members (Volken et al., 2007; Fredston & Fesler, 2011; Harvey et al., 2012).

In avalanche education *safety equipment* has been regarded as an important factor. Groups should completely be equipped with transceivers, shovel and probe and the use of this equipment should be trained (Harvey et al., 2009; CAA, 2010; AIARE, 2011). Another established safety measure is to check transceivers of all group members at the trailhead, before the trip starts (see, e.g., McClung & Schaerer, 2006; Tremper, 2008; Fredston & Fesler, 2011; Harvey et al., 2012).

Psychological attributes

Compared to the structural attributes, psychological group characteristics are less investigated. Most attention was put on the *decision making* process and its difficulties. McCammon (2001) distinguished analytic decision making, heuristic decision making and decision making built on expertise. While he concluded that a fully analytical approach is not practicable due to the complexity of decisions in avalanche terrain, he considered heuristic decision making and decision making built on expertise to be valuable approaches in general although they have their shortcomings. McCammon (2002) paid attention to these shortcomings by crystallizing six main heuristic traps which in the meantime have widely been established in avalanche safety literature (Volken et al., 2007; Tremper, 2008; Harvey et al., 2012). Further, the role of decisions based on intuition was discussed. Following the explanation of Stewart-Patterson (2008) and Zweifel and Haegeli (2014) intuition is a highly questionable strategy due to the "wicked" learning environment in avalanche terrain (Hogarth, 2001). In addition, Zweifel and Haegeli (2014) found that groups who either trivialized or even avoided decisions adopted an unfavorable strategy.

Winkler et al. (2012) described several factors for good decision making: (1) have the full freedom to decide, (2) decide deliberately and take the affordable time to decide, (3) make decisions transparent for all group members and (4) be courageous to make unpopular decisions such as turning-back without reaching a summit. Further, the benefit of decision aid tools such as the Graphical Reduction Method (GRM), the Snowcard or the Avaluator has

been shown in different studies (McCammon & Haegeli, 2007; Haegeli & Haider, 2008; Haegeli et al., 2010). A common agreement on decisions was named as another factor leading to good decisions (McCammon, 2002). To reach agreement, discussion is necessary. Bright (2010) found that groups discuss regularly in early planning stages but only little in later stages of the trip and especially after the trip. However, recent literature suggests to de-brief after a trip and to discuss safety issues (Harvey et al., 2012).

In order that all group members enjoy the trip it is important to know and to adjust the *goals and expectations* of all group members, especially in newly formed groups (CAA, 2010; Harvey et al., 2012; Winkler et al., 2012). If goals and/or expectations of sub-groups diverge diametrically one should consider splitting-up the group.

Another important influence on group's decisions comes from *environmental factors* like the influence of weather, snow conditions or other groups. Do (2014) mentioned that too much excitement can push groups towards more risk taking behavior. Such excitement can either come from blue sky and fantastic powder conditions but also from other groups who ski extreme terrain and therefore give a wrong sense of safety.

Several avalanche researchers mentioned the *risky shift effect* (Stoner, 1961) as an important group factor assuming large groups taking more risk than small groups (see, e.g., Munter 1992, Tremper, 2008, Harvey et al., 2012).

Beside of leadership organization (described above) the *style of leadership* plays an important role too. Tremper (2008) described the optimal leader as someone who seeks opinion from everyone. Adams (2005) and Bright (2010) also pointed on the advantages of this consultative leadership style. However, in professionally guided groups with a considerable difference in avalanche expertise between the guide and the group members, the autocratic style seems to be more common and is certainly adequate in critical situations when clear instructions may be vital (Winkler et al., 2012). In any case decisions should be clear for all group members (Tremper, 2008; Winkler et al., 2012, Harvey et al., 2012).

Communication

Communication skills are regarded as crucial for groups to perform effectively not only in winter backcountry activity (see, e.g., Adams, 2005; Tremper, 2008; Fredston & Fesler, 2011; Harvey et al., 2012) but also in other outdoor recreation settings (see, e.g., Priest and Gass, 1997) and in organizational settings (see, e.g., 2008; Garicano & Wu, 2012). On the other

hand, poor communication has been identified as an important factor causing avalanche accidents (Atkins, 2001). Di Salvo et al. (1989) found group communication as a main pitfall in group decision making. Adams (2005) concluded in her study on avalanche experts that "environments that encouraged effective and open communication resulted in improved judgment and decision actions, and reduced subjective biases that may have been present in an individual decision-maker" (p. 213).

However, to find recommendations for effective communication one has to review other research fields than avalanche safety. Bischof and Eppler (2011) proposed the CLEAR formula for clarity in communication. The CLEAR formula promotes to communicate **C**ontextualized, **L**ogically structured, **E**ssential, **A**mbiguity-free and **R**esonating. However, similarly to the enhancement of avalanche expertise, to enhance communication skills needs training and exercise.

7.1.4 Expert workshop

First, participants of the expert workshop elaborated recommendations for the key elements leadership, decision making, group structure and motivational factors (→ tab. 7-a). For an effective leadership the meeting phase where group members get to know each other was seen as important and a round of introductions was mentioned as requisite. Participants further pointed on the importance of communication and that an open communication should lead to a climate of trust in the group. Discussing decision making the group concluded that anomalies can be spotted when the risk behavior of the group does not correspond to the willingness to take risk of any of the group members. Leaders should further always screen for anomalies like heuristic traps (McCammon, 2002). As structural factors participants pointed out the importance of gender and age distribution and proposed to make a list of unfavorable group settings concerning negative group dynamics. Furthermore, one should consider group size and clarify roles with respect to responsibility. Concerning motivational factors, leaders should know skills and fitness of each group member and check their goals and expectations.

Second, the expert workshop worked on formal requirements of a group check tool. Participants suggested the tool to be simple and easily usable. Several workshop participants proposed the use of key words, mnemonics or acronyms.

Table 7-a: Key elements and important factors as elaborated in the expert workshop of the Swiss Snow Sport Avalanche Accident Prevention core training team.

Key Element	Recommendations
Leadership	Let everyone introduce himself so that group members get to know each other. Stimulate a climate of trust within the group with an open communication.
Decision making	Check for anomalies; are there any heuristic traps (McCammon, 2002) present? Check whether the risk behavior of the group corresponds to the willingness to take risk of the individual group members.
Group structure	Consider group size. Clarify roles of group members with respect to responsibility. Check for unfavorable structures (gender, age) with respect to negative group dynamics.
Motivational factors	Check skills of group members. Match goals and expectations of group members.

The benefit of acronyms has been shown in learning as well as motivational aspects (Stalder, 2005). For this reason I based my group check tool on an acronym related to the topic of groups and human factors.

7.1.5 Group check tool SOCIAL

Following the different approaches and concepts reviewed above, I propose the following S-O-C-I-A-L acronym for checking groups traveling in avalanche terrain. To help backcountry travellers to check group relevant factors with respect to avalanche safety, they can also ask themselves the diagnostic check questions which correspond to each group element. Further, I proposed related recommendations (→ tab. 7-b).

The explanation for the elements behind this acronym can be summarized as followed: *Skills* – be it skiing skills, skills in avalanche hazard evaluation, skills in the use of avalanche safety equipment or physical constitution – are a basic characteristic of every group member. The overall goal for a safe trip is thereby to match skills of all group members with the difficulty of the planned trip. *Organization* sets the course for group characteristics such as group type and group size but also clarifies roles and responsibilities of group members. *Communication* should be open and clear for a good group performance; lack

of it is often causing poor decisions. *Identification* of group members with the goals and expectations of the other group members and/or the organization is a prerequisite for groups to harmonize. All group members and leaders in particular should pay attention to any *Anomalies* to normal, "healthy" group behavior such as risky shift, heuristic traps (McCammon, 2002) or influencing environmental factors. Finally, *Leadership* is the controlling factor of all group phenomena and in optimal case sensitive to any group dynamics and facilitating group performance but in the worst case can lead the group into a disaster.

Table 7-b: Group check tool SOCIAL with six elements, corresponding explanations, key questions and recommended actions.

Element	Explanation	Key questions	Action
Skills	Skills of group members (skiing skills, skills in avalanche hazard evaluation, skills in the use of avalanche safety equipment and physical constitution) should match the difficulty and conditions of the planned trip.	▪ What are the skills of the weakest member in the group; is he able to follow the planned trip? ▪ Is there a considerable gap in skills between the group members? ▪ Are all group members equipped with avalanche safety equipment and trained in the use of it?	▪ Clarify skills of group members. ▪ Adapt the trip, route selection or time planning. ▪ Plan time for safety equipment instructions.
Organization	In the planning stage important group factors such as group size or type, roles and responsibilities of group members can be influenced.	▪ Do group members know each other? ▪ How large is the group and does the group size fit with the planned trip (time, difficulty)? ▪ Are the roles of the group members clear?	▪ Plan a timeslot for a round of introductions. ▪ Split the group or use risk reduction strategies (keep distances, stay in a specified corridor). ▪ Clarify roles of group members.

Communication	The group should cultivate an open communication and a climate of trust. The communication should be CLEAR (Contextualized, Logically structured, Essential, Ambiguity-free and Resonating).	▪ Are decisions concerning avalanche hazard discussed in the group? ▪ Does everyone in the group understand the decisions? ▪ Would everyone voice his concerns at any time?	▪ Stimulate discussion on avalanche hazard relevant decisions. ▪ Ask for confirmation. ▪ Ask everyone for concerns.
Identification	Each member of the group can identify himself with the tour goal and with the expectations of the other group members. Furthermore, group members can always identify with the taken decisions.	▪ Are expectations of each of the group members clear? ▪ Does a reasonable alternative exist in case of disagreements? ▪ Is everyone happy with the decisions taken?	▪ Discuss expectations with all group members. ▪ Plan alternatives. ▪ Make a de-briefing after the trip.
Anomaly	Group members should permanently search for anomalies to normal, “healthy” group behavior such as heuristic traps (in particular expert halo, familiarity, social proof and consistency), risky shift effects or environmental factors which mislead the group to unwanted behavior.	▪ Would everyone make the same decision if he would travel alone? ▪ Is an expert halo, a familiarity, a social proof or a consistency trap present? ▪ Does anyone try to impress others (on individual or group base)? ▪ Are any love stories going on in the group? ▪ Are many other groups present?	▪ Imagine traveling alone and make decisions accordingly. ▪ Use rule-based tools to check decisions. ▪ Make defensive decisions in the presence of anomalies that cannot be cured.

Leadership	One should be aware whether one travels in a group with a professional guide, with an informal guide or without a guide. Group members should be critical with their leader and the leader should be critical with himself.	▪ How is the group guided and is the leader the best suited person in the group for this job? ▪ Does the leader communicate openly and clearly? ▪ Would everyone always voice concerns to the leader?	▪ Determine a leader. ▪ Change the leader. ▪ Ask the leader to explain his decision.

7.1.6 Conclusions

I reviewed existing literature on group phenomena among recreational groups traveling in avalanche terrain and conducted an expert workshop with the goal to propose a group check tool and summarized the six most important elements of group phenomena – skills of group members, organization, communication, identification, anomalies to "healthy" group behavior and leadership. The devoted acronym SOCIAL should help recreationists traveling in avalanche terrain to structure group related processes and decisions and therefore to be less susceptible to unwanted group effects.

Since such a tool has to be simple enough to be practicable in real life situations with limited time and limited capacity of individuals it is per se limited in content. For sure, many further topics such as conflict, power (Forsyth, 2010) or personal mastery (Adams, 2005) are of interest in group management and could be further investigated. However, I assume the form and applicability of a practice tool at least as important as its content. I therefore encourage avalanche safety educators to explicitly pay attention to these aspects in future.

During winter 2014-2015 I plan to test the group check tool SOCIAL with different user groups such as backcountry skiers, off-piste skiers, recreational groups, mountain guides, ski instructors, freeride guides or snowshoers and to collect their feedback. I will seek insight into the usability of the single factors of the tool in regard to the trip phases according to Munter's (1992) 3-by-3 matrix (planning at home, evaluating conditions on-site and deciding at the slope-scale). With adaptations based on users' feedback our tool will be publicized to winter backcountry recreationists in the fall 2015.

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8 Discussion and conclusions

In this final chapter, I combine and summarize the findings from the presented research studies into a collective picture and propose implications for theory and practice. In the beginning, I give a summary and synthesis of the research findings with respect to the research objective. Then I discuss the limitations of the study. Furthermore, I provide some implications for avalanche safety practice and for avalanche research combined with directions for future research. In the end, I close with an overall conclusion and outlook.

8.1 Summary and synthesis of research findings

Driven by an existing research gap, I explored the group phenomena of recreationists traveling in avalanche terrain. The overall goal of this dissertation is to improve our understanding of group behaviors and from there derive simple recommendations for recreationists to further enhance safety in winter recreational activities. The motivation for this dissertation was not only driven by the lack of research but also by personal experience. As described at the very beginning of this work, I experienced a situation – years ago – where I unconsciously became involved in group phenomena where my actions were totally controlled externally. The fact that one can become involved in situations where behavior deviates from normal safety rules and standards made me curious to understand group processes leading to such situations.

I approached the research topic with three studies following three guiding research questions and finally proposed a group checklist as a practical application of the research findings. First, I investigated groups who have been involved in avalanche accidents in detail in order to understand the target public for avalanche safety recommendations. A detailed knowledge of the target public is crucial for the development of effective risk communication tools (Lundgren & McMakin, 2009). To do so, I followed research question 1: *What are the characteristics of groups involved in avalanche accidents?* In analyzing avalanche accidents, it became clear that a characterization only based on accident data while indeed valuable, does not tell much about risk factors of groups or individuals who travel in avalanche terrain. To explore risk factors, datasets were included which explored how many people behave in recreational settings in winter backcountry. Since these usage datasets are sparse and limited in detail I was only able to explore avalanche risk with

respect to group size. The avalanche risk with respect to group size was explored following research question 2: *Does group size affect avalanche risk?* However, further studies are necessary to bring this research stream forward. Study I and II which followed the first two research questions showed that recreationists in groups of two and three are most often involved in avalanche accidents. However, taking usage data into account, I found indications that groups of four or more people are more at risk than groups of two or people who travel alone. Similar studies would be interesting to explore the risk of age classes or gender. So far, we only know that men between 20 and 30 years are most involved in accidents. The risk of these groups compared to other groups remains unknown.

In the third part of this dissertation, which marks the core of this work, group behaviors were investigated among winter backcountry recreationists with respect to avalanche safety following research question 3: *How do recreational groups that travel in avalanche terrain behave and make decisions?* Since this is a new research field in avalanche safety, I chose qualitative methods for exploring this topic for the first time. Similar to other scholars (e.g., Aas & Onstad, 2013), I found qualitative methods in general and group interviews in particular to be suitable – even in the retrospective view – for the exploration of group behavior. While examining research question 3, I found that the majority of groups use risk management strategies and behave in ways, which are recommended by avalanche prevention. However, I also found behaviors and decision strategies which are questionable or discouraged with respect to avalanche safety such as traveling in emergent groups or blindly trusting the danger level from avalanche reports. Unfavorable decision strategies have been identified among a multitude of different group types such as guided, non-guided groups, backcountry skiers, off-piste skiers, families, groups of friends or emergent groups. This fact motivated the development of a group check tool, which can be used by all types of groups traveling in avalanche terrain.

In the last part this dissertation aims to convert the research results into a practical tool to improve avalanche safety. Based on the findings of these previous stages, an extensive literature review and an expert workshop, the group check tool SOCIAL was proposed. The goal of this tool is to make recreationists aware of potentially dysfunctional group aspects and to give simple recommendations to help face these problems.

8.2 Limitations

This dissertation investigated group phenomena among winter backcountry recreationists in a general manner and several results emerged that should apply to a wide variety of users. However, I also found hints of considerable differences in the behavior of different user groups (e.g. backcountry skiers vs. off-piste skiers) and as a main limitation of this dissertation, I cannot say if my findings and final interpretations make sense for all users. This means it is not clear whether the generalization of my results is valid or not. Future research should have a view to exploring this aspect.

As already mentioned in this thesis, there are considerable limitations coming from methodological challenges. Existing datasets are either sparse (e.g., backcountry usage data) or limited in detail (e.g., avalanche accident data). While online surveys allow us to reach a broad audience indeed, there are indications of a sample bias towards users who have an above-average awareness of avalanche risk. In-field studies, intercept surveys and interviews represent valuable alternatives as they allow for direct contact with the research object and make it possible to gain in-depth knowledge. However, to collect qualitative data directly in the field is both extremely time consuming and highly dependent on environmental conditions (e.g. avalanche hazard, weather conditions). As a researcher exploring human factors and the decision making processes of backcountry skiers, one would wish to be part of the group as an invisible drone. Although this may not be possible in the immediate future, technical developments have great potential to improve such research.

8.3 Implications for avalanche safety practice

The best analyses of avalanche danger, snowpack stability or terrain factors do not help at all if a group in the end makes a decision which is mainly driven by group dynamics and not based on avalanche safety rules. Although avalanche educators have promoted lessons on the human dimension of avalanche safety in recent years, I see considerable potential for further improvements in this sector of avalanche prevention.

First of all, avalanche prevention should furthermore state the risk of problematic decision strategies and behaviors such as traveling in emergent groups, traveling in groups without a leader, not communicating decisions concerning avalanche risk, avoiding or trivializing decisions or deciding spontaneously (Zweifel & Haegeli, 2014). However, in personal discussions with key avalanche researchers I concluded that instead of exclusively focusing

on risky behaviors it may be at least as effective to teach recommended behaviors, such as traveling in established groups, considering group size, avoiding to include risk takers in a group, traveling in groups with experienced leaders or deciding based on avalanche safety rules (Zweifel & Haegeli, 2014).

As a summary of practical implications I proposed the group check tool SOCIAL, which is presented with minor adaptations form the original research article in the next section.

8.4 Implications for avalanche research

In my opinion, the examination of the human dimension in avalanche safety has been restricted by a limited use of different research methods. Qualitative approaches have gained only little attention so far (e.g., Adams, 2005), although they are established in the social sciences (Denzin & Lincoln, 1994). Therefore, I encourage avalanche researchers to consider qualitative approaches while exploring human factors in avalanche safety. The limited presence of social science in avalanche safety research is likely rooted in the natural science origins of the safety initiatives. It is therefore suggested that avalanche safety institutions consider this mismatch in their strategic planning.

There are also promising technical approaches, such as the use of audio-recorders or beepers in studies (Fitzpatrick & Boulton, 1994; Borrie & Roggenbuck, 1995; Christensen, Barrett, Bliss-Moreau, Lebo, & Kaschub, 2003) or GPS tracking, as recently applied in avalanche terrain (Hendrikx, Shelly, & Johnson, 2014).

The results of my research also suggest improvements in data collection. Accident records could be adjusted with findings from Study II, as well as with some general group related factors, such as group structure, group type or leadership style. However, I am aware of the difficulty in collecting meaningful and detailed accident data. One possibility is to ask for in-depth information only regarding specific accidents where people involved are willing to provide detailed data. In addition, my investigation on risk factors clearly calls for further user observations or surveys. There is still a lack of good usage datasets, such as that obtained by Procter and her colleagues in 2011 (Procter et al., 2013). Researchers should thereby take new technologies into account.

Finally, from this dissertation a number of new research questions emerged which could be explored in future. These are summarized with the following questions:

- What is the role of power between members of winter backcountry groups?
- Does conflict play an important role?
- Recreationists from different winter backcountry activities showed very different travel motivations. How does this affect the behavior of these recreationists?
- What is the role of intergroup relations?
- Why are recreationists who travel alone not more at risk than groups? How is their behavior characterized?
- Have previous research findings related to human factors in the avalanche context (e.g. Adams, 2010; Bright, 2010) had an effect on avalanche safety practice? If yes, how; if not, why?

8.5 Overall conclusions

In this dissertation I explored the effect of group dynamics on avalanche safety among winter backcountry groups with a mixed-method approach structured in four studies. First, I characterized avalanche victims – individuals and groups – in order to know our target group better. Results of this first study confirmed existing studies where young men and groups of two and three people are most frequently involved in avalanches. However, combining accident data with usage data suggested that groups of two and people traveling alone are less at risk than large groups. In the second part I investigated group behavior with in-field group interviews and found that while the majority of behaviors are related to recommended concepts from avalanche safety, I also found strategies and behaviors which may cause dangerous situations. Further, I found that in group organization and planning, a structured process is missing. This motivated the development of the SOCIAL group check tool, to be used as an awareness tool for recreationists. With SOCIAL, group leaders or other group members can identify critical group factors. My final hope is that my research and its outcomes – SOCIAL at the forefront – will prove to be a valuable addition to the avalanche safety toolbox, and thereby improve avalanche safety.

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A Appendix

A.1 Online survey questionnaire – Study I

This survey with questions on group composition and decision making of groups traveling in avalanche terrain was posted on http:--www.slf.ch-umfrage_entscheidungsfindung in German and English from May to July 2012.

Questionnaire: Group composition and decision making in avalanche terrain

Approximate time to complete: 5 to 10 minutes

The questionnaire is only intended if you travel sometimes off the secured ski runs. However, it does not matter how often you do you this.

When answering the questions select a typical day with a typical group composition while practicing your sport. It may be easiest to select a specific day from last winter. If you travel in different groups, choose the one where the group members are the most homogenous in their level of experience. Answer all questions for this constellation.

Questionnaire: Group composition and decision making in avalanche terrain

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1. What winter sport do you practice most?

- Backcountry skiing or snowboarding
- Off-piste skiing or snowboarding
- Backcountry snow shoe hiking
- Other:

Group composition

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2. Fill out the table for your typical group. If you are not sure, estimate the answers as good as possible.

Group member		Myself	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	No.11	No.12
Experience in the assessment of avalanche danger	Expert	○	○	○	○	○	○	○	○	○	○	○	○	○
	A lot of experience	○	○	○	○	○	○	○	○	○	○	○	○	○
	Moderate experience	○	○	○	○	○	○	○	○	○	○	○	○	○
	Little experience	○	○	○	○	○	○	○	○	○	○	○	○	○
	No experience	○	○	○	○	○	○	○	○	○	○	○	○	○
Number of days per winter when the sport is practiced														
Number of years the sport has been practiced														
This person has a specific education in avalanche assessment or winter guiding (mountain guide, tour leader SAC, J & S guide, etc.)		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
This person leads the group		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
This person likes to decide		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
This person does not like to decide		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
This person is aware of the risk of being caught by an avalanche		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Willingness to take a risk	High	○	○	○	○	○	○	○	○	○	○	○	○	○
	Mean	○	○	○	○	○	○	○	○	○	○	○	○	○
	Low	○	○	○	○	○	○	○	○	○	○	○	○	○
This person has previously been caught by an avalanche		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Age														
Gender		○ m ○ w	○ m ○ w	○ m ○ w	○ m ○ w	○ m ○ w	○ m ○ w	○ m ○ w	○ m ○ w	○ m ○ w	○ m ○ w	○ m ○ w	○ m ○ w	○ m ○ w
Nationality														

3. With whom do you travel most?

- ○ Family with children or young people
- ○ Spouse or partner
- ○ Organized group
- ○ Friends
- ○ Other:

4. What are your motivations to go with these people (e.g., because you know them, or because you know their capabilities of the other)?

5. What is your motivation to practice this sport?

- ☐ Fitness/exercise
- ☐ Outdoor recreation
- ☐ Adrenalin rush on the downhill
- ☐ Getting away from daily stress
- ☐ Summit experience
- ☐ Powder snow
- ☐ Other:

Decision making in planning

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6. Do you normally plan your trip in advance?

- ○ Yes, we plan
- ○ No, we decide spontaneously
- ○ No, we go with a guide
- ○ No, we always go on the same tour/route
- ○ Other:

7. Who does normally decide where (area, region) to go?

- ○ Mostly you
- ○ Sometimes you
- ○ Never you
- ○ Mostly joint decision
- ○ Other:

8. How does the group normally decide where (area, region) to go? Which information is used to make this decision (describe in your own words)?

9. Which factors affect this decision in planning?

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly desagree
Accessibility of the tour/route	○	○	○	○	○
Length and difficulty of the tour/route	○	○	○	○	○
The downhill is very worthwhile	○	○	○	○	○
Group size	○	○	○	○	○
Experience of individual group members	○	○	○	○	○
Skiing ability and physical condition of the group members	○	○	○	○	○
Weather	○	○	○	○	○
Snow conditions	○	○	○	○	○
Avalanche danger according to avalanche bulletin	○	○	○	○	○
Avalanche danger by your own assessment	○	○	○	○	○

Other:

Decision making in terrain

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10. How does the group normally make decisions in the terrain and which information is used (describe in your own words)?

11. Which factors affect this decision in the terrain?

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly desagree
Untracked slope	○	○	○	○	○
Terrain	○	○	○	○	○
Group size	○	○	○	○	○
Experience of individual group members	○	○	○	○	○
Atmosphere in the group	○	○	○	○	○
The leader decides himself (without discussion)	○	○	○	○	○
All decisions are discussed in the group	○	○	○	○	○
Physical constitution of the group members	○	○	○	○	○
Equipment of the group members	○	○	○	○	○
Weather	○	○	○	○	○
Snow conditions	○	○	○	○	○
Avalanche danger according to avalanche bulletin	○	○	○	○	○
Avalanche danger by your own assessment	○	○	○	○	○

Other:

12. Have you ever made any wrong decisions in back-country terrain before? Why (describe in your own words)?

13. How much do you think the following factors have the potential for making wrong decisions in avalanche terrain?

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly desagree
Group pressure	○	○	○	○	○
Group dynamics	○	○	○	○	○
Poor communication in the group	○	○	○	○	○
"Powder-blindness" (We do not consider the danger appropriately due to our great enthusiasm in powder snow.)	○	○	○	○	○
One person decides for all	○	○	○	○	○
Wrong assessment of the avalanche hazard / risk	○	○	○	○	○

Other:

14. To ensure that only one questionnaire per person is evaluated, please enter your initials and your date of birth (example: John Smith, born on 28 April would enter JS0428)

15. How did you hear from this survey?

www.gipfelbuch.ch www.skirando.fr facebook Friends Other:

16. If you want to participate in the draw for 3 avalanche shovels Lynx Black Diamond and 10 CD's WhiteRisk please provide your contact

Name:

Email:

17. Would you be interested to participate in an in-depth study or in a group discussion on decision making in avalanche terrain?

Yes No

Thank you very much for answering!

A.2 Interview guideline of qualitative Interview – Study III

The group interviews were structured according to the following guideline. However, additional questions emerged during the interviews.

Einstieg **Ziel: „Aufwärmen“, Beschreibung der Tour**
Ich hoffe, ihr hattet eine schöne Tour. Wo seid ihr gewesen? Welche Route habt ihr genau begangen?

1. Planung **Ziel: Details über die Planung der Gruppe für die Tour herausfinden**
Wie habt ihr die Tour geplant? Beschreibt das mal bitte im Detail. Wer hat die Tour geplant? Habt ihr die Tour schon lange geplant? Was bedeutet diese Tour für euch? Habt ihr für die Planung Hilfsmittel benutzt? Wenn ja, welche? Hat euch die Planung bei der Tour geholfen?

2. Motivation
Ziel: Was hat die Gruppe für die Tour motiviert?

Was hat euch für diese spezielle Tour motiviert?

Ist das auch bei anderen Touren eure übliche Motivation? Habt ihr auch andere Motivationsmotive?

Haben sich eure Motivationsgründe im Lauf eurer Tourenlaufbahn verändert? Wenn ja wie?

Haben sich eure Erwartungen an den Tag erfüllt?

3. Führungsstil
Ziel: Wie ist die Gruppe geführt (Zuordnung zu einem Führungsstil möglich)?

Hat jemand von euch eine Führungsrolle inne?

Wenn ja, wie würdet ihr euren Führungsstil beschreiben?

Wer geht jeweils in der Spur als Vorderster? Warum der oder die?

4. Entscheidungsstil
Ziel: Werden überhaupt bewusst Entscheide gefällt? Wenn ja wie? Dies alles mit dem Fokus auf die Lawinengefahr und nicht auf die Schneeverhältnisse.

Habt ihr heute auf der Tour eine Entscheidung gefällt, die im Bezug mit der Lawinensituation stand?

Wenn ja, wie habt ihr entschieden? Beschreibt bitte einmal den Entscheidungsprozess so genau wie möglich. Was habt ihr gesprochen?

Gabe es Faktoren, die ihr gegeneinander abgewogen habt?

Habt ihr für diese Entscheidung Hilfsmittel benutzt? Wenn ja, welche?

Gab es bei Entscheidungen Konflikte? Wart ihr mal nicht gleicher Meinung?

Habt ihr Entscheidung getroffen, die ihr alleine nicht getroffen hättet?

Habt ihr über einen Entscheid nachgedacht, ohne dass dann etwas entschieden wurde? Oder ohne, dass darüber diskutiert-gesprochen wurde?

Falls ja, was waren eure Überlegungen?

Habt ihr euch mit den Entscheidungen wohl gefühlt? Gab es Ängste oder Bedenken?

5. Gruppenstruktur
Ziel: Wie ist die Gruppe zusammengesetzt und wie entstanden?

Wie ist eure Gruppe entstanden? Woher kennt ihr euch?

Wie steht ihr zueinander?

Wie lange geht ihr schon zusammen auf Touren?

Geht ihr immer in derselben Gruppe oder ändert sich das stark?

Habt ihr schon mal gemeinsam heikle Situationen erlebt?

Wie empfindet ihr eure Gruppenkonstellation?

6. Risikobereitschaft, Erfahrung, Alter **Ziel: Wie hoch ist die Risikobereitschaft der Gruppenteilnehmer (Brief sensation seeking scale)? Wie ist ihre Erfahrung im Beurteilen der Lawinengefahr (eigene Beurteilung)**
Siehe eigenes Blatt
Möchtet ihr noch etwas ergänzen, wonach ich jetzt noch gar nicht gefragt habe?

Herzlichen Dank!

A.3 Participant list of expert workshop

The following persons participated in the expert workshop in May 2014 at Innertkirchen, Switzerland: Samuli Aegerter (Swiss working insurance company SUVA), Aldo Berther (Swiss Snowsports), Pascal Burnand (Federal Office of Sports BASPO), Lukas Dürr (WSL Institute for Snow and Avalanche Research SLF), Andreas Fuhrer (Association of Swiss Mountain Guides), Thomas Good (Association of Swiss Mountain Guides ASMG), Stephan Harvey (WSL Institute for Snow and Avalanche Research SLF), Bruno Hasler (Swiss Alpine Club SAC), Hans-Marin Henny (Swiss Army), Bruno Jelk (Rescue Organisation of the Canton of Valais KWRO/OCVS), Hansueli Rhyner (WSL Institute for Snow and Avalanche Research SLF), Erich Sommer (Association of Swiss Mountain Guides ASMG), Thommy Villars (Swiss Association of Mountaineering Schools SAMS), Thomas Wälti (Association of Swiss Mountain Guides ASMG)

A.4 German publications

A.4.1 jung & wild vs erfahren[10]

jung & wild vs erfahren

Benjamin Zweifel hat bereits in bergundsteigen 1/08 einen Beitrag zum Thema „Risiko im Lawinengelände" geschrieben. Nun hat er seine Doktorarbeit zum Thema „Entscheidungsfindung von nicht organisierten Gruppen im Lawinengelände" gestartet und dabei zuerst mithilfe von Unfalldaten aus dem SLF-Archiv und Befragungen versucht, „das Lawinenopfer" näher zu charakterisieren.

78 | bergundsteigen 4/12

[10] Zweifel, B. (2012). jung & wild vs erfahren. *bergundsteigen - Zeitschrift für Risikomanagement im Bergsport. Oesterreichischer Alpenverein, Innsbruck, Austria, 21*(4), 78-82.

Benjamin Zweifel arbeitet am SLF Davos als Lawinenprognostiker, ist auch für die Unfallstatistiken zuständig und schreibt die jährlich erscheinenden Berichte über Lawinenunfälle für die Schweiz. Begeisterter Freerider, Schitourenfahrer und Kletterer.

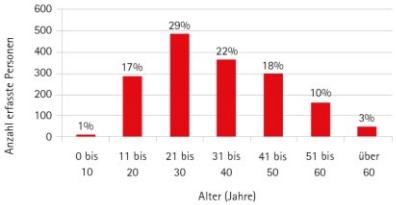


Abb. 1 Altersverteilung der von Lawinen erfassten Personen von 1970/71 bis 2009/10. 29 % der Opfer waren 21 bis 30 Jahre alt.

von Benjamin Zweifel

Da fast alle Lawinenopfer ihre Lawine selber ausgelöst haben, ist der Mensch an sich ein wichtiger Faktor, den es bei der Beurteilung des Lawinenrisikos zu berücksichtigen gilt. In neueren Lawinenkunde-Büchern wird daher vermehrt auf diesen „Faktor Mensch" eingegangen.
Doch wie funktioniert er, dieser Mensch im Lawinengelände? Wie entscheidet er oder wie kann er seine Entscheidungen verbessern? Fragen, die in der Lawinenforschung zunehmend im Fokus stehen.
Auch wir haben uns dies gefragt. Erst einmal aber wollen wir der Frage „Wer ist das Lawinenopfer?" auf den Grund gehen. Wir haben Alter, Geschlecht und Nationalität, aber auch Gruppenfaktoren wie Gruppengröße oder ob die Gruppe geführt war oder nicht, untersucht. In einem zweiten Schritt haben wir mit einer Umfrage erste Informationen gesammelt, wie Personen im Lawinengelände entscheiden.

40 Jahre detaillierte Lawinenunfalldaten als Datenbasis

Die Schadenlawinendatenbank des SLF Davos enthält rund 14.000 Einträge zu Lawinen mit Personen- oder Sachschäden; eine einmalige Datensammlung, ein Kondensat von großen Aktenbergen, die im Archiv des SLF lagern. Die Einträge gehen zurück bis in historische Zeiten, Lawinen mit Todesopfern sind seit 1936/37 vollständig erfasst. Seit 1970/71 sind die Einträge in einem hohen Detailgehalt vorhanden. Wir haben deshalb für diese Studie eine 40-jährige Periode von 1970/71 bis 2009/10 analysiert und dabei vor allem die Lawinenopfer selber unter die Lupe genommen. Da uns vor allem das Entscheiden und Verhalten der Leute im freien Gelände interessiert, haben wir uns auf Lawinenunfälle abseits gesicherter Gebiete beschränkt und Lawinenopfer auf Verkehrswegen und in Siedlungen weggelassen. Unser Fokus war auf Winteraktivitäten wie Schitouren, Variantenabfahrten oder Schneeschuhwanderungen beschränkt. Retter, Bergsteiger (im Sommer und Winter), Wanderer, Jäger, Pilzsammler, Gleitschirmflieger, Speedflyer, Personen beim Schlittenfahren und andere seltene Gruppen wurden weggelassen.
Schlussendlich hatten wir einen Datensatz mit 1.971 Lawinenabgängen für die 40-jährige Periode von 1970/71 bis 2009/10, wobei 3.965 Personen erfasst und 749 getötet wurden. Damit haben wir einen zwar traurigen, aber auch stattlichen Datensatz, der detaillierte Analysen zulässt.

Die „jungen Wilden" und die kleinen Gruppen

81 % der erfassten Personen waren männlich, 19 % weiblich und fast ein Drittel aller erfassten Personen war zwischen 21 und 30 Jahre alt. Interessanterweise zeigten aber Lawinenerfassungen von Personen jünger als 25 Jahre einen abnehmenden Trend über die 40 Untersuchungsjahre (Abb. 1).

Die Unfallzahlen zeigten auch, dass wir unser Augenmerk im Lawinengelände nicht alleine auf unsere Gruppe beschränken dürfen, passieren doch immerhin 6 % aller Unfälle mit mehr als einer beteiligten Gruppe. Obwohl aus den Daten kein steigender

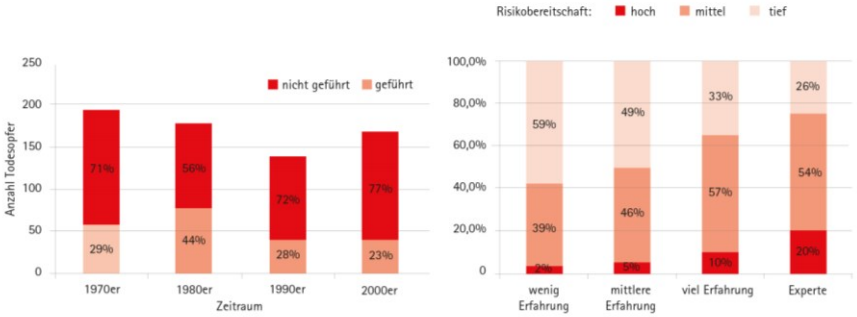
Trend ersichtlich war, kann man sich gut vorstellen, dass diese Zahl in Zukunft zunehmen wird, wo doch viele Modetouren immer stärker frequentiert werden.
Die meisten Unfälle betrafen kleine Gruppen mit zwei oder drei Personen. Unfälle mit Einzelgängern haben über den untersuchten Zeitraum zugenommen, obwohl in der Prävention immer wieder auf das hohe Risiko vom „alleine gehen" hingewiesen wird. Unfälle mit Gruppen von zehn und mehr Personen haben hingegen abgenommen; nach einer Serie von schweren Unfällen Ende der 1980er-Jahre mit großen Gruppen gab es nur noch wenige solche Unfälle. Diese Unfälle haben zu einer Sensibilisierung und einem konsequenten Risikomanagement beim Gruppenbergsteigen sowie verschiedenen Maßnahmen, unter anderem der Reduktionsmethode geführt. Wir vermuten, dass diese Abnahme darauf zurückzuführen ist (Abb. 2).
Männer zwischen 21 und 30 Jahren, nennen wir sie die „jungen Wilden", sind demnach tatsächlich am häufigsten vertreten unter den Lawinenopfern. Doch sind sie auch die Gruppe mit dem höchsten Risiko? Dazu müssten wir die Unfallzahlen mit Begehungszahlen vergleichen, welche allerdings Mangelware sind. Betrachten wir einmal das Verhältnis Männer zu Frauen, welches laut den Unfallzahlen 81 % zu 19 % beträgt. In einer Südtiroler Studie (Procter eta al 2012), wo Leute an Startpunkten zu Touren gezählt wurden, betrug das Verhältnis Männer zu Frauen 66 % zu 34 %. In einer Studie des Bundesamtes für Sport in der Schweiz haben Hochrechnungen für Schi-, Snowboard- und Schneeschuhtouren ein Verhältnis Männer zu Frauen von 48 % zu 52 % ergeben. Wir sehen also, dass der Männeranteil bei den Unfällen deutlich höher ist als der Männeranteil bei der Gesamtheit der Leute, die unterwegs sind. Das würde bedeuten, dass Männer ein höheres Risiko haben, von einer Lawine erfasst zu werden als Frauen, sofern diese Zahlen so vergleichbar sind.
Betreffend der Altersverteilung fehlen genaue Zahlen, die solche Schlüsse über das Risiko zulassen würden. Die Verteilung der Gruppengrößen ist in der Südtiroler Studie sehr ähnlich wie in den Unfallzahlen. Das würde heißen, es gibt keine großen Unterschiede im Risiko zwischen verschiedenen Gruppengrößen. Obwohl die „jungen Wilden" oft in Lawinenunfälle involviert sind, dürfen wir nicht vergessen, dass fast ein Drittel der von Lawinen erfassten Personen über 40 Jahre alt ist. Älter und erfahrener werden alleine reicht also nicht aus, um vor Lawinen sicher zu sein. Denn wie sagte schon der Lawinenexperte André Roch: „Experte, pass auf! Die Lawine weiß nicht, dass du Experte bist."

Snowboard oder Schi, Touren oder Varianten?

Betreffend Schneesportgerät bei den Lawinenopfern ist die Antwort klar: Schi. 80% der Todesopfer bei Lawinenunfällen waren auf Schiern unterwegs. Snowboarder waren erst in den 90er-Jahren (mit 8 %) und in den 2000er-Jahren (mit 11 %) unter den Todesopfern vertreten. In den 2000er-Jahren waren 7% der Opfer Schneeschuhgeher; eine Gruppe, die für die Prävention zunehmend wichtig wird.

Ob mehr Touren- oder mehr Variantenfahrer erfasst werden, schwankt von Jahr zu Jahr sehr stark und ist vor allem von den

Abb. 2 Gruppengröße bei Lawinenunfällen von 1970/71 bis 2009/10. Am meisten von Lawinen betroffen waren Zweier- und Dreiergruppen (links).
Abb. 3 Anteil der Todesopfer bei Lawinenunfällen mit geführten und nicht geführten Gruppen. Der prozentuale Anteil von Opfern bei geführten Touren war in den 2000er-Jahren am geringsten (Mitte).
Abb. 4 Risikobereitschaft im Vergleich zur Erfahrung in der Lawinengefahrenbeurteilung. Personen mit wenig Erfahrung gaben eine tiefere Risikobereitschaft an als Personen mit viel Erfahrung oder Experten (rechts).



Schneeverhältnissen abhängig. Bei Situationen mit einem lange andauernden Altschneeproblem in der Schneedecke sind Tourenfahrer stärker betroffen als Variantenfahrer. In Wintern mit vielen Neuschneesituationen sind die Variantenfahrer in der Regel stärker betroffen als die Tourenfahrer. Das langjährige Verhältnis liegt bei 70 % erfassten Tourenfahrern zu 30 % erfassten Variantenfahrern. Ein Trend zu mehr Variantenfahrern, wie dies oft vermutet wird, ist nicht feststellbar.

Nationalität

Unter den Todesopfern bei Lawinenunfällen waren 64 % Schweizer, 17 % Deutsche und 6 % Franzosen. Die übrigen 13 % verteilten sich auf zahlreiche andere Nationen. Man sieht, wie die Mobilität im Untersuchungszeitraum zugenommen hat: während die Schweizer Opfer anteilsmäßig abnahmen (1970er-Jahre: 71 %, 1980er-Jahre: 64 %, 1990er-Jahre: 63 %, 2000er-Jahre: 55 %), zeigten vor allem die Franzosen und die übrigen Nationen eine markante Zunahme.

Unfälle mit geführten Gruppen

Über die 40 Jahre gesehen ereigneten sich 27 % der Lawinenunfälle in geführten Gruppen. Der Anteil der Todesopfer von Unfällen mit geführten Gruppen war mit 44 % in den 1980er-Jahren am höchsten und mit 23 % in den 2000er-Jahren am kleinsten. Wir sehen einerseits sehr hohe zeitliche Schwankungen in diesem Bereich, welche wahrscheinlich auf Zufälligkeiten in den eher kleinen Unfallzahlen zurückzuführen sind, anderseits scheint die Bilanz aus Führersicht in der letzten betrachteten Dekade positiv zu sein (Abb. 3).
Auch wenn sich in jüngerer Zeit mit neuen Beurteilungsmethoden, genaueren Wetter- und Lawinenprognosen und verbesserter Notfallausrüstung viel bewegt hat, wird die Lawinengefahr auch in Zukunft eine schwierig zu beurteilende objektive Gefahr in den Bergen bleiben und uns noch etliches Kopfzerbrechen bereiten. Denn parallel zu diesen Verbesserungen nimmt auch das Verlangen der Gäste nach immer mehr Abfahrtsmetern im Pulverschnee und steileren Hängen und damit der Druck auf die Führer zu.

Wie entscheiden Personen und Gruppen im Lawinengelände?

Wenn wir nun herausfinden wollen, wie die Personen, welche in Lawinenunfälle involviert waren, entschieden haben, wird es schwieriger: Die Informationen, die wir von den Lawinenunfällen haben, sind dafür zu wenig detailliert. Sie reichen nicht, um nachvollziehen zu können, wie und aus welchen Gründen so entschieden wurde.

Wir haben deshalb mit einer Umfrage im Frühjahr 2012 versucht, dem auf die Spur zu kommen. Zuerst fragten wir nach der Erfahrung in der Lawinengefahrenbeurteilung, nach lawinenspezifischer Ausbildung, Führungs- und Entscheidungspräferenzen, Risikobewusstsein, Risikobereitschaft, Alter und Geschlecht. Im zweiten Teil des Fragebogens ging es dann um Faktoren, welche die Personen für eine Tour motivieren, Entscheidungsfaktoren während der Planung und während der Tour

sowie Faktoren, die zu schlechten Entscheidungen führen können. Die Umfrage haben wir auf Internetseiten, die über die Verhältnisse im Gebirge informieren (www.gipfelbuch.ch, www.skirando.fr, www.camptocamp.org), auf Facebook und mit verschiedenen Email-Verteilerlisten gestreut. Mit 570 ausgefüllten Fragebögen hatten wir einen guten Rücklauf. Das Durchschnittsalter war mit 40 Jahren höher als das Durchschnittsalter von 33 Jahren bei den Lawinenopfern. Auch hatten die Teilnehmer wohl eine überdurchschnittlich große Erfahrung in der Lawinengefahrenbeurteilung, gaben doch immerhin 47 % der Teilnehmer an, dass sie Experte sind oder viel Erfahrung haben (Abb. 4).

Die Umfrage zeigt, dass die Gefahr wenigstens einmal von einer Lawine erfasst zu werden, mit zunehmender Anzahl an Geländetagen ansteigt. 36 % der Teilnehmer, die sich als Experte oder Personen mit viel Erfahrung bezeichneten, waren bereits einmal von einer Lawine erfasst worden. Und dies unabhängig von Ausbildung und Risikobereitschaft. Interessant war, dass die von den Teilnehmern angegebene Risikobereitschaft mit zunehmender Erfahrung stieg, d.h. Personen mit wenig Erfahrung gaben meist eine tiefe und mittlere Risikobereitschaft an, während (selbsternannte) Experten eher eine mittlere und hohe Risikobereitschaft angaben. Zudem gaben Männer eine höhere Risikobereitschaft an als Frauen und Personen mit hoher Risikobereitschaft wurden öfter von Lawinen erfasst als Personen mit tiefer Risikobereitschaft.
Natürlich kann die Fähigkeit der Teilnehmer, ihre eigene Risikobereitschaft einzuschätzen, angezweifelt werden, gerade bei den Anfängern, die vielleicht gar nicht wissen, welchem Risiko sie sich aussetzen. Oder man kann sich auch vorstellen, dass einzelne Teilnehmer bewusst eine hohe Risikobereitschaft angegeben haben, um sich aus der Affäre zu ziehen und nicht zugeben zu müssen, dass sie einen Fehler gemacht haben.
Aber die Resultate deuten darauf hin, dass unsere persönliche Risikobereitschaft doch sehr wichtig ist – wichtiger vielleicht als unsere Erfahrung in der Gefahrenbeurteilung.

95 % der Teilnehmer gaben an, dass sie sich dem Risiko, von einer Lawine erfasst zu werden, bewusst sind. Nach einer Umfrage im Schigebiet Davos entspricht dies nicht der Realität: Dort waren sich 25 % der Leute dem Risiko nicht bewusst; gerade diese Personengruppe mit einer solchen Umfrage zu erreichen, ist allerdings schwierig. Deshalb sind die Ergebnisse hier wahrscheinlich in dem Sinn verzerrt, dass überdurchschnittlich viele Personen mit vorhandenem Risikobewusstsein gegenüber Lawinen an der Umfrage teilgenommen haben.

Die Ergebnisse der Motivationsfaktoren waren wenig überraschend: Schitourenfahrer gewichteten das Gipfelerlebnis deutlich mehr als Freerider - dafür gaben diese dem Adrenalinkick auf der Abfahrt mehr Gewicht. Beide Gruppen werteten die Erholung in der Natur und den Pulverschnee hoch.

Die Frage, wie die Leute in der Planung oder im Gelände entscheiden, hat vor allem gezeigt, dass die meisten Personen Wetter- und Lawinenfaktoren (zB Wetter, Lawinengefahr oder Schneeverhältnisse) stärker gewichten als den Charakter der geplanten Tour (Schwierigkeit und Länge) oder Faktoren der Gruppe (zB Gruppengröße, Erfahrung und Schikönnen der Gruppenmitglieder). Woran das liegt, ist schwierig zu beurteilen, vielleicht ist ein Grund, dass die sogenannten harten Faktoren wie Wetter, Schnee oder Lawinengefahr einfacher zu greifen und zu beurteilen sind, als die sogenannten weichen Faktoren wie zum Beispiel die Gruppendynamik. Die Frage nach den Faktoren, die zu schlechten Entscheidungen führen können, ergab kaum aufschlussreiche Antworten. Hier müssen wir weiterbohren.

Wie weiter?

In der klassischen Lawinenforschung standen bisher physikalische Faktoren wie der Anbruchmechanismus von Lawinen, das physikalische Verständnis der Schneedecke oder die Lawinendynamik im Vordergrund. Da heutzutage über 90 % der Lawinenunfälle bei Freizeitaktivitäten im freien Gelände geschehen und die betroffenen Personen fast immer ihre Lawine selber auslösen, sollte der Mensch stärker in den Fokus der Forschung rücken.

Um Verbesserungen in der Ausbildung oder bei der Informationsverbreitung der Lawinenprognosen zu erzielen, sind fundierte Kenntnisse über das Zielpublikum enorm wichtig. Dieses ist aber sehr breit gefächert, vom Touristen, der unabsichtlich neben die Piste kommt, über den gut ausgebildeten Schitourenfahrer bis hin zum Bergführer, der im Schnee schon fast zu Hause ist.

Allerdings sollten wir das Zielpublikum nicht nur aufgrund von Unfallzahlen charakterisieren, denn diese Zahlen alleine lassen keine Rückschlüsse auf das Risiko verschiedener Gruppen zu. Dazu müssen wir die Zahlen in Relation mit der Anzahl Personen, die potentiell betroffen sein könnten, setzen. Wenn wir also wissen, dass 20- bis 30-jährige Männer am häufigsten in Lawinen kommen, heißt dies noch nicht zwingend, dass sie die größte Risikogruppe sind. Es stellt sich auch die Frage, ob es sinnvoll ist, in der Prävention auf die Gruppen mit den höchsten Risiken für einen Lawinenunfall zu fokussieren. Vielleicht sind diese sehr resistent gegenüber Präventionsmaßnahmen. Wenn wir uns wieder die „jungen Wilden" vorstellen, wage ich zu bezweifeln, ob wir deren Risikobereitschaft groß beeinflussen können. Wir sollten also weiter versuchen, mehr über das Denken und Handeln von Personen im Lawinengelände herauszufinden, jenseits von Unfallzahlen.

Entscheidungen im Lawinengelände sind komplex und hängen von vielen verschiedenen Einflüssen ab. Einflüsse, die wir je nach Tagesform anders wahrnehmen und die sich unglücklich aneinanderreihen können, wie man das bei vielen Lawinenunfällen sehen kann. Oft ist es schon schwierig, für sich selbst im Nachhinein nachzuvollziehen, weshalb man so entschieden hat. Dies wissenschaftlich zu ergründen, ist dementsprechend noch schwieriger.

Optimal wäre, wenn wir als unsichtbare Drohne mit einer Gruppe mitfliegen und deren Gedanken und Entscheidungen verfolgen könnten. Bis uns das die Technik erlaubt, werden wir noch viele Leute beobachten, Entscheidungsexperimente machen lassen, mit Umfragen belästigen, interviewen oder in Gruppen diskutieren lassen.

Fotos: Knaus Mathe, Brandmaier Christine

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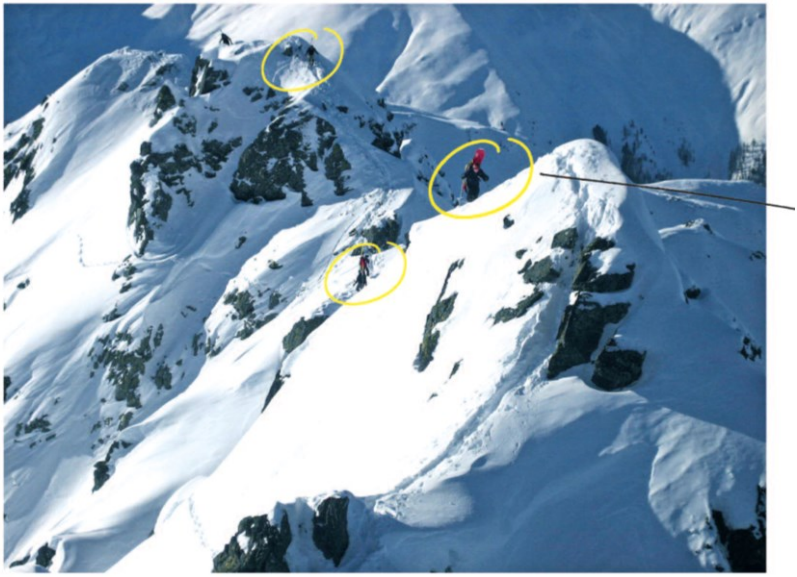
A.4.2 Gruppendynamik[11]



Gruppendynamik

Januar, Sonnenschein, geringe Lawinengefahr, beste Powder-verhältnisse, Urlaub – und diesmal ist's kein Traum, sondern real. Ich frage meinen Freeridepartner und klar, auch er nimmt sich frei, um die günstigen Verhältnisse zu nutzen. Bald sind wir uns einig – das Leidbachhorn mit seinen Couloirs ist das perfekte Ziel. Nur noch den Treffpunkt vereinbaren und schon ist die Planung abgeschlossen. Am Morgen treffen wir uns an der Rinerhornbahn, bereit für ein neues Abenteuer. An der Bergstation begegnen wir einem Freund, der gemeinsam mit seinem Kollegen ebenfalls das Leidbachhorn als Ziel hat. Wir gehen zusammen – was sollte auch dagegen sprechen ...

[11] Zweifel, B. (2014). Gruppendynamik. *bergundsteigen - Zeitschrift für Risikomanagement im Bergsport. Oesterreichischer Alpenverein, Innsbruck, Austria, 23*(1), 46-51.

Endspurt über den Grat des Leidbachhorns.
Wer schafft es wohl zuerst, in ein Couloir zu fahren?

von Benjamin Zweifel

Doch ab diesem Zeitpunkt nimmt die Tour eine seltsame Wendung: Das Tempo wird angezogen - von wem, weiß keiner genau. Vor dem Gipfel müssen die Skier getragen werden, anstrengende Spurarbeit steht an. Wir schwitzen und kämpfen - aber nicht im Team, sondern im Contest-System. Schon lange sind wir in einem Stadium, wo jeder beweisen will, dass er der Beste ist; dessen bewusst sind wir uns in diesem Moment aber nicht. In Einzelkämpfermanier erreicht jeder den Gipfel. Der Letzte kommt gerade außer Atem oben an, als der Erste bereits wortlos in einem dunklen Couloir verschwindet. Der nächste sofort hinterher, schließlich hat die Rinne im oberen Bereich nicht Platz für vier Spuren. Also los, ebenfalls runter. Nun, alle erreichen wohlbehalten und in bestem Powder das Sertigtal und weil es so sensationell war, gehen wir die Tour noch ein zweites Mal. Mit exakt denselben Verhaltensmustern wie zuvor.
Ein typisches Beispiel für Gruppendynamik, wie es in jedem Lehrbuch stehen könnte. Interessanterweise wird mir dies erst Jahre später bewusst. Dabei waren an diesem Tag und in dieser Gruppe die Grundzutaten für negative gruppendynamische Effekte vorhanden wie Zucker, Eier und Mehl für einen Kuchen.

Gruppen erforschen, aber wie?

Die Beschreibung und Erforschung von Gruppeneffekten steckt im Bereich des Outdoor-Sports noch in den Kinderschuhen. Vielleicht, weil es bereits anspruchsvoll genug ist, unsere eigenen Wahrnehmungs- und Entscheidungsfallen kennenzulernen oder sogar zu kontrollieren. Dasselbe Bild findet man im wissenschaftlichen Bereich: entsprechende Publikationen zum Thema Gruppendynamik im Lawinengelände sind rar, obwohl dieses Forschungsgebiet vermutlich beachtenswertes Potential zur Risikoreduzierung hätte. Gruppen als soziale Systeme können am besten mit Methoden der empirischen Sozialforschung untersucht werden, zB durch Beobachten, Befragen oder mit Experimenten. Im Lawinengelände haben diese Methoden aber alle ihre Tücken.

Beobachtung
Aus Forschungssicht wäre man am liebsten als unsichtbare Drohne bei einer Gruppe dabei und würde das Geschehen beobachten. Beobachten ist tatsächlich eine nicht selten verwendete Forschungsmethode im Themenfeld der Sozialpsychologie. Im Fall von Skitouren oder Freeriden hat das Beobachten allerdings seine Schwierigkeiten: Beobachtet man aus der Ferne - was den Vorteil mit sich bringt, dass keine Beeinflussung des Beobachters auf die Gruppe erfolgt - sieht man zwar gewisse Verhaltensmuster, aber man erfährt nichts über die Diskussionen in der Gruppe und die eigentlichen Entscheidungsprozesse. Begleitet der Beobachter eine Gruppe, kann sich das Verhalten der Gruppenmitglieder verändern. Denkbar wäre auch eine technische Lösung: Gruppen mit Helmkameras oder Diktiergeräten ausrüsten und so etwas über die Diskussionen und Entscheidungen erfahren.

Experiment
Viele Psychologen arbeiten auch mit Experimenten. Solche realitätsnahen Experimente zu Skitouren oder Freeriden – direkt draußen im Gelände – sind zwar denkbar, aber durch die sich

Ob der Hinterste wohl weiß, was der Vorderste im Sinn hat?

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ändernden Bedingungen ist es kaum möglich, die Rahmen-Parameter konstant zu halten. Einfacher geht dies in simulierten Experimenten, zB Entscheidungsexperimenten, die eine mögliche Situation möglichst real beschreiben. Solche Experimente haben sich auch bereits im Bereich von Wintersportlern bewährt, allerdings nicht auf Gruppenbasis, sondern für einzelne Personen.

Befragung
Um mehr über Gruppen herauszufinden, kann man diese befragen. Dazu ist man auf deren Mitarbeit mit offenen und ehrlichen Antworten angewiesen. Ein geeigneter Rahmen für eine solche Befragung ist deshalb ein wichtiges Element dieser Methodik. Möglichkeiten zur Befragung gibt es unzählige: in der ganzen Gruppe, einzeln, per Internet-Fragebogen oder direkt draußen im Gelände, mit einem strukturierten oder unstrukturierten Interview, mit vorgegebenen Antworten oder mit offenen Antworten, wobei jede Methode Vor- und Nachteile mit sich bringt.

Gruppeninterviews Winter 2012/13

Um mehr über das Themenfeld der Gruppendynamik im winterlichen Lawinengelände zu erfahren, haben wir im Winter 2012/13 Touren- und Freeridegruppen im Raum Davos befragt. Dazu haben wir mit 29 Gruppen und total 98 Personen halbstrukturierte Interviews durchgeführt. Halbstrukturiert bedeutet, dass die Fragen vorgegeben sind, aber so, dass sie offene Antworten zulassen. Wir haben die Gruppen zu Themen wie Planung, Motivation, Führung, Entscheidungsprozess, Gruppenstruktur und Risikobereitschaft befragt. Wichtig war uns, die Gruppen direkt nach der Tour oder der Abfahrt zu befragen, weil dann die Erinnerungen an die Entscheidungen und das Verhalten noch frisch sind. Ebenfalls wichtig war uns, dass dies nach der Tour oder Abfahrt geschieht, weil dann der Zeitdruck weg ist und die Gruppen sich gerne für ein Interview eine halbe Stunde bis eine Stunde Zeit nehmen. In diesem Beitrag gehe ich vor allem auf das Thema der Gruppenplanung näher ein: Also wie wir es schaffen, negative Gruppeneffekte in der Planung zu reduzieren oder uns dessen wenigstens bewusst zu werden.

Nur die „jungen Wilden"?

Erst einmal müssen wir aber wissen, wer betroffen ist. Nun, wir waren damals - bei der eingangs beschriebenen Tour - jung und wild. Wenn man aber genauer hinschaut, stellt man fest, dass ungewollte gruppendynamische Effekte auch in anderen Gruppen stattfinden. Unsere Befragungen im Winter 2012/13 haben gezeigt, dass folgende Gruppen besonders anfällig sind:

Gruppe von Experten
Seien dies Lawinenexperten im Schneeprofil, Bergführeraspiranten auf ihrer Konditions-Bewährungstour oder Patrouilleure beim Inspizieren ihrer Sprengpunkte. Vor allem alltägliche Routine-Situationen, in denen keine klare Führungsstruktur vorhanden ist, sind prädestiniert für Gruppendynamik.

Gruppen, in denen sich nicht alle Teilnehmer kennen
Klassisches Beispiel: Der bekannte Partner bringt einen Freund mit. Wissen wir, wie sich dieses neue Gruppenmitglied verhält?

Konforme Gruppen ohne Führung
Gleichgeschlechtlich und gleichaltrig, oft auch noch in anderen Bereichen konform, ähnlicher Kleidungsstil, gleiche Vorstellungen vom Skifahren usw. Hier herrscht oft ein Gruppendenken, wobei Entscheidungen gefällt werden, die sich an einer erwarteten Gruppenmeinung orientieren und nicht den Vorstellungen der einzelnen Gruppenmitglieder entsprechen.

Geführte Gruppen in einem stressigen Umfeld
Insbesondere bei hohen Erwartungen der Teilnehmer und in stressigem Umfeld (zB Freeriden oder bekannte Hochtourenziele) kann der Gruppenleiter unter Erfolgsdruck kommen. Dies vor allem, wenn er seine Teilnehmer nicht kennt.

Gruppen mit Liebesgeschichten
Paare, die sich neu kennen lernen, oder zwei Männer, die um dieselbe Frau buhlen.

Weniger gefährdet für negative gruppendynamische Effekte sind hingegen:

Familien oder langjährige Paare
In diesem Umfeld, das meist von großem gegenseitigen Vertrauen gekennzeichnet ist, werden Bedenken, Ängste oder Fragen häufiger offen ausgesprochen.

Geführte Gruppen in einem stressarmen Umfeld
Wenn der Leiter genug Raum und Zeit hat, seine Pläne und Entscheidungen transparent zu kommunizieren, kann er möglichen Erfolgsdruck verhindern. Es hilft auch, wenn der Leiter seine Teilnehmer kennt.

Gemischte Gruppen, in denen sich die Teilnehmer gut kennen
Beide Geschlechter, allenfalls Skifahrer und Snowboarder gemischt und Personen, die sich von vielen Touren bereits gut kennen.

Neben der gruppeninternen Charakteristik haben auch andere Gruppen einen wichtigen Einfluss auf die Gruppendynamik. Allgemein wirkt ein Umfeld, wo viele Gruppen unterwegs sind – sprich Freeridebereich oder vielbegangene Touren – begünstigend für gruppendynamische Effekte zwischen verschiedenen Gruppen. Nach dem Motto „wenn diese Gruppe dort schon gefahren ist, können wir hier sicher auch fahren", während wir auf einer einsamen Tour kaum unter Druck gekommen und den Hang wohl nicht gefahren wären.

Gruppenplanung

Gruppendynamische Prozesse mit negativen Konsequenzen sind, wenn die Voraussetzungen mal gegeben sind, kaum mehr zu verhindern. Selbst wenn wir uns des Risikos bewusst sind. Das anfangs geschilderte Beispiel zeigt dies gut. Der eigentliche Fehlentscheid geschah, als die beiden Gruppen sich zusammengeschlossen haben, ohne sich in ihren Zielen und Erwartungen neu abzusprechen. Es gab keinen Startschuss für diese neue Gruppe. Ab diesem Punkt nahm das gruppendynamische Geschehen seinen eigenen Lauf, obwohl sich die einzelnen Personen nicht unbedingt wohl gefühlt hatten. Können wir solche Risiken vielleicht ausschließen oder wenigstens reduzieren, indem wir nicht nur

Was ist Gruppendynamik?

Gruppendynamik beschreibt das Verhalten und die psychologischen Prozesse, die innerhalb einer sozialen Gruppe (intra) oder zwischen Gruppen (inter) stattfinden. Mit Gruppen sind in diesem Fall zwei oder mehr Personen gemeint. Der Psychologe Kurt Lewin (1951) nutzte den Begriff Gruppendynamik, um zu beschreiben, wie Individuen oder Gruppen in sich ändernden Umständen agieren und reagieren. In der Sozialpsychologie gibt es die psychologische Sichtweise, die sich vorwiegend mit dem Individuum beschäftigt und die soziologische Sichtweise, die sich mit der Gruppe beschäftigt. Und hier ist die Gruppendynamik angesiedelt. Schaut man in Lehrbücher, die das Thema Gruppendynamik erläutern, umfassen diese Themen wie Gruppenentwicklungsphasen, Einfluss, Macht, Führung, soziale Rollen, Entscheidungsfindung, Performance, Stress, Aggression oder Konflikt (Forsyth, 2009). In Lawinenlehrbüchern findet man den Begriff Gruppendynamik im Kapitel zum Faktor Mensch. Und obschon der Begriff Gruppendynamik allgemeine Gruppen-Verhaltensmuster beschreibt, werden in der Lawinenkunde meistens negative Verhaltensmuster mit dem Begriff assoziiert. Oft beschrieben wird der risky-shift- oder herding-instinct-Effekt: Die Tendenz, dass Leute in der Gruppe größere Risiken eingehen, weil die anderen Gruppenmitglieder ein Sicherheitsgefühl vermitteln.

Benjamin Zweifel, Lawinenprognostiker und Unfallexperte am SLF Davos, macht momentan eine Doktorarbeit über Gruppendynamik bei Skitourenfahrern und Freeridern.

den Routenverlauf und die Schneeverhältnisse, sondern auch die Gruppe planen? Fragen wie „Wer kommt mit?" oder „Wie viele Personen kommen mit?" sind schon lange in der Planung verankert. Eine Gruppenplanung kann aber deutlich weiter ins Detail gehen. In unseren Gruppeninterviews haben wir erfreulicherweise festgestellt, dass die meisten Tourenfahrer oder Freerider ihre Gruppe deutlich detaillierter planen. Im Folgenden wollen wir deshalb auf die wichtigsten Punkte eingehen, die wir in den Interviews festgestellt haben.

Gruppenstruktur
Gruppen sind geprägt durch ihre Struktur. Ob eine Familie, ein Paar, gute Freunde oder eine professionell geführte Gruppe, macht einen großen Unterschied im Verhaltensmuster der Gruppe. Wenn sich alle Gruppenmitglieder kennen, sind die Erwartungen meistens gut geklärt. Dies sind gute Voraussetzungen für eine vorbildliche Gruppe, insbesondere, wenn ein enges Vertrauensverhältnis zwischen den Gruppenmitgliedern vorhanden ist. Vorsicht ist geboten, wenn neue Mitglieder zur Gruppe stoßen oder sich sogar kurzfristig unterwegs weitere Leute der Gruppe anschließen. In solchen Fällen lohnt es sich, die Erwartungen und Motivationen neu abzuklären. Man kann sich auch mal überlegen, ob man immer in der gleichen Gruppe unterwegs ist oder ob die Gruppenzusammensetzung oft wechselt. Konstante Gruppen neigen in der Regel weniger zu ungewollten Gruppeneffekten, wobei sich auch in diesen Gruppen ungünstige Verhaltensmuster einschleichen können.

Führung
Hier sollten wir zwischen professionell geführten Gruppen, informell geführten Gruppen und nicht geführten Gruppen unterscheiden. In professionell geführten Gruppen ist es wichtig, dass die Teilnehmer dem Führer vertrauen. Dies wiederum tun sie am ehesten, wenn der Führer offen und ehrlich kommuniziert und seine Entscheide erklärt. Der Führer kann sich so vor Erwartungsdruck schützen. In informell geführten Gruppen ist wichtig zu wissen, ob der Führer die am besten geeignete Person ist, um die Gruppe zu führen. Hat er die Fähigkeit, sich selber vernünftig einschätzen und auch entsprechend zu handeln? Dies sollten sich alle Gruppenmitglieder überlegen. Bei Vorbehalten ist es empfehlenswert, diese anzusprechen – das braucht Mut. In Gruppen ohne Führer ist große Vorsicht geboten. Ungewollte Gruppeneffekte sind hier an der Tagesordnung. Hier lohnt es sich zu überlegen, ob allenfalls eine Person als Führer bestimmt werden kann. Auch wechselnde Führung (zB Aufstieg und Abfahrt aufteilen) sind möglich.

Entscheidungsverhalten
Das Entscheidungsverhalten ist in der Regel abhängig von der Gruppenstruktur und der Führung. In der Planungsphase einer Gruppe kann man sich dazu aber auch schon einiges überlegen. Werden Entscheide so gefällt, dass alle damit zufrieden sind? Werden Entscheide vom Führer erklärt? Werden Entscheide in der Gruppe diskutiert? Je mehr man grundsätzlich über das Entscheidungsverhalten seiner Kollegen weiß, desto weniger sind ungewollte Gruppeneffekte zu erwarten.

Motivation
Die Motivationen auf eine Skitour oder zum Freeriden zu gehen, sind sehr unterschiedlich und reichen von Erholung in der Natur über sportliche Betätigung und Bewegung, Gipfel sammeln bis zum Adrenalinkick beim Powdern. Diese Motivation der Gruppenmitglieder zu kennen, ist ein Grundstein der Gruppenplanung. Je mehr sich diese decken, desto einfacher wird die Tourenplanung. Gehen die Wünsche stark auseinander, wird es schwieriger, dass alle Gruppenmitglieder zufrieden sind. Dann ist Kreativität in der Tourenplanung gefragt. In jedem Fall ist es wichtig, die Motivationsgründe zu klären und miteinander abzustimmen.

Risikoverhalten
Die Risikobereitschaft unterscheidet sich von Person zu Person. Haben alle Gruppenmitglieder eine ähnliche Risikobereitschaft, fühlen sich diese wohler in ihren Entscheidungen. Gehen die Bereitschaften zum Risiko stark auseinander, passt es meistens nicht mehr für alle Gruppenmitglieder. Vorsicht ist mit Partnern geboten, bei denen man weiß, dass man sich bezüglich deren Risikobereitschaft nicht wohlfühlt - auch wenn dieser vielleicht am Tag X der einzige ist, der Zeit hat.

Kondition und Skitechnik
Hier gilt es abzuklären, ob die geplante Tour auch dem konditionellen und skitechnischen Können der Gruppenmitglieder entspricht. Richtwert ist der schwächste Teilnehmer in der Gruppe. Sollte dieser aber eine starke Gruppe in ihren Möglichkeiten zu fest bremsen, können auch Alternativen überlegt werden.

Alternativen planen

Was machen wir, wenn wir ein hohes Potential für ungewollte Gruppendynamik feststellen? Bleiben wir zu Hause? Zuerst sollten wir die verschiedenen Möglichkeiten nutzen, das Risiko der ungewollten Gruppendynamik zu reduzieren. Oft hilft bereits das Klären von offenen Fragen. Beispielsweise können wir das Risiko, dass am Morgen der Tour kurzfristig weitere Leute mit dazukommen, mit einer genauen Nachfrage bei allen Gruppenmitgliedern ausschließen. Oder das Klären der Motivationsgründe hilft weiter. Vielleicht ist ja der „2000-Höhenmeter-Kollege" angeschlagen und für einmal auch mit einer kleinen Tour zufrieden. Oder vielleicht lässt sich der „Aufstiegsmuffel", der normalerweise lieber zum Freeriden geht, angesichts von schlechten Schneeverhältnissen auch mal von einer Skitour überzeugen. Sollten sich die Motivationsgründe der Gruppenmitglieder nicht vereinen lassen, können wir alternativ auch zwei Gruppen mit verschiedenen Zielen bilden. Man trifft sich dann im Berggasthaus und hat so auch einen gemeinsamen Teil des Tages. Vielleicht gibt es auf der Tour auch Möglichkeiten für schwächere Personen, an einer sicheren Stelle in der Sonne zu warten. Wenn Unsicherheit über das Gruppenverhalten besteht, kann man das Tourenziel anpassen und allenfalls eine defensivere Variante planen. Wichtig bleibt jedenfalls, sich nicht nur über die Risiken, die von der Schneedecke oder vom Wetter herrühren, zu unterhalten, sondern sich auch über seine Gruppe Gedanken zu machen und diese auch anzusprechen. Dies ist oft nicht einfach, man will niemanden beleidigen oder verletzen. Offene und klare Kommunikation ist hier wohl der Schlüssel zum Erfolg. Und da können wir vielfach wortkargen „Bergler" sicher noch lernen.

PS: Wir planen, im Winter 2013/14 einen Gruppen-Risiko-Check sozusagen auf Bewährung freizulassen. Das Feedback wird dann im Frühling 2014 ausgewertet; über die Ergebnisse berichte ich gerne in bergundsteigen. ■

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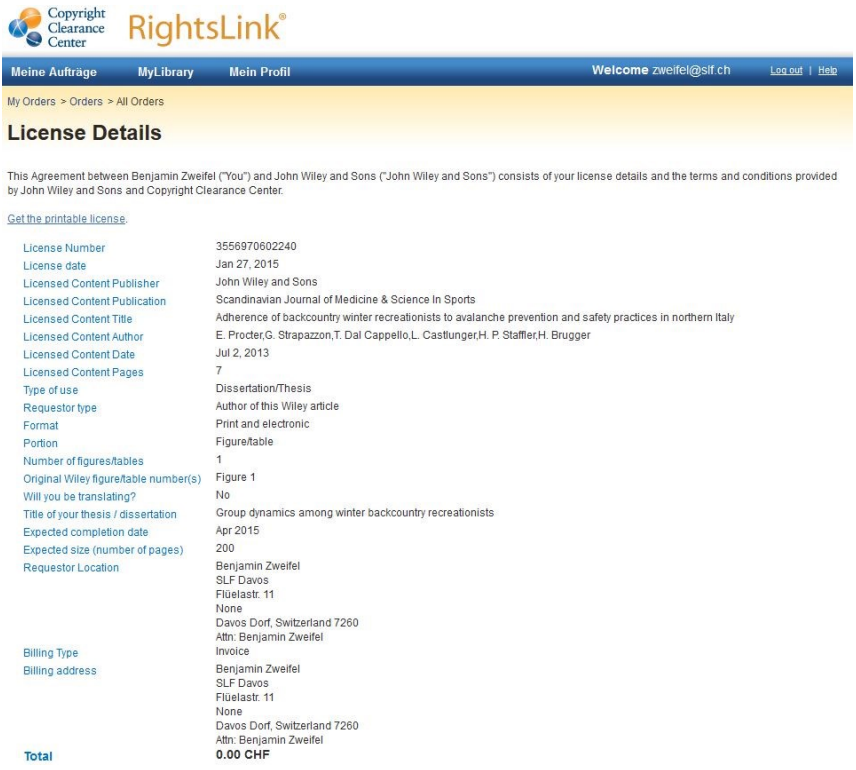

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Curriculum Vitae

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09-1995–02-2000	*ETH Zurich* Studies of Glaciology, Hydrology, Geology and Geography B.A., MSc in Natural Science, final grade 5.28

Professional Experience

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Scientific officer Swiss national Avalanche Forecasting

Selected competences:

- trainer and lecturer in avalanche education and prevention
- research topics: avalanche accidents, prevention and avalanche education
- coordinator of observer network
- coordinator of avalanche safety equipment: expert in courses and scientific analysis
- representative in European Avalanche Warning Services: harmonization of danger levels, glossary "snow and avalanches"
- webmaster of the official forecasting website

03-2008–04-2008 — *Avalanche Forecasting Services in Colorado, Wyoming and Montana, USA*

Delegate for avalanche forecaster exchange