OUT OF BOUNDS SKIERS AND AVALANCHE RISK: HIGH-RISK COHORT IDENTIFICATION AND CHARACTERIZATION

by

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ABSTRACT

The popularity of out-of-bounds skiing and snowboarding has been growing steadily over the last decade despite the avalanche risk inherent to the activity. As a consequence, out-of-bounds skiers and snowboarders have become an important target audience for avalanche safety messages. The present research focuses on identifying and characterizing out-of-bounds skiers most at risk of involvement in an avalanche incident. An innovative multidimensional approach that integrates the three central dimensions of avalanche risk management (training and experience, risk mitigation practices and terrain choices) is used to assign a risk level to out-of-bounds skiers and snowboarders participating in an extensive online survey. Subsequently, high-risk and low-risk groups are compared with respect to motivations and attitudes, risk perception, sensations seeking, self-efficacy, and understanding of ski area out-of-bounds policies. The results of this study offer useful insights for the development of avalanche awareness messages specifically targeted at out-of-bounds skiers and snowboarders most at risk.

Keywords: High-risk recreation; out-of-bounds skiing; avalanche risk; multidimensional risk assessment; high-risk cohort; risk perception; sensation seeking scale; self-efficacy; discrete choice experiment; latent class analysis; risk management; risk communication.

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1: INTRODUCTION

1.1 Out-of-Bounds Skiing

Out-of-bounds skiing and boarding (hereafter referred to as OB skiing) is the activity that skiers and snowboarders engage in when they leave official runs within a resort area to ski or ride terrain beyond the resort boundary. OB terrain is generally defined as the terrain adjacent to a ski resort that is primarily accessed through the use of the resort's lift system, though short sections of hiking may be required to reach the top of a run. OB ski runs typically lead participants back into the resort in order to facilitate continued use of the resort's lift system. These characteristics distinguish OB skiing, which is possible from many North American ski resorts, from the related activity of *backcountry skiing*. In backcountry skiing, participants ascend wilderness slopes under their own power, rather than use a lift system, in order to access ski terrain which usually independent of a ski resort.

Within a ski area, it is the responsibility of the local ski patrol to manage avalanche hazard to provide the visitor with a safe skiing experience. In order to reduce the avalanche risk to an acceptable level, ski areas have extensive avalanche safety programs to secure their skiing terrain. Common risk mitigation methods include the continuous monitoring of weather and snowpack conditions throughout the season, use of explosives to artificially trigger avalanches, and temporary closures of skiing terrain. Since OB terrain is outside of the ski area boundary, it is

outside the region where the ski patrol typically manages and controls avalanche activity, and thus OB skiers may expose themselves to considerable avalanche hazard. In OB terrain, the responsibility for risk management lies squarely with the individuals who make the choice of skiing outside the secured perimeter of the ski area.

Due to the complexity of the avalanche phenomenon, it is impossible to easily recognize avalanche hazard through casual observation. In fact, it takes years of training and experience to reliably recognize conditions of increased hazard and more experience still to effectively manage it. This complexity and the need for training and practical experience stand in stark contrast to the fact that all that is required to engage in OB skiing is passing under a boundary rope. The general ease of access to OB terrain allows for spontaneous engagement without a substantial investment in time, effort or specialized equipment. The consequence of this low-investment participation is the potential for people with a variety of preparation levels and ambitions to easily expose themselves to significant avalanche hazard. This characteristic of OB skiing, combined with the current trend of rapid growth in participation (Hägeli, 2005) has led to a number of avalanche involvements and fatalities in Canadian OB terrain in recent years. During the six year period spanning the 2003/2004 ski season to the 2008/2009 season, OB avalanche fatalities accounted for 23% (219 of 973) of the known avalanche related deaths worldwide (IKAR-CISA, 2004-2009). In Canada, 19 people were killed while skiing OB or on closed resort terrain in the last 15 years, accounting for 8% of all avalanche fatalities. Given that OB skiers make up a considerable proportion of avalanche

fatalities, they should be considered a key target group for current avalanche safety initiatives.

1.2 Avalanche Awareness Programs

In Canada, public avalanche awareness initiatives are coordinated by the Canadian Avalanche Centre (CAC). The programs of the CAC primarily focus on providing information about the current conditions (public avalanche bulletins, special avalanche warnings) and promoting avalanche awareness education among recreationists (avalanche skills training courses). Together, they provide recreationists with the necessary information and skills to make educated choices when travelling in avalanche terrain. These awareness initiatives rely on participants to actively seek out information and training prior to engaging in an activity in avalanche terrain. While this approach works well for backcountry skiing, an activity which requires specialized equipment and planning in order to participate, it stands in strong contrast with the characteristics of OB skiing. The potential for spontaneous participation and low investment prior to engagement in OB activity means that participants may be completely unaware of the existing avalanche hazard when crossing the ski area boundary. Furthermore, spatial and logistical aspects of OB skiing create a situation where the time frame for communicating safety messages and the collection of relevant observations is very narrow. These characteristics present a unique risk management challenge for ski resorts and the avalanche community. Since the current avalanche awareness initiatives are not well suited for effectively reaching OB skiers, it is necessary to

develop awareness programs that are specifically tailored to the particular needs of OB skiers.

The development of evidence-based avalanche awareness programs that effectively use available OB skiing communication opportunities requires an in-depth understanding of the target audience. While media sources covering OB avalanche incidents typically portray participants as a homogeneous group of risk taking adventure seekers, preliminary research indicates a more diverse and complex picture (Haegeli, Haider, Longland, & Beardmore, 2010). Previous studies of OB skiing behaviour have identified heterogeneity within the OB skiing population such as variation in risk management behaviour, training and experience, and perception of exposure to risk (Björk, 2007; McCammon, 2009). I hypothesize that the OB skiing community consists of distinct subpopulations with respect to their willingness to expose themselves to avalanche hazard and their ability to manage the resulting avalanche risk. I also hypothesize that the individuals most at risk of being involved in an avalanche accident are a small subgroup of the entire population. To my knowledge, no study has specifically focused on risk heterogeneity with the intention of characterizing perceptions and attitudes of OB skiers most likely to be involved in an avalanche incident. Detailed knowledge of this group's characteristics is crucial for the development of specifically tailored safety messages.

While this targeted approach to risk communication is novel to OB skiing and outdoor recreation research in general, it has been applied extensively to other activities under the health behaviour paradigm. In public health campaigns,

characteristics such as demographics, perceptions, and inherent personality traits are frequently used to facilitate the development of risk messages and management strategies (Atkin & Freimuth, 2000). An extensive body of health behaviour research, for example, has examined sexual activity among youth to identify the characteristics of subpopulations with different risk exposure levels (L. Donohew et al., 2000; Kalichman, Heckman, & Kelly, 1996; Khumsaen & Gary, 2009; Rosenthal , Moore , & Flynn, 2006).

1.3 Research Questions

The goal of this research project is to create an evidence-based foundation for the development of programs to promote avalanche awareness among OB skiers and to reduce their overall exposure to avalanche risk. Specifically, this research is designed to identify characteristics of OB skiers who would benefit most from an avalanche safety campaign, as well as relevant and appropriate safety messages and functional communications channels for that population. Following the paradigm of health behaviour research, the study was conducted as formative research to addresses the following research questions:

1) Who are the OB skiers most at risk of being involved in an avalanche incident?

2) What are behavioural, motivational, perceptual and attitudinal characteristics of OB skiers most at risk of being involved in an avalanche incident? What potential management implications can be inferred from these characteristics?

1.4 Organization of Document

The *Literature Review* starts with an examination of trends in OB skiing and existing avalanche accident prevention initiatives, followed by a review of strategies that have been used in health behaviour campaigns to identify and characterize risk groups, or that would provide an important perspective on decision-making of OB skiers. The *Methodology* section contains a description of the process used for identifying and characterizing high-risk OB skiers. The *Results* section presents distinguishing characteristics of the high-risk OB population. The *Discussion* section focuses on the characteristics of the high-risk OB skier segment and management implications supported by the research. The *Appendices* include a description of a verification process for the online survey and a discussion of its results.

2: LITERATURE REVIEW

2.1 Trends in OB Skiing

Many indicators point to a tremendous growth in popularity of OB skiing in the recent past. Though no explicit quantitative information exists on participation in OB riding, Haegeli (2005) obtained estimates of growth in OB skiing in Western Canada through expert interviews. While medium-sized ski resorts reported a steady increase in OB skier numbers, larger ski resorts such as Whistler, Lake Louise and Sunshine reported exponentially increasing OB traffic. These estimates suggest a cultural change towards increased OB skiing and riding, which is fuelling the highest growth rate in the non-commercial backcountry segment; the OB population is expected to eclipse the backcountry ski group in the future (Hägeli, 2005). In a Snowsports Industries of America panel comprised of 5000 consumers, 35.6% of skiers and 42.6% of snowboarders had ventured into backcountry terrain (SIA, 2008).

Sales of equipment for backcountry and OB skiing and snowboarding also reflect a growing interest in the activity with retailers reporting year after year growth in the market (Geraci, 2004; O'Gorman, Hein, & Leiss, 2003). Currently, some of the most popular apparel items are garments that incorporate avalanche safety devices (Taylor, Yang, & Strom, 2007). Avalanche beacons, a key component of minimum safe travel practices in avalanche terrain (Tremper, 2008) have appeared as 'must have' items in mainstream media (Financial Post, 2006; Toronto Star,

2007); not surprisingly, sales of beacons grew by 38% from 2005/2006 to 2006/2007 (SIA, 2008). The increased popularity of OB skiing is further confirmed by the growing interest of the popular media in the sport. (see, e.g., Johnson, 2005; Solomon, 2004; Solomon, 2007; Weeks, 2007). This combination of media references and increased equipment sales suggests a growing interest in OB skiing within mainstream ski culture.

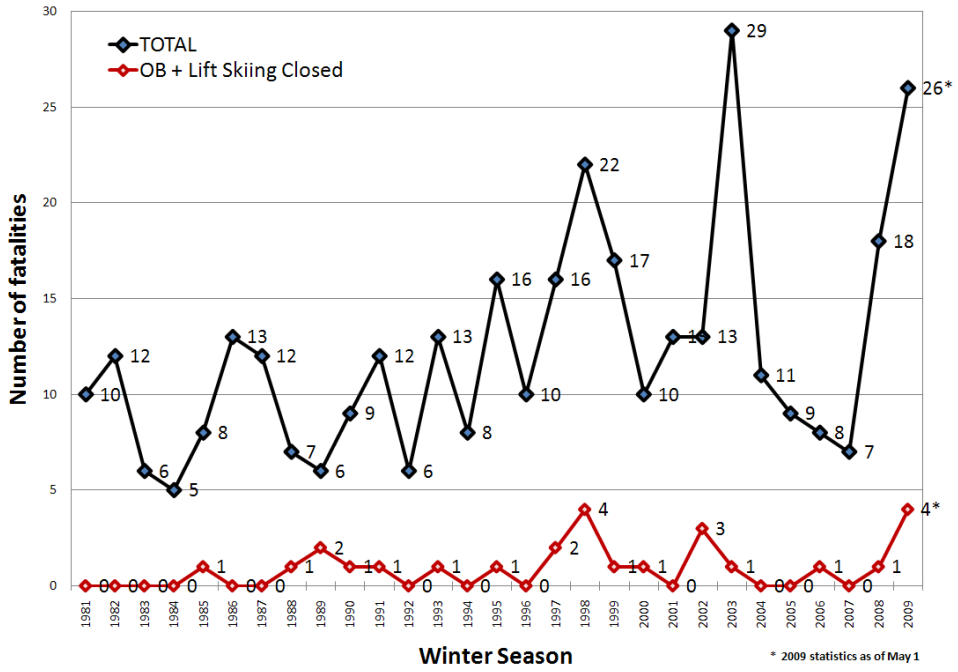
Many different factors seem to contribute to the recent increase in popularity of OB skiing. The adventure of skiing untracked powder snow presents a strong lure for skiers and snowboarders (Atkinson, 2008; Johnson, 2005; Lloyd, 2005; Pennington, 2007). Media influences likely play a part in encouraging this interest (Egan, 2003; Fortney, 2008). Improvements in equipment quality and availability have also played a role in facilitating OB and backcountry skiing (Abdollah, 2008; Brandt, 2005; Geraci, 2004; Johnson, 2005; Longland, Haider, Hägeli, & Beardmore, 2005; Sloan, 2005).

An additional factor that may have either directly or indirectly contributed to the promotion of OB skiing are the ski resorts themselves. The downhill ski industry in North America is currently facing two issues that suggest future market decline: a drop of international visitors (SIA, 2008) and a loss of 'core' and 'revival' skiers (Fristole, 2006). It appears that the growing interest in backcountry and OB skiing has been recognized by resorts as an opportunity to provide visitors a new kind of experience (Bisby, 2005). Many resorts now offer guided hikes into OB terrain (Alderson, 2006; Brandt, 2005; Briley, 2003; Dafoe, 2002; Sloan, 2005; Solomon, 2004) and popular 'quasi-out-of-bounds' areas where avalanches are controlled but

skiers must hike to reach ski terrain (Bisby, 2005; Geraci, 2004; Lloyd, 2005; Pennington, 2007; Sloan, 2005; Solomon, 2007; Stephenson & Southwell, 2006). This 'quasi-out-of-bounds' terrain may lead to increased interest in true OB terrain (Bisby, 2005). Some ski resorts are using OB and backcountry terrain in their marketing campaigns (Johnson, 2005; Solomon, 2004), perhaps in response to visitors who appear to be attracted to resorts with good OB terrain (Pigg, 2007) and liberal boundary policies (Thornton, 2007).

Unfortunately the increased popularity of OB skiing comes at a cost. Since a local ski patrol does not control the avalanche hazard in OB terrain, every time OB skiers travel beyond resort boundaries they face the possibility of avalanche involvement. In the last 15 years, 19 people were killed while skiing OB or on closed resort terrain in Canada. This accounts for 8.2% of all Canadian avalanche deaths over that period (CAC, 2009) (Figure 2.1).

Figure 2.1 Canadian avalanche fatalities by year – total and OB/closed inbounds runs.



In a 1999 analysis of American avalanche deaths spanning a 45 year period, OB skiing accounted for 10.0% of all fatalities (Page, 1999). In Europe[1], where the density of ski resorts is much higher than in North America, the numbers of OB avalanche fatalities is considerably higher. In the six ski seasons from 2003/2004 to 2008/2009, 219 avalanche deaths were reported in OB terrain of European and North American ski resorts accounting for 23% of all avalanche fatalities in Europe and North America (IKAR-CISA, 2004-2009). Given the inherent risks of OB skiing and its current growth trend, an avalanche safety program targeting this group is clearly warranted.

[1] In Europe, OB skiing is commonly referred to as 'off-piste skiing.'

2.2 Avalanche Safety Initiatives

In Canada, avalanche awareness and education initiatives are coordinated by the Canadian Avalanche Centre (CAC). The available awareness products and activities include:

- issuing the public avalanche bulletin;
- issuing avalanche information reports;
- issuing special avalanche warnings;
- communicating with media to promote public avalanche awareness;
- coordinating public avalanche awareness and education programs including courses and workshops;
- providing online avalanche awareness and rescue training (Canadian Avalanche Centre, 2005; Clayton, 2008; Kelly, Storm, & McAllister, 2006).

Education and awareness products such as courses, workshops and online bulletins are built on the assumption that participants heading into avalanche terrain will actively seek them out prior to engaging in the activity. These products have grown out of the backcountry skiing community, which has a strong safety culture and includes a distinct planning stage prior to entering avalanche terrain. In fact, participation statistics of avalanche awareness initiatives show that they have become much more popular over recent years; requests for the avalanche bulletin have grown by over 2400% over the ten years ending in 2005 (Canadian Avalanche Centre, 2005). In OB skiing, however, the decision to enter avalanche terrain can be

an unplanned spontaneous choice made by individuals who engaged in resort skiing with no intent of crossing the area boundary. This scenario creates the potential for an individual to end up in avalanche terrain without having had exposure to avalanche awareness products. Avalanche awareness initiatives face an additional challenge with OB skiers due to the limited communication window available to reach them as they leave the boundary of the resort. Boundary policies vary between resorts, and while some resorts funnel OB skiers through gates which provide a distinct communication opportunity, boundaries in other resorts can be crossed in almost any location (McCammon, 2009), further limiting communication opportunities. Given the discrepancies between the design of current awareness initiatives, and the nature of OB skiing, the delivery of avalanche injury prevention initiatives should be improved for this population. In order to effectively utilize available resources, an OB avalanche safety program should be developed so that it specifically targets skiers who are most at-risk of being involved in an avalanche accident. To create such a program, it is crucial to have an in-depth knowledge of the characteristics, motivations and behaviour of the target audience. While avalanche risk is an inherent part of OB skiing, the relatively low fatality rate shows that is it possible to ski OB without involvement in an avalanche incident. It is therefore worth investigating if the exposure levels to avalanche hazard varies among OB skiers, and if it does, detailed knowledge about the subgroup at the highest risk level will be important for the development of effective targeted awareness initiatives.

2.3 Characterization of High-Risk Sports Participants

The possibility that OB skiers vary in risk taking behaviour and attitudinal characteristics suggests that an OB avalanche safety program would benefit from a targeted approach. Research into the homogeneity and heterogeneity among participants of other high-risk sports provides a useful starting point for this research.

Numerous examples of research exist that focus on characterizing participants of high-risk sports such as rock climbing and skydiving. In general, high-risk sports refer to athletic pursuits where errors in judgment or execution are associated with the potential for fatal consequences as opposed to medium-risk contact sports such as football or low-risk sports such as running or walking (Zuckerman, 2007). Much of the high-risk sport research treats participants as homogeneous groups and compares their characteristics to other sports communities or the general public. The goal of these studies is to explore the underlying reasons for participation in these high-risk sports in general. Personality characteristics, such as Sensation Seeking (Zuckerman, 1994) or Self-efficacy (Bandura, 1997), are frequently used to characterize participants of high-risk sports. At the broad scale, the Sensation Seeking Scale (SSS) has been successfully used to distinguish between participants of high-risk or low-risk sports (Jack & Ronan, 1998; Zarevski, Marusic, Zolotic, Bunjevac, & Vukosav, 1998) with high-risk sports participants generally scorning higher and exhibiting distinct patterns on the four different subscales of the SSS framework. Mountain climbers, for example, score high on the complete SSS as well as the Thrill and Adventure Seeking and

Experience Seeking subscales (Cronin, 1991; Freixanet, 1991; Rossi & Cereatti, 1993). OB skiers score higher on Thrill and Adventure seeking in comparison to non skiers and resort skiers (Ajcardi & Therme, 2008). Other similar studies on high-risk sports have used personality traits such as arousal seeking (Kerr, 1991), extroversion, emotional stability and conformity to social norms (Freixanet, 1991) and self-efficacy. Slanger and Rudestam (1997) found that high-risk sport participants were motivated by a desire for thrills, aesthetic considerations and, most commonly, mastery. A high level of self-efficacy is an additional characteristic commonly observed in high-risk sport participants, and has been identified as the factor most responsible for the disinhibition associated with risk taking (Bandura, 1997). Participants of high-risk sports identify confidence as the most important factor that leads to acceptance of increased risk taking (Slanger & Rudestam, 1997).

Only a small number of studies examine heterogeneity related to behaviour and personality characteristics amongst participants of a specific high-risk sport. In a Turkish study (Asçi, Demirhan, & Dinç, 2007), rock climbers with different years of experience, or taking routes of different difficulties did not differ in sensation seeking, physical self perception or motivation. A British study, however, found that rock climbers did exhibit differences in participation frequency, risk taking and level of difficulty undertaken, dependent on confidence and self-efficacy; higher risk taking was also associated with increased age, sensation seeking and impulsivity (Llewellyn & Sanchez, 2008; Llewellyn, Sanchez, Asghar, & Jones, 2008). Mountaineers in Denali National Park stated different motivations dependent on their level of experience (Ewert, 1994). These studies provide clear evidence for

considerable diversity in personality characteristics, attitudes, motivations and behavioural patterns within individual high-risk sport communities.

2.3.1 Heterogeneity amongst OB Skiers

While the media generally depicts OB skiers as a homogeneous group of less experienced, risk taking adventure seekers (Egan, 2003; Fortney, 2008; Hardy, 2006; Spector, 2008), existing research on OB and backcountry skiing suggests that heterogeneity exists across a variety of characteristics and behaviours. A study on backcountry skiers by Kobe and Jenkins (1990) identified variations in propensity to carry safety equipment, which was associated with risk orientation, as well as differences in avalanche information gathered prior to the activity. Tase (2004) examined the characteristics of individuals who had personal avalanche involvement experiences. Individuals with prior involvements were primarily male, belonged to an older age group, had received a higher level of avalanche training, were very prepared (including using rescue gear) and held extreme adventure goals. These studies clearly indicate that heterogeneity exists within the backcountry skiing population.

A small number of studies examined diversity within the OB community. Silverton (2006) found that OB skiers who had taken an avalanche course were more likely to engage in minimum safe travel practices than those who had not. Björk (2007) examined the risk perceptions and behaviours of OB skiers through intercept surveys in Davos, Switzerland and an online survey. This study specifically examined facets of risk perception and management in the OB skier population and

identified aspects of participant heterogeneity along the lines of gender, age and skiing skill level. Björk concluded that, when examined according to ability level, OB skiers vary in frequency of activity participation, perception of exposure to risk and risk management behaviour (Björk, 2007). Finally, McCammon (2009) conducted focus groups, expert interviews and site visits in order to construct a working framework for the promotion of avalanche awareness among OB skiers. This study provides the most in depth examination of heterogeneity in the OB population to-date, segmenting skiers based on education and experience. McCammon identified a five stage model of awareness and precautionary behaviour which OB skiers progress through as they learn to recognize and mitigate avalanche hazard. The five stages are: Unaware, Unengaged, Engaged, Emergent and Practitioner.

Together these studies provide strong support for the hypothesis that considerable heterogeneity exists within the OB skiing community. While the existing studies identify numerous aspects of heterogeneity that are related to avalanche safety behaviour, none of these studies incorporate a broad spectrum of characteristics into a single dimension which allows ranking of exposure to avalanche risk. The creation of such a scale could facilitate the identification of individuals who expose themselves to the highest level of risk.

2.4 Identification & Campaign Design: A Health Behaviour Approach

Using background research to better understand the characteristics of the target audience is a common approach in the development of effective injury prevention programs to address public safety concerns. The extensive literature on

the development of health behaviour campaigns provides a fertile source of information for the development of an OB avalanche prevention program. Studies have examined issues of program efficacy in fields such as drug and safe sex education (Noar, 2006; Snyder et al., 2004). Successful risk education programs tend to share common features such as precise, clearly stated goals that focus on perception change rather than behaviour change, the use of risk ladders, and a focus on simple mitigation measures (McCammon, 2004). While undoubtedly many additional lessons can be learned from the existing studies of program efficacy, this review is not intended to comprehensively cover the broad range of strategies and qualities that make a health behaviour campaign successful. Instead, the focus will be on one of the initial steps in the development of a campaign, the use of *formative research*. Formative research is used to define the problem, learn about the intended audience and investigate factors that may limit program implementation (Valente, 2000). In order to create a successful health behaviour campaign, it is important to devote considerable resources to this type of preproduction research (Flay & Burton, 1990). Formative research can be used to investigate a number of attributes such as knowledge, beliefs, attitudes, salience and efficacy (Atkin & Freimuth, 2000). Examining the target audience's knowledge base enables identification of knowledge gaps and misconceptions that need to be addressed. Formative research can address beliefs held by the target audience such as perceived social norms or the probability of a given behaviour related outcome, which in turn can direct emphasis on pertinent campaign messages. Understanding attitudes and values held by the target audience can direct campaigns towards a concentration on creation,

conversion, reinforcement or activation of these attitudes and values. Research into cognitive and affective orientations can be used to direct which process campaigns should target in order to increase or decrease salience. Research into efficacy of the target audience can identify behaviours that fail despite motivations due to a lack of confidence in ability. In addition, formative research is useful for identifying subpopulations of high-priority targets by identifying which categories of individuals are at-risk (Atkin & Freimuth, 2000). This segmentation allows messages to be effectively adapted to the context, expectations, needs and frames of reference of the specific target audience. Without segmentation of audiences, public communication campaigns are unlikely to succeed (Slater, 1995). Clearly, in order to create an effective health behaviour program for a high-risk activity, it is important to first identify and then characterize at-risk participants of the activity.

The method used to identify the target audience depends on the specific nature of the risk behaviour. An example of a health campaign is the promotion of helmets to prevent head injuries from skiing and snowboarding accidents. Several studies have demonstrated a protective effect associated with helmet use without an increase in the risk of neck injury (Hagel, Pless, Goulet, Platt, & Robitaille, 2005; B. Hagel, 2005; Mueller, 2008; Sulheim, 2006). Based on this evidence, helmet use has been suggested as a method of injury prevention (B. Hagel, 2005) and health behaviour campaigns have been used to increase helmet use at ski resorts (Levy, Hawkes, & Rossie, 2007). In this type of campaign, adoption of the healthy behaviour in question can be assessed as one variable, for example, as the number of people who accept a helmet as part of a ski rental package. Another example of

identifying a target audience relates to the use of sun protection during winter recreation. The use of sun protection is effective in reducing skin cancer caused by exposure to ultraviolet rations (American Cancer Society, 2006; CDC, 2002). A health behaviour campaign designed to reduce exposure to ultraviolet radiation assessed individuals who are at-risk according to the use of sunscreen and protective clothing (Walkosz, 2008). Many health behaviour campaigns focusing on safe sex practices identified those at-risk through the use of condoms (Edgar, Noar, & Freimuth, 2008; Naughton & Rhodes, 2009). What these campaigns have in common is that the target segment for behaviour change can be readily identified through an investigation into one clearly defined variable. In these examples, a handful of questions can be used to identify whether or not an individual is at risk, not having taken the desired precautions. If a person has not decided to use a helmet, applied sunscreen or sun protection, or is not using a condom, they could be identified as an at-risk target for the appropriate health behaviour campaign.

In contrast to these campaigns, identifying the OB population most at risk of getting involved in an avalanche accident is much more challenging. While OB skiing inherently involves exposure to avalanche hazard, it is possible to reduce the related risk to an acceptable level by choosing appropriate skiing terrain for the existing hazard conditions. Participation in the sport alone is therefore inadequate for identifying the at-risk segment of the population. Instead, I must consider both the avalanche hazard and the exposure a person has to that hazard. Avalanche hazard is a function of the probability of an avalanche occurring and the likely size of a resulting avalanche (Statham, 2008). The level of exposure for an individual or

group is determined by a combination of terrain choices and travel techniques employed by the group (Tremper, 2008). The risk level for an OB skier in avalanche terrain is influenced by a wide variety of factors that affect both hazard and exposure. Furthermore, large numbers of potential levels for each of these contributing factors lead to wide spectrum of avalanche risk across participants of OB skiing. Given the complexity of avalanche hazard and exposure, determining avalanche risk for OB skiers requires a more complex approach than the single parameter approach used in the previously presented health behaviour campaigns. To identify OB skiers most at risk of avalanche involvement, a strategy must be used that integrates several indicators which contribute to an increased risk level.

2.5 Identification: At-Risk OB Skiers

To the best of my knowledge, no clearly defined strategy exists for identifying OB ski participants most likely to be involved in an avalanche incident. Avalanche hazard is subject to considerable spatial and temporal variability, therefore the risk environment within which OB skiers recreate is complex and difficult to predict. In addition, decision-making and travel styles can considerably influence group and individual exposure to the existing hazard. Seemingly minor decisions, such as which side of a gully to ski, where to wait for your companions, or what equipment is carried, can have life or death implications.

To effectively identify those OB skiers most at risk of accident involvement, a multi-dimensional approach must be used that considers the spectrum of elements that either contribute to, or help mitigate, the risk of avalanche involvement. The

following review of existing research and written expert opinions is used to identify key indicators for measuring the risk OB skiers are willing to expose themselves to during the activity.

2.5.1 Identification Criteria for Avalanche Risk

Several studies of backcountry and OB skiers have examined the relationship between *training and experience* and avalanche involvement. Tase's study (2004) of backcountry skiers identified an association between higher levels of avalanche training and a higher probability of previous avalanche involvement. Silverton (2006) found that OB skiers and riders predominantly have no formal avalanche training, while 60% of OB participants in a survey by Haegeli et al. (2010) had at least an avalanche awareness seminar. McCammon (2009) constructed an OB skiing health behaviour model largely based on a progression through stages of education and experience.

In addition to academic research, avalanche text books and awareness manuals frequently refer to the importance of training and experience in avalanche decision-making. In many examples, experts attribute the quality of many critical avalanche decision-making skills to the degree of training and experience. For example, novices are generally unaware of stability issues (Fredston & Fesler, 1999) and ignorance and lack of experience are attributed as the cause of many avalanche accidents (Daffern, 1992; McClung & Schaerer, 2006), therefore completing an avalanche course is an important factor in avalanche risk management (Kurzeder & Feist, 2003). In addition, experience travelling in avalanche terrain is important for

the development of avalanche skills and for optimal risk management groups should include experienced members (Daffern, 1992; Jamieson, 2000; LaChapelle, 2003). Developing skills such as effective terrain management is an ongoing process and "can take a lifetime" (Tremper, 2008).

Risk mitigation practices is another area of study related to avalanche risk that has received considerable attention. Researchers have examined a variety of strategies employed by backcountry and OB skiers to reduce the risk of an avalanche fatality. Kobe and Jenkins (1990) concluded that only 49% of backcountry skiers sought avalanche information before heading into backcountry areas and that respondents oriented towards risk were more likely to carry avalanche equipment. For backcountry skiers, Tase (2004) identified an association between being very prepared (including using rescue gear) and having previous involvement in avalanche incidents. Silverton (2006) looked at use of safety equipment by OB skiers and found that significantly fewer OB recreationalists followed minimum safe practices than backcountry skiers; only 26% of skiers and 2% of snowboarders travelled with a partner, beacon and shovel. In addition, most OB skiers and boarders were willing to venture into avalanche terrain without proper safety gear on days that they think have a high avalanche hazard. Björk (2007) identified considerable variation in risk mitigation practices amongst OB skiers in Davos, Switzerland. Björk found that OB skiers who were less likely to ski with unequipped friends and more likely to check avalanche bulletins and carry avalanche transceiver believed they were more likely to be involved in an avalanche incidents. Older OB skiers were more likely to check the avalanche bulletin and to carry rescue

equipment, while those with higher self reported skill levels were more likely to use rescue gear and less likely to accept skiing with unequipped friends. In contrast, younger skiers were more likely to accept ski partners who did not have safety equipment. Björk observed a positive correlation between self-reported exposure to avalanche risks and increased risk management behaviour. These studies suggest the existence of heterogeneity in OB risk mitigation practices and highlight its importance for assessing risk-taking behaviour of OB skiers.

Expert opinion supports the importance of these risk mitigation practices in avalanche terrain. Many of these practices are considered mandatory behaviour for winter recreation. Prior to heading into avalanche terrain parties should check the avalanche bulletin (Jamieson, 2000; Kurzeder & Feist, 2003) and seek out local information where available (Jamieson, 2000; LaChapelle, 2003). A beacon, shovel and probe are considered mandatory safety equipment for travel in avalanche terrain and should be carried by all members of an OB skiing party (Daffern, 1992; Jamieson, 2000; Kurzeder & Feist, 2003; LaChapelle, 2003; McClung & Schaerer, 2006; Tremper, 2008). Groups also benefit from discussion of avalanche hazards and an effective, cohesive decision-making process (Daffern, 1992; Jamieson, 2000; Tremper, 2008).

Making appropriate *terrain choices* when travelling in avalanche terrain is the most critical method for limiting avalanche risk to an acceptable level. Without sufficiently steep terrain, avalanches are not possible. More importantly, subtleties of terrain can make avalanches more likely under certain conditions, or can increase the consequences of being caught in an avalanche. Slope characteristics such as size,

steepness and the presence of terrain traps influence the potential risk of injury or death caused by avalanches (Tremper, 2008). As avalanche hazard increases, more conservative terrain choices are necessary to either avoid slopes that could avalanche, or to choose slopes where the consequences of an avalanche would be low. Experts recommend careful terrain selection to minimize risk (Fredston & Fesler, 1999) and consider route-finding skills to be critical (Daffern, 1992; LaChapelle, 2003; McClung & Schaerer, 2006), if not the most important risk management skill (Tremper, 2008).

However, terrain choices have only been examined by a limited number of previous backcountry and OB skiing studies. Tase (2004) found that backcountry skiers with extreme adventure goals were more likely to have previously been involved in avalanche incidents. Haegeli et al. (2010) conducted a winter backcountry recreationist intercept and web based survey that included OB skiers and found that good snow and challenging terrain are primary motivational factors for OB skiers. In their online survey, Haegeli et al. (2010) used a discrete choice experiment to explicitly examine the tradeoffs between avalanche hazard and terrain in the decision-making of backcountry winter recreationalists and to identify the strengths and weaknesses of their decision-making process. The response patterns of amateurs were compared to the choice preferences of professionals before and after the introduction of a decision aid. Haegeli concluded that the decision-making of OB skiers was considerably less detailed than backcountry skiers, less focused on avalanche hazard and more focused on maximizing enjoyment. In comparison to backcountry skiers and snowmobile riders, OB skiers

exhibited a weaker commitment to participating in their sport, most likely because of the in-bounds options that are always available.

In reviewing these findings, several key indicators can be identified which could be used to identify OB subpopulations according to avalanche risk. Building on existing research and expert opinion, *training and experience*, *risk mitigation practices*, and *terrain choices* are important indicators of the risk OB skiers expose themselves when skiing beyond the ski area boundary. However, since each of the three indicators only covers a specific aspect of the involved risks, it stands to reason that a combined assessment of these three contributing factors would provide a more comprehensive perspective on the risk of individual OB skiers being involved in an avalanche incident.

2.5.2 Combined Assessment

Many previous research projects have highlighted associations between *training and experience* and the other two proposed key indicators for the identification of high-risk OB skiers. Kobe and Jenkins (1990) found that, for backcountry skiers, experience had a positive correlation with preparation, such as carrying avalanche equipment and checking the avalanche bulletin. These findings are supported by Silverton (2006), who found that OB skiers who had taken an avalanche course were 1.4 times more likely to carry a shovel and beacon and travel with a partner. These results are encouraging as they show that avalanche awareness education has an effect on the behaviour of backcountry travellers.

If avalanche awareness education has any impact among OB skiers, these correlations most likely also exist among the target audience of this study. High-risk OB skiers could therefore be identified by focusing on individuals with limited formal avalanche *training and experience*. However, while most participants with avalanche awareness training will exhibit higher skills in risk mitigation, individuals who do not follow this pattern are a particularly critical group to identify. An individual who has achieved a high level of training but nevertheless makes aggressive terrain choices without using good mitigation practices would be an important target for a health behaviour campaign. A study that exclusively focuses on *training and experience* based on the assumption that *terrain choices* and *risk mitigation* are highly correlated to *training and experience* would certainly misidentify the risk exposure of such an individual. Support for this possibility can be found in research by McCammon (2000), who, based on an analysis of 344 recreational avalanche accidents, concluded that avalanche training did not appear to significantly decrease the hazard to which backcountry skiing groups exposed themselves.

2.6 Characterization of At-Risk OB Skiers & Management Implications

Identification of OB skiers most at risk of injury or death in an avalanche incident is an important first step towards developing a prevention program. The second step is to develop a detailed profile of the characteristics of the high-risk group. A better understanding of the high-risk subpopulation's characteristics is

crucial for the development of effective awareness messages. Characteristics such as sensation seeking and self-efficacy have been studied in relation to both risk taking behaviour and health behaviour campaigns and have proven to be useful considerations. Other characteristics such as understanding of boundary policies and perception of ski patrol attitudes have relevance to OB skiing behaviour and could provide additional important insights into behaviour and decision-making.

Knowledge about perceptual and attitudinal characteristics of a target population can be used in the development of a health behaviour campaign. Research has been carried out on the effective design of such campaigns in relation to characteristics such as sensation seeking and self-efficacy. This research provides a field of study that may be applied to the design of an OB avalanche safety program. Once the high-risk OB skiing subpopulation has been characterized, personality traits can be considered for implications relevant to the design of a health behaviour strategy.

2.6.1 Sensation Seeking

Identifying subpopulations of risk takers according to criteria may have some utility for those interested in managing a health behaviour campaign. Sensation seeking is a personality trait which is used to characterize an individual's need for varied, novel, and complex sensations and experiences, and the willingness to take physical and social risks for the sake of such experiences (Zuckerman, 1979). High sensation seeking has been associated with risk taking behaviour with regards to activities such as sexual behaviour and is associated with number of partners,

willingness to engage in a variety of activities, frequency of unprotected sex, use of alcohol before sex, and inability to refuse unsafe sex (Donohew et al., 2000; Kalichman et al., 1996). Sensation seeking is assessed through questionnaires that focus on four subscales. The first subscale is *experience seeking*, which represents the seeking of experiences through mind and senses, travel and nonconforming life-style. The second subscale is *boredom susceptibility*; this represents an aversion to repetition, routine and restlessness when things are unchanging. The third subscale is *thrill and adventure seeking*; this subscale reflects a desire to engage in sports or other activities involving speed or danger. The fourth and final subscale is *disinhibition*; this subscale represents the desire for social and sexual disinhibition as expressed in partying, drinking and seeking variety in sexual partners (Zuckerman, Eysenck, & Eysenck, 1978). All four sensation seeking subscales may significantly contribute to the decisions of OB skiers to leave controlled terrain within the resort and enter OB areas. Sensation seeking is typically assessed using the Form V of the Sensation Seeking Scale (Zuckerman et al., 1978) which contains 40 items, however an 8 item questionnaire known as the Brief Sensation Seeking Scale – 8 (BSSS-8) (Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002) has been developed and used to assess intention to use marijuana, tobacco and alcohol (Hoyle et al., 2002). The shorter BSSS-8 scale allows for a more efficient assessment of the different sensation seeking scales in lengthy questionnaires.

Considerable research has been conducted on the design of effective communication strategies based on sensation seeking attributes in the area of drug use preventing programs. High sensation seekers demonstrate a preference for

messages that are novel, unusual, intense and elicit strong sensory, affective and arousal responses (Palmgreen et al., 1991). Messages designed for these audiences should be dramatic, emotionally powerful or physically arousing, graphic, explicit and unconventional or suspenseful. Messages with high sensation value are more effective than low sensation value messages in producing more negative drug attitudes and lower intention to use drugs (Donohew, Lorch, & Palmgreen, 1991; Everett & Palmgreen, 1995; Lorch et al., 1994; Palmgreen et al., 1991; Palmgreen, Donohew, Lorch, Hoyle, & Stephenson, 2001).

2.6.2 Self-efficacy

The relationship between self-efficacy and risk taking behaviour has been examined in a number of studies. Though knowledge about and skills related to risk reduction are important, they are not sufficient for behaviour regulation. Unless people believe that their actions will have the desired effect, they will have little incentive to act or to persevere through challenges (Bandura, 1990). Self-efficacy models related to safe sex behaviour are supported by numerous studies. In a study of sexually active teenagers, high self-efficacy, specifically in the ability to say no, has been associated with safer sexual behaviour (Rosenthal et al., 2006). Several studies support that condom use self-efficacy is associated with high condom use (Khumsaen & Gary, 2009; Wulfert & Wan, 1993). Self-efficacy is also related to safe sex communication among college students (DiIorio, Dudley, Lehr, & Soet, 2000).

Self-efficacy has also been used as the basis for health behaviour campaigns when the at-risk group was found to be characterized as having low self-efficacy in a

relevant attribute. Programs designed to improve behaviour skills and consequently increase the perceptions of self-efficacy have had positive results, for example related to alcohol use (Baer et al., 1992). Understanding variations in self-efficacy related to avalanche hazard identification, rescue, and group communication and decision-making could inform health behaviour campaigns for high-risk OB skiers.

2.6.3 Perception and Comprehension

Perceptions and attitudes of OB skiers are likely to influence behaviour and lead to differences in risk taking. It is possible that differences in perception of accident likelihood lead to variations in precautionary behaviour. Differences in their perception of ski patrol attitudes may influence the likelihood of OB skiers to seek avalanche safety information. Differences in comprehension of boundary policies might lead to unrealistic expectations or assumptions about the type of avalanche control work done beyond boundaries and the kind of rescue services available in the event of an accident. Differences in consequence acceptance may lead to more aggressive terrain choices or lower mitigation behaviour. Variations in motivations could affect behaviour and therefore exposure to avalanche risk.

An understanding of high-risk OB skiers' perceptual and motivational characteristics will facilitate the development of an injury prevention program by creating a context for health behaviour communication. This type of knowledge could be useful in a variety of ways. For example, an OB skier communication program would benefit from a substantially different design if the target audience engaged in high-risk sports, because they did not believe an actual risk of avalanche

involvement existed as opposed to a belief that avalanche risk existed, but that the consequences of getting caught were acceptable. A low level of knowledge related to OB policies could be addressed with a comprehensive education program, while negative impressions of ski patrol attitudes might require a resort employee education program and a novel marketing campaign to promote better skier-patroller relationships. Differences in consequence acceptance and perception of avalanche likelihood could be addressed by targeted signage. Information along these lines could be important in the development of an OB safety program.

2.7 Literature Review Summary

As indicated in the preceding literature review, the activity of OB skiing has been growing in popularity in recent years, despite the risk of being caught or killed in an avalanche that accompanies this sport. While many initiatives exist to reduce the likelihood of avalanche fatalities, no such programs are specifically directed at OB skiers. Given ongoing occurrences of avalanche fatalities involving OB skiers, there is justification for the development of an OB specific avalanche safety initiative. Utilizing a health behaviour approach, the research presented in this paper is intended to identify and characterize a target audience of high-risk OB skiers so that avalanche safety program resources could be utilized in the most effective manner. To properly identify those most at risk of involvement in an avalanche incident, several key indicators need be used in combination to segment OB skiers according to risk levels. Expert opinion and existing research support the use of *training and experience*, *risk mitigation practices*, and *terrain choices* as key

dimensions for this purpose. Each of these three dimensions addresses separate elements of avalanche risk management; when combined they form a comprehensive perspective that can facilitate identification of a high-risk OB cohort. Finally, this cohort can be characterized using a number of attributes such as sensation seeking, self-efficacy, risk perception and policy comprehension. Characterization along these themes has the potential to inform management strategies which could then be utilized by ski resorts or avalanche safety organizations.

3: METHODS

This chapter contains background information on the statistical techniques used to segment OB skiers into risk taking levels according to the three dimensions: *training and experience*, *risk mitigation practices* and *terrain choices*. The first statistical technique described is Latent Class Analysis (LCA), which was used to segment OB skiers for two dimensions: *training and experience*, and *risk mitigation practices*. LCA is useful for this investigation given its utility in identifying classes of an unobservable (latent) variable based on observed variables. The second statistical technique described is the Discrete Choice Experiment (DCE), which was used to investigate *terrain choices* of OB skiers. Using the same concepts as in a LCA, the results of the DCEs can be used to identify latent classes within the OB population based OB ski terrain choices. After the discussion of statistical techniques follows a description of the strategy used to classify OB skiers according to risk level using results for the LCA and DCE. The chapter ends with an overview of the online survey instrument that was the primary tool used to gather data for this study. A detailed description of the DCE is included along with information about the implementation and promotion of the online survey.

3.1 Research Strategy

To create an evidence-based foundation for the development of an OB avalanche safety program, this study targeted two specific research questions:

1. Who are the OB skiers most at risk of being involved in an avalanche incident?
2. What are their behavioural, motivational, percepual and attitudinal characteristics?

For questions related to OB skiing behaviour, direct monitoring would be the optimal assessment strategy for determining the level of risk associated with individual choices under varying avalanche conditions; however, the dispersed nature of OB skiing combined with the temporal and spatial variability associated with snow stability makes an accurate field monitoring assessment program impractical. Therefore, to address the research questions, this study utilized a comprehensive online survey that contained a variety of questions related to OB skiing behaviour and decision-making. Responses to the online survey questions were used to classify participants according to risk of avalanche involvement. Background questions focused on avalanche education, years of experience skiing and travelling in avalanche terrain, and resorts most frequently visited. Individual behaviour was addressed through questions such as travel and safety equipment carried on trips, frequency of rescue practice, details about typical OB group composition and a DCE was used to simulate OB terrain choices under varying avalanche conditions. For this simulation, participants described a common OB ski party they would travel with and outlined the experience, equipment, training, risk mitigation behaviours, preparation and decision-making process of this hypothetical group. See Appendix E (Section 7.5) for a sample of all questions included in the online survey.

In addition, the survey included questions about motivational, perceptual and attitudinal characteristics, which enabled characterization of OB skiers most at risk of avalanche involvement. Perception and personality questions examined a wide variety of topics, including motivations for engaging in OB skiing, avalanche skills self-efficacy, consequence acceptance, perception of avalanche involvement likelihood, demographics, perception of patrol impression, and the Brief Sensation Seeking Scale questionnaire. A number of questions addressed comprehension of resort boundary policies; participants responded to the validity of statements regarding avalanche control, access and rescue in OB terrain as well as temporary and permanent closures. The intent of these questions was to assess if OB travel was more likely given specific management expectations.

Finally, this research project relied on an intercept survey conducted at several ski resorts in Western Canada, to select a random sample of OB skiing participants. See Appendix A for details and results of the intercept survey.

3.2 Classification OB Skiers

Unlike simple health behaviours such as the use of sunscreen or condoms, exposure to avalanche risk during travel in OB is difficult to assess. Given the challenges of finding a single indicator for safe behaviour in avalanche terrain, this study utilizes indirect indicators of avalanche risk taking behaviour on the three main dimensions: *training and experience*, *risk mitigation practices* and *terrain choices*. To classify OB skiers according to avalanche risk, relevant responses from the online survey were analyzed with the goal of segmenting participants into risk

cohorts for each of the three dimensions. For two of the dimensions: *training and experience* and *risk mitigation practices*, responses related to OB skiing behaviour were examined using LCA, which facilitated segmentation of participants according to risk level. For the third dimension, *terrain choices*, a DCE was used to simulate terrain selection when skiing OB. Using the same approach as in a LCA, responses from this DCE were used to segment participants according to willingness to expose themselves to avalanche hazard. Once all survey participants had been segmented along the three dimensions, the three assessments were combined so that all participants could be classified according to overall risk of avalanche involvement. Subjective assessment by the research team of the interaction between the three dimensions was used to combine the individual assessments to assign the overall risk level.

3.2.1 Latent Class Analysis (LCA)

The first research question was addressed through classification of OB skiers by risk taking behaviour and identification of high-risk OB skiers. Classification of OB skiers' overall risk of being involved in an avalanche incident was accomplished by segmenting OB skiers into exposure levels on the three separate dimensions of *training and experience*, *risk mitigation practices*, and *terrain choices*. To segment OB skiers according to the first two dimensions, *training and experience* and *risk mitigation practices*, the online survey included broad sets of questions examining these aspects of the individual survey participants. The online survey focused on observed categorical data from which latent classes related to the indicator of

interest could be extrapolated. In latent class models the population is assumed to consist of a number of homogeneous groups which have internal similarities in preference characteristics that differ from each other. In LCA, observed multivariate categorical data is used to identify these unobserved, latent variables, which are composed of a distinct number of mutually exclusive categories. Class membership and the number of segments depend on unobserved latent characteristics identified through data analysis. The latent variables and classes identified through LCA allowed classification of OB skiers' avalanche risk at multiple levels on each of these two dimensions of avalanche safety. Latent Gold 4.0 (Vermunt & Magidson, 2005a) was used to perform LCA in this study.

3.2.1.1 Methodological Background

In LCA, two sets of unknown parameters are estimated. The first parameter is a set of unconditional class membership probabilities, which represents the probability that any given individual belongs to a particular class. This parameter can be interpreted as class prevalence. The second parameter is a class-specific response probability, which indicates how likely a member of a given class is to give a particular response to a question. Maximum likelihood algorithms serve as the basis for the Latent Gold program used to estimate these conditional response probabilities. In order to avoid local maxima, Latent Gold uses multiple sets of random starting values when estimating these parameters (de Vries et al., 2008).

One assumption in LCA is the local independence assumption, which states that the association between the observed responses can be fully explained by a

limited number of latent classes. In other words, it is assumed that the observed variations in responses are mutually independent given an individual's class membership (de Vries et al., 2008; Goodman, 1974; Vermunt & Magidson, 2004). However, it is possible to deal with some local dependence through modification of the model by adding direct effects associated with two variables that have large bivariate residuals (Vermunt & Magidson, 2005a).

In Latent Gold 4.0 it is possible to limit latent class estimates to be order restricted, meaning that the resulting clusters are ordered in accordance with structure in the observed variables. In choosing order-restricted estimates, class-specific item probabilities and means are limited to be monotonically increasing. In these situations, the parameters corresponding to class x + 1 are equal to or larger than parameters corresponding to class x. Results of this type of analysis are known as ordinal LCA (Vermunt & Magidson, 2005a; Vermunt & Magidson, 2005b). Ordinal LCA was used for analysis of *training and experience*, and *risk mitigation practices* so that a clear pattern of risk taking behaviour within the range of the variable could be identified for each subpopulation.

3.2.1.2 Survey Implementation

In the online survey, the questions focused on the avalanche safety practices of a typical group with which the respondent travelled. Questions related to *training and experience* included years of individual experience for the survey respondent as well as for other members of their OB skiing group, as did questions focused on group training (Table 3.1).

Table 3.1 Variables and levels used for the latent class analysis of training and experience.

Variable	Description	Levels
Individual Experience	The number of years of OB skiing experience that the respondent has.	First Year
		1-2 Years
		3-5 Years
		6+ Years
Group Experience	The number of years of OB skiing experience that the most experienced person in the respondent's typical OB skiing group has.	Experience Level of Group Members:
		First Year
		1-2 Years
		3-5 Years
		6+ Years
Backcountry Experience	The number of years of backcountry skiing experience that the most experienced person in the respondent's typical OB skiing group has.	Experience Level of Group Members:
		First Year
		1-2 Years
		3-5 Years
		6+ Years
Group Training	The highest level of avalanche training that the most experienced person in the respondent's typical OB skiing group has.	No Training
		Seminar
		Online Course
		Introductory Course
		Advanced Course
		Professional Course

Questions related to *risk mitigation practices* included checking the danger rating, discussion of hazard, decision-making strategies, safety equipment carried and group size (Table 3.2).

Table 3.2 Variables and levels used for the latent class analysis of risk mitigation practices

Variable	Description	Levels
Check Danger Rating	The most detailed information source regarding avalanche conditions that is normally consulted by a member of the respondent's typical OB skiing group.	No Info/Do Not Know
		Check at Info Kiosk
		Check at Out-of-Bounds Gate
		Talk to Ski Patrol
		Check Public Bulletins on Internet
		Check Rating on Resort Website
Discuss Hazard	The frequency with which the respondent's typical OB skiing group talks about avalanche hazard while going OB skiing.	Never Talk
		10% Talk
		20% Talk
		30% Talk
		40% Talk
		50% Talk
		60% Talk
		70% Talk
		80% Talk
		90% Talk
		100% Talk
Decision-making	The style of decision-making that is used by respondent's typical OB skiing group.	Solo
		Individual Choices
		Person in Front Decides
		Distinct Decision Maker
		Everyone Contributes Equally
Avalanche Safety Gear	Avalanche safety equipment that is typically carried by members of the respondent's typical OB skiing group.	No Safety Equipment
		Beacon
		Shovel
		Probe
		Cell Phone
		AvaLung
		Balloon Pack

3.2.1.3 LCA Model Selection

Iterative goodness-of-fit testing was used in the LCA to determine the number of classes in the model for both *training and experience*, and *risk mitigation practices*. Three measures were used to evaluate goodness-of-fit: the log likelihood

test statistic (L^2) which follows a chi-squared distribution, Akaike's information criterion (AIC) and Bayesian information criterion (BIC). The L^2 highlights the amount of the observed relationship between the response variables that is not explained by the model. Smaller L^2 values indicate a better fit of the model to the data and better explanation of the observed relationships. An associated p-value>0.05 confirms the null hypothesis that the indicated model is not significantly different from the true population model and that it is a good fit for the data (Goodman, 1974; McCutcheon, 1987). AIC and BIC are used to assess goodness-of-fit and select the appropriate number of classes. These measures of goodness of fit take into account model parsimony, which penalize for the number of parameters in relation to maximum possible number of parameters; a lower value indicates a better model (Vermunt & Magidson, 2004; Vermunt & Magidson, 2005a). Since these values may continue to fall as the number of classes increases, it is important to also consider class interpretation when selecting the final model. Furthermore, since these three tests may indicate different optimal models, class interpretation is a crucial consideration when selecting the final model (de Vries et al., 2008).

Wald statistics were used to assess significance when selecting variables to be included in the final model. The Wald statistic is used to indicate if variables included in the model are statistically significant for all classes. Only variables that were significant according to the Wald statistic were retained in final models. The Wald(=) statistic is used to indicate if a difference in the variables between classes is significant. To determine the best number of latent classes regarding both *training and experience* and *risk mitigation practices*, models with 1-5 classes were assessed.

For each of the variables used in this analysis, such as 'Group Training' or 'Avalanche Safety Gear', the class-specific response probability determined by LCA represents the likelihood that respondents from a particular class had a given level of training, experience or mitigation practices when OB skiing. By utilizing LCA in this manner, it was possible to examine multiple behavioural variables and identify an appropriate number of distinct segments within two dimensions of avalanche risk exposure: *training and experience*, and *risk mitigation practices*.

3.2.2 Discrete Choice Experiment (DCE)

Decisions regarding what terrain OB skiers descend have large implications on the amount of avalanche risk they are exposing themselves to. For the third dimension of avalanche exposure, the challenge of monitoring terrain choices in the field necessitated a strategy to examine OB preferences through the use of an online survey instrument. To address this challenge I used a Discrete Choice Experiment (DCE)(Louviere, Hensher, & Swait, 2000) to assess how OB skiers choose runs in a variety of snow and avalanche conditions. DCEs have been used successfully to address avalanche hazard decision-making (Haegeli et al., 2010) and are particularly appropriate for this application given the familiarity that survey participants have with OB terrain selection. For the DCE, participants described a common OB ski party they would travel with and outlined the experience, equipment, training, preparation and decision-making process of this hypothetical group.

3.2.2.1 Methodological Background

In a DCE, participants are presented with sets of options known as a 'choice set' and are asked to select the preferred option (Figure 3.1). The alternatives within a given choice set differ in terms of attributes and levels; participants evaluate each option as a package rather than evaluating each variable individually. The distribution of variables in each choice set is matched to an orthogonal experimental design plan to ensure attributes are uncorrelated. Participants of a DCE survey are assumed to maximize utility between alternatives by making tradeoffs between attributes (McFadden, 1974). Each choice set contains a baseline alternative (the status quo) so that one of the options is always feasible for the respondent; this also allows interpretation in standard welfare economic terms.

Figure 3.1 Example of a choice set in the discrete choice experiment.

DCEs have been used in research for transportation (Ben-Akiva & Lerman, 1985; Train, 1986), spatial consumer choice behaviour (Timmermans, Borgers, & van der Waerden, 1992), and recreation preferences (Haider & Ewing, 1990; Louviere & Timmermans, 1990; Stynes & Peterson, 1984). DCEs enjoy several advantages for examining preferences in recreational research. In a choice set, respondents can evaluate an experience as a whole while allowing the researcher to determine utility values for individual attributes through statistical analysis. DCEs allow respondents to express relative rather than absolute preferences and to make tradeoffs between aspects of alternatives as they do in true recreational preference decision-making. Finally, DCEs allow the researcher to control the alternatives presented, something that would be impossible in a revealed preference study (Haider, 2002). DCEs used in a recreational context face challenges however, in that they cannot represent all aspects of the physical reality nor can they address emotional and social influences than exist in actual decision-making situations (Haegeli et al., 2010).

DCEs are based in random utility theory (McFadden, 1974; Train, 2003) where the overall utility (U) gained by person q from alternative i consists of a deterministic (observed) component (V_{iq}) and a stochastic component (ε_{iq}) (McFadden, 1974).

1. $U_{iq} = V_{iq} + \varepsilon_{iq}$

Therefore, an individual will choose alternative i if $U_{iq} > U_{jq}$ for all $j \neq i$. Choice behaviour, which is assumed to be deterministic at the individual level, is

modelled as an aggregate stochastic process where the probability of choosing alternative *i* is described as:

2. $\text{Prob}\,\{i\ chosen\} = prob\,\{V_{iq} + \varepsilon_{iq} > V_{jq} + \varepsilon_{jq};\ \forall j \in C\}$

where C is the set of possible alternatives in a given choice set. The deterministic component (V_{iq}) may be expanded as:

3. $V_{iq} = \beta_{0iq} + \sum_{k=1}^{K} \beta_{kiq} S_{kiq}$

where β_{ik}, known as the part-worth utility (PWU), represents the utility parameters that measure the contribution of the attribute to the overall alternative utility. S_{ikq} represents the attributes and associated levels (k) for each alternative (i) presented to the individual q. The analysis of these choice responses relies on maximum likelihood estimations to determine estimates for part-worth utilities for all attribute levels used in the survey. Using the multinomial logit (MNL) model, the probability of choosing alternative *i* is equal to the exponential function of all measurable elements of alternative i divided by the sum of the exponential functions of all measurable elements of alternative j is the given choice set C:

4. $P_{iq} = \frac{exp^{V_{iq}}}{\sum_{j \in C} exp^{V_{jq}}}$

For the segmentation of participants according to *terrain choices*, responses from the DCE were analyzed using Latent Gold Choice 4.0 (Vermunt & Magidson, 2005a). For this analysis, the basic MNL form can be expanded to a mixed logit form in order to account for preference heterogeneity. Latent class choice models combine a choice model with maximum likelihood analysis and a probabilistic

approach in order to estimate latent class membership of individuals (Train, 2003; Boxall & Adamowicz, 2002).

3.2.2.2 Survey Implementation

In the DCE component of the online survey, each choice set contained two OB ski runs under a given avalanche hazard rating alongside the option of staying on in-bounds ski runs (Figure 3.1). Each ski run option presented in a choice set was created as a combination of six variables, each with multiple levels (Table 3.3).

Table 3.3 Attributes and levels used in the discrete choice experiment.

Attribute	Description	Levels
Danger Rating	The avalanche danger rating as normally available from the public avalanche bulletin.	Low, Moderate, Considerable, High
Slope character	Type of terrain that characterizes the majority of the OB run.	Open, Trees, Chute
Slope Size	Largest open slopes that could avalanche on the OB run. Small ~10m wide, Medium ~50m wide, Large ~100m wide.	Small, Intermediate, Large
Slope Steepness	Incline of slope at the steepest part of the OB run where an avalanche could be triggered.	Blue, Black, Double Black
Use	Frequency of traffic on the OB run. Indicates the potential for skier compaction on the slope.	Rarely, Occasionally, Regularly
Tracks	Number of tracks currently visible on the OB run.	None, Two, Several

Factors most likely to influence either avalanche hazard or OB skiers run preferences were selected as attributes in the choice set. Danger Rating represents a measure for the seriousness of the current avalanche hazard according to five levels: low, moderate, considerable, high and extreme (Canadian Avalanche Association, 2007). Avalanche danger ratings are published as part of public avalanche bulletins

throughout the winter by the Canadian Avalanche Centre and other avalanche safety agencies. While it is common for avalanche bulletins in Canada to publish danger ratings for each elevation band individually (alpine, treeline and below treeline), I opted for a single avalanche danger rating to describe the existing avalanche conditions in order to reduce unnecessary complexity in the experiment. Furthermore, the single danger rating applied to all alternatives in a given choice set (context variable). Slope character refers to the type of terrain such as tree skiing, open slopes or rocky chutes, and was chosen due to the influence that character can have on skier run preference and consequences of avalanche involvement (Jamieson, 2000). Slope size was chosen due to the impact of this variable on potential slides (Jamieson, 2000); as slope size increases, the largest potential avalanche on that slope increases accordingly. Slope steepness was selected since angle is the most important variable in determining whether or not it is possible for a given slope to avalanche (Fredston & Fesler, 1999). Frequency of use was included in the choice scenario to account for skier compaction, which can lead to increased stability of upper snowpack layers in some OB ski terrain (McClung & Schaerer, 2006). Finally, existing tracks in the snow were included to examine the potential influence of tracks on the perception of stability among OB skiers. In addition to the main effect, interaction effects between the Danger Rating and all other main effects were included in the DCE design so that it would be possible to analyze how tradeoffs were made for individual variables as the danger rating increased. Danger rating was chosen as the only variable for which to analyze interactions because it is the key variable representing snowpack stability and avalanche hazard in the

experiment. OB recreationalists who decide to modify terrain selection based on snowpack stability do so to according to the Danger Rating variable.

Individual attributes were combined into a choice set using a mix of presentation strategies (Figure 3.1). Two OB ski runs were presented along with the option of remaining in bounds on ski resort runs. The Danger Rating variable, a context variable, was presented in text that was set in a coloured box as it is normally presented by the Canadian Avalanche Centre. Frequency of use and existing tracks in the snow were presented as text for each OB run option. The remaining variables, slope character, slope steepness and slope size were presented together in the form of a photo. For each possible combination presented, a separate image was used which depicted ski terrain matching the attributes and levels. A scale and a graphic representation of ski run steepness (symbols used at ski resorts to represent difficulty—blue square, black diamond or double black diamond) were included to clarify features represented in the photo (Figure 3.2, Figure 3.3 and Figure 3.4). In order to study how different individuals exposed themselves as a function of avalanche hazard, the DCE was based on a statistical design that explicitly included all interactions with the danger rating variable.

Figure 3.2 Slope steepness and slope character are represented visually in the discrete choice experiment. These visual representations were used under the condition 'Small Slope Size'.

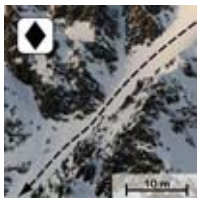
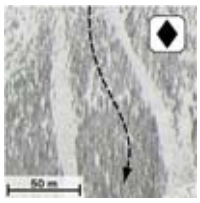
Steepness	Chute	Trees	Open
Blue	Chute and Blue not compatible.		Open and Small not compatible.
Black Diamond			Open and Small not compatible.
Double Black Diamond			Open and Small not compatible.

Figure 3.3 Slope steepness and slope character are represented visually in the discrete choice experiment. These visual representations were used under the condition 'Medium Slope Size'.

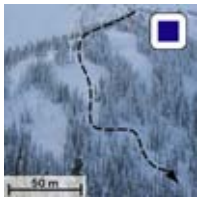
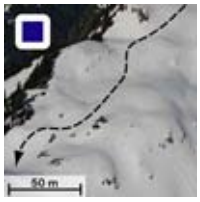
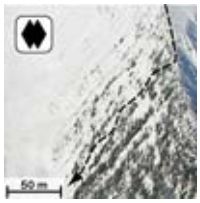
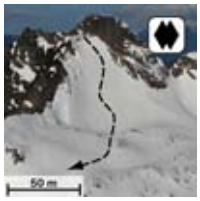
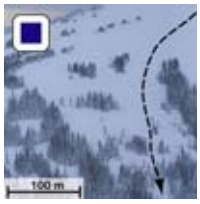
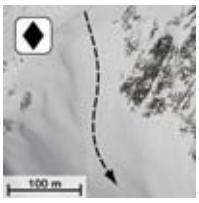
Steepness	Chute	Trees	Open
Blue	Chute and Blue not compatible.		
Black Diamond			
Double Black Diamond			

Figure 3.4 Slope steepness and slope character are represented visually in the discrete choice experiment. These visual representations were used under the condition 'Large Slope Size'.

Steepness	Chute	Trees	Open
Blue	Chute and Large not compatible.		
Black Diamond	Chute and Large not compatible.		
Double Black Diamond	Chute and Large not compatible.		

By using Latent Gold Choice 4.0 (Vermunt & Magidson, 2005a) in the analysis of participants' DCE responses, it is possible to identify the tradeoffs between avalanche hazard and slope characteristics such as steepness, size and character.

3.2.2.3 DCE Model Selection

When used to estimate latent class membership for DCEs, Latent Gold Choice 4.0 produces PWUs, standard errors and z-scores for each attribute level and latent class. Wald statistics were used to assess statistical significance in order to select which variables would be included in the final model.

The AIC and BIC were used to assess goodness-of-fit and select the appropriate number of classes. As with LCA, the AIC and BIC may continue to fall as

the number of classes increase, therefore class interpretation must be considered when selecting the final model. Market shares amongst the different model classes are calculated for hypothetical choice sets to assist in the interpretation of the final model results. In the DCE literature this approach is commonly referred to a decision support system (DSS; Haider, 2002).

3.2.3 Risk Matrix

Following the selection of models for the three latent indicators related to risk of avalanche involvement, the next step was to use these indicators to segment the online survey population according to their overall risk of being involved in a serious avalanche accident. For this purpose I integrated the three ranked latent indicators of *training and experience*, *risk mitigation practices*, and *terrain choices* into a three dimensional matrix and assessed each combination. This stage of classification used subjective expert opinion of the characteristics for all possible permutations in the matrix. Using this strategy, all participants were classified into three categories according to avalanche risk: low, moderate and high.

3.3 Characterization of High-Risk OB Skiers

Once respondents were classified regarding their overall risk of injury or death due to avalanche involvement, the second research question was addressed: what are the characteristics of OB skiers most at risk of an avalanche incident? In this second step, the high-risk group was examined in comparison to the low-risk group in order to identify significant differences between the two groups. Investigative characteristics included motivations for engaging in OB skiing,

avalanche skills self-efficacy, consequence acceptance, perception of avalanche involvement likelihood, comprehension of resort boundary policies, perception of patrol impression, demographics, and the BSSS-8 questionnaire (Hoyle et al., 2002). ANOVAs, chi-squared tests and Wilcox rank-sum tests were used depending on the nature of the variable examined. An associated p-value <0.05 allowed rejection of the null hypothesis that the characteristics to the two populations where the same. For questions related to motivations, principal component analysis was performed on responses to a series of Likert scale questions that addresses possible motivational factor for OB participation. An ANOVA test was used to identify significant differences in principle component scores between the high- and low-risk groups. Significant differences between the two populations were combined to create a perception and personality profile of at-risk OB skiers.

3.4 Survey Distribution

Several strategies were used to promote the online survey, its objectives and prizes that could be won by participants (Table 3.4). In the first quarter of 2008, posters and business cards promoting the web address of the survey were distributed to ski retailers and ski resorts in Banff, Lake Louise, Golden and Whistler. Individuals who visited the site at that time were asked to leave contact information for when the survey was ready. On April 21st, 2008 the survey was launched online and email invitations to the survey were sent to a convenience sample of OB and backcountry skiers known to the administrators of the study, followed by email invitations to all intercept survey participants who provided an

email address. In addition, the survey was promoted on 14 well-known OB skiing websites, including large forum-style sites. These websites were chosen due to their targeted content and popularity with OB and backcountry skiers. A second recruitment campaign at the start of the 2008/2009 winter season included promotion through 16 websites. In this second round, the majority of websites promoted the survey through articles that were highlighted by administrators of the websites. The survey was available for participants to complete continually through to April 18, 2009 when the final dataset was drawn from the database.

Table 3.4 Dates and web addresses of all promotion activities for the online survey including email mailings and websites.

Promotion Channel	Date of Posting	Web Address
Test Emails - Personal Contacts	21-Apr-2008	
Intercept Survey Participants	24-Apr-2008	
snowheads.com	28-Apr-2008	http://snowheads.com/ski-forum/viewtopic.php?t=39371
Powder Magazine Forum	28-Apr-2008	http://forum.powdermag.com/forum/ubbthreads.php
Telemark Tips Forum	28-Apr-2008	http://www.telemarktalk.com/phpBB/viewtopic.php?t=45511&highlight=avalanche+decision+making+survey
Teton Gravity Research Forum	28-Apr-2008	http://www.tetongravity.com/forums/showthread.php?t=121514&highlight=Avalanche+Survey
turns-all-year.com	28-Apr-2008	http://www.turns-all-year.com/
cascadeclimbers.com	28-Apr-2008	http://cascadeclimbers.com/forum/ubbthreads.php?ubb=showflat&Number=793720
Backcountry Magazine Forum	28-Apr-2008	http://www.backcountryworld.com/showthread.php?t=4718
Biglines Forum	28-Apr-2008	http://www.biglines.com/msgbrd/viewtopic.php?t=14433&highlight=outofbounds+survey
nsmb.com Forum	29-Apr-2008	http://bb.nsmb.com/showthread.php?t=110243
doglotion.com Forum	29-Apr-2008	http://www.doglotion.com/avalanche-decision-making-survey
J2Ski Forum	30-Apr-2008	http://www.j2ski.com/ski-chat-forum/posts/list/3597.page
SKI3R.COM Forum	6-Nov-2008	http://www.ski3r.com/topics/exercise/
wildsnow.com Forum	10-Nov-2008	http://www.wildsnow.com/1516/avalanche-survey/
Snowboard Magazine Forum	22-Jan-2009	http://www.snowboard-mag.com/node/34144
Snowboarder Community Forum	22-Jan-2009	http://snowboarder.ning.com/forum/topics/outofbounds-avalanche-survey
snowboard.com Forum	22-Jan-2009	http://snowboard.colonies.com/forums/topic/49327/
Transworld Snowboarding Forum	23-Jan-2009	http://snowboarding.transworld.net/2009/01/23/out-of-bounds-avalanche-survey-prizes-available/
Freeskier Magazine Forum	23-Jan-2009	http://powderroom.net/news/us-canada/26jan2009/win-a-prize-taking-avalanche-survey
Transworld Snowboarding Forum	23-Jan-2009	http://snowboarding.transworld.net/2009/01/23/out-of-bounds-avalanche-survey-prizes-available/
Telemark Tips Forum	23-Jan-2009	http://www.telemarktalk.com/phpBB/viewtopic.php?t=53239&highlight=avalanche+decision+making+survey
Big Lines Article	24-Jan-2009	http://www.biglines.com/blarticles/4366/Out-of-Bounds_Avalanche_Survey_-_Prizes_Available!
clubtread.com Forum	25-Jan-2009	http://www.clubtread.com/sforum/topic.asp?TOPIC_ID=29633
powder room.net Article	26-Jan-2009	http://powderroom.net/news/us-canada/26jan2009/win-a-prize-taking-avalanche-survey
ACC Vancouver Newsletter	1-Feb-2009	http://www.accvancouver.ca/Echoes/2009/Feb09.pdf
Teton Gravity Research Forum	1-Feb-2009	http://www.tetongravity.com/forums/showthread.php?t=149604&highlight=Avalanche+Survey
Off Piste Article	7-Feb-2009	http://www.offpistemag.com/archives.asp?chosenYear=2009&chosenMonth=2
CAA Facebook Site	9-Feb-2009	http://www.facebook.com/canadianavalanchecentre
MEC Facebook Site	9-Feb-2009	http://www.facebook.com/mecbikes?ref=mf
skiinggolden.com Article	15-Mar-2009	http://www.skiinggolden.com/journal/2009/3/15/out-of-bounds-avalanche-survey-prizes-available.html
kootenayskier.wordpress.com Article	16-Mar-2009	http://kootenayskier.wordpress.com/2009/03/16/caa-survey/
newschoolers.com Forum	16-Mar-2009	http://www.newschoolers.com/web/forums/readthread/thread_id/448438/

4: RESULTS

The online survey instrument used in this research project was designed to provide information for identifying and characterizing OB skiers with the highest risk of being involved in an avalanche incident. This chapter begins with a general description of all online survey participants, focusing specifically on socio-demographics, training and experience, and OB skiing behaviour. Results are then presented from the analysis of the three dimensions of avalanche risk used to segment OB skiers: *training and experience*, *risk mitigation practices* and *terrain choices*. Following this, results from the combination of these dimensions and subsequent classification of participants according to avalanche risk level are described. The chapter concludes with a section that compares low and high-risk OB skiers in order to identify statistically significant differences between the two groups.

4.1 Description of Online Sample

A total of 1602 respondents completed the online component of this study, however 165 were screened out due to completing the survey in an unreasonably short period of time or because they had not participated in OB skiing in North America. This left a total of 1437 useable participants. An additional 498 individuals visited the survey website but did not complete the survey; 164 of these dropped out after the first page (68% completion rate).

4.1.1 Sociodemographics

Respondents were predominantly male (90.9%) with the 25-34 year old group being the largest age demographic represented (43.3%). Most respondents were from either the United States or Canada (94.2%). Education levels were high with the largest cohort having completed university (38.9%) or a post graduate degree (20.8%) (Table 4.1).

Table 4.1 Demographic characteristics of entire survey population.

Variable			%
Demographics			
	Gender		n = 1424
		Male	90.9%
		Female	9.1%
	Age		n = 1435
		under 20	11.2%
		20-24	15.5%
		25-34	43.3%
		35-44	17.7%
		45-54	8.9%
		55 or more	3.4%
	Education		n = 1434
		Less Than High School	4.7%
		Completed High School	6.7%
		Some Post Secondary Education	16.7%
		Trades, Certificate or Diploma	12.3%
		Completed University	38.9%
		Post Graduate Degree	20.8%
	Nationality		n = 1437
		USA	52.3%
		Canada	41.8%
		United Kingdom	2.2%
		Australia	0.8%
		Switzerland	0.5%
		Other	2.4%

4.1.2 Training and Experience

Avalanche education levels were high; well over half (60.3%) of all respondents had taken at least an introductory avalanche awareness course. Respondents had considerable skiing experience; over three quarters had been

skiing for more than 10 years. The most common experience level for OB skiing was 3-5 years, and almost all (92.5%) respondents had at least some backcountry skiing experience (Table 4.2).

Table 4.2 Training and experience characteristics of entire survey population.

Variable			%
Training - Highest Avalanche Education			n = 1437
		No Training	25.4%
		Seminar	14.3%
		Introductory Course	35.4%
		Advanced Course	9.2%
		Professional Course	15.7%
Experience			
	Skiing Experience		n = 1437
		First Year	0.4%
		1-2 years	0.8%
		3-5 years	7.4%
		6-10 years	14.0%
		11-15 years	21.1%
		16-20 years	19.3%
		21-25 years	13.6%
		25+ years	23.3%
	OB Experience		n = 1437
		First Year	6.5%
		1-2 years	15.5%
		3-5 years	27.8%
		6-10 years	22.3%
		11-15 years	12.5%
		16-20 years	6.9%
		21-25 years	2.5%
		25+ years	6.0%
	Backcountry Experience		n = 1425
		None	7.5%
		First Year	10.4%
		1-2 years	16.6%
		3-5 years	25.6%
		6-10 years	16.7%
		11-15 years	9.3%
		16-20 years	5.9%
		21-25 years	2.4%
		25+ years	4.7%

4.1.3 OB Behaviour

Respondents used a variety of equipment to travel in OB terrain; just over a third (35.5%) used alpine touring equipment and slightly less (29.4%) used

downhill equipment (Table 4.3). Respondents used telemark equipment and snowboards to a lesser extent, and very few use splitboards. Self reported use of avalanche safety equipment during OB skiing was high; over three quarters (78.6%) claimed to use beacons, similar numbers (75.9%) claimed to carry probes (Table 4.3). Slightly more respondents carried shovels (82.5%); however, use of AvaLungs© and ABS backpacks© was low. A large proportion of participants reported carrying a cell phone and over three quarters (81.4%) reported use of the avalanche bulletin prior to OB trips. Self reported avalanche triggering was also high: 40.6% of respondents reported having triggered an avalanche that could have buried or killed someone (Table 4.3).

Table 4.3 OB skiing behaviour characteristics of entire survey population.

Variable			%
	Travel Equipment Used		n = 1437
		Downhill Skis	29.4%
		Snowboard	13.8%
		Telemark	17.5%
		AT	35.5%
		Splitboard	3.9%
Risk Mitigation			
	Self Reported Bulletin Use		n = 1437
		Checks Bulletin	81.4%
		Does Not Check Bulletin	18.6%
	Proportion of Equipped Respondents		n=1437
		Beacon	78.6%
		Shovel	82.5%
		Probe	75.9%
		Cell Phone	70.8%
		Avalung	15.0%
		ABS Pack	0.9%
Avalanche Involvement			n = 1435
		Yes	40.6%
		No	59.4%

4.2 Classification OB Skiers

The following section describes the analytical processes used to select the best models for latent indicators. In addition, each of the three models is described, with a focus on characteristics of the identified classes.

4.2.1 Training and Experience Latent Class Model

4.2.1.1 Model Selection and Description

All relevant data gathered through the online survey was combined in the initial model after which the Wald statistics for individual variables were examined. An iterative process of adding and subtracting variables was used to determine which variables were appropriate for inclusion in the final model. The final model included three variables: group experience, backcountry experience and group training. The BIC and AIC criteria show improvements up to the 3-class solution and do not improve further with the addition of a fourth or fifth class. In addition, class preferences in the 3-class solution are considerably easier to interpret than the four and five class solutions. Given the improvements in the AIC and BIC as well as the ease of interpretation, the 3-class solution was chosen as the most accurate latent-class model for OB skiers *training and experience* (Table 4.4).

Table 4.4 Goodness-of-fit measures for the five investigated latent class models for training and experience latent class analysis. The final model selected is in italics.

	LL	BIC(LL)	AIC(LL)	Class.Err.	Npar	df
1-Class	-3611.1	7279.722	7238.209	0	8	31
2-Class	-3460.08	7006.429	6944.159	0.1279	12	27
3-Class	*-3431.64*	*6978.302*	*6895.275*	*0.1676*	*16*	*23*
4-Class	-3430.75	6990.907	6897.502	0.2005	18	21
5-Class	-3430.71	7005.21	6901.426	0.3898	20	19

The final latent class model for *training and experience* included three variables. The highest level of training within the group was used as the group training variable, as was the highest level of experience in the group for the experience variable. In addition, previous backcountry skiing experience within the group was assessed. These group variables were used to reflect the possibility that, through communication, a group travelling in OB terrain can benefit from the knowledge and experience of the most senior member of the group.

4.2.1.2 Latent Class Description

Based on the results of the LCA, the three categories of OB skiers according to *training and experience* present substantially different profiles (Table 4.5).

Table 4.5 Latent class analysis of training and experience variables.

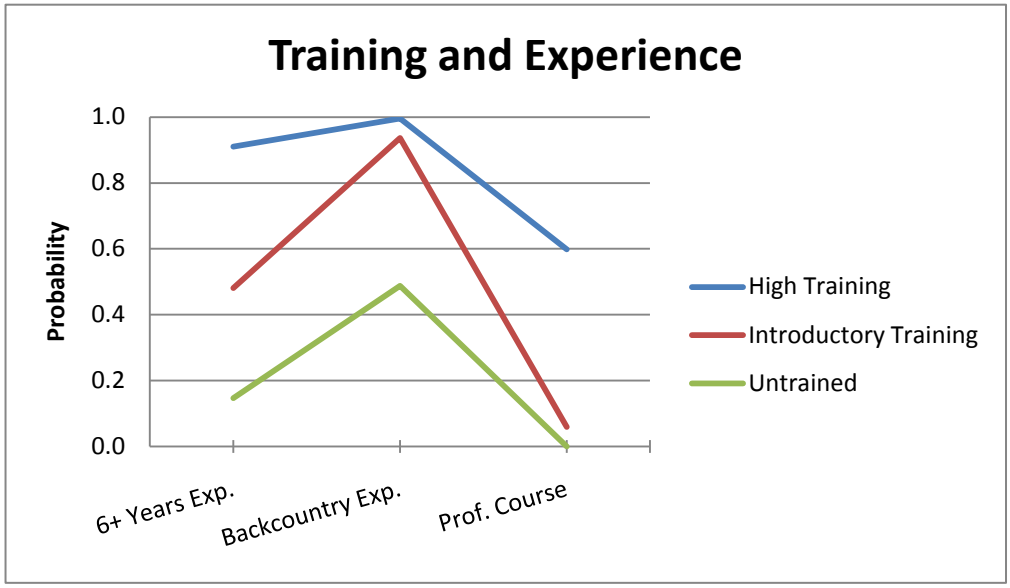
	Classes		
	High Training	**Introductory Training**	**Untrained**
% of Total Sample	41.9%	50.6%	7.5%
Variable			
Group Experience			
First Year	0.0%	3.7%	23.1%
1-2 Years	0.5%	15.2%	34.6%
3-5 years	8.4%	33.1%	27.6%
6+ Years	91.0%	48.1%	14.7%
Backcountry Experience			
No Backcountry Experience	0.5%	6.4%	51.2%
Backcountry Experience	99.6%	93.7%	48.8%
Group Training			
No Training	0.0%	5.5%	63.3%
Seminar	0.7%	18.3%	26.5%
Introductory Course	13.1%	53.6%	9.8%
Advanced Course	26.3%	16.7%	0.4%
Professional Course	59.9%	5.9%	0.0%

Class 1 is a highly trained and experienced group. Most members of this group have six or more years of OB skiing experience and have backcountry skiing experience. Over half have taken a professional avalanche course. For the remaining class members who haven't taken a professional course, the likelihood of having some type of formal avalanche education is very high, including either an advanced avalanche course or an introductory course. Cumulatively, virtually all members of Class 1 have formal avalanche education. For the purpose of further analysis, Class 1 will be labelled '*High Training'.* Class 2, which is the largest class, has less experience than class 1, but is likely to have several years of OB skiing experience. Almost half of the members of this class have six or more years of OB skiing experience. Similar to Class 1, members of this class have a very high probability of having backcountry experience. Most of this class has formal avalanche education; however few members have taken a professional course. Class 2 members have the highest probability of having taken an introductory course. In this analysis, Class 2 will be labelled '*Introductory Training'*. Class 3 is the smallest class. This class is the least experienced; over half have 2 or less years of OB skiing experience. Unlike Classes 1 and 2, Class 3 has a much lower probability of having backcountry skiing experience. Finally, Class 3 is the least likely to have any avalanche training, with only a 10% probability of having formal avalanche training. Class 3 will be labelled '*Untrained'*.

Clearly, Class 1 has the most *training and experience* while Class 3 has the least. Figure 4.1 offers an alternative view of these classes by presenting the

probabilities that a member of a given class has the highest levels of the variables included in the *training and experience* dimension.

Figure 4.1 Probabilities that class members have the highest levels of variables included in the training or experience dimension (6+ years experience in OB skiing; any experience backcountry skiing; and has taken a professional level avalanche course).



4.2.2 Risk Mitigation Practices Latent Class Model

4.2.2.1 Model Selection and Description

As with *training and experience*, the same iterative statistical process was used to identify variables for inclusion in the final *risk mitigation practices* model based on the significance of the Wald statistic. The BIC and AIC criteria were applied to determine the ideal number of classes; the 3-class solution was selected as the best model (Figure 4.6).

Table 4.6 Goodness-of-fit measures for the five investigated latent class models for risk mitigation practices latent class analysis. The final model selected is in italics.

	LL	BIC(LL)	AIC(LL)	Class.Err.	Npar	df
1-Class	-3398.04	6889.834	6822.084	0	13	226
2-Class	-3191.55	6534.547	6425.104	0.0037	21	218
3-Class	*-3144.91*	*6498.956*	*6347.821*	*0.0562*	*29*	*210*
4-Class	-3137.35	6541.53	6348.702	0.2848	37	202
5-Class	-3132.41	6589.331	6354.811	0.2603	45	194

The minimum avalanche safety equipment carried by all members of the OB skiing group was used as the Avalanche Safety Gear variable, reflecting the need for all members of a ski party to carry safety equipment so that any member can be saved if buried by an avalanche. The most specific source of a danger rating consulted for any group member was used as the 'Check Danger Rating' variable. In addition, the frequency of avalanche hazard discussion and the decision-making strategy used within the OB skiing group were both included in the final model. The use of these variables reflects the possibility that avalanche hazard can be better mitigated through bulletin checking, group discussion and effective decision-making.

4.2.2.2 Latent Class Description

Results from the LCA identify three classes of OB skiers that vary considerably in risk management practices (Table 4.7).

Table 4.7 Latent class analysis of risk mitigation practices variables.

	Classes		
	Good Mitigators	**Poor Mitigators**	**Deficient Mitigators**
% of Total Sample	85.3%	10.9%	3.8%
Variable			
Check Danger Rating			
No Info/Do Not Know	0.3%	7.6%	13.7%
Check at Kiosk/Gate	0.4%	9.2%	0.0%
Talk to Patrol	2.2%	6.8%	1.9%
Checked Rating (Web)	97.1%	76.4%	84.4%
Discuss Hazard			
Never Talk/Solo	0.1%	5.0%	95.1%
10%-40% Talk	0.8%	34.3%	4.9%
50%-90% Talk	44.0%	59.8%	0.0%
100% Talk	55.2%	0.9%	0.0%
Decision Making			
Individual Choices/Solo	2.2%	11.5%	98.7%
Person In Front Decides	0.4%	3.7%	0.0%
Leader or Everyone Contributes	97.4%	84.8%	1.3%
Avalanche Safety Gear			
No Safety Equipment	1.3%	20.8%	97.2%
Cell Phone	6.4%	40.5%	2.8%
Some in Group Have Beacons	7.7%	19.5%	0.0%
Everyone has Beacons or Beacons and Shovel	7.4%	7.4%	0.0%
Everyone has Beacon, Shovel and Probe	77.3%	11.9%	0.0%

Class 1, the majority of respondents; exhibit the best risk management practices of respondents. Almost all members of Class 1 check the danger rating prior to heading OB. Class 1 exhibits group dynamics that promote discussion of avalanche conditions and sound backcountry decision-making; over half of Class 1 travels in a group that always discusses avalanche conditions, and just under half travel in a group that discusses avalanche conditions 50-90% of the time. For decision-making, almost all members of Class 1 have coordinated processes such as a dedicated leader or involving the contribution of all members. Finally, Class 1 is likely to be well equipped; over three quarters of its members carry a beacon, shovel

and probe. For the purpose of further analysis, this group will be labelled '*Good Mitigators*'.

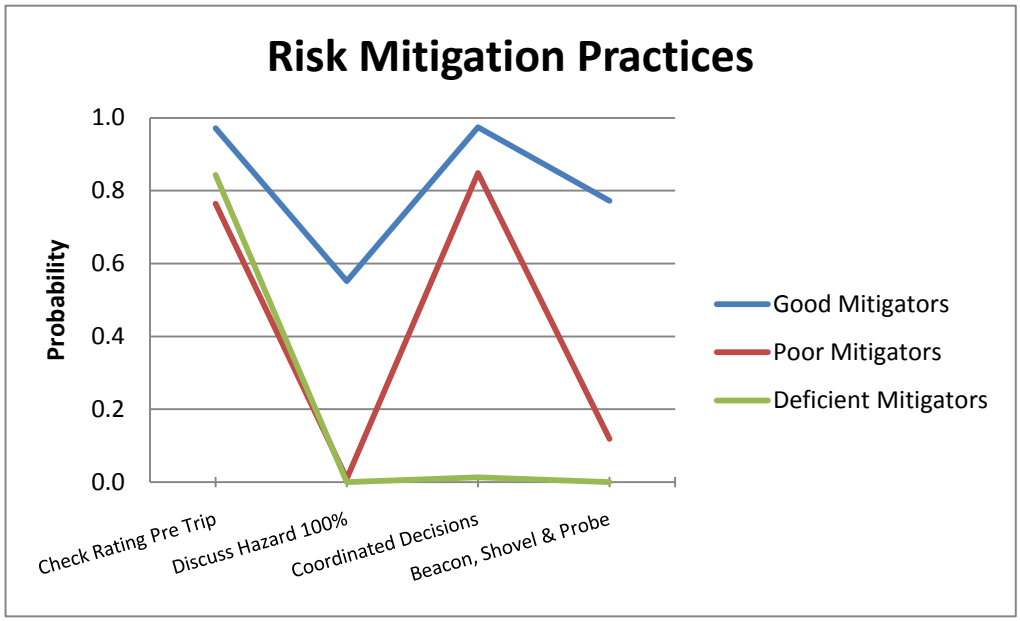
Class 2 exhibits risk management behaviours that are inferior to those of Class 1. Just over three quarters of Class 2 check the danger rating prior to heading OB. Group dynamics were less conducive to sound avalanche safety practices than those found in Class 1; over one third of members travel with a group that discusses avalanche conditions 10-40% of the time. In addition, a small proportion of members belong to a group where either whoever is in front makes decisions or everyone makes their own decision. Finally, Class 2 is far less likely to carry the key avalanche equipment; just over 10% of members travel with a group where all members carry a beacon, shovel and probe. Members are much more likely to travel in a group where either only some members have a beacon or there is no safety equipment whatsoever. For the purpose of further analysis, this group will be labelled '*Poor Mitigators*'.

Class 3, which only makes up a small portion of the total population, exhibits the worst risk management strategies. While members are slightly more likely than Class 2 to check the danger rating prior to heading into OB ski terrain, members have a very high probability of either travelling solo, or travelling with a group that never discusses avalanche conditions. In addition, group decision-making in Class 3 is poor; most members travel with a group where either everyone makes individual decisions or where they are travelling solo. Finally, most members of Class 3 travel with no avalanche safety equipment. This class therefore pools two distinct subgroups, solo travellers and groups using very poor avalanche mitigation

measures. This grouping is appropriate as both groups exhibit behaviours that make effective companion rescue following an avalanche incident very unlikely. The probability of checking the danger rating is slightly higher for Class 3 than that of Class 2, which may reflect the distribution of experience within Class 3. For the purpose of further analysis, this group will be labelled '*Deficient Mitigators*'.

Figure 4.2 offers an alternative view of these classes by presenting the probabilities that a member of a given class has the highest levels of the variables included in the *risk mitigation practices* dimension.

Figure 4.2 Probabilities that class members have the highest levels of variables included in the risk management practices dimension (check danger rating prior to trip; discuss avalanche hazard 100% of the time; use an effective decision making strategy; and carry a beacon probe and shovel).



4.2.3 Terrain Choices DCE Model

4.2.3.1 Model Selection and Description

In order to select the appropriate model during the analysis of respondents' terrain choices in the DCE, 1, 2, 3 and 4 class models were assessed. The BIC was lowest for the 3-class model ($BIC_{3\text{-class}}$ = 17599.98) indicating that the optimal model was the 3-classes solution (Table 4.8). This 3-class model was easy to interpret when calculating market shares for the individual classes, which clearly highlighted their varying levels of risk taking when choosing the terrain (Section 4.2.3.3).

Table 4.8 Comparison of best fit criteria for choosing terrain in the discrete choice experiment. The final model is in italics.

	LL	BIC(LL)	AIC(LL)	Npar	df
1-Class Choice	-9102.7254	18416.2899	18263.4509	29	1408
2-Class Choice	-8609.5967	17648.1419	17337.1935	59	1378
3-Class Choice	*-8476.3871*	*17599.8321*	*17130.7743*	*89*	*1348*
4-Class Choice	-8392.2534	17649.674	17022.5068	119	1318

The main effects of the variables Danger Rating, Slope Character, Slope Steepness, Slope Size and Use were significant in the final model while Tracks was not significant and was removed. In addition to the main effects, the final model also included significant interaction effects between Danger Rating and all terrain characteristics: Slope Size, Slope Character, and Slope Steepness. Interactions between Danger Rating and Use, and Danger Rating and Tracks were not significant and were removed from the final model.

4.2.3.2 Latent Class Description

Results of the DCE for the 3-class model are presented in Table 4.9. The model constant (or intercept) of each class represents the general preference of the class to stay in-bounds regardless of the values of any other attributes. Examination of the constant shows that Class 1 exhibited a preference for staying inbounds, while Class 2 exhibited a mild preference for leaving the resort for OB runs and Class 3 exhibited a strong preference for leaving the resort for OB runs. Examination of individual attributes and the associated PWU for the three groups allows further interpretation. These variables, which characterize the differences in terrain preferences between classes, are Danger Rating, Slope Character, Steepness, Size, both Danger Rating-Size interactions, one Danger Rating-Character Interaction and one Danger Rating-Steepness Interaction.

While all participants had an aversion to high avalanche hazard, Class 3 had the weakest aversion to high hazard. Class 1 and 2 exhibited stronger statistically significant preferences for low and moderate hazard, while Class 3 did not. With respect to Slope Size, Class 1 exhibited a stronger general preference for small slopes than did Class 2.

In order to examine class differences in terrain choices it is necessary to examine the interactions between avalanche hazard and other terrain attributes. For the Danger Rating-Slope Character interaction, as danger increases from low to high all classes' initial preference for the aggressive chute terrain reverses to aversion. Class 3 however has the weakest aversion to chutes at a high Danger-Rating. With respect to the Danger Rating-Slope Steepness interaction, as the

Danger Rating increases all classes exhibit an increased aversion to the steepest terrain, however Class 3 again has the weakest aversion to the steepest terrain at a high Danger Rating.

Table 4.9 Part worth utility estimates and z-statistic for the three class latent class model.

		Class 1		Class 2		Class 3	
Attribute	**Level**	**PWU**	**z-value**	**PWU**	**z-value**	**PWU**	**z-value**
Constant							
	Remain In Bounds	0.88	8.90	-0.72	-1.41	-1.44	-5.91
Danger Rating[1,2]							
	Low	3.72	21.10	4.57	3.88	-0.17	-0.33
	Moderate	1.45	9.78	1.87	2.38	0.78	1.72
	Considerable	-1.72	-7.12	-1.12	-1.49	1.44	1.59
	High	-3.45	-12.21	-5.32	-2.33	-2.05	-5.33
Slope Character[1,2]							
	Trees	1.06	10.31	0.55	4.98	0.24	0.92
	Open	0.09	0.73	-0.20	-1.78	-0.30	-1.02
	Chute	-1.14	-9.03	-0.35	-4.29	0.06	0.31
Slope Steepness[1,2]							
	Blue	-0.10	-0.68	-0.35	-2.11	-0.41	-1.39
	Black	0.17	1.68	-0.01	-0.14	0.22	1.15
	DblBlack	-0.07	-0.81	0.36	3.85	0.20	1.07
Slope Size[1,2]							
	Small	1.18	6.41	0.46	4.58	0.21	1.43
	Medium	-0.75	-4.64	0.15	1.77	0.04	0.40
	Large	-0.43	-2.92	-0.60	-6.86	-0.25	-1.60
Use[1]							
	Regularly	-0.42	-6.36	-0.30	-6.12	-0.25	-2.51
	Occassionally	0.00	-0.02	-0.15	-3.25	-0.06	-0.72
	Rarely	0.42	5.55	0.45	6.84	0.31	2.93
Danger Rating Low-Size Interaction[1,2]							
	Small	-0.94	-4.34	-0.75	-3.87	-0.21	-0.63
	Medium	0.55	2.91	-0.38	-2.70	-0.13	-0.58
	Large	0.39	1.74	1.13	4.73	0.34	0.90
Danger rating Moderate-Size Interaction[1,2]							
	Small	-0.98	-4.29	-0.79	-5.51	-0.88	-2.96
	Medium	0.99	5.44	-0.03	-0.33	0.23	1.41
	Large	-0.01	-0.04	0.82	6.17	0.64	2.40
Danger Rating Low-Character Interaction[1]							
	Trees	-1.04	-7.62	-1.30	-8.48	-0.56	-1.81
	Open	0.02	0.13	0.01	0.06	0.14	0.37
	Chute	1.02	4.87	1.29	5.79	0.42	1.18
Danger Rating Considerable-Character Interaction[1,2]							
	Trees	0.46	1.63	1.06	6.97	-0.07	-0.21
	Open	0.82	2.48	-0.24	-1.46	0.30	0.77
	Chute	-1.28	-2.38	-0.81	-5.41	-0.22	-0.80
Danger Rating High-Character Interaction[1]							
	Trees	0.45	1.23	2.46	0.84	0.37	1.03
	Open	-0.10	-0.19	1.74	0.59	0.33	0.89
	Chute	-0.36	-0.62	-4.20	-0.72	-0.70	-2.79
Danger Rating Moderate-Slope Steepness Interaction[1]							
	Blue	0.67	3.26	0.55	2.36	0.34	0.66
	Black	-0.02	-0.15	0.03	0.21	-0.37	-1.30
	DblBlack	-0.65	-4.26	-0.57	-3.97	0.03	0.10
Danger Rating Considerable-Slope Steepness Interaction[1,2]							
	Blue	0.94	4.01	1.58	7.33	0.26	0.66
	Black	-0.09	-0.36	-0.15	-1.11	-0.30	-1.22
	DblBlack	-0.85	-2.80	-1.43	-8.40	0.04	0.12
Danger Rating High-Slope Steepness Interaction[1]							
	Blue	0.62	1.99	1.12	5.61	0.81	2.27
	Black	0.36	1.24	-0.09	-0.54	0.08	0.31
	DblBlack	-0.99	-2.34	-1.03	-5.60	-0.89	-3.39

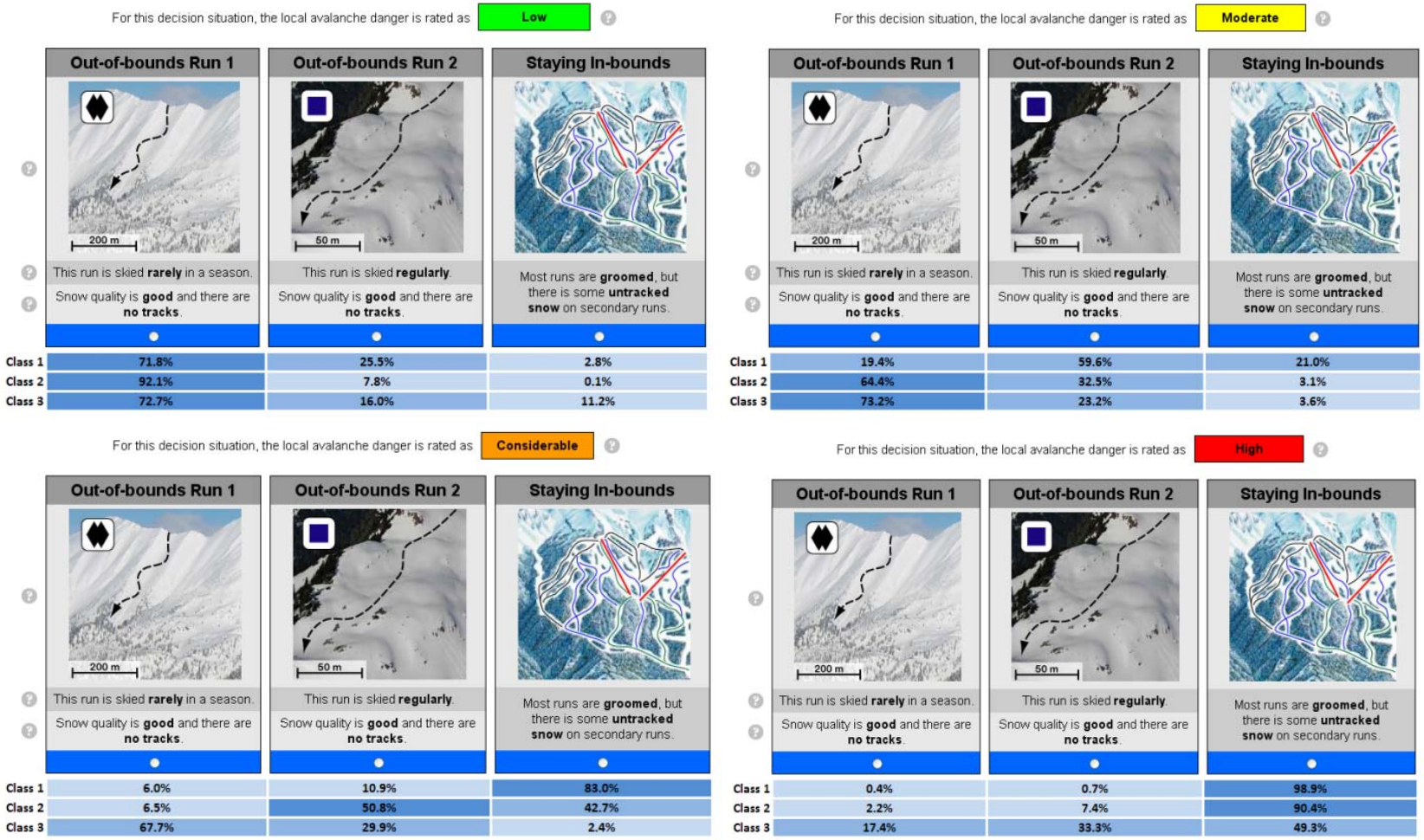
[1] Attribute has a significant impact on respondent choice of alternatives at the 5% level (Wald Statistic).

[2] Attribute parameters are significantly different between segments at the 5% level (Wald(=) Statistic).

4.2.3.3 Class Market Shares for Choice Scenarios

To illustrate the combined effect of the main and interaction effects on the choice behaviour of the three classes, their market shares were calculated for different choice scenarios. For each class, the probability of choosing one alternative over any other alternative in a given choice set is computed passed on the specific PWUs of each class. The four scenarios presented in Figure 4.3 show a typical response pattern of the three classes as the Danger Rating increases.

Figure 4.3 Examples of the results from the discrete choice experiment output for four different scenarios with market shares for the three classes.



In the Low Danger Rating example, all three classes are more likely to choose the more aggressive terrain, though Class 2 is the most likely to choose the aggressive terrain and Class 1 the least likely. In the Moderate Danger Rating example little change is observed for Class 2 and 3, however Class 1 is less likely to choose the aggressive terrain. In the Considerable Danger Rating example, most of Class 1 will remain in bounds, while over half of Class 2 will choose the less aggressive OB run; however, almost half of Class 3 will choose the aggressive OB run; fewer respondents from Class 2 and almost none from Class 1 will choose the aggressive run. This commitment of Class 3 to the aggressive terrain option and the lack of commitment to skiing OB by Class 1 represent opposite ends of the spectrum for terrain choices with respect to avalanche hazard consideration. This pattern is emphasized again in the High Danger Rating example, where almost all members of Class 1 and Class 2 will stay in bounds while over half of Class 3 will still choose to ski OB, many of which will choose the aggressive run. The DSS provides the clearest picture of the three classes' terrain choices and clarifies that Class 1 is the most conservative and exposes itself to the least risk while Class 3 is the least conservative and exposes itself to the most risk. For the purpose of this analysis, Class 1 will be labelled as 'Low Exposure', Class 2 will be labelled 'Moderate Exposure', and Class 3 will be labelled as 'High Exposure'.

4.3 Risk Matrix

Once all survey respondents were segmented along the three dimensions of avalanche risk (*training and experience*, *risk mitigation practices*, and *terrain*

choices), the three indicators were combined in order to derive a single risk classification for all respondents. The purpose of such a classification is to facilitate an overall segmentation which clearly identified the OB skiers most at risk of being involved in a serious avalanche incident. Since each indicator of avalanche risk had three levels, the combined matrix resulted in 27 permutations of the three indicators. Each permutation was assessed for overall risk.

Low-risk was assigned to combinations where either no obvious risk management failure existed, or sufficiently strong skills and practices were available to manage the given hazard. Moderate risk was assigned to combinations where, despite having either strong strategies or experience to adequately manage given hazards, some key risk management factors were absent or weak, for example a lack of good mitigation strategies or a propensity to make terrain choices involving moderate exposure without a combination of effective risk mitigation strategies and experience. Finally, high-risk was assigned to combinations that both lacked strong strategies to manage given hazards and had obvious weaknesses in one or more areas. Based in this subjective assignment, over half of the online participants were categorized as low-risk OB skiers, slightly more than one quarter were classified as moderate risk OB skiers and only 8.0% were labelled as high-risk OB skiers (Table 4.10 and Figures 4.4 to 4.6).

Table 4.10 Classification of survey participants for overall risk of injury or death due to avalanche involvement based on a combined evaluation of the three dimensions: terrain choices, risk mitigation practices, and training and experience.

Terrain Choices	Low Exposure	Moderate Exposure	High Exposure
Good Mitigators			
High Training	11.4%	25.2%	3.2%
Introductory Training	18.3%	23.5%	3.2%
Untrained	1.6%	1.7%	0.3%
Poor Mitigators			
High Training	0.1%	0.3%	0.1%
Introductory Training	1.8%	2.2%	1.2%
Untrained	1.1%	0.7%	0.3%
Deficient Mitigators			
High Training	0.4%	0.6%	0.1%
Introductory Training	1.1%	1.3%	0.1%
Untrained	0.0%	0.0%	0.0%
Total Skiers (n = 1340)			
Low Risk OB Skiers	59.8%		
Moderate Risk OB Skiers	32.2%		
High Risk OB Skiers	8.0%		

Figure 4.4 Combinations of the three dimensions (terrain choices, risk mitigation practices, and training and experience) where survey participants were classified as low risk for overall risk of injury or death due to avalanche involvement.

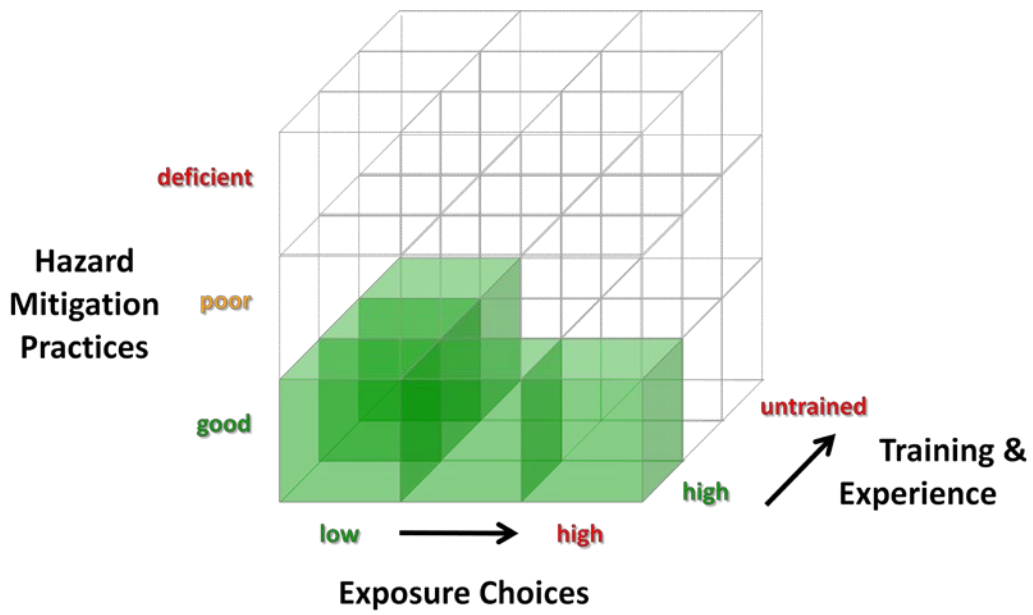


Figure 4.5 Combinations of the three dimensions (terrain choices, risk mitigation practices, and training and experience) where survey participants were classified as moderate risk for overall risk of injury or death due to avalanche involvement.

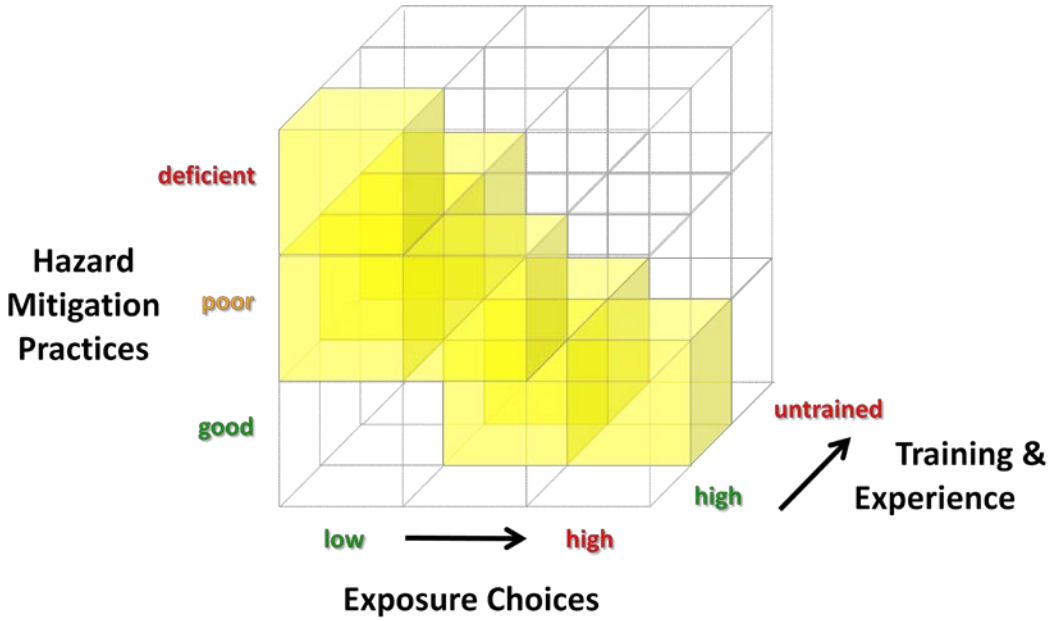
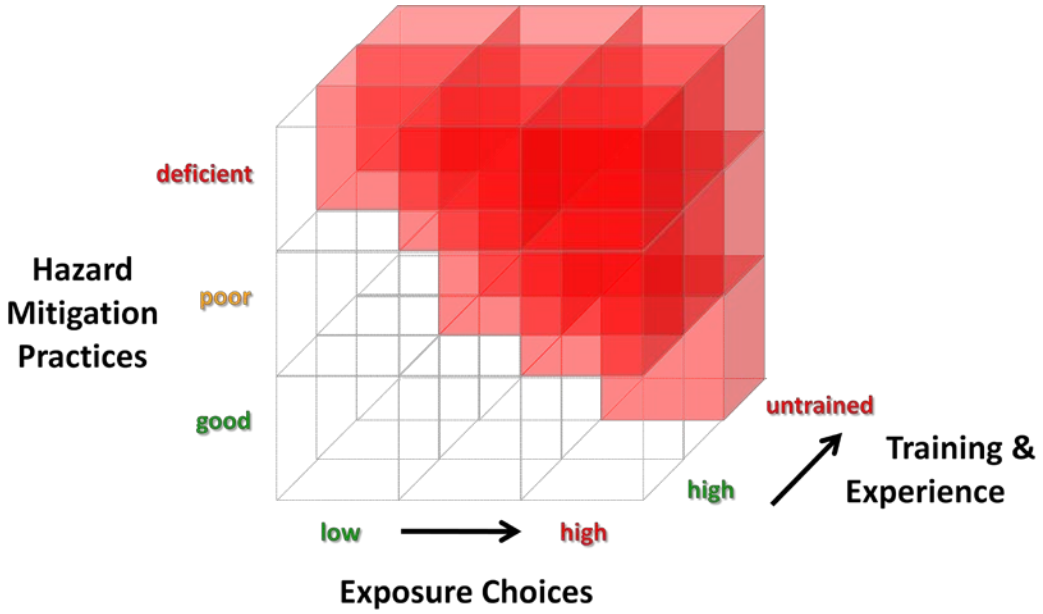


Figure 4.6 Combinations of the three dimensions (terrain choices, risk mitigation practices, and training and experience) where survey participants were classified as high risk for overall risk of injury or death due to avalanche involvement.



4.4 Characterization: High-Risk OB Skiers

In this section, results from the statistical comparison of high and low-risk OB skiers are presented. The high-risk cohort was compared to the low-risk cohort, as opposed to the moderate risk cohort, in order to maximize the chances of identifying significant differences. Given that the focus of this research is the high-risk OB cohort, low and moderate risk OB skiers were not characterized in detail. Significant differences between the two groups are identified with respect to demographics, resort policies comprehension, reported past OB behaviour, perceptions and motivations, sensation seeking and self-efficacy.

4.4.1 Demographics

When compared to the low-risk cohort, the high-risk cohort is younger, has a lower level of completed education and a larger proportion of males, and is more likely to travel on downhill skis or snowboards than equipment designed specifically for backcountry travel (Table 4.11). They are more likely to self-identify at a lower level on McCammon's OB Precaution Adoption Process Model (PAPM) (McCammon, 2009) than those in the low-risk cohort (Table 4.12).

Table 4.11 Comparing high-risk and low-risk OB skiers: demographics.

Variable	Test		High	Low	p-value
			%	%	
Age			n = 96	n = 788	
	Wilcoxon rank sum	Under 20	27.1%	7.0%	< 0.01
		20-24	12.5%	12.3%	
		25-34	31.3%	45.8%	
		35-44	12.5%	20.7%	
		45-54	12.5%	10.3%	
		55+	4.2%	3.9%	
Education			n = 96	n = 788	
	Wilcoxon rank sum	< High School	13.5%	3.0%	< 0.001
		High School	12.5%	5.1%	
		Some Post Secondary	15.6%	15.5%	
		Trades or Certificate	8.3%	13.8%	
		Complete University	33.3%	39.8%	
		Post Grad Degree	16.7%	22.7%	
Gender			n = 96	n = 783	
	Chi Squared	Male	96.9%	87.9%	0.01
		Female	3.1%	12.1%	
Travel Gear			n = 96	n = 762	
	Chi Square	Downhill Skis	36.5%	25.3%	< 0.001
		Snowboard/Splitboard	28.1%	13.5%	
		Telemark	15.6%	20.2%	
		AT	19.8%	40.9%	
		Splitboard	2.1%	2.9%	

Table 4.12 Comparing high-risk and low-risk OB skiers: precautionary adoption process model (PAPM) classification.

Variable	Test		High	Low	p-value
			%	%	
PAPM Scale			n = 96	n = 762	
	Wilcoxon rank sum	Unaware	4.2%	0.1%	< 0.001
		Unengaged	3.1%	0.3%	
		Engaged	55.2%	22.0%	
		Emergent A	20.8%	31.0%	
		Emergent B	15.6%	39.4%	
		Practitioner	1.0%	7.2%	

4.4.2 Resort Policies Comprehension

The high-risk cohort is less likely to believe that they completely understand resort boundary policies while it is considerably more likely to be uncertain about such policies. They are less likely than low-risk OB skiers to believe OB skiing is

permitted under resort policies (Table 4.13). High-risk OB skiers are more likely to believe that the ski resort controls avalanches in OB terrain and will rescue injured skiers in OB terrain (Table 4.14). No significant differences in perceptions of ski patrol attitudes were observed between high and low-risk cohorts (Table 4.15).

Table 4.13 Comparing high-risk and low-risk OB skiers: resort policy comprehension part 1.

Variable	Test		High	Low	P-Value
			%	%	
Understanding of Boundary Policies			n = 97	n = 791	
	Wilcoxon rank sum	Completely Understand	76.3%	93.0%	< 0.001
		Uncertain	20.6%	5.8%	
		Don't Know	3.1%	1.1%	
Is OB Skiing Permitted			n = 96	n = 789	
	Chi Squared	No	12.5%	5.4%	< 0.01
		Unsure	14.6%	9.0%	
		Yes	72.9%	85.6%	

Table 4.14 Comparing high-risk and low-risk OB skiers: resort policy comprehension part 2.

Variable	Response	High	Low	P-Value
OB Terrain		%	%	
The ski resort regularly controls avalanches in this terrain.	TRUE	32.6%	18.4%	<0.01
	FALSE	67.4%	81.6%	
If I get injured in this terrain, rescue will be available from the resort.	TRUE	67.4%	46.9%	<0.001
	FALSE	32.6%	53.1%	
It is against ski resort regulations to go into this terrain.	TRUE	30.3%	11.8%	<0.001
	FALSE	69.7%	88.2%	
This terrain is within the ski area boundaries.	TRUE	23.5%	15.2%	0.07
	FALSE	76.5%	84.8%	
Whenever possible, this terrain is opened by the ski area for skiing.	TRUE	52.8%	44.0%	0.14
	FALSE	47.2%	56.0%	
Ski patrollers are concerned that avalanches in these areas could affect skiers and snowboarders on regular runs inside the ski area boundary	TRUE	57.3%	48.0%	0.12
	FALSE	42.7%	52.0%	
Temporary Closures		%	%	
The ski resort regularly controls avalanches in this terrain.	TRUE	83.5%	85.8%	0.67
	FALSE	16.5%	14.2%	
If I get injured in this terrain, rescue will be available from the resort.	TRUE	80.7%	80.7%	0.89
	FALSE	19.3%	19.3%	
It is against ski resort regulations to go into this terrain.	TRUE	83.1%	87.7%	0.29
	FALSE	16.9%	12.3%	
This terrain is within the ski area boundaries.	TRUE	79.1%	89.7%	<0.01
	FALSE	20.9%	10.3%	
Whenever possible, this terrain is opened by the ski area for skiing.	TRUE	85.4%	90.7%	0.17
	FALSE	14.6%	9.3%	
Ski patrollers are concerned that avalanches in these areas could affect skiers and snowboarders on regular runs inside the ski area boundary	TRUE	88.9%	91.0%	0.65
	FALSE	11.1%	9.0%	
Permanent Closures		%	%	
The ski resort regularly controls avalanches in this terrain.	TRUE	33.0%	45.0%	0.04
	FALSE	67.0%	55.0%	
If I get injured in this terrain, rescue will be available from the resort.	TRUE	54.0%	62.4%	0.16
	FALSE	46.0%	37.6%	
It is against ski resort regulations to go into this terrain.	TRUE	90.0%	93.3%	0.35
	FALSE	10.0%	6.7%	
This terrain is within the ski area boundaries.	TRUE	67.8%	74.5%	0.22
	FALSE	32.2%	25.5%	
Whenever possible, this terrain is opened by the ski area for skiing.	TRUE	6.7%	6.8%	0.85
	FALSE	93.3%	93.2%	
Ski patrollers are concerned that avalanches in these areas could affect skiers and snowboarders on regular runs inside the ski area boundary	TRUE	81.1%	84.9%	0.44
	FALSE	18.9%	15.1%	

Table 4.15 Comparing high-risk and low-risk OB skiers: perception of ski patrol attitudes.

Variable	Test		High	Low	P-Value
			%	%	
Perception of Ski Patrol			n = 96	n = 787	
Ski patrollers want to open in-bounds runs as soon as it is safe to ski or ride there.	Wilcoxon rank sum	Strongly Disagree	0.0%	1.5%	0.58
		Disagree	6.3%	2.3%	
		Neither Agree nor Disagree	1.0%	5.0%	
		Agree	37.5%	31.0%	
		Strongly Agree	47.9%	54.1%	
		I don't know	7.3%	6.1%	
Ski patrollers have a favorable impression of people who go out-of-bounds.	Wilcoxon rank sum	Strongly Disagree	6.3%	4.7%	0.65
		Disagree	10.4%	9.1%	
		Neither Agree nor Disagree	33.3%	35.7%	
		Agree	19.8%	26.7%	
		Strongly Agree	7.3%	9.8%	
		I don't know	22.9%	14.0%	
Ski patrollers are approachable and openly talk about out-of-bounds conditions.	Wilcoxon rank sum	Strongly Disagree	1.0%	1.9%	0.92
		Disagree	6.3%	5.8%	
		Neither Agree nor Disagree	17.7%	14.1%	
		Agree	37.5%	38.2%	
		Strongly Agree	20.8%	32.7%	
		I don't know	16.7%	7.2%	
I can rely on ski patrollers for accurate information about out-of-bounds avalanche conditions.	Wilcoxon rank sum	Strongly Disagree	3.1%	3.3%	0.53
		Disagree	5.2%	7.9%	
		Neither Agree nor Disagree	19.8%	18.9%	
		Agree	38.5%	37.0%	
		Strongly Agree	20.8%	25.4%	
		I don't know	12.5%	7.5%	

4.4.3 Reported Past OB Behaviour

Members of the high-risk cohort are less likely than those of the low-risk cohort to report that they consider avalanche hazard when OB skiing (Table 4.16). They are also more likely to have skied in permanent and temporary closure areas (Table 4.17). Members of the high-risk cohort are considerably less likely to have been involved in an avalanche incident that could injure or kill someone (Table 4.18).

Table 4.16 Comparing high-risk and low-risk OB skiers: avalanche consideration.

Variable	Test		High		Low		p-value
			Median	IQR	Median	IQR	
			n = 97		n = 787		
	Wilcoxon rank sum	Avalanche Consideration	80	50	100	10	< 0.001

Table 4.17 Comparing high-risk and low-risk OB skiers: frequency of resort rule violations.

Variable	Test		High	Low	p-value
		Frequency	%	%	
Skied Permanent Closures			n = 92	n = 775	
	Wilcoxon rank sum	Never	63.0%	75.6%	0.02
		Once	17.4%	10.2%	
		Occasionally	18.5%	11.9%	
		Regularly	1.1%	2.3%	
Skied Temporary Closures			n = 92	n = 775	
	Wilcoxon rank sum	Never	55.4%	67.9%	0.02
		Once	12.0%	10.7%	
		Occasionally	29.3%	17.3%	
		Regularly	3.3%	4.1%	

Table 4.18 Comparing high-risk and low-risk OB skiers: previous avalanche involvement.

Variable	Test		High	Low	P-Value
			%	%	
Involved in Avi Incident			n = 97	n = 789	
	Chi Squared	Yes	29.9%	44.1%	0.01
		No	70.1%	55.9%	

4.4.4 Risk Perceptions and Motivations

4.4.4.1 Risk Perceptions

No significant differences were observed regarding perception of avalanche likelihood between the two groups (Table 4.19). Marginally significant differences were observed between the low and high-risk groups regarding acceptance of avalanche involvement consequences (Table 4.20). High-risk OB skiers appear slightly more accepting of loss of gear, partial or complete burial, minor injuries and

death. The marginal significance with regards to consequence acceptance may be related to the small sample size of the high-risk group.

Table 4.19 Comparing high-risk and low-risk OB skiers: perception of avalanche likelihood.

Variable	Test		High	Low	p-value
			%	%	
Likelihood of triggering			n = 59	n = 360	0.17
	Wilcoxon rank sum	1 every 100,000 yrs	5.1%	3.3%	
		1 every 10,000 yrs	10.2%	6.9%	
		1 every 1,000 yrs	6.8%	6.9%	
		1 every 100 yrs	27.1%	23.9%	
		1 every 10 yrs	23.7%	23.3%	
		1 every 5 yrs	11.9%	18.3%	
		1 every 2 yrs	6.8%	5.8%	
		1 per year	6.8%	7.5%	
		2 per year	0.0%	2.2%	
		5 per year	0.0%	0.6%	
		10 per year	1.7%	1.1%	
Liklihood of injury			n = 59	n = 359	0.78
	Wilcoxon rank sum	1 every 100,000 yrs	6.8%	3.1%	
		1 every 10,000 yrs	13.6%	10.3%	
		1 every 1,000 yrs	3.4%	10.3%	
		1 every 100 yrs	28.8%	32.6%	
		1 every 10 yrs	20.3%	19.8%	
		1 every 5 yrs	13.6%	15.3%	
		1 every 2 yrs	3.4%	3.1%	
		1 per year	6.8%	2.5%	
		2 per year	3.4%	0.8%	
		5 per year	0.0%	1.4%	
		10 per year	0.0%	0.8%	
Liklihood of fatality			n = 59	n = 360	0.93
	Wilcoxon rank sum	1 every 100,000 yrs	22.0%	15.8%	
		1 every 10,000 yrs	20.3%	21.7%	
		1 every 1,000 yrs	5.1%	11.4%	
		1 every 100 yrs	27.1%	30.3%	
		1 every 10 yrs	13.6%	11.7%	
		1 every 5 yrs	5.1%	6.4%	
		1 every 2 yrs	1.7%	0.6%	
		1 per year	3.4%	0.8%	
		2 per year	0.0%	0.0%	
		5 per year	1.7%	0.8%	
		10 per year	0.0%	0.6%	

Table 4.20 Comparing high-risk and low-risk OB skiers: avalanche consequence acceptance.

Variable	Test		High	Low	p-value
			%	%	
Consequence Acceptance			n = 96	n = 762	
	Wilcoxon rank sum	No Avalanche Acceptable	42.7%	44.0%	0.09
		Trigger an Avalanche	26.0%	38.8%	
		Taken for a ride	5.2%	5.6%	
		Lose or damage gear	8.3%	3.5%	
		Partially Buried	6.3%	3.4%	
		Completely Buried	5.2%	1.7%	
		Minor Injuries	2.1%	1.2%	
		Seriously Injured	0.0%	0.4%	
		Killed	4.2%	1.3%	

4.4.4.2 Motivations

Participant responses to a series of Likert scale questions related to motivations for OB skiing were analyzed using principal component analysis. Principal components 1-4 exhibited Eigenvalues greater than 1 (Table 4.21) and were utilized in the comparison of high and low-risk OB skiers. The four motivational principal components identified were Powder (PC1), Enjoyment of Nature vs. Hanging Out (PC2), Adventure (PC3), and Anti-Authority vs. Powder (PC4) (Table 4.22). The four principal components utilized in this analysis only explain 54.1% of the observed variability in participants' responses to the motivations questions (Table 4.21).

Table 4.21 Principal component analysis: eigenvalues and proportion of variance explained for first four components loading for OB skiing motivations.

	PC1	PC2	PC3	PC4	PC5
Eigenvalue	1.969	1.513	1.194	1.029	0.976
Proportion of Variance	0.242	0.143	0.089	0.066	0.060
Cumulative Proportion	0.242	0.385	0.475	0.541	0.600

Table 4.22 Principal component analysis: factor loadings.

Motivation	PC1	PC2	PC3	PC4
Powder	-0.0669	-0.1133	0.4308	-0.6026
Crowds	-0.1522	0.3032	0.3655	-0.1447
Exercise	-0.2594	0.3556	-0.0683	0.2112
Friends	-0.3204	0.1534	-0.1718	0.0413
Nature	-0.2800	0.3228	-0.0306	0.0677
DMSkill	-0.3111	0.2112	-0.2510	-0.0027
LifeStyle	-0.3452	0.0688	-0.2072	-0.2107
Identity	-0.3267	0.0665	-0.1206	-0.3226
Adventure	-0.2950	-0.0164	0.3528	0.2643
Terrain	-0.2625	-0.2003	0.3344	0.1384
Bored	-0.2047	-0.0415	0.4725	0.1633
NotSup	-0.1423	-0.3019	0.0046	0.3400
Impress	-0.2117	-0.3382	-0.0753	0.1530
Kicker	-0.1582	-0.4131	-0.1592	-0.1818
About	-0.2320	-0.3371	-0.1442	0.1483
Pics	-0.2441	-0.2354	-0.1178	-0.3269

Significant differences between the low and high-risk cohorts regarding the importance of a number of motivational factors were identified for the following principle components (Table 4.23):

- PC1 – No significant differences were identified.
- PC2 – High-risk OB skiers were more likely than low-risk OB skiers to choose motivational factors pertaining to 'Hanging Out' which include going OB skiing because: they are not supposed to, to impress friends, to build a kicker, and to see what OB is all about. High-risk OB skiers are less likely to choose factors pertaining to 'Nature', which include: to escape crowds, to get exercise and to enjoy nature.
- PC3 – While no significant differences were identified between high and low-risk OB skiers for PC3, the mean of high-risk OB skiers for PC3 was very close to that of moderate risk OB skiers. Moderate risk OB skiers were significantly

different from low-risk OB skiers in that they were more likely to choose motivational factors related to adventure which include: to find powder, to get away from crowds, to be adventurous, to test abilities in challenging terrain and to avoid boredom. Given the similarity in PC3 means for high and moderate risk OB skiers, the lack of significant differences between the high and low-risk groups may be related to sample size.

- PC4 – No significant differences were found between high and low-risk OB skiers.

Table 4.22 Comparing high-risk and low-risk OB skiers: ANOVA on motivation principal components.

Variable	Test		High	Low	p-value
			Mean	Mean	
Motivations			n = 97	n = 785	0.17
	ANOVA	PC1	0.1130	0.0688	0.15
		PC2	-1.1530	0.3370	< 0.001
		PC3	0.1586	-0.1000	< 0.001
		PC4	0.1384	0.0451	0.01
	Tukey honest significance test	PC2 High-Low	-1.1530	0.3370	< 0.001
		PC3 Mod-Low	0.1586	-0.1000	< 0.01
		PC4 High-Mod	0.1384	0.0451	0.07
		PC4 Mod-Low	0.1384	0.0451	0.02

These differences in motivational factors suggest that high-risk OB skiers are more likely to be motivated by social and adventure factors and less likely to be motivated by nature experiences.

4.4.5 Sensation Seeking and Self-efficacy

Analysis of survey participant responses to the BSSS – 8 questionnaire and three questions on avalanche skills self-efficacy facilitated the identification of significant differences between low and high-risk OB skiers regarding sensation seeking qualities and self-efficacy. The high-risk OB skier cohort scored significantly higher than the low-risk cohort on all four categories of the BSSS – 8 (Table 4.23). The largest observed difference between scores for the high and low-risk OB skiers was in the disinhibition category.

Table 4.23 Comparing high-risk and low-risk OB skiers: Brief Sensation Seeking Scale - 8 Item.

	High n=95		Low n=776		p-value
	Mean	sd	Mean	sd	
Experience seeking					
1. I would like to explore strange places.	4.43	0.60	4.24	0.73	0.02
2. I would like to take off on a trip with no pre-planned routes or timetables.	3.88	0.98	3.28	1.28	<0.001
Thrill and adventure seeking					
3. I would like to do bungee jumping.	3.43	1.37	2.82	1.34	<0.001
4. I like to do frightening things.	3.57	1.06	3.01	1.11	<0.001
Disinhibition					
5. I like wild parties	3.21	1.37	2.61	1.22	<0.001
6. I would love to have new and exciting experiences, even if they are illegal.	3.43	1.07	2.70	1.10	<0.001
Boredom susceptibility					
7. I prefer friends who are exciting and unpredictable.	3.62	0.97	2.93	1.06	<0.001
8. I get restless when I spend too much time at home.	4.33	0.84	4.11	0.90	0.01

The high-risk cohort rated all three measures of self-efficacy significantly lower than the low-risk group: confidence in their ability to recognize situations they are likely to trigger an avalanche, confidence in their ability to rescue a partner who is completely buried by an avalanche, and confidence in their ability to talk partners out of skiing a slope they think is dangerous (Table 4.24). Of note is the

scale of differences between the two groups. While the low and high-risk groups were closest in self-efficacy for avalanche assessment, the most challenging expertise to develop, they differed most in their self-efficacy to rescue an avalanche victim, which is a more technical skill.

Table 4.24 Comparing high-risk and low-risk OB skiers: self-efficacy.

Variable	Test		High		Low		p-value
			Median	IQR	Median	IQR	
Self Efficacy			n = 97		n = 787		
	Wilcoxon rank sum	Confidence in Assessment	60	20	70	20	<0.001
		Confidence in Rescue	50	40	80	20	<0.001
		Confidence in Convincing Partner	70	40	90	20	<0.001

4.5 High-Risk OB Skier Profile Summary

Through the preceding comparisons between high and low-risk OB skiers it is possible to create a comprehensive picture of the high-risk OB cohort. This high-risk group is more likely than the low-risk group to be young males. They are less likely to report complete understanding of boundary policies but are more likely to believe ski resorts control avalanches and conduct rescues in OB terrain. High-risk skiers are less likely than low-risk skiers to consider avalanche hazard when OB skiing and are more likely to have skied in permanently and temporarily closed areas of a ski resort. The high-risk cohort is less likely to have a history of previous involvement in an avalanche incident and is more willing to accept of the following avalanche related consequences: loss of gear, partial or complete burial, minor injuries and death. High-risk OB skiers are more likely to be motivated by social and adventure factors and less likely to be motivated by nature experiences. High-risk OB skiers score higher on all four sensation seeking subscales, but report lower self-

efficacy for avalanche skills such as stability assessment and rescue. These findings provide a broad perspective on characteristics of those OB skiers most at risk of being involved in an avalanche incident.

5: DISCUSSION

The present research was designed as *formative research*, with the intent to provide foundation knowledge that could inform the development of avalanche safety initiatives specifically aimed at OB skiers. To achieve this goal, two lines of inquiry were pursued: identifying OB skiers most at risk of being involved in an avalanche incident, and characterizing the attitudes, perceptions, and motivations of this high-risk OB cohort. To complete the characterization portion of the research, comparisons were made between high and low-risk OB skiers, making significant differences easier to identify. This set of differences provides key background information that can assist in the development of a safety program targeting the high-risk group. This chapter begins with a review of characteristics of high-risk OB skiers and a review of how those findings compare with existing relevant research. The benefits of using a multidimensional assessment for the identification and characterization of high-risk OB skiers are then discussed. Management implications of the new insights gained about the high-risk profile are discussed as a foundation for an avalanche safety health behaviour campaign.

5.1 High-Risk OB Skier Profile

5.1.1 Demographics

Our characterization of OB skiers by risk level indicate that over 70% of the high-risk segment is under 34 years old, and females are almost 4 times less likely to

be classified as high-risk than low-risk. This finding is supported by Björk's (2007) study of OB skiers. Björk concluded that males under the age of 30 who report higher skiing skill level expose themselves to more risk and exhibit poor risk management behaviour.

With respect to the entire OB population, this research indicates that the largest proportion of OB skiers is in their late 20's. It is possible that this age represents a period when skiers have developed the requisite skiing skills to enjoy more challenging terrain and snow, but have grown accustomed to skiing in bounds and are ready to explore new terrain. These results are comparable to results from other surveys of OB skiers. While online survey participants in Björk's study had a median age of 26, respondents to his intercept survey had a median age of 29 (Björk, 2007). OB participants of Silverton's (2006) intercept survey had a mean age of 28 (Silverton, 2006). McCammon (2009) examined pooled OB avalanche fatalities from the United States and Canada and found a median age of 25.5 and a mean age of 28.5 (McCammon, 2009).

In my online survey, over 90% of respondents were male. Other surveys have found similar domination by males in OB skiing with proportions of male participation ranging from 72.5% to 88.5% (Björk, 2007; Longland et al., 2005; McCammon, 2009; Silverton, 2006).

5.1.2 Resort Policy Comprehension

High-risk OB skiers demonstrated considerable differences from low-risk skiers regarding comprehension of resort policy comprehension. High-risk OB

skiers were less likely to report complete understanding of boundary policies and more likely to report uncertainty or a lack of understanding regarding these policies. The accuracy of responses for resort policy comprehension was not analyzed, however overall patterns between the two risk groups were examined. High-risk skiers were more likely to believe ski resorts controlled avalanches and conducted rescues in OB terrain, and that it was against resort policy to enter OB terrain.

5.1.3 OB Behaviour

Aside from those indicators used to classify OB skiers by risk level, responses from the high-risk group to questions of perception and behaviour appear to confirm their high-risk designation. High-risk skiers were less likely to consider avalanche hazard, and were more likely to have skied in permanently and temporarily closed areas of a ski resort.

Our research indicates that high-risk OB skiers are also less likely than low-risk OB skiers to have a history of previous involvement in an avalanche incident. This finding may appear counter-intuitive at first, given the plausible expectation that those exposing themselves to increased avalanche risk should be more likely to have been involved in an avalanche incident. However, history of avalanche involvement may be a poor indicator of present behaviour as it fails to account for the potential impact of the avalanche involvement on current behaviour. It is likely that a personal avalanche involvement creates a heightened awareness to such hazard and in turn lead to more cautious behaviour.

Research on characteristics of backcountry skiers with previous avalanche involvement supports the finding of this study. Tase (2004) concluded that skiers were more likely to have previous avalanche involvement if they belonged to an older age group, had received a higher level of avalanche training and were very prepared, for example carrying safety equipment. These characteristics correspond with those of the low-risk OB skiers in this study who are more likely to have had previous avalanche involvement compared to the high-risk cohort. Based on these findings, Tase suggests the need for further research into the reasons why these variables are associated with higher levels of avalanche involvement; however, she does not examine the possible discrepancy between historical and present behaviour as a result of avalanche involvement. Further studies should examine the potential of this relationship as a causal link.

5.1.4 Risk Perceptions and Motivations

Our findings show that high-risk OB skiers appear slightly more accepting of loss of gear, partial or complete burial, minor injuries and death. However, the percentage of OB skiers accepting death is considerable lower than the 15% suggested by Longland et al (2005)

Regarding perception of avalanche likelihood, no significant differences were observed between the two groups. High-risk OB skiers are more likely than low-risk OB skiers to be motivated by social and adventure factors and less likely to be motivated by nature experiences.

5.1.5 Sensation Seeking and Self-efficacy

Our results confirm that Zukerman's Sensation Seeking Scale (Zuckerman, 1994) is useful for distinguishing high and low-risk cohorts within a community that is engaged in what is generally considered a high-risk activity already. High-risk OB skiers scored significantly higher than low-risk OB skiers on total sensation seeking and all four subscales. The largest difference between high and low-risk OB skiers was in the disinhibition category. The next largest difference was in boredom susceptibility, which was followed by thrill and adventure seeking. Higher levels of disinhibition among high-risk OB skiers may represent an increased interest in activities which they consider taboo or forbidden. Higher levels of boredom susceptibility among high-risk OB skiers could be interpreted as higher levels of aversion to the repetition and routine of inbounds skiing with a consequently stronger drive to ski OB despite an increase in risk. Higher levels of thrill and adventure seeking among high-risk OB skiers could be interpreted as an increased desire to engage in sports that involve danger, which could also drive interest in OB skiing. Although the use of sensation seeking to indentify differences in risk exposure among participants of high-risk sports has failed in some studies (Asçi et al., 2007), it has been used successfully with rock climbing, kayaking and skiing (Slanger & Rudestam, 1997). Potential explanations for the observed variability in these results include differences in the methods used to measure risk exposure for participants, or differences in participant make up of the sports themselves.

A comparison of self-efficacy between low-risk and high-risk OB skiers indicates that high-risk OB skiers report lower self-efficacy for skills that would help

mitigate the risks of avalanches such as stability assessment and rescue. Related to this finding is a study by Slanger and Rudestam (1997), who examined participants of skiing, rock climbing, kayaking and piloting, and identified high self-efficacy and confidence as the factor most responsible for the disinhibition associated with moving from high-risk to extreme risk. These two findings appear to contradict each other; higher risk taking behaviour among OB skiers is associated with lower self-efficacy, while higher risk taking among skiers, rock climbers, kayakers and pilots is associated with higher self-efficacy.

One potential explanation for this variation is Slanger and Rudestam's focus on self-efficacy of technical skills as opposed to this research's focus on self-efficacy of judgment skills. A high level of technical rock climbing skills may provide additional safety and confidence in an environment where physical abilities can make the difference between life and death. With OB skiing, skiing self-efficacy may facilitate engagement in the activity, but is unlikely to increase safety given the nature of avalanche risk. In the OB context, a lower self-efficacy with regards to judgment and rescue skills appears to be associated with higher risk behaviour.

5.2 Comprehensive Multi-dimensional Assessment

The distribution of survey participants along the three indicators of avalanche risk confirms the importance of the multidimensional approach used in this study (Figure 4.10). Each dimension used to identify high-risk OB skiers demonstrated utility as participants could be found across the range of the indicator. This multi-dimensionality is important, as it suggests that, in order to

effectively identify high-risk OB skiers, approaches that examine only one dimension of avalanche risk may misclassify some individuals. Individuals may demonstrate a low-risk according to one indicator, but through high-risk behaviour in another indicator, actually expose themselves to considerable hazard.

An example of a classification system for OB skiers primarily based on one dimension is McCammon's OB Precaution Adoption Process Model (McCammon, 2009). This model is an example of a single dimension approach to risk assessment, primarily using avalanche education levels, which could lead to misclassification. As would be expected, I found significant differences between high and low-risk OB skiers with respect to a self-assessment using McCammon's model. High-risk OB skiers were more likely to belong to the first three categories: unaware, unengaged and engaged. These results support McCammon's conclusion that the least-developed precautionary stages pose the greatest difficulties for resort managers. However, findings from this study suggest that high-risk OB skiers can be members of the upper 'emergent' and 'practitioner' levels of McCammon's model (Figure 4.12). McCammon addresses the potential for high-risk behaviour among members of the top precautionary stages as occasional lapses in mitigation activities. Significantly higher sensation seeking scores and lower self-efficacy of the high-risk OB group may be personality traits that lead to such lapses for educated and experienced OB skiers. Regardless, while these OB skiers would fall into a low-risk category for on the *training and experience* indicator, aggressive *terrain choices* or poor *risk mitigation practices* would reveal their increased exposure to avalanche

risk. Thus, the use of multiple indicators of avalanche risk provides a more comprehensive picture of exposure to avalanche hazard for these individuals.

5.3 Implications for OB Avalanche Safety Campaign Design

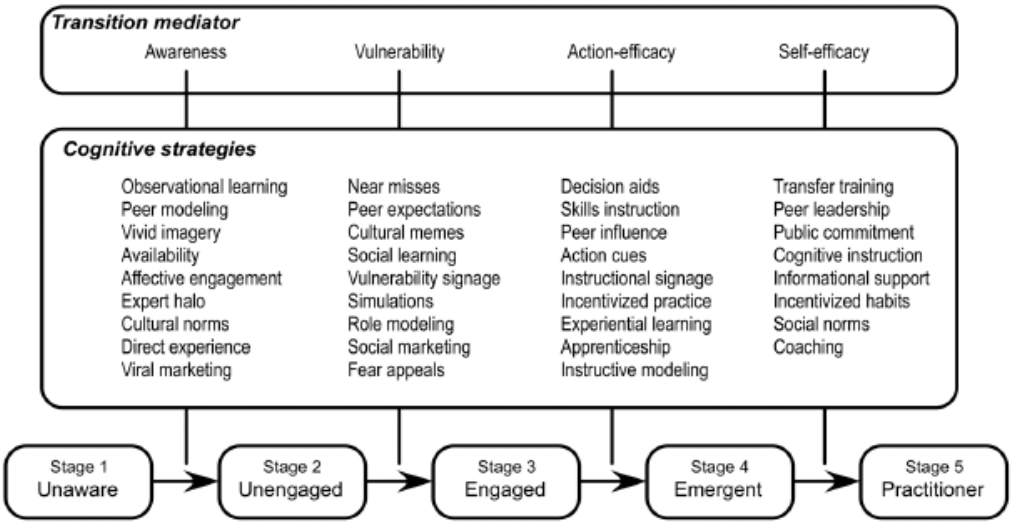
5.3.1 Management Implications Approach

The goal of this formative research was to segment and better understand the behaviour and perceptions of OB skiers at risk of being involved in a serious avalanche incident. By segmenting OB skiers based on risk, it is possible to focus on the defining characteristics of those who are most able to benefit from a targeted avalanche safety campaign. Such a campaign could avoid wasting resources on individuals who are unlikely to be involved in an avalanche, and is more likely to reach those at risk due to a detailed knowledge of their behaviour and characteristics. Using this research, relevant lessons can be extracted regarding the knowledge base, beliefs, attitudes, salient priorities, efficacy and sensation seeking traits of high-risk OB skiers. In this section I examine these findings to identify the implications they hold for current and future avalanche accident prevention programs.

As a reference for avalanche prevention strategies aimed at OB skiers in North America, McCammon's (2009) assessment of avalanche risk communication for out-of-bounds recreation provides an excellent overview of current practices. McCammon identifies safety initiatives and cognitive strategies in the context of 'transition mediators'. These 'transition mediators' are tools or strategies which facilitate movement to higher levels of precaution adoption stages (Figure 5.1). This

model, which offers practitioners tangible advice regarding the development of OB avalanche safety programs, can be complemented by management implications identified through this characterization of high-risk OB skiers. This marriage of research findings and current practices should facilitate improvement of both program design and program delivery in avalanche safety campaigns.

Figure 5.1 Cognitive constructs for facilitating transition to higher precaution adoption stages in the context of OB avalanche hazard (McCammon 2009).



5.3.2 Implications on Campaign Design

Several weaknesses in the knowledge base of high-risk OB skiers provide targets for improvement. An important distinction in the decision-making of high-risk OB skiers suggests that salience of the danger rating could be a useful target within a health behaviour campaign. Most members of the high-risk OB group exhibited aggressive terrain choices despite higher avalanche danger ratings. This tendency toward higher risk terrain suggests a lowered sensitivity to avalanche

hazard as is evident when comparing choices made by the three OB groups shown in Figure 4.7. The high-risk OB group's lack of sensitivity indicates a limited awareness of the extent of stability decrease represented by increasing hazard ratings. Experts generally view the avalanche danger scale as increasing exponentially with each step (Haegeli et al., 2010), however the terrain choices of the high-risk group suggest a perception of the scale as linear. Prior research has identified this potentially dangerous misconception among some groups of OB skiers, backcountry skiers and snowmobilers (Björk, 2007; Longland et al., 2005). An awareness of the increased possibility of fatalities at higher danger ratings may promote salience of the danger rating's importance and consequently more conservative *terrain choices* at a given hazard rating. This strategy could be applied to a number of cognitive strategies across all levels of transition mediators outlined in McCammon's model (Figure 5.1). In particular, these lessons apply to vivid imagery, vulnerability signage, fear appeal, instructional signage and informational support (McCammon, 2009). Increasing the salience of danger ratings represents an important component of an OB avalanche safety strategy.

An additional lessons related to salience can be identified with regards to the development of avalanche education programs. High-risk OB skiers stated less frequent consideration of avalanche hazard than low-risk OB skiers. The consideration of avalanche hazard and consequent evaluation of run suitability is an additional process that could be targeted for increased salience in an OB campaign. Rather than attempt to dissuade OB skiers from engaging in the activity, messaging could focus on the promotion of evaluative decision-making. These lessons apply to

many of the cognitive strategies currently in use including: availability, peer modelling, cultural norms, peer expectations, skills instruction, instructive modelling, simulations, role modelling, decision aids, instructional signage, instructive modelling, peer leadership, social norms and coaching (McCammon, 2009). These strategies could help to establish evaluative decision making as an expected practice among OB skiers.

Despite the fact that knowledge of the current avalanche danger rating is critical to evaluative decision making, results from the intercept survey (Appendix A) indicate that many OB skiers are unaware of the current danger rating. To address this deficiency, danger rating information should be made more prominent and accessible so that OB skiers are more likely to have this information when engaging in evaluative decision-making. In addition, OB policies vary widely between resorts and no clear standards exist (McCammon, 2009). This lack of consistency may contribute to poor comprehension of resort boundary policies. Since high-risk OB skiers exhibit worse comprehension than low-risk OB skiers, clarifying and potentially standardizing resort boundary policies and signage should be a part of OB management strategies. Both increased access to the avalanche danger rating and consistent signage are excellent examples of the availability strategy of McCammon's (2009) 'Awareness' transition mediator.

Beliefs and norms of OB skiers observed in this study indicate two possible recommendations for OB avalanche safety programs. First, these findings suggest that high-risk skiers do not perceive the potential consequences of their behaviour on the probability of avalanche involvement. High and low-risk OB skiers exhibit

marginally significant differences in their acceptance of avalanche consequences with high-risk OB skiers more likely to accept negative avalanche related outcomes; however, the two groups do not exhibit significant differences in the perceived likelihood of avalanche involvement. The lack of a significant difference in expectations of avalanche likelihood despite considerable differences in behaviour, route selection, training and experience suggest that high-risk OB skiers are not aware of the potential implications of their shortcomings. Avalanche safety campaign messages should therefore highlight the impact that variations in decision-making, route selection and risk mitigation practices have on avalanche involvement and survival. This message could form the basis of a number of cognitive strategies outlined by McCammon (2009) such as vivid imagery, viral marketing, vulnerability signage, fear appeal and informational support.

Second, both high and low-risk OB skiers demonstrated generally positive perceptions of ski patrollers as approachable and reliable information sources. This perception may indicate a level of trust in the ski patrol which could be utilized in an accident prevention campaign. Given the trust that the ski patrol appears to have from OB skiers, the ski patrol could be used as an informational conduit to reach OB skiers from a range of experience and risk levels. In addition, McCammon (2009) suggests that OB skiers who are more advanced on the OB Precaution Adoption Process Model are motivated to learn and reduce hazard exposure and can be allies in communicating to less experienced OB skiers through strategies such as observational learning, peer modelling, expert halo, role modelling, skills instruction, apprenticeship, instructive modelling, peer leadership and coaching.

With encouragement, it is possible that instruction passed from ski patrol to experienced OB skiers could be transmitted to less experienced OB skiers. This provides a plausible communication channel that may be capable of reaching a wide spectrum of OB skiers.

Self-efficacy regarding avalanche assessment, rescue, and convincing partners not to ski a run they felt was unsafe was considerably lower among high-risk OB skiers than low-risk OB skiers. Research indicates that self-efficacy is a distinct and powerful predictor of behaviour. In situations where individuals exhibit low self-efficacy, behaviours may fail despite motivations to the contrary. Experimental manipulation of self-efficacy suggests that self-efficacy may be enhanced, and enhancement can be related to subsequent behavioural change (Strecher, Devellis, Becker, & Rosenstock, 1986). Existing avalanche education courses address the development of self-efficacy through knowledge and skills training. Our research suggests that activities that specifically target the development of confidence in assessment, rescue and communication skills address critical components of self-efficacy for OB skiers. Development of self-efficacy can be facilitated through rehearsing behaviours in situations where efficacy is low while being supported by counselling from credible sources (Strecher et al., 1986). These strategies should be used respectively in courses or in interactions with resort staff. Development of self-efficacy as a goal for promoting safe OB behaviour is supported by McCammon's (2009) transition mediators of 'action-efficacy' and self-efficacy that includes strategies such as decision aides, skills instruction, incentivizing

practice, experiential learning, instructive modelling and coaching as opportunities for reaching higher development in the OB Precaution Adoption Process Model.

High-risk OB skiers scored significantly higher on total sensation seeking as well as all four subscales: thrill and adventure seeking, boredom susceptibility, experience seeking and disinhibition. Several management implications can be indentified based on these results. According to Zukerman (2007) sensation seeking is a basic personality trait and, as such, is it difficult to change. Risky sex is another high-risk activity where health behaviour campaigns can be guided by sensation seeking characteristics. A review of different approaches to address risky sex found that programs aimed at reducing unprotected sex were more successful than programs with only abstinence as a goal (Kirby, 2002). In applying these lessons to high-risk OB skiers, it may be more effective to focus on providing participants with tools to make safe OB skiing decisions, such as ranking risk associated with various terrain features. Given the findings of this research, this approach is likely to be more effective than attempting to dissuade OB skiing entirely, as was considered by British Columbia's Minister of Public Safety and Solicitor General in 2009 following OB skiing fatalities (Fowlie, 2009). Given that high-risk OB skiers are more likely to believe that OB skiing is against resort policies, attempts at discouragement do not seem promising.

In addition, several lessons can be drawn from research into safe sex programs aimed at high sensation seekers. Successful programs concentrate on reducing one or more behaviours, give a clear message about condom use or contraceptive, give info about avoiding intercourse or making it safer and give

instructions in communication, negotiation and refusal skills (Zuckerman, 2007). Applying these lessons to high sensation seeking OB skiers, a program focused on explicit skills training combined with knowledge focused on safe terrain selection, or go-no go decision-making might be successful options. In addition, training in communication and decision-making strategies for use with partners could address circumstances where skiers are facing potential route options that other members of their party feel are safe, but they personally do not. The ability to suggest safer substitutes to a high-risk activity, such as a system that facilitates identification of OB terrain with lower exposure to avalanches, could provide options of participation with less risk. These skills and decision strategies could be used as curricular foci in McCammon's (2009) 'action-efficacy' transition mediator, which includes the cognitive strategies of decision aids and skills instruction.

With regards to communication strategies, the high sensation seeking characteristics of high-risk OB skiers indicates that particular styles of communication will be more effective than others. Communication should be dramatic, emotionally powerful or physically arousing, graphic, explicit and unconventional or suspenseful (L. Donohew et al., 1991; Everett & Palmgreen, 1995; Lorch et al., 1994; Palmgreen et al., 1991; Palmgreen et al., 2001). Given the importance of public avalanche bulletins and the inability of most OB skiers to accurately recall the danger rating (see Appendix D, Section 7.4.4.2), novel and prominent methods should be used to promote this information at multiple areas frequented by OB participants in order to elicit attention. The typical, text heavy minimal posting of avalanche information found at many OB gates is one area that

has potential for considerable improvement. Other applications of a communication method optimized for high sensation seekers could be applied to a multitude of avalanche awareness efforts. Many other strategies identified as transition mediators by McCammon (2009) could benefit from using a communication style targeted at high sensation seekers. These strategies include viral marketing, vulnerability signage, social marketing, fear appeals, instructional signage and informational support. Use of this communication style is supported by Kobe and Jenkins (1990), who concluded that avalanche education that conveyed stories and examples through a wide range of media channels was likely to have a positive effect on behaviour.

Additional support for the use of dramatic or emotionally powerful messaging can be identified with respect to previous avalanche experience. My findings support the theory that previous avalanche involvement is associated with lower risk OB skiing behaviour. If this type of personal experience is indeed capable of facilitating behaviour change, then avalanche awareness initiatives aimed at OB skiers should incorporate activities that attempt to convey these emotional experiences. Educational programs that engage OB skiers and help them imagine and understand the risks and consequences involved in the activity may be able to promote the lower risk behaviour observed amongst individuals who have had personal experiences with avalanches.

5.4 Methodological Contribution

The present study was designed to identify and characterize a high-risk subpopulation within the OB ski community. In the development of many health behaviour campaigns, at-risk populations can be identified through a straightforward assessment of a single behaviour; examples include identifying the number of people who accept a helmet as part of a ski rental package to prevent head injuries (Levy et al., 2007), use sunscreen and protective clothing to prevent skin cancer (Walkosz, 2008), or use condoms to prevent sexually transmitted infections (Edgar et al., 2008; Naughton & Rhodes, 2009). The dispersed nature of OB skiing and the lack of organization within the OB skiing community, combined with the temporal and spatial variability of avalanche hazard, make it impractical to assess individual avalanche risk based on one single stated behaviour, let alone observed behaviour in an OB setting. To achieve the goal of identifying high-risk OB skiers, a novel approach was utilized, which accommodated the multidimensional characteristics of the avalanche hazard mitigation among OB skiers. By examining a range of behaviours and characteristics related to risk taking and exposure mitigation though an online survey, respondents could be segmented along three indicators of avalanche risk. This use of multiple indicators was a critical component of the research since it facilitated an investigation of a complex risk environment that cannot be adequately examined through a single behaviour or characteristic. Creating a matrix that integrated these three indicators was an important final step as it resulted in a comprehensive assessment of overall risk, which allowed comparison between subpopulations and characterization of the high-risk segment.

It is unlikely that the management implications suggested by this research would have been apparent without completing this comprehensive assessment and segmentation. This approach could be adapted to different circumstances, and may prove useful in the identification and classification of high-risk subpopulations for other activities where single behavioural characteristics do not allow a comprehensive picture of risk taking behaviour.

5.5 Limitations

Due to the recruitment strategy used for the online survey in this research, the respondents cannot be considered a representative sample of all OB skiers. The survey was promoted through a variety of websites and email lists; however, it is probable that the sample may be biased towards individuals more committed to OB skiing and thus more likely to spend time visiting skiing themed websites. Furthermore, avalanche awareness surveys are more likely to be visited by particiapants with an already existing interest in avalanche safety. Occasional OB skiers with a low degree of avalanche awareness may have been less likely to find their way to the online survey. This possibility is supported by the low proportion of individuals who self identified themselves at a less developed stage on the OB Precaution Adoption Process Model. To identify possible biases within the online survey, an intercept survey was conducted. While the intercept survey cannot be considered a true representative sample for a number of reasons, it is likely a better representation of the OB skiing population than the online survey and is therefore useful as a comparison to the online survey OB skiing population.

To assess potential biases in the results of the online survey, a number of different comparisons were conducted as part of the intercept survey analysis. First, responses of individual who completed both the online and intercept survey were compared to assess possible compliance biases. Second, responses to online survey questions were examined in relation to recruitment method (intercept survey versus web promotion) to assess possible self selection biases. Possible self selection biases were also assessed through comparison of intercept survey responses between individuals who completed the online survey and those who did not.

A variety of conclusions can be draw from the results of the verification analysis. Comparison of responses from individuals who completed both surveys suggests that online respondents may have a tendency to overstate their safety behaviour. Results from the comparison of the complete intercept and online samples suggest that the intercept population (the more representative sample of the true OB skier population) has less experience and training and are less likely to carry safety gear and check the avalanche bulletin than the online survey population. Comparing intercept responses suggests those respondents who completed the online survey were more likely to be low-risk OB skiers than those who did not complete the online survey. Similarly, comparison by recruitment method indicates that respondents of the online survey who were recruited through online promotion (the recruitment method for the bulk of the online respondents) were more likely to be low-risk OB skiers than those recruited through the intercept survey. This may be due to a self-selection bias, in which OB skiers who are more

engaged in the activity, and possibly more engaged in avalanche safety, are more likely to visit websites with OB related content and encounter the online postings. In this scenario, less engaged OB skiers who may consequently be less aware or less able to mitigate avalanche hazard, may be less likely to spend time visiting OB related websites where the OB survey was promoted. While these higher-risk OB skiing individuals may not be as likely to complete the online survey, they make up a considerable proportion of the OB skiing population as reflected in the intercept survey. Based on the results of the verification analysis I can extrapolate that the overall OB skiing population is likely to contain more individuals who would be classified as high-risk than the online survey suggest. The actual proportion of high-risk OB skiers is therefore likely higher than the suggested 8.0% found among online survey participants. More details from these comparisons and others can be found in Appendix A.

Terrain choices were assessed through the use of a DCE, which presented hypothetical decision situations. Even though terrain images were used to make scenarios as realistic as possible, DCEs are unable to represent the physical and emotional reality of an OB skiing run. While it is inherently difficult to obtain comprehensive revealed preference data on decision-making in avalanche terrain to further validate the results of the stated preference experiment, a number of comparative studies on recreational site choice (Loomis 1993; Haener et al. 2001; Grijalva et al. 2002) and hurricane evacuation behaviour (Whitehead 2005) provide empirical evidence that models based on stated preferences exhibit predictive validity in areas similar to decision situation examined in this study. Furthermore,

List and Gallet (2001) emphasize that if stated preference studies are based on familiar behaviour, their predictive validity typically increases. The successful application of a DCE in the avalanche context by Haegeli et al. (2010) as well as the realistic interpretation of the results in the present study support the conclusion that DCEs offer a meaningful approach for studying decision-making in avalanche terrain in a controlled environment.

6: CONCLUSION

When visitors to ski resorts cross area boundaries and venture beyond into uncontrolled terrain, they are exposing themselves, either wittingly or unwittingly, to the risk of involvement in a serious avalanche incident. A multitude of strategies and choices carried out both on the slope, or in advance, can impact the degree of risk faced by these OB skiers. Variations in behaviour related to this activity result in risk heterogeneity among participants. With the current growth in OB skiing, and ongoing occurrences of heavily publicized avalanche fatalities, the need for an effective avalanche safety health behaviour campaign is evident.

A solid evidence-based foundation is key to the development of a successful health behaviour campaign. To address this initial step, this study examined OB skiing participants using an online survey that incorporated questions regarding behaviour, perceptions and attitudes. Participants were then assessed on three separate dimensions related to avalanche risk: *training and experience*, *risk mitigation practices*, and *terrain choices*. By combining these three indicators, all participants were assigned an overall risk of being involved in an avalanche. Characterizing the members of the high-risk segment facilitated the development of a series of management strategies regarding the development of an OB avalanche safety health campaign.

Important implications drawn from this research include:

- Avalanche bulletin information should be accessible and more prominent to OB skiers.
- Resort boundary policies and signage should be clarified and perhaps standardized.
- High-risk OB skiers should be made aware of potential implications of their behaviour.
- A high level of trust in patrol could be utilized in avalanche safety campaigns.
- The exponential increase in risk as a result of increased avalanche danger ratings should be better communicated to OB skiers.
- Development of self-efficacy related to avalanche hazard assessment and rescue should be a goal of safety programs.
- Safety programs should include skills training focused on safe terrain selection and go-no go decision-making.
- Safety programs should include training in communication and decision-making strategies for use with OB skiing partners.
- Communication designed to reach OB skiers should be dramatic, emotionally powerful or physically arousing, graphic, explicit and unconventional or suspenseful.

Findings from this paper suggest that these strategies will be effective components of an avalanche safety program, given the characteristics of those most at risk of being involved in an avalanche accident.

7: APPENDICES

7.1 Appendix A – Intercept Survey

In order to validate the results of the online survey, an intercept survey was conducted at a number of ski resorts in Western Canada. This section provides an overview of the methods used in the intercept survey as well as an outline of the intercept sample characteristics. The details of the verification analysis are discussed in Appendix D.

7.1.1 Methods

To better understand the relationship of the online survey population to the general OB skiing population, and to assess potential biases in the characteristics of the online survey respondents, an intercept survey was conducted at several ski resorts in Western Canada (Figure 7.1). The specific resorts were chosen due to historical incidences of fatal OB avalanche accidents, or because they are well known areas of high OB skiing activity. All intercept interviews were conducted during the first quarter of 2008 (Table 7.1 for details). In total, fifty-five hours and thirty minutes were spent intercepting out-of-bounds skiers. Intercept surveys were conducted on days where avalanche conditions ranged from low to considerable, where weather conditions ranged from clear to overcast and snowing . The surveys were conducted over a range of days of the week; however the highest volume of skiers were encountered on weekends.

Figure 7.1 Ski resorts (in red) where intercept surveys were conducted.

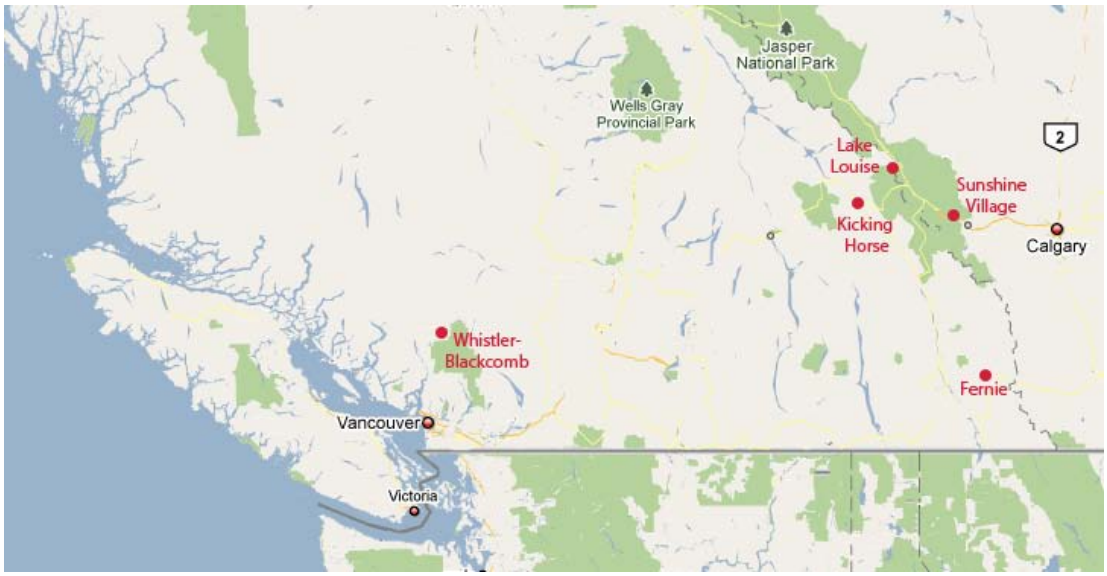


Table 7.1 Locations, dates and conditions where intercept surveys were conducted. BTL = Below Tree Line, L = Low, M = Moderate, C = Considerable; Ratings apply to Alpine-Treeline-Below Treeline).

Date	Resort	Duration Surveyor 1	Duration Surveyor 2	Day	Terrain	CAA Rating	Resort Rating	Weather
06-Jan-08	Whistler	2:50		Sunday	BTL	C-M-L		Snow & Whiteout
12-Jan-08	Sunshine	2:20	1:15	Saturday	All	C-C-M		Sun & Cloud
13-Jan-08	Sunshine	3:35	3:30	Sunday	All	C-C-M		Mostly Cloudy
15-Jan-08	Kicking Horse	2:30		Tuesday	Alpine	C-C-M	C-C-M	Mainly Sunny
16-Jan-08	Kicking Horse	6	2:30	Wed	All	M-C-M	M-C-M	Sun & Cloud
18-Jan-08	Lake Louise	2		Friday	All	C-C-M		Sun & Cloud
19-Jan-08	Lake Louise	5:15		Saturday	All	C-C-M		Cloudy & Whiteout
20-Jan-08	Lake Louise	5:15		Sunday	All	C-C-M		Sunny
17-Feb-08	Blackcomb	6:15		Saturday	Alpine	C-M-M	M-L-L	Sunny
02-Mar-08	Blackcomb	3:30		Sunday	Alpine	C-M-L	M-M-L	Sun & Cloud > Whiteout
15-Mar-08	Fernie	2:20		Saturday	BTL	C-C-C	C-C-C	Cloud, Snow & Whiteout
16-Mar-08	Fernie	5:15		Sunday	BTL	C-C-M	C-C-M	Sun & Cloud
17-Mar-08	Fernie	1		Monday	BTL	C-C-C	C-C-C	Snow & Whiteout

Survey locations were at exit or re-entry points from the ski resort areas to popular OB runs accessible by lifts (see Appendix B for trail map of survey locations). All individuals passing the survey location were questioned about their destination; anyone heading to an OB ski run, as opposed to a backcountry destination, was asked to complete a survey (see Appendix C for survey questions). Interviewers intercepted the maximum number of OB skiers possible by targeting important out-of-bounds entry and exit points, and by approaching all individuals passing through these locations.

The intercept survey was split into two parts: one part was given to participants to be filled out individually, the other part, concerning group composition and behaviour was completed through an interview process with the entire group. The individual survey contained questions about demographics, avalanche education and experience, safety equipment, avalanche skills and decision-making, self-efficacy and previous avalanche involvement. The group component of the survey included questions about group size and composition, destination, public avalanche bulletin recall, group decision-making, safety equipment practice and avalanche involvement. Together, the two components of the intercept survey covered all topics that were used in the online survey to segment respondents along two of the three dimensions of avalanche safety: *training and experience*, and *risk mitigation practices*.

During times of bad weather, OB skiers were interviewed at gondola stations (Sunshine Village, Kicking Horse and Whistler-Blackcomb) for a total of eight hours and thirty minutes. The primary goal of these intercepts was to recruit individuals for participation on the online survey; however, the skiers were also asked to fill out the personal section of the intercept survey. The information collected at gondola stations was not used in the verification analysis.

To limit any sampling biases intercept surveys were conducted at a variety of resorts, at various times of the week and year, and in different weather and avalanche conditions. Despite these efforts, there are several limitations that may have affected the representativeness of the study sample. Only a small number of resorts in Western Canada were visited and for the most part, each resort was only visited at one time during the ski season. It is reasonable to assume that OB activity varies significantly during different times of the year, under different avalanche and weather conditions and during different days of the week. In addition, a selection bias may exist regarding the respondents that participated in the survey; some OB skiers were not interested in answering survey questions and the characteristics of these individuals are unknown. Because of the above-mentioned limitations, the population of the intercept survey has to be viewed as a convenience sample and

cannot be interpreted as a true representative sample of the general OB skier population. However, the sample does provide a meaningful first approximation for examining potential biases in the online survey sample.

7.1.2 Characteristics of Intercept Sample

7.1.2.1 Demographics

A total of 422 respondents were intercepted. Respondents were predominantly male with a median age of 27. Most respondents were from either the United States or Canada (Table 7.2).

Table 7.2 Demographic characteristics of intercept survey population.

Variable			%
Demographics			
	Gender		n = 418
		Male	88.5%
		Female	11.5%
	Age		n = 414
		Mean	29.0
		SD	9.3
		Median	27
		IQR	10
	Nationality		n = 422
		Canada	81.3%
		USA	9.2%
		Norway	2.1%
		Sweden	1.2%
		UK	1.2%
		Other	5.0%

7.1.2.2 Training and Experience

Avalanche education levels were low; almost two thirds of respondents had no formal training. Respondents had considerable skiing experience; most participants had 6 or more years of experience. The most common (89.5%) experience level for OB skiing was 6 or more years and almost three quarters (74.9%) of respondents had some backcountry skiing experience (Table 7.3).

Table 7.3 Training and experience characteristics of intercept survey population.

Variable			%
Training - Highest Avalanche Education			n = 422
		No Training	59.2%
		Seminar	14.2%
		Introductory Course	21.1%
		Advanced Course	5.5%
Experience			
	Skiing Experience		n = 409
		First Year	0.0%
		1-2 Years	1.7%
		3-5 Years	8.8%
		6+ Years	89.5%
	OB Experience		n = 403
		First Year	7.5%
		1-2 Years	22.6%
		3-5 Years	23.9%
		6+ Years	54.3%
	Backcountry Experience		n = 406
		None	26.1%
		First Year	4.9%
		1-2 Years	17.5%
		3-5 Years	18.7%
		6+ Years	32.8%

7.1.2.3 OB Behaviour

The most commonly used equipment for travel in OB terrain was downhill equipment (45.2%) and snowboards (39.1%). While 40% of respondents stated they had checked the avalanche bulletin, few (14.4%) were able to accurately recall all three bulletin ratings. Less than half of those surveyed (46.7%) carried an avalanche beacon; use of other safety equipment was even lower. Almost one third of respondents (32.1%) reported having triggered an avalanche that could bury or kill someone (Table 7.4).

Table 7.4 OB behaviour characteristics of intercept survey population.

Variable			%
	Travel Equipment Used (Group)		n = 471
		Downhill Equipment	45.2%
		Snowboard	39.1%
		Telemark	4.5%
		AT	11.3%
		Splitboard	0.0%
Risk Mitigation			
	Bulletin Use		n = 355
		Reported Having Checked	40.0%
		Claimed Could Recall	36.9%
		Could Recall 1 Rating	28.7%
		Could Recall 2 Rating	21.1%
		Could Recall 3 Rating	14.4%
	Proportion of Equipped Respondents		n = 422
		Beacon	46.7%
		Shovel	38.9%
		Probe	32.2%
		Cell Phone	61.1%
		Avalung	1.4%
		ABS Pack	0.0%
Avalanche Involvement			n = 410
		Yes	32.1%
		No	65.3%

7.2 Appendix B – Intercept Survey Locations

Figure 7.2 Whistler Mountain intercept survey location.

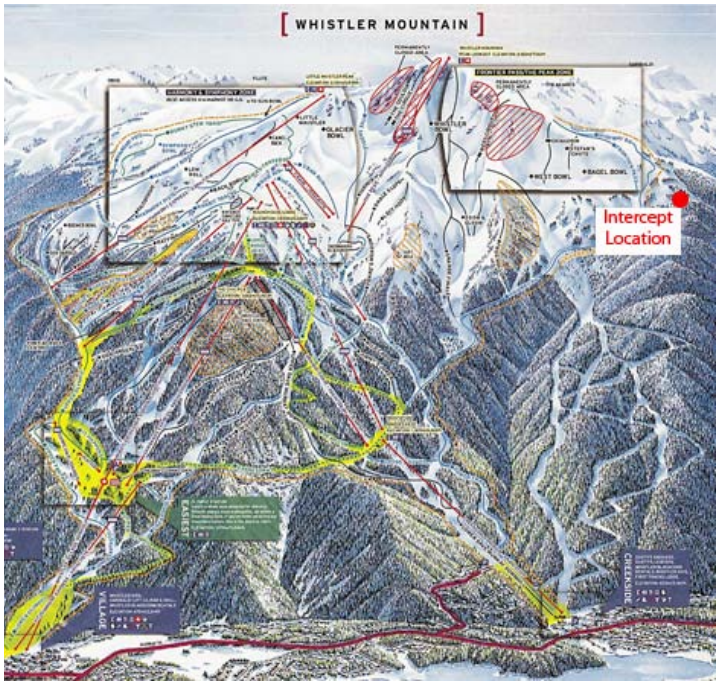


Figure 7.3 Blackcomb intercept survey location.

Figure 7.4 Sunshine Village intercept survey location.

Figure 7.5 Lake Louise intercept survey location.

Figure 7.6 Fernie Alpine Resort intercept survey location.

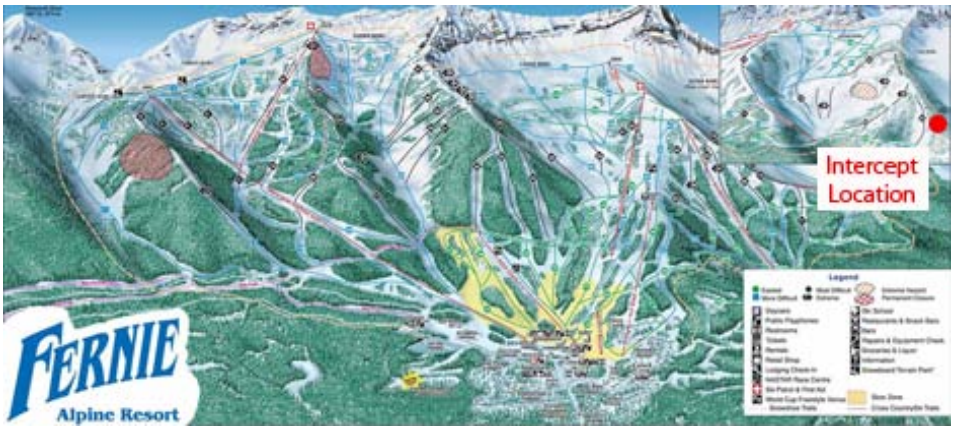


Figure 7.7 Kicking Horse Mountain Resort intercept survey location.

7.3 Appendix C – Intercept Survey

Figure 7.8 Personal interview section.

www.avalanche.ca

TODAY

SFU

Version 080114

OUT-OF-BOUNDS INTERCEPT SURVEY 2008

We would like to inform you that this survey has been approved by the SFU Research Ethics Board. By filling out this questionnaire, you are consenting to participate. Your participation is completely voluntary, you may refuse to answer any one question, or you may terminate the survey at any time. Your responses will be treated completely confidential, and not released to any other parties. If you have any further questions please contact Dr. Hal Weinberg, Director, Office of Research Ethics at 778-782-3447 or hal_weinberg@sfu.ca.

PERSONAL BACKGROUND

1. Gender ○ Female ○ Male → 2. Age ____ years

3. Current residence City/Town: _____ Prov./State: _____ Country: _____

4. How many years have you been skiing/riding in total? ○ First ○ 1-2 ○ 3-5 ○ 6+ years

5. **Out-of-bounds Skiing/Riding:** Accessing uncontrolled slopes outside the ski area boundary using ski lifts.
   How many years have you been skiing/riding out-of-bounds? ○ First ○ 1-2 ○ 3-5 ○ 6+ years
   On average, how many days do you ski/ride at a resort each winter? ○ 1-5 ○ 6-15 ○ 16-30 ○ 31+ days
   ↳ Of those, on how many days do you go out-of-bounds? ○ 1-5 ○ 6-15 ○ 16-30 ○ 31+ days

6. Have you ever used climbing skins, snowshoes or a snowmobile to access skiing or riding terrain? ○ Yes ○ No
   ↳ If yes: How many years of experience do you have backcountry skiing/riding? ○ First ○ 1-2 ○ 3-5 ○ 6+ years
   On average, how many days do you backcountry ski/ride each winter? ○ 1-5 ○ 6-15 ○ 16-30 ○ 31+ days

7. When you go out-of-bounds, how often do you consider avalanche hazard? (circle one number)
   0 (Never) 10 20 30 40 50 (Sometimes) 60 70 80 90 100 (Always)

8. Please rate your confidence in your ability…
   …to recognize situations in which you are likely to trigger an avalanche? (circle one number)
   0 (Cannot do at all) 10 20 30 40 50 (Moderately can do) 60 70 80 90 100 (Highly certain can do)
   …to locate and rescue a partner who is completely buried by an avalanche? (circle one number)
   0 (Cannot do at all) 10 20 30 40 50 (Moderately can do) 60 70 80 90 100 (Highly certain can do)
   …to talk your partners out of skiing/riding a slope that you personally think is dangerous? (circle one number)
   0 (Cannot do at all) 10 20 30 40 50 (Moderately can do) 60 70 80 90 100 (Highly certain can do)

9. What are the sources of your avalanche knowledge? (check all that apply)
   ☐ Friends ☐ Internet/books ☐ 2-3 day course (AST1, IRAC) ☐ 4-5 day course (AST2, ARAC)
   ☐ Avalanche professional friends ☐ Awareness seminar ☐ Other: _____

10. What safety equipment do you have with you today? (check all that apply)
    ☐ Avalanche transceiver (beacon) ☐ Shovel ☐ Collapsible probe ☐ Cell phone ☐ Avalung ☐ Balloon pack
    If you have a beacon, when was the last time you practiced searching with it?
    ○ This winter ○ Last winter ○ Years ago ○ Never

11. Have you or somebody you were with ever triggered an avalanche that could have buried or injured someone? ○ Yes ○ No

12. Have you or somebody you were with ever been caught in an avalanche? ○ Yes ○ No

ONLINE SURVEY PARTICIPATION

We are currently developing an online survey that examines out-of-bounds skiing/riding and avalanche safety in more detail. If you would like to participate in our study, please provide us with your email address and we will send you a message when the survey is ready. Online survey participants will be eligible for draw prizes. We will only use your email address to inform you when the survey is ready and to contact you if you won one of the draw prizes.

Email: _____

PLEASE PRINT CLEARLY!

To be filled out by interviewer:

1. Date: _____ 2. Resort: _____ 3. Interviewer: _____ 4. DM: ○ Yes ○ No 5. ID: _____

4. Location: ○ OB gate _____ ○ Lift line _____ ○ Other _____ 5. Group: _____

Figure 7.9 Group interview section.

Version 080114

GROUP INTERVIEW ABOUT OUT-OF-BOUNDS SKIING/RIDING TODAY

1. Has this group already skied/ridden this out-of-bounds run today?
   O Yes, this group has already skied/ridden this out-of-bounds run today. O No, the group is about to ski/ride this out-of-bounds run.
2. How many people are skiing/riding out-of-bounds in your group today? _____
3. How often do you ski/ride together out-of-bounds?
   O Regularly O Occasionally O For the first time today
4. What gear are you skiing/riding today? ___ Downhill ___ Snowboard ___ Telemark ___ Alpine touring ___ Splitboard
5. Where are you skiing/riding out-of-bounds today?
   Run/Area name: _____
6. What is your primary activity on that run?
   O Skiing/riding a run O Building a kicker O Other: _____
7. How many people in your group have skied/ridden this run before today?
   O All O Most O Half O Few O None
   If None, how would you describe the level of terrain knowledge of the group?
   O Do not know the run at all O Have heard/read a description O Have seen the run from a distance
8. How would you describe the most serious out-of-bounds terrain you exposed/are about to expose yourself on this run?

Main character (choose one)	*Steepness*	*Approx. size of open slopes*	*Options to exit the run and go into more mellow terrain*	*Features below route* (check all that apply)
O smooth open slopes	O blue run	O small (~10m wide)	O non-existent (you had to fully commit)	☐ cliffs
O rocky chutes	O black run	O interm. (~30m wide)	O limited to a few locations	☐ crevasses
O broad ridges	O dbl-black run	O large (~100m wide)	O unlimited along the entire run	☐ gullies/depressions
O open trees/glades				☐ trees
O tree skiing/riding				

9. How often do people ski/ride this specific terrain?
   O Gets completely tracked out after every snowfall O People ski/ride this run occasionally.
   O People ski/ride this run regularly. O This run only gets skied/ridden every couple of years
10. How many people in your group checked the public avalanche bulletin or any local avalanche information postings prior to skiing/riding out-of-bounds O All O Most O Few O None
    If any of you checked, have you discussed avalanche conditions among your group? O Yes O No
    If any of you checked, do you remember the avalanche danger ratings? O Yes O No
    Please specify: Alpine: _____ Treeline: _____ Below treeline: _____
    If any of you checked, do you remember any details from the bulletin text? O Yes O No
    Please describe: _____
11. Which of the following best describes the person(s) who generally made the travel decisions in your group on that day?
    O We all make our decisions individually O Person most familiar with the area
    O Best skier or rider O Most experienced out-of-bounds skier/rider
    O Person with highest level of avalanche safety training O Everybody in the group contributes
    O Person at the front of the group O Other: _____
12. If your group is carrying beacons, have you checked transmit and receive functions today (beacon check)? O Yes O No
★ 13. Have you or somebody in your group triggered an avalanche that could have buried or injured someone today? O Yes O No
14. Comments:

To be filled out by interviewer:

1. Date: _____ 2. Resort: _____ 3. Interviewer: _____ 4. Did DM fill out survey: O Yes O No

4. Location: O OB gate _____ O Lift line _____ O Other _____ 5. Group: _____

7.4 Appendix D – Verification

Data collected through the intercept surveys were used to verify the results of the online survey in four ways.

1. A comparison of the responses from individuals who completed both the intercept survey and the online survey. This assessed the potential biases in the online responses provided by individuals and helped to identify systematic discrepancies between stated and revealed behaviour.
2. A comparison of the entire online sample population against the entire intercept population. This assessed biases that could be attributed to the survey instrument.
3. A comparison of intercept survey participants by online survey participation. This assessed potential biases within the group of intercept participants who chose to complete the online survey as opposed to those who chose not to complete the online survey.
4. A comparison of online responses based on the two recruitment method (intercept vs. online promotion). This assessed the type of respondents who participated in the online survey to identify whether there was a selection bias in the online sample.

7.4.1 Methodology

Indicators used for verification included age, gender, years of experience, self-efficacy, use of the avalanche bulletin, avalanche training, avalanche safety equipment used, past avalanche involvement, group size, and travel equipment used. Indicators were examined for significant differences between the two respective groups using t-tests for normally distributed numeric data, Wilcoxon rank-sum tests for non-normally distributed numeric data and ordinal data, and Pearson's chi-square test for categorical data. A p-value <0.05 was used to reject the null hypothesis that the characteristics of the two populations were the same.

7.4.2 Results

7.4.2.1 Comparison of Select Responses by Individuals Who Completed the Intercept and Online Surveys

To assess the validity of information provided by online survey participants, I compared responses from a subset of individuals (n=71) who completed both the online survey and the intercept survey. A number of stated preferences and behaviours from the online survey were compared to the revealed preferences and behaviours from the intercept survey (Tables 7.5 and 7.6). These preferences and behaviours include equipment use, group size, avalanche education, checking the avalanche bulletin, decision-making processes, hazard consideration, self-efficacy and previous avalanche involvement. Of the group that completed both surveys group, 60 provided answers to intercept survey questions pertaining to the group that they were travelling with in OB terrain.

Table 7.5 Comparison of responses by individuals who completed intercept survey and web survey: part 1.

Variable	Test		Intercept	Online	P-Value
			%	%	
Gender			n = 70		
	Chi Squared	Female	24.3%	25.7%	1
		Male	75.7%	74.3%	
Age			n = 70		
	Wilcoxon rank sum	Under 20	3.0%	4.3%	0.62
		20-24	11.0%	15.7%	
		25-34	43.0%	61.4%	
		35-44	7.0%	10.0%	
		45-54	6.0%	8.6%	
		55+	1.0%	1.4%	
Travel Gear			n=162	n=224	
	Chi Squared	Downhill Skis	46.3%	59.3%	0.32
		Snowboard/Split	31.5%	37.7%	
		Telemark	4.3%	5.6%	
		AT	17.9%	35.8%	
Ski Experience			n = 68	n =71	
	Wilcoxon rank sum	First Year	0.0%	0.0%	0.94
		1-2 Years	1.5%	1.4%	
		3-5 Years	7.4%	7.0%	
		6+ Years	91.2%	91.5%	
OB Experience			n = 69	n =71	
	Wilcoxon rank sum	First Year	10.1%	11.3%	0.89
		1-2 Years	20.3%	15.5%	
		3-5 Years	21.7%	25.4%	
		6+ Years	47.8%	47.9%	
Backcountry Experience			n = 55	n =57	
	Wilcoxon rank sum	First Year	10.9%	14.0%	0.62
		1-2 Years	16.4%	17.5%	
		3-5 Years	27.3%	26.3%	
		6+ Years	45.5%	42.1%	
Avalanche Education			n = 71		
	Pearson's Chi-squared	Seminar	32.4%	35.2%	0.86
		Introductory Course	35.2%	43.7%	0.39
		Advanced Course	8.5%	22.5%	0.04
Avalanche Equipment			n = 71		
Carried	Pearson's Chi-squared	Beacon	71.8%	74.6%	0.85
		Shovel	59.2%	70.4%	0.22
		Probe	50.7%	62.0%	0.24
		Phone	69.0%	69.0%	0.86
		Avalung	2.8%	2.8%	0.61
		ABS Pack	0.0%	0.0%	1
Check Avalanche Bulletin			n = 60	n =71	
	Pearson's Chi-squared	Claim Check Bulletin	53.3%	95.8%	< 0.001
			n = 60	n =60	
		Recall 1 Correct	33.3%	96.7%	< 0.001
		Recall 2 Correct	23.3%	96.7%	< 0.001
		Recall 3 Correct	20.0%	96.7%	< 0.001
Decision Making			n = 55	n =69	
	Wilcoxon rank sum	Individual	0.0%	2.9%	0.43
		Person In front	0.0%	1.4%	
		Distinct leader	30.9%	18.8%	
		Everyone Contributes	69.1%	76.8%	
Avalanche Involvement			n =71	n =71	
	Pearson's Chi-squared	Yes	40.8%	33.8%	0.49
		No	59.2%	66.2%	

Table 7.6 Comparison of responses by individuals who completed intercept survey and web survey: part 2.

Variable	Test		Intercept		Online		P-Value
# of Group Members			n =71		n =71		
	Wilcoxon rank sum	1	22.5%		2.8%		< 0.001
		2	38.0%		25.4%		
		3	26.8%		33.8%		
		4	11.3%		26.8%		
		5+	1.4%		11.3%		
			Median	IQR	Median	IQR	
			2	1	3	2	
Consider Avalanche Hazard			n = 60		n = 71		
	paired t-test		median	IQR	median	IQR	
			90	10	90	20	0.12
Self Efficacy			n = 70		n = 71		
			Median	IQR	Median	IQR	
	paired t-test	Recognize Avalanche Hazard	70	20	70	20	0.74
		Rescue Partners from Burial	70	40	70	40	0.80
		Talk Partners out of a Run	80	30	80	20	0.36

Significant differences at the $p<0.05$ significance level were present in responses regarding:

Group Size - Online participants stated that they travelled in larger groups than observed in the intercept. In the online survey, the median group size was 3; however, in the intercept survey groups were smaller and the median size was 2.

Advanced Training - Online participants were more likely to say they had taken an advanced avalanche course.

Avalanche Bulletin Use - Online participants stated that they checked the public avalanche bulletin more than the intercept indicated. In the online survey 95.8% of individuals who completed both surveys stated that they checked the avalanche bulletin; however, during the intercept survey just over half of those who completed group questions on the online and intercept survey said they had checked the bulletin that day. Of the individuals who completed the group questions, only a third could recall the avalanche hazard rating for one terrain type and only 20.0% could recall all three.

7.4.2.2 Complete Sample Comparison

To assess how the online survey population compared to the actual OB skiing population, responses from participants in the intercept survey and the online survey were compared. (Tables 7.7and 7.8).

Table 7.7 Comparison of responses between the complete online survey population and the complete intercept survey population: part 1.

Variable	Test		Intercept	Online	P-Value
			%	%	
Gender			n=418	n=1424	
	Chi Squared	Female	11.5%	9.1%	0.17
		Male	88.5%	90.9%	
Age			n=414	n=1435	
	Wilcoxon rank sum	Under 20	10.4%	11.2%	<0.001
		20-24	22.9%	15.5%	
		25-34	46.4%	43.3%	
		35-44	11.1%	17.7%	
		45-54	7.5%	8.9%	
		55+	1.7%	3.4%	
Travel Gear			n = 1024	n =4509	
	Chi Squared	Downhill Skis	46.7%	28.1%	<0.001
		Snowboard/Split	42.3%	20.4%	
		Telemark	2.5%	16.8%	
		AT	8.5%	34.7%	
Ski Experience			n =409	n =1437	
	Wilcoxon rank sum	First Year	0.0%	0.4%	0.24
		1-2 Years	1.7%	0.8%	
		3-5 Years	8.8%	7.4%	
		6+ Years	89.5%	91.4%	
OB Experience			n =403	n =1437	
	Wilcoxon rank sum	First Year	6.9%	6.5%	0.38
		1-2 Years	20.8%	15.5%	
		3-5 Years	22.1%	27.8%	
		6+ Years	50.1%	50.2%	
Backcountry Experience			n =300	n =1317	
	Wilcoxon rank sum	First Year	6.7%	11.4%	0.51
		1-2 Years	23.7%	18.1%	
		3-5 Years	25.3%	27.9%	
		6+ Years	44.3%	42.5%	
Any Backcountry			n =412	n =1425	
Experience	Pearson's Chi-squared	Yes	74.5%	92.4%	<0.001
		No	25.5%	7.6%	
Avalanche Education			n = 422	n =1437	
	Pearson's Chi-squared	Seminar	22.3%	43.4%	<0.001
		Introductory Course	22.5%	47.3%	<0.001
		Advanced Course	5.5%	24.8%	<0.001
Avalanche Equipment			n = 422	n =1437	
Carried	Pearson's Chi-squared	Beacon	46.7%	78.6%	<0.001
		Shovel	38.9%	82.5%	<0.001
		Probe	32.2%	75.9%	<0.001
		Phone	61.1%	70.8%	<0.001
		Avalung	1.4%	15.0%	<0.001
		ABS Pack	0.0%	0.9%	0.10
Check Avalanche Bulletin			n = 355	n =1437	
	Pearson's Chi-squared	Claim Check Bulletin	40.0%	94.1%	<0.001
		Recall 1 Correct	28.7%	94.1%	<0.001
		Recall 2 Correct	21.1%	94.1%	<0.001
		Recall 3 Correct	14.4%	94.1%	<0.001
Decision Making			n = 317	n =1372	
	Wilcoxon rank sum	Individual	0.0%	3.1%	<0.001
		Person In front	0.0%	0.8%	
		Distinct leader	44.2%	13.1%	
		Everyone Contributes	55.8%	82.9%	
Avalanche Involvement					
	Pearson's Chi-squared	Yes	32.7%	40.6%	<0.01
		No	67.3%	59.4%	

Table 7.8 Comparison of responses between the complete online survey population and the complete intercept survey population: part 2.

Variable	Test		Intercept		Online		P-Value
# of Group Members			n = 407		n = 1437		
	Wilcoxon rank sum	1	20.1%		3.6%		
		2	34.2%		23.0%		
		3	28.3%		38.5%		
		4	11.5%		26.0%		
		5+	5.9%		8.8%		
			Median	IQR	Median	IQR	
			2	1	3	2	< 0.001
Consider Avalanche Hazard			n =332		n =1436		
	paired t-test		Median	IQR	Median	IQR	< 0.01
			100	20	100	20	
			Mean		Mean		
			83.4		88.0		
Self Efficacy			n = 420		n = 1437		
			Median	IQR	Median	IQR	
	paired t-test	Recognize Avalanche Hazard	70	30	70	20	< 0.001
		Rescue Partners from Burial	60	40	80	30	< 0.001
		Talk Partners out of a Run	80	30	80	20	< 0.001

The following variables demonstrated significant differences at the $p<0.05$ significance level between the two samples:

Age - Intercept participants had a larger proportion of younger respondents
Travel Gear - The intercept survey had a larger proportion of people travelling on downhill skis and snowboards.
Group Size - The median group size of the intercept population was 2, which was smaller than the online median population.
Backcountry Experience - Fewer participants of the intercept survey had any backcountry experience; approximately three quarters of the online survey had been backcountry skiing.
Avalanche Training - The intercept survey participants had considerably less formal training, and fewer intercept participants carried beacons, probes and shovels.
Avalanche Bulletin Use - Fewer intercept participants reported checking the public avalanche bulletin and far fewer could recall the bulletin ratings.
Decision-Making - More intercept parties reported having a distinct leader who handled decision-making. The intercept population reported considering avalanche hazard less frequently.
Self-Efficacy - Self-efficacy of the intercept population was lower for all three variables: confidence in their ability to recognize situations they are likely to trigger an avalanche, confidence in their ability to rescue a partner who is completely buried by an avalanche, and confidence in their ability to talk partners out of skiing a slope they think is dangerous.
Avalanche Involvement - Reported previous avalanche involvement of intercept participants was lower than reported by online participants.

7.4.2.3 Comparison of Intercept Respondents by Online Survey Participation

To assess the self-selection bias in the online survey population, the intercept survey responses of online survey participants were compared to the intercept survey responses of intercept survey participants who did not complete the online survey (Tables 7.9 and 7.10).

Table 7.9 Comparison of intercept survey responses by participation in the online survey: part 1.

Variable	Test		Online Participation	No Online Participation	P-Value
			%	%	
Gender			n =	n =	
	Chi Squared	Female	24.3%	8.9%	<0.001
		Male	75.7%	91.1%	
Age			n =	n =	
	Wilcoxon rank sum	Under 20	4.3%	11.6%	0.21
		20-24	20.0%	23.5%	
		25-34	57.1%	44.2%	
		35-44	8.6%	11.6%	
		45-54	8.6%	7.3%	
		55+	1.4%	1.7%	
Travel Gear			n =	n =	
	Chi Squared	Downhill Skis	46.3%	46.8%	0.43
		Snowboard	31.5%	44.3%	0.54
		Telemark	4.3%	2.2%	0.28
		AT	17.9%	6.7%	<0.001
Ski Experience			n = 68	n = 341	
	Wilcoxon rank sum	First Year	0.0%	0.0%	0.62
		1-2 Years	1.5%	1.8%	
		3-5 Years	7.4%	4.8%	
		6+ Years	91.2%	89.1%	
OB Experience			n = 69	n = 334	
	Wilcoxon rank sum	First Year	10.1%	6.3%	0.53
		1-2 Years	20.3%	21.0%	
		3-5 Years	21.7%	22.2%	
		6+ Years	47.8%	50.6%	
Backcountry Experience			n = 55	n = 245	
	Wilcoxon rank sum	First Year	10.9%	5.7%	0.88
		1-2 Years	16.4%	25.3%	
		3-5 Years	27.3%	24.9%	
		6+ Years	45.5%	44.1%	
Any Backcountry			n = 69	n = 343	
Experience	Pearson's Chi-squared	Yes	79.7%	73.5%	0.50
		No	20.3%	26.5%	
Avalanche Education			n = 71	n = 351	
	Pearson's Chi-squared	Seminar	32.4%	20.2%	0.04
		Introductory Course	35.2%	19.9%	<0.01
		Advanced Course	8.5%	4.8%	0.35
Avalanche Equipment			n = 71	n = 351	
Carried	Pearson's Chi-squared	Beacon	71.8%	41.6%	<0.001
		Shovel	59.2%	34.8%	<0.001
		Probe	50.7%	28.5%	<0.001
		Phone	69.0%	59.5%	0.17
		Avalung	2.8%	1.1%	0.59
Check Avalanche Bulletin			n = 60	n = 295	
	Pearson's Chi-squared	Claim Check Bulletin	53.3%	37.3%	0.03
Decision Making			n = 55	n = 262	
	Wilcoxon rank sum	Individual	0.0%	0.0%	0.03
		Person In front	0.0%	0.0%	
		Distinct leader	30.9%	46.9%	
		Everyone Contributes	69.1%	53.1%	
Avalanche Involvement			n = 71	n = 342	
	Pearson's Chi-squared	Yes	40.8%	31.0%	0.14
		No	59.2%	69.0%	

Table 7.10 Comparison of intercept survey responses by participation in the online survey: part 2.

Variable	Test		Online Participation		No Online Participation		P-Value
# of Group Members			n =		n =		
	Wilcoxon rank sum	1	22.5%		19.6%		0.19
		2	38.0%		33.3%		
		3	26.8%		28.6%		
		4	11.3%		11.6%		
		5+	1.4%		6.8%		
			Median	IQR	Median	IQR	
			2	1	2	1	
Consider Avalanche Hazard			n = 71		n = 351		
	paired t-test		Median	IQR	Median	IQR	< 0.01
			100	10	100	30	
			Mean		Mean		
			89.7		82.1		
Self Efficacy			n = 70		n = 346		
			Median	IQR	Median	IQR	
	paired t-test	Recognize Avalanche Hazard	70	20	68	30	< 0.01
		Rescue Partners from Burial	70	40	60	50	< 0.01
		Talk Partners out of a Run	80	30	80	38	0.02

The following variables exhibited significant differences at the $p<0.05$ significance level between the two samples:

Gender – Intercept respondents who participated in the online survey were more likely to be female than those who did not participate in the online survey.
Travel Gear – Intercept respondents who participated in the online survey were more likely to use AT gear while OB skiing than those who did not participate in the online survey.
Avalanche Education – Intercept respondents who participated in the online survey were more likely to have taken an avalanche safety seminar or introductory course than those who did not participate in the online survey.
Avalanche Equipment Carried – Intercept respondents who participated in the online survey were more likely to carry a beacon, shovel or probe than those who did not participate in the online survey.
Avalanche Bulletin – Intercept respondents who participated in the online survey were more likely to have claimed to check the avalanche bulletin than those who did not participate in the online survey.
Decision-Making – Intercept respondents who participated in the online survey were more likely to use a decision-making strategy where everyone in the group contributes than those who did not participate in the online survey.
Consider Avalanche Hazard – Intercept respondents who participated in the online survey stated that they considered avalanche hazard more often than those who did not participate in the online survey.
Self-Efficacy – Intercept respondents who participated in the online survey stated that they were more confident in their abilities to recognize avalanche hazard and rescue partners from a burial than those who did not participate in the online survey.

7.4.2.4 Comparison by Recruitment Method

To assess if a bias exists based on recruitment methods, online survey responses of participants recruited through advertising on websites and forums were compared to the responses of participants recruited through the intercept survey. While not a representative sample, participants recruited through the intercept survey are assumed to be a closer approximation of the OB skiing population than the online survey population (Tables 7.11, 7.12 and 7.13).

Table 7.11 Comparison of online survey responses by recruitment method: part 1.

Variable	Test		Intercept	Web	P-Value
			%	%	
Combined Risk Assessment			n=96	n=1218	
	Wilcoxon rank sum	High	5.2%	7.6%	0.42
		Moderate	31.3%	32.5%	
		Low	63.5%	59.9%	
Education and Training Risk Assignment			n=96	n=1218	
	Wilcoxon rank sum	High	7.3%	8.5%	0.91
		Moderate	58.3%	55.7%	
		Low	34.4%	35.9%	
Risk Mitigation Practices Risk Assignment			n=96	n=1218	
	Wilcoxon rank sum	High	1.0%	3.1%	0.63
		Moderate	8.3%	7.6%	
		Low	90.6%	89.2%	
Terrain Choices Risk Assignment			n=96	n=1218	
	Wilcoxon rank sum	High	6.3%	5.7%	0.45
		Moderate	47.9%	53.1%	
		Low	45.8%	41.1%	

Table 7.12 Comparison of online survey responses by recruitment method: part 2.

Variable	Test		Intercept		Web		P-Value
# of Group Members			n = 100		n = 1337		
	Wilcoxon rank sum	1	2.0%		3.7%		0.49
		2	25.0%		22.9%		
		3	34.0%		38.8%		
		4	27.0%		26.0%		
		5+	12.0%		8.6%		
			Median	IQR	Median	IQR	
			3	2	3	2	
Consider Avalanche Hazard			n =100		n =1336		
	paired t-test		Median	IQR	Median	IQR	0.73
			90	20	100	20	
			Mean		Mean		
			88.5		88.0		
Self Efficacy			n = 100		n = 1337		
			Median	IQR	Median	IQR	
	paired t-test	Recognize Avalanche Hazard	70	20	70	20	0.81
		Rescue Partners from Burial	70	40	80	30	0.32
		Talk Partners out of a Run	80	20	90	20	0.11

Table 7.13 Comparison of online survey responses by recruitment method: part 3.

Variable	Test		Intercept	Web	P-Value
			%	%	
Gender			n=99	n=1325	
	Chi Squared	Female	24.2%	7.9%	<0.001
		Male	75.8%	92.1%	
Age			n=100	n=1335	
	Wilcoxon rank sum	Under 20	4.0%	11.8%	0.64
		20-24	13.0%	15.7%	
		25-34	61.0%	41.9%	
		35-44	11.0%	18.2%	
		45-54	8.0%	8.9%	
		55+	3.0%	3.4%	
Travel Gear			n =319	n = 4190	
	Chi Squared	Downhill Skis	38.6%	27.3%	<0.001
		Snowboard	28.5%	15.5%	<0.01
		Telemark	5.3%	17.6%	0.01
		AT	25.4%	35.4%	0.44
		Split	2.2%	4.1%	0.52
Ski Experience			n =100	n =1337	
	Wilcoxon rank sum	First Year	1.0%	0.4%	0.6
		1-2 Years	1.0%	0.8%	
		3-5 Years	8.0%	7.3%	
		6+ Years	90.0%	91.5%	
OB Experience			n =100	n =1337	
	Wilcoxon rank sum	First Year	10.0%	6.3%	0.62
		1-2 Years	14.0%	15.6%	
		3-5 Years	27.0%	27.8%	
		6+ Years	49.0%	50.3%	
Backcountry Experience			n =100	n =1337	
	Wilcoxon rank sum	First Year	10.0%	6.3%	0.97
		1-2 Years	14.0%	15.6%	
		3-5 Years	27.0%	27.8%	
		6+ Years	49.0%	50.3%	
Any Backcountry			n =100	n =1325	
Experience	Pearson's Chi-squared	Yes	86.0%	92.9%	0.02
		No	14.0%	7.1%	
Avalanche Education			n =100	n =1337	
	Pearson's Chi-squared	Seminar	40.0%	43.6%	0.55
		Introductory Course	46.0%	47.3%	0.88
		Advanced Course	21.0%	25.1%	0.43
Avalanche Equipment			n =100	n =1337	
Carried	Pearson's Chi-squared	Beacon	78.0%	78.6%	0.99
		Shovel	76.0%	83.0%	0.10
		Probe	69.0%	76.4%	0.12
		Phone	70.0%	70.8%	0.95
		Avalung	8.0%	15.6%	0.06
		ABS Pack	1.0%	0.9%	0.66
Check Avalanche Bulletin			n =100	n =1337	
	Pearson's Chi-squared	Claim Check Bulletin	97.0%	93.9%	0.29
Decision Making			n =98	n =1274	
	Wilcoxon rank sum	Individual	2.0%	3.2%	0.1
		Person In front	1.0%	0.8%	
		Distinct leader	20.4%	12.6%	
		Everyone Contributes	76.5%	83.4%	
Avalanche Involvement			n =100	n =1335	
	Pearson's Chi-squared	Yes	30.0%	41.4%	0.03
		No	70.0%	58.6%	

The following variables exhibited significant differences at the $p<0.05$ significance level between the two samples:

Gender – Intercept recruits had a higher proportion of females than online recruits.
Travel Gear - Intercept recruits had a higher proportion of downhill and snowboard gear and a lower proportion of telemark gear.
Any Backcountry Experience - Intercept recruits had a lower proportion of respondents who had backcountry experience.
Avalanche Involvement - Intercept recruits had a lower proportion of respondents who had been involved in an avalanche.

No significant differences were observed in the distribution of high, moderate and low-risk takers according to the combined assessment, nor were significant differences observed in the distribution between the three risk levels for the three indicators of avalanche risk: *training and experience*, *risk mitigation practices*, and *terrain choices* (Table 7.17).

7.4.3 Discussion

7.4.3.1 Comparison of Select Responses by Individuals Who Completed the Intercept and Online Surveys

Comparison of the responses from individuals who completed both surveys indicates that most answers provided in the online survey can be viewed as accurate. The three areas where significant differences existed were: completion of advanced avalanche training, checking the avalanche bulletin prior to OB skiing, and group size. For all three variables, stated behaviours in the online survey were more 'by the book' and involved less risk taking than revealed behaviour in the intercept survey.

In the online survey respondents reported higher levels of training than they did in the intercept survey. It is possible that this discrepancy was due to course completion in the time between the two surveys. Stated checking of the avalanche bulletins was high among online respondents and considerably lower during the intercept survey. In the online survey, the median group size was three, a size that provides a good possibility of self-rescue in the event of an avalanche. The median group size of two in the intercept survey provides less opportunity for companion rescue in the event of an avalanche accident.

The results from the verification of these responses indicate that, in reality, individuals who completed both surveys exhibit higher risk behaviour than stated in the online survey. This observation hints at the possible presence of a compliance bias in the online responses. A conclusion about the nature of these discrepancies cannot be made; however, possible explanations include a difference between perception of behaviour and actual behaviour, or a misrepresentation of behaviour in the online survey.

7.4.3.2 Complete Comparison

Comparisons of the complete intercept and online survey populations indicate many significant differences between the two groups. A number of these differences are directly related to avalanche risk classification; these include backcountry experience, education, safety equipment carried and checking the avalanche bulletin. In all of these variables, participants of the intercept survey exhibited higher risk behaviour than the behaviours stated by online survey participants. Intercept survey participants were generally younger, more likely to use downhill skis or snowboards, travelled in smaller groups, considered avalanche hazard less, stated lower self-efficacy and had less history of avalanche involvement. These differences parallel the observed differences between the low-risk and high-risk cohorts within the online population.

7.4.3.3 Comparison of Intercept Respondents by Online Survey Participation

Several significant differences were observed between intercept survey respondents who completed the online survey and those who did not. Those who completed the online survey were more likely to have completed avalanche safety training, to carry basic avalanche safety equipment, to claim to have checked the bulletin, and to utilize a decision-making strategy where everyone contributes. These differences suggest that the intercept survey respondents who completed the online survey are more likely to be classified as low-risk OB skiers than those who did not complete the online survey since the pattern of these differences parallel differences between low and high-risk OB skiers within the indicators used to classify survey respondents.

In addition, intercept survey respondents who completed the online survey were more likely to be female, and were more likely to have higher confidence in their abilities to both recognize avalanche hazard and rescue partners from a burial than those who did not participate in the online survey. These differences offer a limited confirmation that the intercept survey respondents who completed the online survey are more likely to be from the low-risk than those who did not complete the online survey OB skiers group since these characteristics are similar to those of the low-risk OB group.

7.4.3.4 Comparison by Recruitment Method

Comparisons of the online survey results by recruitment method indicate few significant differences between the two samples. Two of the variables that do exhibit differences (avalanche involvement and backcountry experience) suggest that the online sample is biased towards the low-risk group. These findings suggest that online survey participants recruited through web promotion are more likely to be low-risk OB skiers than the general OB population.

7.4.4 Conclusion

7.4.4.1 Verification

A variety of conclusions can be draw from the results of the verification analysis. Comparison of responses from individuals who completed both surveys suggests that online respondents may have a tendency to overstate their safety behaviour. Results from the comparison of the complete intercept and online samples suggest that the intercept population (the more representative sample of the true OB skier population) has less experience and training and are less likely to carry safety gear and check the avalanche bulletin than the online survey population. Comparing intercept responses suggests those respondents who completed the online survey were more likely to be low-risk OB skiers than those who did not complete the online survey. Similarly, comparison by recruitment method indicates that respondents of the online survey who were recruited through online promotion (the recruitment method for the bulk of the online respondents) were more likely to be low-risk OB skiers than those recruited through the intercept survey. This may be due to a self-selection bias, in which OB skiers who are more engaged in the activity, and possibly more engaged in avalanche safety, are more likely to visit websites with OB related content and encounter the online postings. In this scenario, less engaged OB skiers who may consequently be less aware or less able to mitigate avalanche hazard, may be less likely to spend time visiting OB related websites where the OB survey was promoted. While these higher-risk OB skiing individuals may not be as likely to complete the online survey, they make up a considerable proportion of the OB skiing population as reflected in the intercept survey. Based on the results of the verification analysis I can extrapolate that the overall OB skiing population is likely to contain more individuals who would be classified as high-risk than the online survey suggest. The actual proportion of high-risk OB skiers is therefore likely higher than the suggested 8.0% found among online survey participants.

7.4.4.2 Bulletin Recall

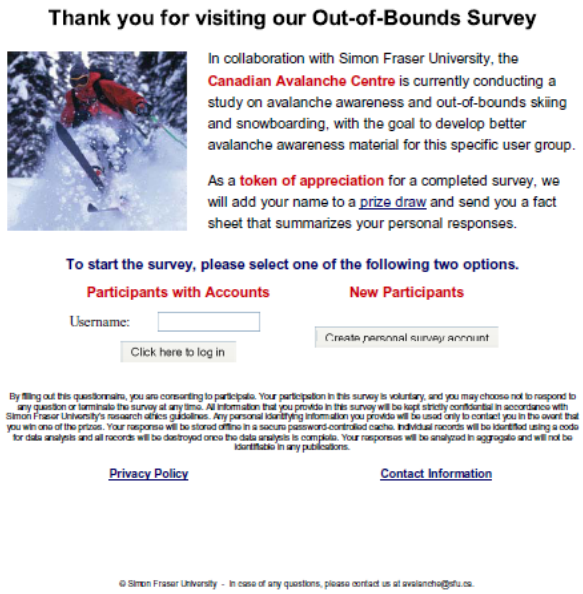
In addition to the intercept survey use in verification, one additional useful conclusion can be drawn from the data. In the intercept survey it is apparent that many intercept survey respondents who claimed to have checked the bulletin were not able to recall danger ratings. This indicates that either respondents were unable to remember the ratings, or that some respondents who claimed to have checked the ratings did not in fact do so.

Generalized OB risk management practices observed in this study are supported by previous research. Kobe and Jenkins (1990) found that 49% of backcountry skiers sought avalanche information before heading into backcountry areas. A comparable number of the OB respondents in this study claimed to have checked the avalanche bulletin, however only 14% could accurately recall several details. Kobe and Jenkins concluded that checking the avalanche bulletin and carrying safety equipment were correlated, a finding that supports the identification of a latent risk management practices indicator. Silverton's (2006) finding that only 26% of OB skiers engaged in minimum safe practices suggests a large proportion of the population exhibit poor mitigation skills. This supports the intercept survey finding that over 60% did not check the bulletin and over 50% did not take a beacon. These findings also support the conclusion that, based on the intercept verification (Appendix 7.1), the true OB skiing population is likely to have a larger proportion of high-risk OB skiers than indicated by the online survey.

This lack of bulletin recall presents a significant problem for good decision-making (Jamieson, 2000; Kurzeder & Feist, 2003) and an important target for an OB safety campaign. Estimates for both Utah and the United States suggest that there is an association between avalanche involvement and failure to check the avalanche bulletin, and that three quarters of avalanche victims have not checked the bulletin (Tremper, 2008). If it is the case that OB skiers interviewed in this survey were over reporting the use of the avalanche bulletin as opposed to simply having forgotten, the discrepancy between reality and statement may reflect knowledge amongst OB skiers that knowing the current avalanche hazard is important. It stands to reason, given the importance of knowing the danger rating, and the low recall exhibited, that bulletin information should be more accessible and more prominent to OB skiers.

7.5 Appendix E – Online Survey Pages

Figure 7.10 Online survey page 1.



Thank you for visiting our Out-of-Bounds Survey

In collaboration with Simon Fraser University, the **Canadian Avalanche Centre** is currently conducting a study on avalanche awareness and out-of-bounds skiing and snowboarding, with the goal to develop better avalanche awareness material for this specific user group.

As a **token of appreciation** for a completed survey, we will add your name to a prize draw and send you a fact sheet that summarizes your personal responses.

To start the survey, please select one of the following two options.

Participants with Accounts

Username:

Click here to log in

New Participants

Create personal survey account

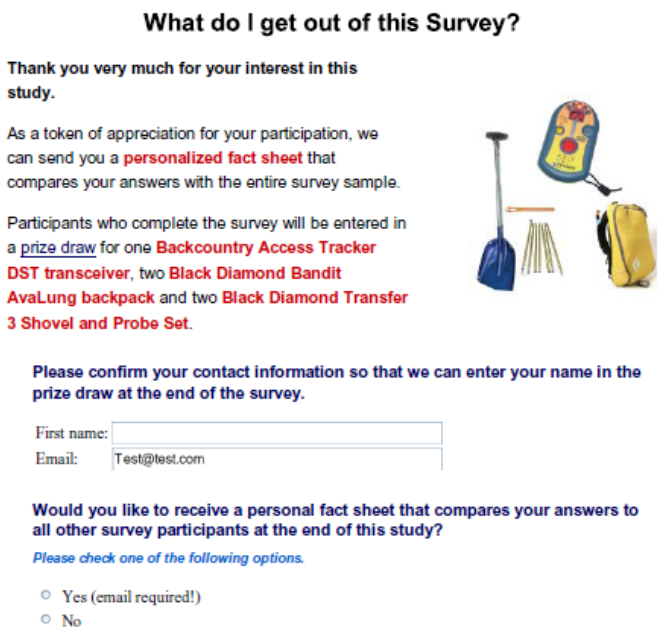
By filling out this questionnaire, you are consenting to participate. Your participation in this survey is voluntary, and you may choose not to respond to any question or terminate the survey at any time. All information that you provide in this survey will be kept strictly confidential in accordance with Simon Fraser University's research ethics guidelines. Any personal identifying information you provide will be used only to contact you in the event that you win one of the prizes. Your response will be stored offline in a secure password-controlled cache. Individual records will be identified using a code for data analysis and all records will be destroyed once the data analysis is complete. Your responses will be analyzed in aggregate and will not be identifiable in any publications.

Privacy Policy

Contact Information

© Simon Fraser University - In case of any questions, please contact us at avalanche@sfu.ca.

Figure 7.11 Online survey page 2.



What do I get out of this Survey?

Thank you very much for your interest in this study.

As a token of appreciation for your participation, we can send you a **personalized fact sheet** that compares your answers with the entire survey sample.

Participants who complete the survey will be entered in a prize draw for one **Backcountry Access Tracker DST transceiver**, two **Black Diamond Bandit AvaLung backpack** and two **Black Diamond Transfer 3 Shovel and Probe Set**.

Please confirm your contact information so that we can enter your name in the prize draw at the end of the survey.

First name:

Email: Test@test.com

Would you like to receive a personal fact sheet that compares your answers to all other survey participants at the end of this study?

Please check one of the following options.

- Yes (email required!)
- No

Figure 7.12 Online survey page 3.

Survey Introduction

This survey will take approximately **20 minutes** to complete and consists of the following five sections.

1. Your Out-of-Bounds Experience
2. Experience of your Out-of-Bounds Partners
3. Interactive **Pick-a-Run Exercise**
4. Ski Resort and Ski Patrol
5. Demographics

Your personal survey username is: **TestA**.
Please write this down for your future reference.

If you get interrupted, you can use your username to log back into the survey at a later time and continue where you had left off.

Please do not use the Back and Forward buttons on your browser when completing the survey.

Figure 7.13 Online survey page 4.

Out-of-Bounds Definition and Gear

First, we would like to review some of the important terms that we will be using throughout this survey.

Out-of-bounds skiing or snowboarding refers to skiing or snowboarding on uncontrolled slopes outside, but close to the ski area boundary primarily using ski lifts and possibly short hikes for access.

Backcountry skiing or snowboarding refers to unguided skiing or snowboarding on uncontrolled slopes in the backcountry away from ski areas. Primary means of access to these slopes are climbing skins, snowshoes or snowmobiles.

Please use these definitions when answering the questions in this survey.

When you go out-of-bounds, what type of gear do you most commonly use?

Please select one of the following options.

- ○ Downhill skis
- ○ Snowboard
- ○ Telemark skis
- ○ Alpine touring skis
- ○ Splitboard

Figure 7.14 Online survey page 5.

Your Out-of-Bounds Experience

How much experience do you have snowboarding ?

Please select the appropriate category in each box.

	Years	Avg. number of days per year
Snowboarding in total	Please select...	
Snowboarding out-of-bounds		
Backcountry snowboarding		
	Years	Avg. number of days per year

In which resorts do you snowboard out-of-bounds the most?

Please select up to three resorts in descending order of importance.

	Country	Resort
1.	Canada	Please select...
2.	Canada	Please select...
3.	Canada	Please select...

Are you or have you been a season or staff pass holder at these resorts?

Please select the appropriate option for each of the resorts.

	Yes	No
1. Resort		
2. Resort		
3. Resort		

Figure 7.15 Online survey page 6.

Your Out-of-Bounds Motivations - 1

Why do you snowboard out-of-bounds?

Please indicate the importance of each of the following statements in explaining why you like to go out-of-bounds.

	Not at all Important		Somewhat Important		Very Important
To find fresh untracked powder.					
To get away from the crowds in-bounds.					
To do something adventurous.					
To test my snowboarding abilities in more challenging terrain.					
To avoid getting bored in-bounds.					
To do something I am not supposed to do.					
To find a place to build a good kicker.					
To get physical exercise.					
To be with my friends.					
To enjoy nature and solitude.					
To impress my friends.					
To see what snowboarding out-of-bounds is all about.					
To be connected to a lifestyle that is important to me.					
To improve my snow assessment and decision-making skills.					
To get good pictures or video of other skiers and snowboarders.					
To engage in an activity that is a big part of who I am.					
	Not at all Important		Somewhat Important		Very Important

Figure 7.16 Online survey page 7.

Your Out-of-Bounds Motivations - 2

Please rate how well the following statements apply to you personally.

Please select one option for each statement.

	Strongly disagree	Disagree	Neither	Agree	Strongly agree
I would like to explore strange places.					
I get restless when I spend too much time at home					
I like to do frightening things.					
I like wild parties.					
I would like to take off on a trip with no pre-planned routes or timetables.					
I prefer friends who are exciting and unpredictable.					
I would like to do bungee jumping.					
I would love to have new and exciting experiences, even if they are illegal.					
	Strongly disagree	Disagree	Neither	Agree	Strongly agree

Figure 7.17 Online survey page 8.

You and Avalanches - 1

Which of the following statements best describes how you think about avalanches when you snowboard out-of-bounds?

Please select the statement that applies most to you.

- I don't generally think about avalanches where I snowboard .
- I know that avalanches can happen in some of the places that I snowboard , but avalanche hazard doesn't really affect the choices I make.
- I worry sometimes that I might get caught in an avalanche. I'd like to learn more about avalanche safety, but haven't had the chance yet.
- I seek out seminars, articles or experienced people so I can learn more about avalanche safety. I plan to take a formal avalanche course soon.
- I have taken a formal avalanche course, but I haven't really applied what I learned.
- I have taken a formal avalanche course, and I practice the skills when I can.
- I have had formal avalanche training and several seasons or more of routinely using route selection, group management, and stability assessment to mitigate avalanche risk.
- I lead groups professionally or guide club trips in avalanche terrain.

Figure 7.18 Online survey page 9.

You and Avalanches - 2

What are the sources of your personal avalanche knowledge?

Please check all options that apply.

- ☐ Friends
- ☐ Friends who are avalanche professionals (e.g., mountain guides, ski patrollers)
- ☐ Books
- ☐ Internet
- ☐ Avalanche awareness seminars (e.g., indoor evening session)
- ☐ 2-3 day introductory avalanche course (e.g., IRAC, AST1)
- ☐ 4-5 day advanced avalanche course (e.g., ARAC, AST2)
- ☐ Professional avalanche course (e.g., CAA Level 1 or 2).
- ☐ Other

How often do you personally use the following information sources to check avalanche conditions before going out-of-bounds?

Please select one option for each statement.

	Never	Sometimes	Most of the time	Always	Not available
Public avalanche bulletin (CAC, USFS, CAIC, NWAC, etc)	○	○	○	○	○
Ski area web site avalanche bulletin	○	○	○	○	○
Postings at info kiosks in-bounds	○	○	○	○	○
Postings at out-of-bounds gates	○	○	○	○	○
Discussion with a ski patroller	○	○	○	○	○

How often do you personally carry the following safety equipment items when going out-of-bounds?

Please select one option for each statement.

	Never	Sometimes	Most of the time	Always
Avalanche transceiver (beacon)	○	○	○	○
Shovel	○	○	○	○
Collapsible probe	○	○	○	○
Cell phone	○	○	○	○
AvaLung	○	○	○	○
Balloon pack	○	○	○	○

Have you or anybody you were snowboarding out-of-bounds with ever triggered an avalanche that could have buried or injured someone?

Please check one of the following options.

- ○ Yes → **How would you best describe the size of the avalanche and your degree of involvement?**
- ○ No

Please select the appropriate option. If you have been involved in several avalanches, please describe the most serious involvement.

Size

Location

Trigger

Involvement

Figure 7.19 Online survey page 10.

You and Avalanches - 3

When you snowboard out-of-bounds, how often do you consider avalanche hazard in your decision-making?

Please select one option.

0 10 20 30 40 50 60 70 80 90 100

Never — Sometimes — Always

Please rate your confidence in your ability ...

... to recognize situations in which you are likely to trigger an avalanche?

Please rate your confidence on a scale from 0 to 100.

0 10 20 30 40 50 60 70 80 90 100

Cannot do at all — Moderately can do — Highly certain I can do

... to locate and rescue a partner who is completely buried by an avalanche?

Please rate your confidence on a scale from 0 to 100.

0 10 20 30 40 50 60 70 80 90 100

Cannot do at all — Moderately can do — Highly certain I can do

... to talk your partner out of skiing or riding a slope that you personally think is dangerous?

Please rate your confidence on a scale from 0 to 100.

0 10 20 30 40 50 60 70 80 90 100

Cannot do at all — Moderately can do — Highly certain I can do

Figure 7.20 Online survey page 11.

You and Avalanches - 4

When you snowboard out-of-bounds, which of the outcomes listed below do you personally consider acceptable, and which ones do you consider to be unacceptable?

Please select one of the two options for each statement.

You or a member of your group...	Acceptable	Unacceptable
... triggers an avalanche.		
... triggers an avalanche and gets taken for a ride.		
... triggers an avalanche and loses/damages some gear.		
... triggers an avalanche and is partially buried.		
... triggers an avalanche and is completely buried.		
... triggers an avalanche and gets minor injuries.		
... triggers an avalanche and gets seriously injured.		
... triggers an avalanche and gets killed.		
	Acceptable	Unacceptable

Figure 7.21 Online survey page 12.

You and Avalanches - 5

In this section we would like to learn a little bit more about how you evaluate your likelihood of getting involved in an avalanche incident during snowboarding out-of-bounds.

The scale for your answers represents the expected number of incidents per year. Here are two examples of how to intepret the numbers:
- '1 every 10 years' means you expect to experience about 1 incident every 10 years.
- '5 per year' means that you expect to experience approximately 5 incidents per year.

As reference points for the small values we inserted the individual likelihoods of getting injured or killed in a car accident for the average driver in British Columbia.

While snowboarding out-of-bounds, how often do you expect that you or a companion would ...

... accidentally trigger an avalanche that has the potential to injure or kill someone?

1 every 100,000 yrs	1 every 10,000 yrs	1 every 1,000 yrs	1 every 100 yrs	1 every 10 yrs	1 every 5 yrs	1 every 2 yrs	1 per year	2 per year	5 per year	10 per year
○	○	○	○	○	○	○	○	○	○	○
	Equivalent to chance of getting killed in a car accident		Equivalent to chance of getting injured in a car accident							

... accidentally trigger an avalanche with the result that someone in your group sustains an injury?

1 every 100,000 yrs	1 every 10,000 yrs	1 every 1,000 yrs	1 every 100 yrs	1 every 10 yrs	1 every 5 yrs	1 every 2 yrs	1 per year	2 per year	5 per year	10 per year
○	○	○	○	○	○	○	○	○	○	○
	Equivalent to chance of getting killed in a car accident		Equivalent to chance of getting injured in a car accident							

... accidentally trigger an avalanche with the result that someone in your group is killed?

1 every 100,000 yrs	1 every 10,000 yrs	1 every 1,000 yrs	1 every 100 yrs	1 every 10 yrs	1 every 5 yrs	1 every 2 yrs	1 per year	2 per year	5 per year	10 per year
○	○	○	○	○	○	○	○	○	○	○
	Equivalent to chance of getting killed in a car accident		Equivalent to chance of getting injured in a car accident							

Figure 7.22 Online survey page 13.

Your Out-of-Bounds Partners

With what type of group do you most commonly go out-of-bounds?

Please select the option that describes your most common out-of-bounds partners best.

- ○ Friends
- ○ Family members
- ◉ Mix of family members and friends
- ○ People you just recently met on the slopes of the resort
- ○ Most of the time, I go out-of-bounds alone.

If you are going out-of-bounds with family members, please describe the family members you most commonly go out-of-bounds with.

Please select all that apply.

- ☐ Spouse/partner
- ☐ Parent(s)
- ☐ Child(ren)
- ☐ Sibling(s)
- ☐ Other family member(s)

When you go out-of-bounds, what is the most common number of people in your group including yourself?

Please fill in the most common (not average) number including yourself.

I most commonly go out-of-bounds with a group of [ ] people (including me).

Figure 7.23 Online survey page 14.

Experience and Training of Your Partners

You mentioned that you most commonly go out-of-bounds in a **group of 3 family members and friends**. Please think of **2 specific family members or friends** with whom you have snowboarded out-of-bounds in the recent past and answer the following questions with these individuals in mind.

To make it easier for you to refer to your individual partners in the following questions, you can name your partners in the first question. This is for your convenience only and the names will not be stored in our database.

What type of gear do your partners normally travel on?

Please select the appropriate option for each group member.

	Downhill skis	Snowboard	Telemark skis	Alpine touring skis	Splitboard	I don't know
Partner 1	○	○	○	○	○	○
Partner 2	○	○	○	○	○	○

How would you best characterize the out-of-bounds experience of your partners?

Please select the experience level for each group member.

	First winter	1-2 winters	3-5 winters	6+ winter	I don't know
Partner 1	○	○	○	○	○
Partner 2	○	○	○	○	○

What level of formal avalanche training have your partners completed?

Please select the highest level for each group member.

	None	Evening Seminar	Online	Introductory 2-3 days	Advanced 4-5 days	Professional level course	Other	I don't know
Partner 1	○	○	○	○	○	○	○	○
Partner 2	○	○	○	○	○	○	○	○
Examples				AST1 IRAC	AST2 ARAC	CAA Level 1		

Figure 7.24 Online survey page 15.

Avalanche Awareness of Your Partners

Please answer the following questions with the **same group of 3 family members and friends** in mind.

Who in your group normally checks official sources for information about the existing avalanche conditions before you go out-of-bounds?

Please check the appropriate items for yourself and each group member.

	Public Bulletins on Internet	Ski area web site	Postings at Info kiosks	Postings at out-of-bounds gates	Talk to Ski Patrol	I don't know
You						
Partner 1						
Partner 2						

How often do you talk in this group about avalanche hazard when you go out-of-bounds?

Please select one option.

0	10	20	30	40	50	60	70	80	90	100
Never					Sometimes					Always

What type of avalanche safety gear do the different members of this group normally carry with them when you go out-of-bounds together?

Please check the appropriate items for yourself and each group member.

	Beacon	Shovel	Probe	Cell phone	AvaLung	Balloon pack	I don't know
You							
Partner 1							
Partner 2							

Figure 7.25 Online survey page 16.

Out-of-Bounds Decision Making

Please answer the following questions with the **same group of 3 family members and friends** in mind.

Which of the following statements best describes how your group decides whether or not to snowboard out-of-bounds avalanche slopes?

Please select the appropriate option.

- We all make our decisions individually.
- Whoever is in the front of the group decides.
- The decisions in this group are generally made by a distinct decision-maker.
- We all contribute equally to a group decisions.

Who is the decision-maker in this group?

Please select the appropriate individual.

- I am the primary decision-maker in this group.
- Partner 1 is the primary decision-maker in this group.
- Partner 2 is the primary decision-maker in this group.

Figure 7.26 Online survey page 17.

Pick an Out-of-Bounds Run - Introduction

On the following pages you will be presented with typical out-of-bounds decision scenarios. Each scenario consists of two hypothetical out-of-bounds runs and the option to stay in-bounds.

Your task is to **pick the option your normal group** (described by you in the recent questions) **would most likely snowboard under the given conditions**.

Figure 7.27 Online survey page 18.

Pick an Out-of-Bounds Run - Introduction

For each decision scenario, the **avalanche conditions** are presented with a danger rating.

Each out-of-bounds run is presented with a photo of the section that is **technically most challenging** and **most exposed to avalanche hazard**.

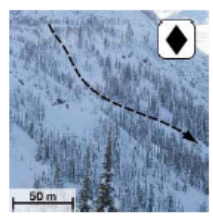
The **dashed line** shows the intended route you are asked to evaluate. Please do not consider any other route options.

Two short sentences describe the **frequency of use** of the run and the current **snow/powder quality**.

Danger Rating — **Moderate**

Out-of-Bounds Run 2

Terrain Character and Steepness



Usage — This run is skied **occasionally**.

Snow/Powder Quality — Snow quality is **good** and there are **no tracks**.

All runs lead **straight back into the resort** at the bottom without any hiking or car shuttling.

Weather is pleasant and **visibility** is good in all decision scenarios.

Please take some time to familiarize yourself with the details of the run characteristics by clicking on the info buttons.

Figure 7.28 Online survey page 19.

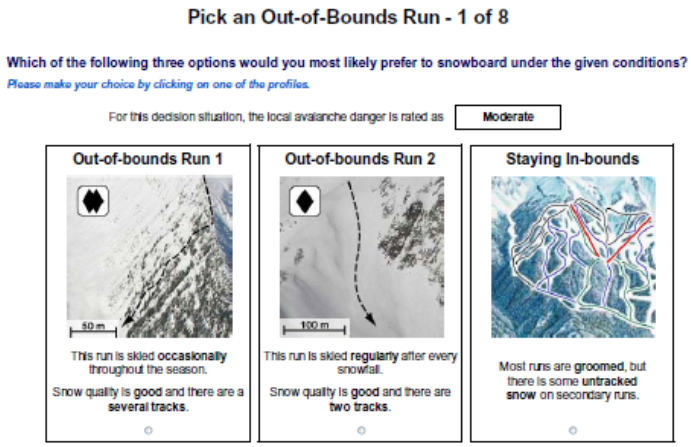


Figure 7.29 Online survey page 20.

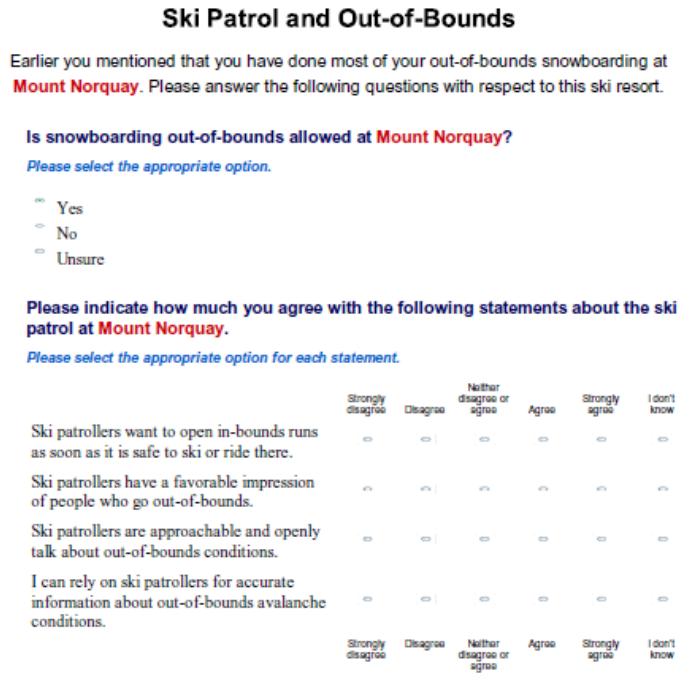


Figure 7.30 Online survey page 21.

Avalanche Areas in and around Ski Resorts

One way ski patrols manage avalanche hazard is to control access to terrain that is directly threatened by avalanche hazard. In and around a ski area, there are generally **three different types of designations** for areas that are potentially threatened by avalanche hazard directly or pose a threat to runs inside the ski area. The three types are:

- **Out-of-bounds**,
- **Permanent Closures**, and
- **Temporary Avalanche Closures**.

Do you know what the differences are among these three designations?

Please select the appropriate option.

- ◉ Yes, I completely understand the differences among these areas
- ○ I know some or all of these names, but I am uncertain about the differences.
- ○ I have never heard these terms.

Figure 7.31 Online survey page 22.

Avalanche Areas in and around Ski Resorts

Please answer the following true or false statements for each of the three designations at Mount Norquay.

Please select whether the statement is true or false for each area type.

	Out-of-Bounds Areas		Temporary Avalanche Closures		Permanent Closures	
	False	True	False	True	False	True
The ski resort regularly controls avalanches in this terrain.	○	○	○	○	○	○
If I get injured in this terrain, rescue will be available from the resort.	○	○	○	○	○	○
It is against ski resort regulations to go into this terrain.	○	○	○	○	○	○
This terrain is within the ski area boundaries.	○	○	○	○	○	○
Whenever possible, this terrain is opened by the ski area for skiing.	○	○	○	○	○	○
Ski patrollers are concerned that avalanches in these areas could affect skiers and snowboarders on regular runs inside the ski area boundary.	○	○	○	○	○	○
	False	True	False	True	False	True

How frequently do you or have you snowboarded in temporary or permanent closures.

Please select the appropriate option for each terrain designation.

	Never	Once	Occasionally	Regularly
Temporary Avalanche Closures	○	○	○	○
Permanent Closures	○	○	○	○

Figure 7.32 Online survey page 23.

Demographics

What is your gender?

Please check the appropriate option.

- Male
- Female

Which of the following age categories describes you?

Please select one of the following options.

- Under 20
- 20 to 24
- 25 to 34
- 35 to 44
- 45 to 54
- 55 or over

What is the highest level of education you have completed?

Please select one of the following options.

- Less than high school
- Completed high school
- Some post secondary education (post secondary not completed)
- Trades or non-university certificate or diploma
- Completed university
- Post graduate degree

Where is your main residence?

Please select the appropriate options.

Country:	Canada	
Province/State:	Please Select ...	(only if you live in Canada or the USA)
City		

Figure 7.33 Online survey page 24.

Last Words

Would you be interested in being approached by us for future research projects on out-of-bounds skiing and snowboarding?

Please check the appropriate option.

- ○ Yes
- ○ No

We are interested in any other comments you might have regarding out-of-bounds skiing or snowboarding.

Please enter your comments here.

Please let us know if you have any specific feedback regarding this survey.

Please enter your comments here.

Figure 7.34 Online survey page 25

Thank you very much for filling out our survey!

Your answers will provide important information for the improvement of avalanche safety programs for out-of-bounds skiers and snowboarders.

Your name has been entered for the prize draw. Winners will be contacted on April 30, 2009.

We wish you an exciting and safe spring in the backcountry.

For information on the current snow and avalanche conditions, please visit the web site of the Canadian Avalanche Centre at www.avalanche.ca.

Privacy Policy

Contact Information

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