HUMAN RISK FACTORS IN AVALANCHE INCIDENTS

Albert (Albi) Sole, Dr. Carolyn Emery
Sport Injury Prevention Research Group, Faculty of Kinesiology, University of Calgary.

ABSTRACT: An average of 12 people die in avalanches each year in Western Canada. The risk factors for the avalanche phenomenon have been extensively studied. The risk factors associated with the decision making process that leads individuals to expose themselves to avalanche hazard are less well understood. The recommended first step in an injury prevention program is to survey the population to discover the extent of the problem and the risk factors that predispose a person to injury. A retrospective, self-report, web-based, cross-sectional survey designed to measure potential risk factors for avalanche involvement was developed and validated. The survey was administered in September – December 2007 so as to obtain a representative sample from the population of skiers, snowboarders, climbers and snowshoers who entered avalanche terrain in Western Canada in the previous year. Back country skiers are at greater risk of experiencing an avalanche incident than out of bounds skiers or cross-country skiers and snowshoers [Odds Ratio (OR)=2.4]. Males who typically travel with other males are at greater risk than females and males who travel in mixed gender groups at least 75% of the time (OR=2.6). Participants in the 25-29 (OR=2.6) year age range are also at greater risk than younger or older people. Attitude may have a strong association with risk of experiencing an avalanche incident (OR=6.7).

KEY WORDS: Risk; attitude; injury prevention; training; perception; avalanche.

1. INTRODUCTION

The 'recursive model of injury etiology and prevention' proposed by van Mechelen, et al (1992) places 'surveillance of the population' and 'discovery of risk factors' as the first two steps in a four step process of injury prevention (Figure. 1).

For this model, surveillance needs to be done on a representative sample from the population for whom the interventions (step 3) will be developed. A specific goal of this study was to obtain that representative sample from a diverse population within a large geographic area; so that findings concerning risk factors could be generalized to that population, and possibly other similar populations.

Many psychological risk factors that may predispose an individual to increased risk of avalanche mortality cannot be obtained retrospectively, and mortality is a rare enough event that a prospective study is not practical.

There are likely strong associations between a failure in decision making that results in an avalanche incident and a failure in decision making which results in mortality. Avalanche incidents are much more common than avalanche mortalities, with between 4%-9% of people reporting an incident each year (Pfeiffer, 2006; Tase, 2004; Sole, 2007).

The primary outcome variable in this study is an avalanche incident being reported as 'having occurred to the participant or anyone else in their party'. Part of the purpose of this study is to obtain a better understanding of the relationship between incidents that lead to mortality and those that don't.

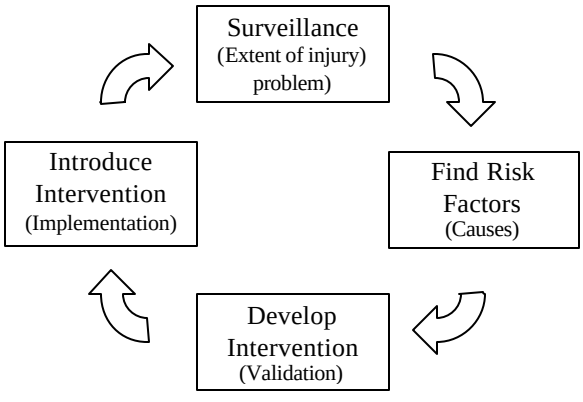

Figure 1: Recursive model of injury etiology and prevention from van Mechelen, Holbil, & Kemper, 1992.

* *Corresponding author address:* Albi Sole, KNA-101, University of Calgary, 2500 University Dr. NW. Calgary, AB. T2N 1N4; Tel 403-220-8638; fax: 403-220-0472; email asole@ucalgary.ca

Choice of this variable is made under the assumption that people make decisions in groups, and thus incidents happen to the group, as well as the individual. For practical and ethical reasons it was not possible to both obtain a representative sample, and to control for the group effect. This presents some challenges in interpretation that will be discussed later.

Definition: *Avalanche Incident* is an avalanche event that was either unexpected, or behaved in unexpected ways, that had the potential to, or did, bury, injure or kill someone.

The interpretation of the results of this study was made under the assumption that people intuitively balance expected gains from an action against the expected loss, and attempt to achieve the optimal level of net benefit (Sole, 2008; Wilde, 1994).

2. METHODS

2.1 Survey Development and Administration

A web based survey was developed to measure a range of variables that might be associated with avalanche risk including: age, gender, socio-economic status, number of days of exposure to avalanche terrain, sport practiced, training level, years of experience, % of time participant traveled with members of the opposite sex, sensation seeking, motivation for participation in sport, and avalanche incident (n=447). For those that experienced an incident (n=35), details of the incident were collected. (The motivation questions can be found in Appendix A)

In April 2008, a second survey was emailed to participants that included a question concerning attitude.

The web based survey was face validated with input from thesis committee members, avalanche course instructors, an expert in serious leisure, and graduate students in the Faculty of Kinesiology at the University of Calgary (Sole, 2008). A pilot survey was conducted in September 2007, and a reliability analysis was conducted on 24 test-retest surveys. Reliability varied between survey elements, but all measures used in this paper were at least moderately reliable (Sole, 2008).

An in-class survey of 398 students enrolled in avalanche courses in the winter of 2006/7 indicated that 100% of skiers, snowshoers, and climbers, and 89% of snowboarders shop at the Mountain Equipment Coop (MEC) (Sole, 2007). It is not known what proportion of snowmobilers, or people working in avalanche terrain shop at the MEC.

The survey was administered between September 19th 2007 and December 12th 2007 at MEC stores in Calgary and Vancouver. Up to six internet-connected laptop computers were set up on 13 dates for the duration of the store hours. Signage advertising the study purpose and inclusion criteria was posted in the stores. Every twenty to thirty minutes, a public announcement was read over the store intercom from a prepared text.

People who identified themselves as having entered avalanche terrain in the previous year, and were either resident or working in Western Canada, were asked to fill out the survey. Those who reported that they did not have time to complete the survey were requested to leave their email address, and were emailed the survey's URL, and a unique identity with a password, so that they could answer the survey later. To encourage people to participate, sponsors provided prizes for a draw open to all participants.

The inclusion criteria accepted snowmobilers, and people who work in avalanche terrain in professions not related to the avalanche industry. However, data relating to these activities is not included in comparisons involving incidents or fatalities.

2.2 Methods for Calculating Population Size

Exposure data for snowboarders was weighted to compensate for a lower proportion shopping at MEC.

Participants were asked if they had taken a two day avalanche awareness course based on the Canadian Avalanche Association's (CAA) curriculum for non-professionals, and the year taken. From the Canadian Avalanche Centre's records of people taking these courses each year, it was possible to estimate the proportion of the population skiing, climbing, snowboarding or snowshoeing in avalanche terrain who participated in the survey.

2.3 Methods for Mortality Density Estimates

Data was provided by the CAA for the avalanche incident record for the nine year period September 1 1996 to August 31 2005. Incidents that resulted in mortality were extracted from this

data. This extracted data was further modified as follows:

1) Those mortalities that occurred outside of Alberta or British Columbia were removed, as were those that occurred to people not resident or working in Western Canada.
2) Fatalities to snowmobilers and people who work in avalanche terrain in professions other than skiing and snowboarding were removed.
3) Data for those under 22 was removed since the assumption that all skiers and 89% of snowboarders shop at the MEC appear to not hold for younger people (based on survey returns).

The data from the process above was compared with the exposure data from the survey to provide an estimate of the incidence density for fatalities, in terms of # of fatalities per 1,000,000 days of that activity.

The mortality rate per kilometre per vehicle in British Columbia was calculated using data from Statistics Canada (Statistics Canada, 2007). The risk for mortality for an individual was based on the assumption that each vehicle traveling to a back-country recreation site would have an average of two people in it. A comparison was then made of how many kilometres of road travel exposed an individual to the same potential for mortality as one day of their sporting activity.

2.4 Methods for Risk Factors Analysis

The effect of gender was considered using a constructed variable that contrasted those who travel with a female less than 75% of the time against females and males who traveled with females 75% of the time or better. This variable is referred to as 'mostly male'

Risk of experiencing an avalanche incident was not linear with age and the sample was divided into three age groups: under 25 years, 25-29 years and 30 years or older.

The association between age, exposure, mostly male, training, experience, socioeconomic status, motivations and sensation seeking; and reporting of an avalanche incident were examined using logistic regression with a backwards elimination approach. All possible interactions between the variables and potential confounders were examined. Results are reported as odds ratios with confidence intervals and p-values.

Since there are too many variables to assess them simultaneously, an initial model containing the dependant variable and days of exposure, age, and sex was assessed. The other variables were added one at a time and assessed for a relationship with the risk of experiencing an avalanche incident. Those variables for which no evidence of an association was found were dropped from the model.

The final model contained 'exposure', 'age-group', 'mostly male', motivated for memories ('Memories'), and motivated for fun ('Fun'). Intermediate results are reported as appropriate.

2.5 Methods for Second Survey

A second survey was emailed to those in the initial sample who agreed then might be contacted. The relatively low response rate did not permit a logistic regression analysis for the attitude question. Results are reported as an odds ratio, confidence intervals and chi^2 with associated p-value.

3. RESULTS

3.1 Selected Distribution Analysis Results

Skiers, snowboarders, snowshoers, and climbers, entering avalanche terrain in Western Canada have a high median income of $44,485, (CI; 40,711-49,060) and a very high education level (65% with graduate or post graduate degrees vs. a national average of 15%).

Females are under-represented (24.83%; CI; 20.83-28.84), but well integrated into the population with 100% of females reporting the travelled with males some of the time and 80% of males reporting they traveled with females 25% of the time or more.

Most people have taken at least a two day avalanche course (77.57%; CI; 73.66-81.48)

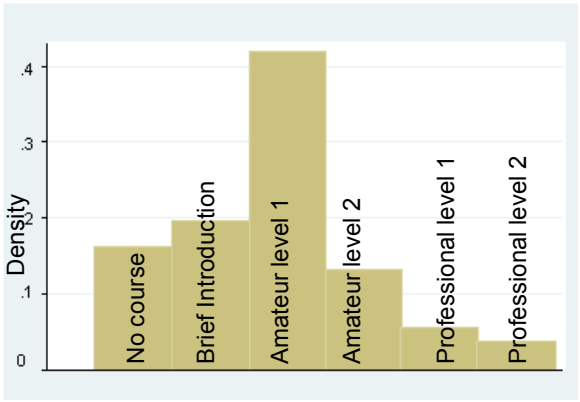

Figure 2: Distribution of training level

Younger people tend to prefer out-of-bounds activities, and older people tend to prefer backcountry activities (Table 1).

Risk factor	# of days Backcountry	# of days out-of-bounds
Under 25 years	15.10	9.03
25-30 years	41.77	6.11
Over 30 years	29.39	3.00

Table 1: Distribution of mean days of activity by age group.

3.2 Results for Incident and Mortality Rates

There were no incidents reported by ice climbers. There was no evidence that back-country skiers and snowboarders experienced a different incidence rate from mechanized skiers, mountaineers or snowshoers. Out-of-bounds skiers and snowboarders experienced a lower incidence density than the other groups that reported an incident (Table 2).

Activity Type	OR	95% CI	p
Back Country Ski/Ride	1		
Mechanized Skiing	0.99	0.23 - 4.14	0.98
Out-of-bounds Ski/Ride	0.12	0.02 - 0.88	0.04
Mountaineering	0.69	0.24 - 1.98	0.5
Snowshoeing	0.79	0.18 – 1.39	0.8

Table 2: incident densities for sport types

Sport Practiced	# of fatalities Per 1,000,000 Days of activity	Kms road travel = to 1 day of sport risk
BC Ski/Ride	5.77	830
O-of-B Ski/Ride	2.30	332
Heli/Cat Ski/Ride	13.05	1,878
Ice Climb	1.43	206
Mountaineering	1.90	263
Snowshoeing	2.15	310
All Sports	4.16	613

Table 3: Estimated incident density for avalanche fatalities by sport for the period Sept. 1, 1996 – Aug. 31, 2005 for people aged 22 years and older.

The estimated incidence densities for mortality suggest that skiing and riding in the backcountry is more risky than participating in the same sports out-of-bounds (Table 3).

Males are more likely to experience mortality than females with 13.16% of the mortalities being female.

3.3 Results for Risk Factor Analysis for Avalanche Incident.

The number of days spent in avalanche terrain is associated with the risk of experiencing an incident (OR = 1.018/day of exposure; CI; 1.011-1.026, $p<0.0005$).

Based on the point estimate alone, there is evidence that males may be more likely to report an avalanche incident than females. There is evidence that males who travel with females less than 75% of the time are more likely to experience an avalanche incident (Table 4).

Activity Type	OR	95% CI	p
Male	2.71	0.93 - 7.86	0.07
Mostly male (With female <75% of time)	2.64	1.26 - 5.52	0.01

Table 4: Risk of incident by sex and for individual in a group containing a female 75% of the time or better

There is evidence that risk of experiencing an avalanche incident increases with training (Table 5). Once these results are adjusted for days of exposure, there is only point evidence that risk increased with level of training (Table 6). Of those reporting an incident, 77% reported that there was a person with a higher level of training in the group.

Training Level	OR	95% CI	p
No Course	1		
Amateur training	2.1	0.8 – 5.5	0.01
Professional training	7	2.3 – 21	0.001

Table 5: Risk of incident by training

Training Level	OR	95% CI	p
No Course	1		
Amateur training	1.8	0.7 - 4.6	0.2
Professional training	2.2	0.5 - 9.2	0.3

Table 6: Risk of incident by training adjusted for exposure

The relationship between age and risk of an avalanche incident is not linear. There is evidence that people aged 25-29 years of age are at greater risk of experiencing an avalanche incident then either younger or older people (OR = 2.45, CI; 1.14-5.25)

There was no evidence that experience or socioeconomic status was associated with risk of experiencing and incident.

The sensation seeking scale has two components: 'desire for intense experiences', and 'desire for novel experiences'. There is no evidence that either 'desire for novel experiences' or the combined scale is associated with having an avalanche incident. There is evidence that desire for intense experiences is associated with avalanche incidents (Table 7).

AISS high vs. low score	OR	95% CI	p
Novelty	1.2	0.6 - 2.6	0.57
Intensity	2.5	1.2 - 5.1	0.02
Sensation seeking	1.9	0.9 - 4.0	0.08

Table 7: Risk of incident and Sensation Seeking

Motivation	OR	95% CI	p
Memories	0.16	0.05 - 0.53	0.003
Use of talents	0.98	0.45 - 2.12	0.96
Express Knowledge	0.59	0.27 -1.30	0.2
Self Expression	0.95	0.44 - 2.01	0.9
Fun	4.58	1.18 -17.79	0.03
Revitalization	1.06	0.47 - 2.40	0.87
Social life	1.62	0.76 - 3.42	0.2
Physical exercise	1.89	0.75 - 4.79	0.18

Table 8: Risk of incident and motivations

Amongst the motivations, two were found to be associated with risk of an incident. People who scored *'My sport helps me create memorable experiences'* as '5' on a 5 point Likert scale were less likely to experience an avalanche incident (OR 0.16; CI; 0.05 - 0.53). Those who scored '5' for *'Participation in my sport is fun'*, were found to be more likely to experience an avalanche incident (OR 4.58; CI 1.18 -17.79) (Table 8).

To ensure that motivation questions were not measuring sensation seeking, the association between sensation seeking and motivations was examined for 'Memories' and 'Fun'. No association was found for 'Memories', but 'Fun' was found to positively associated with sensation seeking (OR 1.90, CI 1.11-3.25)

3.4 Final Model for Risk Factors

The final model found that there were five factors that were positively associated with risk of experiencing and avalanche incident, exposure, traveling in groups with women less than 75% of the time, being aged 25-30 years, not being motivated for 'memory creation', and being motivated by having fun (Table 9).

Risk factor	OR	95% CI	p
Exposure	1.018	1.010 - 1.026	<0.0005
Mostly Male	2.43	1.11 - 5.31	0.027
Aged 25-30	2.76	1.23 - 6.91	0.014
Memories	0.13	0.04 - 0.46	0.002
Fun	4.44	1.11 - 17.75	0.035

Table 9: Risk factors in the final model

3.5 Results for Attitude Survey

Those who reported that they would 'drive the same' if they were forced to drive without a seat belt were more likely to have reported an avalanche incident. (OR 0.38, CI 0.01-4.96, chi^2 =0.73, chi^2 p = 0.04).

4. DISCUSSION

4.1 Interpretation

When a person dies as the result of an avalanche incident, the necessary causes for that include the decisions that that person has made. While these decisions are personal, they are influenced by the group they are traveling with. Therefore, an incident is the result of failed

decision making at the level of the individual, and at the level of the group. A consequence of this decision making scenario, is that the presence of a risk factor in the group typically changes the risk level for others in the group.

Because of the way in which individual risk characteristics contribute to outcomes; comparing variables measured at the level of the individual, to an experience at the level of the group, requires that there be a strong association before statistically significant results are obtained. Thus, associations will be easier to see if the same variable is measured for the rest of the group.

This pattern for statistical association is seen with gender. The association between incidents and gender failed to reach statistical significance when only measured at the level of the individual (OR 2.71, p=0.07). By comparing it to the likelihood of a female being present in the group, statistical significance was reached (OR 2.64, p=0.01). The association is confirmed at the level of the mortality record where females who are 25% of the population provided only 13% of the fatalities.

Although the point estimates for the association between training and incidents were not statistically significant, they most probably indicate that increased training results in increased risk taking. Of those reporting an incident, 77% reported that there was someone with a higher level of training in the group. No measure was obtained for what percentage of the time people traveled with people who had a higher training than themselves on those days they did not have incidents, consequentially no statistical comparison can be made that is similar to the 'mostly male' one made for the gender effect. Unfortunately, the mortality record rarely reports training levels.

That training fails to confer increased safety, and is probably associated with increased risk taking, should not be taken as a failure of the training programs. The tendency for people to subconsciously attempt to optimize net gain, by subconsciously comparing expected gains and losses, is predicted to result in increased risk taking when training provides increased access to an activity that confers great benefits (Sole, 2008).

That risk of both incident and mortality appear to peak in the late 20's may be explained by the activity pattern of the typical person. Sole (2007) found that most participants in the introductory level avalanche programs at the University of Calgary already had many years of backcountry experience in sports not exposed to avalanche risk. This activity pattern is probably a reflection of the significant barriers to participation in avalanche exposed sports. Not only are these sports intimidating because of their reputation for risk, but they typically require considerable expertise in areas such as winter survival, route finding, as well as considerable competency in the physical skills. It appears this same pattern exists within the sports exposed to avalanche risk, with people gaining confidence in out-of-bounds sports first. Their transition to the back country happens later and is unavoidably accompanied by increased risk taking.

This finding has implications for avalanche training for younger people. Such training needs to be carefully structured, so that it does not encourage young people to move to a back-country venue at an age where their naturally higher risk propensity will put them at unacceptably high levels of risk.

There is some indication that the propensity to seek intense experiences is associated with experiencing an incident. This relationship was not confirmed in the final model, probably because it is subsumed within 'Fun'. Sensation seeking has been found by others to be associated with participation in adventure sports (Zuckerman, 2007). This association may explain why people take up such sports, and why they enjoy them, but it does not appear to be a strong predictor of risk for those who participate.

The association between 'Fun' and sensation seeking suggests that sensation seekers are more likely to see their sport as fun, but since there is a stronger association between 'Fun' and incidents than there is for sensation seeking and incidents, it is possible that life experiences have resulted in a reinforcement of this genetically inherited trait.

The association between 'Memories' and incidents has no obvious causal explanation. It is possible that this question measured an attitude concerning risk taking that biases how individuals assess the probability of incident. The secondary survey was intended, in part, to investigate this possibility. The question tested the attitude a person might have with respect to their ability to control risk. Driving the same, with and without a seat belt, would be irrational behaviour (Wilde 1994). While a person might be able to modify their behaviour in such a way if they were highly motivated to do so, typically people will compensate for the loss of a safety device with more conservative behaviour (Hedlund, 2006, Sole, 2008). Possibly, people who report that they would 'drive the same' have an attitude toward risk that over-estimates their ability to control it. If so,

such an attitude would bias their perception of expected loss.

The small sample size made it impossible to compare the association between reporting 'I would drive the same' and reporting that 'memories' are a motivation. However it is possible that both are measuring an attitude toward risk that has a stronger association with risk than any other factor investigated in this study.

3.4 Study limitations

Although 100% of skiers, climbers and snowshoers shop at the MEC, it is possible that not all of them shopping on survey days participated. It is not known if those who chose to not identify themselves have characteristics that bias the results.

The distributional results are specific to the population sampled, and should be interpreted with care when generalizing to other geographical areas, or to snowmobilers and those working in avalanche terrain other than the avalanche industry.

Random error is likely a factor for some of the less practiced sports and may account for the higher than expected mortality rates for mechanical skiing.

The relationship between avalanche incidents and avalanche mortalities is likely complex. Generalizing from risk factors for incidents to those for mortality needs to be done with care. In particular, the results for ice climbing do not indicate low risk for ice climbers. The low estimation for the incident rate is likely associated with of the high probability of mortality if an incident occurs.

5. CONCLUSIONS

Once a person has decided to enter a slope, the avalanche consequences, if any, are largely determined by the risk factors in the physical environment. However, this study shows that the risk factors for a person deciding to enter that slope are rooted in the psychological characteristics of that person. These characteristics find expression in beliefs concerning gains and losses that are expected to result from a decision.

This study suggests that the strongest predictors of risk may the particular motivations a person has for participating, and attitude.

Attitude may bias perceptions of risk, such that an individual is making subconscious risk decisions based on inaccurate appraisal of risk. There is no basis for arguing that the risk decision of an individual is irrational if it is the result of a valid perception of the expected gains and losses. However, if a person with an inappropriate attitude is making risk calculations that inaccurately expresses the relationship between expected loss and gain, then they may need to consider the implications of such an attitude.

6. BIBLIOGRAPHY

DiGiacomo, N. J., 2006. Toward better decision making: Recognizing the effects of selection bias in the analysis of recreational avalanche data. International Snow Science Workshop, Telluride, Co. pp. 244-252.

Hedlund, j., 2006. Risky business: Safety regulations, risk compensation, and individual behavior. Injury Prevention, 6, 82-89.

Pfeiffer, N., & Foley, J., 2006. Skill and knowledge mastery of students in level 1 avalanche courses. International Snow Science Workshop, Telluride, Co. 264-273.

Sole, A.; 2007. In class survey of avalanche students, Dec. 2006 - April 2007. Unpublished Survey.

Sole, A., 2008. Human risk factors in avalanche incidents. Unpublished MSc, The University of Calgary

Tase, J. E., 2004. Influences on backcountry recreationalists' risk of exposure to snow avalanche hazards. Unpublished Ma, The University of Montana, Retrieved from http://www.avalanche.org/~nac/NAC/techPages/theses/tase.pdf

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

Zuckerman, M.; 2007. Sensation seeking and risky behavior. Washington: American Psychological Association

APPENDIX A

Motivation Questions

Using the following scale where:
‘1’ is ‘Unimportant’
‘5’ is ‘Extremely Important’

1 2 3 4 5

☐ ☐ ☐ ☐ ☐ My sport helps me create memorable experiences
☐ ☐ ☐ ☐ ☐ I achieve full use of my talents and potential through practicing my sport
☐ ☐ ☐ ☐ ☐ My sport allows me to express my knowledge and expertise
☐ ☐ ☐ ☐ ☐ My sport allows me to express who I am as an individual
☐ ☐ ☐ ☐ ☐ Participation in my sport enhances my self-image
☐ ☐ ☐ ☐ ☐ Practicing my sport provides me with a profound sense of personal fulfillment
☐ ☐ ☐ ☐ ☐ Participation in my sport is fun
☐ ☐ ☐ ☐ ☐ I feel revitalized after a day practicing my sport
☐ ☐ ☐ ☐ ☐ The social life that my sport makes possible is attractive to me
☐ ☐ ☐ ☐ ☐ I enjoy the physical exercise