SKI INJURY PREVENTION:
AN EPIDEMIOLOGICAL INVESTIGATION OF THE SOCIAL, BEHAVIOURAL AND ENVIRONMENTAL DETERMINANTS OF INJURY

by

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Abstract: This dissertation research is a case study of the distribution and determinants of morbidity among a population of young (under 18 years) alpine skiers and snowboarders at one major North American ski resort. It is an interdisciplinary investigation that encompasses sports medicine, epidemiology, education, sociology and health promotion.

The research includes two phases, a retrospective case series analysis of 2,139 injury events during the 1992 ski season and a 1993 prospective case series analysis of 540 injured alpine skiers and snowboarders in three age groups (0-6, 7-12, 13-17 years). The study employed ski patrol data and a specially designed questionnaire administered to over 800 uninjured skiers and 114 injured skiers. It was framed using the PRECEDE-PROCEED health promotion planning model. The research employed replicable and reliable skier visit data that enabled calculations for age-specific incidence rates of injury.

The major findings include: 1) adolescents (13-17 years) have the highest incidence of injury in the skiing population; 2) injury patterns differ between males and females as well as between alpine skiers and snowboarders; 3) children on school-sponsored ski programs are injured at a significantly greater rate than their non-school cohorts; 4) weather variables do not play a significant role in general injury rates; 5) environmental factors that include both the social and physical environments influence skiing behaviour.

Alpine skiing and snowboarding injuries are both predictable and preventable events. In light of the findings, several intervention strategies are discussed that may reduce the incidence and/or severity of injury by influencing the social, behavioural and environmental determinants of skiing-related activities.

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Chapter 1

Introduction

Alpine skiing and snowboarding are popular sports. Both attract a large and growing number of participants from around the world. Unfortunately, injuries attributable to skiing (hereinafter including all alpine skiing and snowboarding) happen to thousands of people every year causing individual lifestyle change, personal suffering and financial hardship to families and the social costs of lost productivity and health care (Regnier, 1990). The major emphasis of this thesis is the confirmation of adolescents as a high risk group in the skiing population, the investigation of injury patterns and the description of the behavioural and environmental influences affecting the injury events. The general literature on injury prevention indicates that young people are a prime target for interventions based on their increased incidence of injury. It is likely that this trend also exists in skiing. This research also seeks to make a theoretical contribution by demonstrating the utility of the PRECEDE-PROCEED Model as an ecological approach to health promotion planning in a sport-related injury prevention investigation.

The Ecological Approach to Injury Analysis and Prevention

One of the objectives of this thesis is to consider sport-related injuries among adolescents from an ecological perspective with an eye to injury interventions. The *ecological perspective* is one which attends to behavioural, social and physical features of the environment under study. By *intervention*, I refer to strategies and techniques designed to change established behavioural patterns or to prevent the development of hazardous behaviour patterns or environments. Good interventions are the result of planning. Good planning usually includes establishing the extent of the injury problems, defining the etiology and mechanisms of injury, introducing preventive measures and evaluating the effectiveness of the program (van Mechelen, 1992). A research model which undertakes to study the distribution and determinants of injury and its prevention must be able to handle complicated interactive relationships between the environment and behaviour. Unfortunately, in sport and recreation, injury is often considered an accident, bad luck, or some failure on the part of the individual which often results in the phenomenon of "victim blaming" (McLeroy, Bibeau, Steckler & Glanz, 1988). Such a focus on individual action and responsibility for injury rather than on a range of situational factors inhibits the development and implementation of population-based injury prevention measures. The ecological approach, on the other hand, allows broad investigations of the combined and interacting behavioural, social and environmental determinants of injury (Green, Richard & Potvin, 1995; McLeroy, et al., 1988; Miner & Ward, 1992; Richard, Potvin, Kishchuck, Prlic & Green, 1996). Therefore, an ecological approach seemed appropriate as a perspective to use in this thesis research.

Two Ecological Approaches to Health Promotion Planning: The Precede-Proceed Model and the Host-Agent Environment Model

The interdependencies surrounding complex human behaviour in recreational environments require numerous levels of investigation, especially when framed within this ecological health promotion perspective. Micro-level examination of individual injury causation may detract from the larger effort of developing systematic health promotion interventions that address adolescent ski injury patterns. The Precede-Proceed model of health promotion planning (Green & Kreuter, 1991) incorporates ecological principles in its design. These ecological constructs have been articulated as the social and environmental issues influencing health conditions, situations and behaviours and the reciprocal relationships between these behavioural, social and environmental factors. The model recognizes that changes in the environment can result in different health outcomes even without modifications in behaviour (Green, et al., 1996). For instance, football players engage in the sport with the same habits and degree of skill regardless of whether the goal posts are padded or not. A collision with a padded goal post will result in fewer and less serious injuries than a collision with a steel goal post.

A second ecological approach is the epidemiological Host-Agent-Environment Model in the injury prevention literature (Haddon,Jr., 1972; Sleet, Egger & Albany, 1991) that recognizes three components involved in ski injury events. According to this analytical scheme, *host* refers to the person sustaining the injury; *agent* is used with reference to equipment; and *environment* connotes the physical and social dimensions of the setting. In the skiing example, the host is a skier with a range of knowledge, skills and experiences. The agent is represented by the skiing equipment and its effect on performance. Finally, and perhaps most importantly, is the environment--which includes both the social (*e.g.*, companions, type of occasion, and supervision) and physical features (weather, snow conditions, hill design, and crowding) of the situation. These three factors function alone or, more frequently, in combination. According to the assumptions of this framework, they are presumed to be responsible for injuries of all types, including, for our purposes, alpine skiing and snowboarding injuries.

<u>Background to the Study and the Researcher</u>

This section might be subtitled, "How I independently discovered the Host-Agent-Environment Model through casual observation of skier injuries!" I approached this project with some degree of relevant expertise. As a ski patroller with 13 years experience, I was able to identify common injury patterns involving the person, the equipment and the environment while gaining first-hand experience treating a wide range of injuries from sprained thumbs to fatal head wounds. In each case, I have questioned the reason why the incident occurred. While still a novice patroller, I came to believe that injury was the result of bad luck and individual misfortune. But, upon reflection I noted that "bad luck" was not nearly as significant a causative factor as I had once presumed. I realized that the most productive questions related not so much to what ski injuries were occurring but rather to whom did they happen, when and why. My assumption, even then, was that young people were getting hurt at a rate disproportionate to the rest of the skiing population, and that peer pressure and the actual skiing conditions played a role in injuries. Now, in retrospect, I recognize that I had made a transition from the victim-blaming perspective to an ecological approach to injuries based simply on my casual observations.

Examples Comparing a Victim-Blaming Perspective with an Ecological Analytical Perspective

1) A case emphasizing host or person-

Michèle is a 14 year old skier who was injured while skiing with her school classmates on a blue square run (designated more difficult) during the middle of the day. She was practicing skills, gaining experience and having fun with friends when she lost control and fell head first into the snow. Michèle described what happened when she was hurt .

> "I start off pretty good so then I pick up speed. Suddenly, I'm leaning too far back on my skis. Quickly, I lean forward but not before my feet jam forward in my boots, my skis cross and I'm heading straight down the hill out of control. At the last moment I realize my problem but it is too late and I'm falling through the air. I land with a jarring impact, my face in the snow, my hands by my head and my skis get pulled forward and hit the back of my neck before I can get my muscles to tighten and hold my skis in the air over my head. I don't move. I'm waiting for the laughter but it doesn't come. I don't even want to move, though I'm not sure why yet. From behind, I can hear Andrea asking how I am. I don't reply. My head begins to throb and pain to shoot down my neck. Then Andrea is there, she is talking to me but I can't understand her amid the pain..."

Michèle was placed on a spineboard with a neck brace and transported to an awaiting ambulance. At the clinic, x-rays were taken and the diagnosis was fortunately a good one, muscle and ligament damage, no neurological deficits, and no cervical fractures.

The victim-blaming perspective would identify a lack of skill and a poor choice of ski runs. The ecological approach, on the other hand, would investigate the social and environmental conditions that predisposed, reinforced and enabled Michèle to get into this situation as well as the physical environmental factors that contributed to the injury. The fact she was with her school friends on a school ski trip may have affected her behaviour, their encouragement may have pressured her to ski a run above her ability level and perhaps Michèle was unable to recognize subtle clues from the physical environment which might have altered her skiing behaviour prior to the injury event if only she had recognized them. An ecological investigation is an ideal tool for weaving apparent causative threads involved in this injury event.

2) A Case involving agent or equipment-

One of the most common 'agent' factors described in skiing is the ski binding. Peter, a 16 year old male was skiing for the first time ever and was with some friends. He took a lesson in the morning and was practicing on a "green run" (designation easiest) later that day.

> "From the top, I went down the slope again. I was at my usual speed- which was quite fast. Once I reached the level part, I tried to slow down by snowplowing. It wasn't working (as usual). Anyways, I fell and I was sliding on my side very quickly and for what seemed like forever (I was quite used to falling and sliding by this point). As I was fighting to slow down, I somehow rolled and slid on my butt. As this was going on, my left knee turned one way and my left ski went the other way and I felt a "pop" or "crack" in my knee. My skis did not fall off. This was the only exception to all the other times I fell."

Peter was taken down the hill in a ski patrol toboggan to a waiting ambulance. His diagnosis was a torn anterior cruciate ligament which required a few days in the hospital, surgery, and a long rehabilitation program. The behavioural (victim-blaming) perspective alone would blame Peter for skiing above his ability and in a reckless manner. Peter blames his bindings which did not release. The agent factor, in this case the ski binding, is one which has received the most attention in the ski injury literature. Peter believed that the binding should have released. However, the release binding is designed to release when forces are generated to fracture the tibia and not the lower level forces capable of damaging soft tissue in the knee. In fact, the binding functioned correctly because the binding did not release and Peter did not break his leg. Other important questions considered in an ecological investigation of injury would include: what did each of the factors (the binding, the behaviour of the skier and his friends, his skill level and the environment) have to do with this injury event?

3) An example focusing on environmental factors in injury-

Erin, a 13-year-old girl, details what she remembers of an injury probably caused by features of the environment.

> "What I remember before I crashed is starting the run. We were on the way to the chairlift. It was not very steep, then I don't remember anything until I was being lifted into the helicopter on some type of a stretcher. I had been skiing with someone. My partner is on a racing team every winter, so she was a lot better than me. She was ahead and did not see what happened to me. The snow was fine but it was slightly foggy but the run we were on was not foggy. I have a steel rod in my leg now from my thigh to my knee and it is also bolted."
>
> Erin's mother added that "she was cut off by another skier and this resulted in her fall".

This injury occurred in a relatively flat area. The snow was hard packed and the weather was overcast but with good visibility. The main reported factor in the injury was a loss of control and a fall likely caused by a near skier collision where someone cut in front of Erin and she had to swerve to miss the collision. Her injuries were significant. She seriously fractured her femur, right scapula (shoulder blade), and left clavicle (collar bone), and she had a concussion. She was in the hospital for over a week, had surgery and missed nearly a month of school. Once again the victim-blaming view would report that Erin was skiing out-of-control. The ecological perspective seeks to find out why she may have been out of control. Some questions might include: how was this injury event influenced by the social and physical environment? Was the ski run appropriately designed? Was crowding on the run a problem that day?

Objective and Scope of this Research

The objective of this thesis is to provide a review and analysis of recoverable data on use and injury for a recreational ski area (namely, Blackcomb Mountain, B.C.) in order to formulate strategies and techniques designed to reduce ski injuries.

Theoretical Value of this Research

Using a quantitative hypothetico-deductive approach, this research constitutes a replicable treatment of a social epidemiological issue (ecological aspects of skiing injuries among youth). Although previous studies have looked at data relating to similar injury events, they have taken a clinical perspective (Giddings, McCallum & Duff, 1993; Johnson, Ettlinger & Shealy, 1995; Morrow, McQuillen, Eaton & Bernstein, 1988). The social epidemiological dimension of the research derives from an ecological theoretical perspective (Green, et al., 1996; McLeroy, et al., 1988), which examines social and physical aspects of injuries using Green and Kreuter's Precede-Proceed model and the Host-Agent-Environment model. Framing the study in social epidemiology and the ecological perspective represents a significant theoretical contribution.

Practical Importance of this Research

More than 10,000 British Columbian's seek a physician's help regarding a skiing injury every winter. The cost of treatment to the provincial health care system is enormous. These injuries not only burden the health care system but create hardship for individuals and families. A practical goal of this thesis is to contribute to the understandings necessary to the development of ski injury prevention strategies. In particular, health educators and curriculum planners need to have a clear understanding of the skiing environment, the injury patterns, the causative factors associated with injuries in order to develop and implement effective intervention programs. In response to this perceived need, further pragmatic objectives of this thesis are:

a) To provide descriptive data and a template for similar social epidemiological studies in the future;

b) To develop understandings and generalizations regarding behavioural, social and environmental factors of adolescent ski injuries in particular, and their extension to other recreational risk activities;

c) To provide specific, data-based recommendations for curriculum developers and health educators regarding implementable interventions targeted to specific age groups.

Scope of the Project

This research has a number of limitations. As a case study, it only investigates injuries at a single venue; and as micro-analysis, it is non-comparative. It is the goal of this thesis to treat the available data relating to adolescent ski injuries at Blackcomb Mountain between 1992 and 1995 as completely and exhaustively as possible. However, I recognize that the ecological approach is limited in its ability to measure and evaluate behavioural, social and environmental issues in all their complexity, a limitation pointed out by Richard, et al. (1996). Note that it is not the intention of this dissertation to attempt to go beyond the limitations of the Precede-Proceed model. Finally, although the literature indicates that skiing and snowboarding do indeed have different injury patterns based on sport-specific technique and equipment factors, for the most part the two sports will not be distinguished (although they are treated separately with regard to sport-specific injuries, see page 138) because they share similar risk factors.

Chronology of the Research and Ethical Considerations

This research was conducted under the supervision of my dissertation committee, the University of British Columbia's Office of Research Services, the Faculty of Graduate Studies and the Institute of Health Promotion Research. Because this research involved human subjects, the conduct and procedures of the study were submitted to, and approved by, the Screening Committee for Research Involving Human Subjects.

The dissertation research was conducted between 1991 and 1995. The following Gantt chart describes the major chronological events (Figure 1.1).

Figure 1.1: Chronology of the Dissertation Research

	1991-1992		1992-1993		1993- 1994		1994-1995		1995-96
Activity	**W**	**S**	**W**	**S**	**W**	**S**	**W**	**S**	**W**
Literature Review	X	X	c	c	c	c	c	c	
Research Committee		X	X						
Ethics Approval			X						
Retrospective Study		X	X						
Prospective Study Instrument Development		X							
Data Collection			X	X					
Analysis					X	X			
Weather/Injury Rate Data Collection/ Analysis							X	X	
Final Draft								X	
Dissertation Defense									X

Winter (W) is defined as November-May,
Summer (S) is defined as June-October
(c) denotes continued emphasis on this phase of the research.

Organization of the Thesis

The thesis is divided into six chapters. Chapter 1 has provided an overview of the study, the identification of the injury problem and the importance of the research in terms of theory and practice. Chapter 2 presents the methodology or theoretical foundation of the study and clarifies the assumptions used in generating and refining of hypotheses. Chapter 3 focuses on the development of the hypotheses. The process of generating and refining the hypotheses derives from understandings and generalizations that became apparent during the literature review and a preliminary retrospective investigation of ski injuries at Blackcomb. Chapter 4 details the methods and conduct of the prospective study. Chapter 5 presents the results and discussion of the prospective study while Chapter 6 describes the implications and conclusions that have been generated by this thesis investigation.

Chapter 2 Research Methodology and Theoretical Foundation

This chapter describes the research methodology employed in this dissertation and then, after discussing theoretical perspectives that have been used in previous injury prevention research, details the theoretical approach that I will use in my research. By *research methodology* I refer to a general framework of research design (which I distinguish from methods, *i.e.,* the techniques and instruments used in data collection and analysis, discussed in Chapter 4). I define *theoretical perspective* as a set of assumptions presumed to have explanatory adequacy in treating the generalizations that arise in this study.

Research Methodology

The methodology employed in this thesis research is a quantitative and hypothetico-deductive micro-analytical case study of one site using hypotheses developed from a review of the literature and from a preliminary investigation of retrospective data collected prior to the study.

The terms deductive and hypothetico-deductive are often used synonymously in research. I am distinguishing them with the intention of emphasizing the hypothesis testing and refining that characterizes this research. Readers should note that the hypothesis generating stage of this project relies on research which comprised the first phase of the study. For that reason, I am using the term hypothetico-deductive to characterize clearly my approach in which the hypotheses arose and were refined and focused during the initial stages of the project. These hypotheses were not generated purely on the basis of previous research, which is the more usual expression of deduction. This approach insured that relevant and apparent generalizations/claims were not left unexplored. Of course, there is an element of inductivity in even the most rigidly deductive research. Although my study is hypothesis oriented, I will be vigilant for and open to generalizations arising from the data that are not responsive to the hypotheses that I am investigating (in other words, I will not disregard findings that do not relate directly to my hypotheses).

A quantitative model is being used. Quantitative research is empirical and replicable, based on the data of quantifiable (*i.e.*, measurable) factors treated as material phenomena. On the other hand, qualitative research is sometimes considered a less rigid perspective with the goal of discovering and describing the perceived experience of others using replicable and reliable strategies of its own. The use of the terms social and behavioural in describing the focus of this research in epidemiology and in the ecological model would suggest that a qualitative approach might reasonably have been considered for this study. In fact, I have elicited some qualitative information in the course of this research and have clearly treated it in a non-quantitative manner (*e.g.*, asking interviewees about what scares them and querying questionnaire-respondents about their feelings; and, their answers are presented in the thesis in a qualitative manner). Despite those occasional forays into qualitative data collection and analysis, this research is primarily quantitative and deductive. The reasons selected for a more quantitative approach are:

a) Because the majority of similar studies employ a quantitative approach-- by taking that perspective, my research could be used in future comparative macro-analytic studies;

b) In the interest of replicability a quantitative methodology seemed the best choice; and

c) Since the target audience of this thesis is predictably accustomed to, persuaded by, or biased toward quantitative studies, it seemed prudent to use a quantitative perspective.

<u>The Case Study Approach and Micro-Analytical Perspective</u>

A case study approach, as defined for this research, is an analytical design which investigates a particular phenomenon in a specific situation. It is a non contrived form of research where there is no intended manipulation of the conditions or of the experience. According to Labovitz and Hagedorn (1976), a case study is "low on control when compared with experimental research, and low on representativeness when compared with survey research"(p.69).

Micro-analysis presumes that it is looking at a community which is, to a great extent, localized and homogeneous; whereas macro-analysis applies to large-scale systems linking different settings to one another through causal networks (Hammersley & Atkinson, 1983,p.204). Thus, it is apparent that micro-analysis and case studies are synonymous to a great extent. For our purposes, I use the term case study to imply that a single site is being investigated and use micro-analysis to suggest that the perspective is non-comparative. Choosing a micro-analytic case study approach was the easiest methodological choice involved in determining the methodology to be used in this thesis. It was apparent that a case study of one major ski area might enable greater precision in measuring specific variables associated with ski injuries. Therefore, a case study project was designed, limited in its generalizability but with strengths in enabling the understanding of complex relationships which are beyond the parameters of an experimental study. My reasons in opting for a one-site micro-analytical case study included the following:

a) Realization of the difficulty of keeping variables constant when doing diachronic analysis or when using data from multiple sites, (although the 22 year longitudinal study of ski injuries at Sugarbush, Vermont, demonstrates that it is possible to control variables with rigorous protocols (Johnson, et al., 1995)). My proposed research required constancy in those variables that reflect social and physical environmental aspects of the data.

b) Using data from a single site was, in fact, partially a matter of convenience, since it allowed me to draw upon a pre-existent data base and had advantages for data collection and the administration of questionnaires.

c) My own personal contacts as a long-standing employee at Blackcomb assured access to records, permission to collect data on the slopes, and personal familiarity with aspects of the study site (*e.g.,* historical, administrative, geographic, etc.) that would be difficult to obtain at other sites.

d) Although a single site, Blackcomb is a major facility representing a cross section of skiers in terms of ability, age, and geographic derivation, as discussed below.

Recognizing the time constraints confining dissertation research and the absences of major research funding, a one site study appeared to be the most feasible and productive option.

Site Selection for the Case Study

In selecting a site for the case study that would provide the data and setting for this research, my long term association with and employment at Blackcomb Mountain led me to consider it immediately. Blackcomb appeared in many ways to be not only appropriate but optimal. Because of my employment, I already had the necessary contacts and access to injury data. Blackcomb proved to be a progressive facility that was interested in and supportive of an injury prevention study. They also maintained an immense data base on injuries, which documented more than 2500 annual injury reports. Blackcomb was, in fact, an ideal research site and I was delighted when the administration was receptive to my proposal.

Because various features of Blackcomb Mountain will be mentioned in the course of this thesis, it is useful to provide some description and background of the mountain and its facilities. Blackcomb has defined itself as a leader in the ski industry and has taken an active position in developing a quality skiing environment. According to the popular skiing literature, this ski area is one of the top ski resorts in North America. Blackcomb hosts the largest vertical rise of lift-serviced slopes on the continent and attracts a large population of skiers from around the world. The international clientele combined with a large regional and local skiing population ensures that the sample is as representative as possible of skiers. During the period of this investigation skier visits have ranged from 750,000 to 975,000 annually. This is considered in the high range of skier visits and is exceeded by only a few ski areas in North America.

Blackcomb provides excellent facilities and an outstanding environment which attract skiers. During the study period, the ski area had the following features and facilities: the vertical rise of the mountain was 1,609m with a lift capacity of 26,350 people an hour. There were 14 lifts including one high speed covered quad chairlift, four high speed quad chairlifts, five triple chairs, one double chairlift, two T-bars and one handle tow. (The 1994-95 season saw the elimination of two triple chair and the addition of an eight person sit-down gondola and another high speed quad chairlift.) The total amount of terrain is 3,416 acres with 90 designated runs. The terrain was rated as 25% advanced (black diamond), 55% more difficult (blue square) and 20% easiest (green circle). The average annual snowfall was 8.35m and the average temperature in the alpine was about -10 degrees Celsius. The winter ski season began in mid-November and concluded near the end of May and the hours of operation were generally 8:30-15:30.

[Note that the term "alpine" may be used both to distinguish geographic zones (*i.e.* , alpine versus sub-alpine and montane) and to differentiate between alpine (downhill) skiing from other types such as Nordic or cross-country. In this thesis, except for the immediately preceding reference, the term "alpine" is being used with the latter connotation.]

Theoretical Foundation

An Introduction to Theory in Injury Prevention Research

The prevailing paradigm of disease etiology in the past was a single cause-single consequence relationship according to Milos Jenicek (1995). However, Jenicek points out that modern thinking and technology have enabled researchers to investigate "webs of causation". He goes on to state that:

> "One of the greatest challenges in understanding disease and its epidemiological approach is our ability to define, measure and understand with equal rigour all of the above mentioned categories of factors (*i.e., chemical, physical, biological and social)*. Traditionally, physicians are most comfortable following biological factors, sociologists in studying social factors, psychologists, following stressful events and so on. **Obviously the etiology of disease is not a disciplinary affair and as such must be approached with a maximum of interdisciplinary understanding."**
>
> (Jenicek, 1995, p27)

Jenicek's notion of web of causation infers an ecological perspective to disease/injury epidemiology. Human ecology defined by Green (1990) is "the study of that relationship as it works in both directions-from human adaptation to the environment, and from environmental adaptation to human behaviour and organization (page 25)". Interventions based on ecology provide a simple framework for the study of disease or injury that approaches phenomena or settings as ecosystems. Thus, these approaches are appropriately referred to as ecological, because they focus on the social and physical environment in which illness or injury occurs. Environment, on the other hand, includes all of the factors external to the individual. These two factors (the individual and the environment) combined influence the behaviour, norms and values, learning and experience of each individual. In turn they have an affect on the health of that individual and his/her community.

Injury Prevention

Injury prevention (which is synonymous with injury control) is based on changing behaviours and altering the environment. There is a huge literature on injury prevention which reaches into many disciplines in one form or another (CDC, 1985). The literature is largely divided into intentional and unintentional injury. *Intentional injury* includes assault, self-harm, suicide and homicide. *Unintentional injury* results from actions which do not have the objective of causing injury. In 1990, the International Working Group defined unintentional injury as physical or tissue damage that results from the unintentional rapid transfer of energy or the interference with normal energy exchange mechanisms (International Working Group, 1990). The major improvement of this definition, according to the formulators, is that it excludes the notions of "Acts of God" and "accidents". The term accident is not a productive construct as it implies that prevention is impossible due to its randomness. Injury prevention is the preferred term as it encompasses both the primary prevention of incidents leading to injury (*e.g.,* preventing crashes or falls) and secondary prevention of injury following incidents (*e.g.,* cushioning the impact, providing medical services, etc.).

Haddon's Environmental Approach to Injury Prevention

William Haddon, Jr.(1972,1973) emphasizes the environment with respect to injury prevention. In order to do that, he defines injury with a precision that would allow typologies of injury events and causes. This rigour led him to define injury as damage to human tissue resulting from an individual's inability to accommodate received energy. He distinguished between *vector* (*e.g.* a car, campfire or rock) and the *external environment* (*e.g.,* road conditions, social attitudes, etc.) in describing the *agent of injury* (the form of energy or interference with energy exchange). Haddon describes three phases of an injury event:

1) *The pre-injury event phase-* during which the factors are operative that determine whether a potentially damaging exchange will occur;

2) *The injury event phase-* during which the transfer of energy (or interference with energy exchange) occurs and tissues are damaged; and

3) *The post injury event phase-* during which efforts are made (by the body, the individual, the health care system) to limit any ongoing damage process and restore function.

Evidence of Haddon's environmental focus can be noted in the ten countermeasures which he proposes as interventions to limit the energy exchange involved in injury. These include:

1) Prevent the creation of hazards in the first place;
2) Reduce the amount of hazard brought into being;
3) Prevent the release of the hazard;
4) Modify the rate of release of the hazard from its source;
5) Separate the hazard from that which is to be protected by time and space;
6) Separate the hazard from that which is to be protected by a physical barrier;
7) Modify relevant basic qualities of the hazard;
8) Make what is to be protected resistant;
9) Begin to counter damage done by the hazard;
10) Stabilize, repair and rehabilitate the object of the damage.

Haddon's work represents one of the pillars of injury epidemiology and injury prevention. It is recognized that the strategies described by Haddon will not cover every situation; but his work facilitated the analysis of injury problems and it encourages a full range of intervention options which focus on the environment and, in particular, the agent.

The International Working Group [IWG] (1990) reports that the likelihood that a measure will result in protection varies inversely with both the frequency and the amount of effort required of the individual. In other words, they encourage passive interventions (where the individual does not need to act) rather than active interventions (where the individual must consciously act). An example provided by the IWG suggests that educational campaigns advising people to lock their medicines away out of the reach of children after each use (frequent and consistent effort) predictably affords less protection than dispensing medications in childproof containers and in non-lethal dosages.

The Social Cognitive Approach to Injury Prevention

A second pillar of injury epidemiology and injury prevention lies with behaviour and the psychosocial theories of behaviour change. There are numerous theoretical perspectives that treat individual behaviour change. However, in this research we will focus on Alfred Bandura's Social Cognitive Theory (Bandura, 1977b; Bandura, 1986) and other theoretical frameworks with similar constructs.

Social Cognitive Theory (SCT) is based on three major constructs:

a) behavioural capacity (having the skills and knowledge necessary for performing the desired behaviour);
b) efficacy expectations (beliefs regarding one's ability to carry out a course of action or perform a behaviour successfully);
c) and outcome expectations (beliefs that performance of a behaviour will have desired effects or consequences) (Bandura, 1986).

Further, according to SCT, behaviour is determined by reciprocal determinism, the interaction of three elements:

i) the person,

ii) the person's behaviour

iii) the environment,

The actions of a person and the environment help to form the person's cognitions or expectancies. Expectancies are of three types:

a) *Expectancies about environmental cues*- that is, beliefs about how events are connected, about what leads to what;

[*e.g.* a skier crossing underneath an avalanche closure fence line does not believe the risk of avalanche to be present nor believes the judgment made by the ski area's avalanche forecaster and ski patrol that crossing the line is a serious risk which may result in death].

b) *Expectancies about the potential consequences of specific actions* - that is, the opinions about how the individual's behaviour is likely to influence outcomes. [*e.g.* a young snowboarder who approaches a highly visible wind-lip at high speeds to get "big air" does not include paraplegia as a possible outcome or consequence of that behaviour].

c) *Expectancies about one's own competence to perform the behavior needed to influence outcomes* - this is termed efficacy expectation or self-efficacy. [*e.g.,* novice adult skier must believe that he/she has sufficient skill before proceeding to an intermediate slope].

(Rosenstock, Strecher & Becker, 1988,p.176)

Rosenstock (1988) describes incentives (or reinforcement) as the perceived value of a particular object or outcome. The valued outcome may be health status, physical appearance, approval of others, economic gain or other consequences. Behaviour is regulated by its consequences (positively by reinforcement or negatively, by withholding reward incentives) but only as those consequences are understood by the individual (p.176).

The sources of individual understanding about these efficacies are performance attainments, vicarious experience, verbal persuasion and the individual's physiological state (Blair, 1993). As this applies to sport, such as in skiing, participants are often bombarded with this sort of information. Efficacy expectations are, thus, derived by the effects of personal performance and from the social environment (onlookers and co-participants).

Personal performance accomplishments attained through direct experience are the most influential causes of efficacy expectations because they are based on personal mastery experiences (Stretcher & DeVillis, 1986). For example, a skier who completes several small jumps successfully may attempt more difficult ones in a progressive manner. It is generally assumed that this escalation occurs because of the incremental personal success achieved and rewarded with reinforcements that are both extrinsic (outside of self, *e.g.,* peers) and intrinsic (from within, *e.g.,* satisfaction of the desire to improve one's skill level).

People do not live in isolation from the rest of the world and as social beings they observe others. This observation of other people's behaviour and the subsequent rewards and punishments that they receive as a result, is known as *vicarious learning*. Vicarious experience obtained through observation of the successful and unsuccessful performances of others is the second most influential source of reinforcement (after direct experience discussed above). It is also one of the most basic and perhaps one of the most important ones for life-long learning (Bandura, 1977a). Bandura also believes that *models* (persons performing a given behaviour who are current or potential role models) should be as similar to the observer as possible or be a person idolized or respected by the observer for maximum impact. Verbal persuasion and psychological states (*e.g.,* depression or exhilaration) can influence efficacy as well. If an individual is being coerced by peers or superiors, then she may succumb to the persuasion and attempt something beyond her recognized ability. Sometimes the physiological state may also be an influencing factor. For instance, those injured on the last run of the day often report being fatigued and upon reflection recall having considered taking the chairlift down...but didn't.

All this is easily applicable to research in skiing. It is impossible to ski without being influenced in some way by the people in the environment. Skiing is a social activity and most participants do so with friends and families, yet none of the previous skiing research investigates the influence of being in a social situation on resultant behaviours, some of which are injury producing. It is my experience, as a ski patroller, that the most extreme risk behaviours occur when people have an audience present. Few people ski extreme slopes without an audience, few adolescents go "cliff jumping" without friends encouraging and watching, few people race themselves to the bottom of the hill, few people go for "big air" off jumps without spectators. On the other hand, it must be recognized that the recounting of these exploits carry a significant weight in impressing an audience at a later date. The actual event is at one level, the subsequent retelling is a process of self-expression and identity affirmation that reinforces risk-taking behaviours. The notion of peer pressure, then is not only something that may be present on-site but which permeates the culture in which the youth resides.

Application of Social Cognitive Theory (SCT) to explain and modify behaviour in skiing has not been overtly explored. Bandura (1986), as previously discussed, describes human functioning in terms of a triadic reciprocity where the person, the behaviour, and the environment all operate as interacting determinants of one an other. The following assumptions derive from Bandura's approach. People (including skiers) have the capacity to use symbols to give meaning, form, and continuance to lived experience and then to use these symbols in forethought. Thus, skiers can anticipate the consequences of their prospective actions and consider alternatives; they can set goals and make plans to achieve their objectives. To facilitate this goal setting process, people have the capacity to learn by observing other people's behaviour without having to go through a long and tedious trial and error ritual. An example in skiing is the person who wishes to up-load (*i.e., get* on the lift going uphill) on a chairlift and who has never done so before. Watching others load the lift provides the individual with an understanding of the skills and technique necessary to perform the task and it is likely that this observational learning will be sufficient to enable the person to perform the activity successfully.

For the skier, Bandura's "expectancies and incentives" are largely derived from both the social and physical environment. A snowboarder looking down a double black diamond run with several friends who are encouraging her to do it, may quickly decide against attempting it because of environmental cues and the potential consequences of an error. The steep terrain with large rocks (cues) may be associated with serious pain from an uncontrolled fall (consequence), all of which overrides the peer pressure (incentives).

The adoption of safe behaviours is dependent on three important factors. First, that skiers involved have the necessary predisposing factors, including the appropriate safety knowledge, beliefs, attitudes and values. Second, they have the necessary enabling factors such as the skills needed to perform the desired behaviours and the third factor is the reinforcement for practice and repetition of the safe behaviours.

<u>Hochbaum and Rosenstock's Health Belief Model</u>

The Health Belief Model developed by Hochbaum and Rosenstock for use in disease-based interventions focuses on perceptions of susceptibility and severity of health outcomes which are balanced by convenience and by beliefs that behaviours may reduce those threats (Rosenstock, 1974). In determining the predisposing factors associated with beliefs, the Health Belief Model (HBM) is another model that employs constructs similar to those used in SCT. The perceived susceptibility to injury and the perceived severity of injury are two major constructs of the HBM which are consistent with SCT and based similarly on value-expectancy theories that predate both (the HBM predates SCT, having been first published in 1959 by Hochbaum). For example, the danger of contracting HIV through unprotected sex is salient and accepted as potentially lethal, and the use of a condom is an intervention measure that is of proven benefit even though it requires a recurrent behaviour in applying a condom for each encounter. A health researcher who wished to use the Health Belief Model in developing interventions would seek information on the following issues:

> 1)The existence of sufficient motivation (or health concern) to make health issues salient or relevant.
>
> 2)The belief that one is susceptible (vulnerable) to a serious health problem or to the sequalae of that illness or condition. This is often termed "perceived threat".
>
> 3)The belief that following a particular health recommendation would be beneficial in reducing the perceived threat and at a subjectively-acceptable cost. Cost refers to perceived barriers that must be overcome in order to follow the health recommendation; it includes, but is not restricted to, financial outlays.
>
> (Rosenstock, et al., 1988,p.177)

Health Behaviours-An Application of SCT

The non-cognitive aspects of Bandura's SCT can be applied to the issues covered in this dissertation: skiing injuries in general, how skier behaviour is affected by social and physical environment, and eventually, the development of intervention strategies. Bandura distinguishes and defines the determinants of behaviour with a clarity that allows us to investigate factors that influence skier decisions...decisions that may either result in injury or in the avoidance of injury. Whether an individual takes health compromising risks or practices health promoting behaviours, could be argued according to Bandura's SCT, to be influenced by the social and environmental cues and efficacy expectations. We have no measures of efficacy expectations in skiers but we can estimate some of the social influences which can be either normative (those which distinguish behaviour as defined by role) or persuasive (those influences which encourage specific behaviours, this is often referred to as peer pressure) can be a series of factors affecting an individual's behaviour (Fisher, 1988). The social influence of a peer group can encourage or discourage safe behaviours.

Behaviour Change Strategies- An Application of SCT

Psychosocial approaches to behaviour change, in particular SCT, have proven to be an important area of research in the prevention literature. For example, the Minnesota Heart Health Youth Program was a school-based health education program designed to reduce the risks of cardiovascular disease and encouraged healthful eating and exercise. The program was based on SCT principles, and utilized expectations (consequences of behaviour), behavioural capability (resistance training to peer pressure), and observational learning (videos, speakers). The smoking prevention component of the program revealed that participating students were half as likely to start smoking in the next year as students in the community who had not been involved in the program (Perry & et al., 1989).

If the social environment plays a role in sport injuries, either by encouraging unsafe behaviours or by discrediting or disparaging safe behaviours, then further investigation is required to clarify the causative relationship between aspects of the social environment and health outcomes. One theoretical model that has been used to investigate the effect of the social environment is the social norms approach. This strategy emphasizes the provision of alternative activities to high-risk behaviours . Some prevention programs based on this approach attempt to influence the social norms in a particular environment directly. For example, Rundall & Bruvold's (1988) work on preventing adolescent substance abuse indicates that young people take up substance use because of an absence of explicit norms for behaviour or because the social norms governing behaviour encourages conformity. The authors indicate that interventions should involve the creation of social groups with desirable social norms or the attempt to modify social norms present in the school environment through communication and modeling.

The social influence approach views risk behaviour as a learned social phenomenon. This model, in substance abuse, attempts to enable young people to become inoculated from the undesirable influences. Programs based on the model rely on activities that a) help youth identify where pressures to use drugs come from, b) help them examine the motivations behind those pressures, c) assist them with ways to respond to those pressures, and d) help them learn skills that they can use to say no to pressure situations. Another important aspect of this strategy is the use of older teens or young adults to provide the program and act as role models (Frankish, et al., 1994).
These approaches based on SCT may provide important strategies for the prevention of skiing injuries and high-risk skiing behaviour.

Levine and Gorman (1994), appear to have been using the assumptions of the HBM in their study of the influence of skiers' perceptions of danger in skiing. They found that older skiers were more aware (*i.e.,* salience of the problem) of recent fatalities at the ski area (*i.e.,* severity of the problem) and that those who were informed tended to have modified their skiing behaviour (*i.e.,* recognizing the benefit of reducing the perceived threat at an acceptable cost). Although this model appears promising, there are apparently no other applications of this theoretical approach in skiing research and few in other areas of injury prevention.

Since a central issue in this dissertation has to do with developing interventions for young people, the work of Stember, Stiles and Rogers (1987), using this model is particularly relevant. Their study which used this model, investigated school-aged children's perceptions of severity and susceptibility. Of particular interest is his findings that (a) girls perceived potential health problems as more severe and thought that they were more vulnerable to them than boys, and (b) that injury was the second most salient potential problem in terms of both vulnerability and severity. Also extremely interesting in that it is suggestive of interventions, is the authors' conclusion that perceived severity was a function of direct experience (rather than of developmental stages). This finding would certainly argue for trying to develop intervention programs that provide young people with direct experience of injury and the injured. A local example is the "Heroes" program of the Canadian Injury Prevention Foundation that brings a multi-media show to schools and combines video with a special presenter who is a survivor of serious injury (e.g., paraplegia) (Anonymous, 1994a).

In summary, Social Cognitive Theory in its various forms appears to represent an enabling theoretical approach for research involving ski injuries and the development of preventive strategies. Among the various expressions of Social Cognitive approach are two that will be applied to this study (particularly in the development of interventions discussed in Chapter 6, page 222). The social norms approach, which attempts to provide alternatives to youth, and the social influence approach that looks at training young people to handle more constructively the pressures exerted by their peer group. The health belief model investigates perceptions related to behaviour motivation and has direct relevance to ski injury prevention as was described by Levine (1994).

Ecological Approaches to Health Research

Injury prevention stands on a number of pillars, but the main supporting feature of all injury prevention interventions and programs is a strong epidemiological foundation. The foundation is based on having accurate and reliable epidemiological evidence which clearly defines the problem and its etiology. *Epidemiology* refers to the study of health and illness in human populations and concentrates on the patterns of health or disease and its antecedent factors (Dawson-Saunders & Trapp, 1990). *Etiology* refers to the antecedents or determinants of disease or illness and can include both behavioural and environmental factors. My research on the epidemiology and etiology of skiing injuries will use an ecological perspective to study the relationships between injury, behaviour and the environment. The importance of the ecological models, according to McLeroy (1988), is that they view behaviour as not only being affected by the social and physical environments but that reciprocal cause and effect relationships exist between behaviour and these environments as well. Furthermore, these models have proven to be useful in health promotion research. For those theoretically persuasive reasons, I have chosen an ecological perspective for research on sports injuries such as this. As mentioned in Chapter 1, I chose two ecological models on which to base my research and analysis for this thesis: the *Precede-Proceed Model* and the *Host-Agent-Environment Model*. While these two perspectives complement one another to the point of overlapping, each brings important features and applications to injury research in general and to my thesis in particular. It should be noted that these two models are often considered as health promotion theories. Green and Kreuter (1991) state that Precede-Proceed is a <u>theoretically robust</u> model that addresses a major acknowledged need in health promotion and health education: comprehensive planning (page 24). Green prefers to think of the model as a meta-theory or a theoretical framework with each link having a unique opportunity to employ one or more of a variety of theoretical perspectives. The model is often used as a theoretical tool by practitioners and policy-makers to design and evaluate programs.

<u>The Precede-Proceed Model</u>

This planning model is considered by many to be the leading expression of the ecological approach to health promotion research. It has provided the theoretical framework for the research or programs reported in over 450 published articles. It has proved to be applicable and enabling in studies that deal with a) the work place (*e.g.,* Bertera's (1990) study of health promotion and absenteeism in a large industrial population); b) school (*e.g.*, Atlender, Price, Telljohann, Didion and Locher (1992) study of the predisposing and other factors associated with AIDS education and Junior High School students); and c) clinical settings (*e.g.*, Singer, Lindsay and Wilson (1991) study on promoting physical activity in primary care facilities). However, the model has previously been used in only one other study relating to sports injuries, Gielen's 1991 study of bicycle injuries in Maryland.

Figure 2.1 illustrates the model and allows one to understand why it is called Precede-Proceed. Precede and Proceed are acronyms which represent the diagnostic process leading to intervention development (Precede) and the process involved in the development, implementation and evaluation of interventions (Proceed).

Precede	Proceed
Predisposing	**P**olicy
Reinforcing	**R**egulatory and
Enabling	**O**rganizational
Constructs in	**C**onstructs in
Educational (and environmental)	**E**ducational and
Diagnosis and	**E**nvironmental
Evaluation	**D**evelopment

This health promotion planning model, then, is a nine phase sequence for diagnosing (*i.e.,* analyzing and identifying) health problems and their determinants or antecedents and then responding (*i.e.,* planning, implementing and evaluating interventions). Green and Kreuter describe the issues involved in diagnosing health issues, which are phases 1-5 (Precede) of the model below:

> Social Diagnosis: The assessment in both objective and subjective terms of high-priority problems, defined for a population by economic and social indicators and by individuals in terms of their quality of life.

Epidemiological Diagnosis: The delineation of the extent, distribution, and causes of a health problem in a defined population.

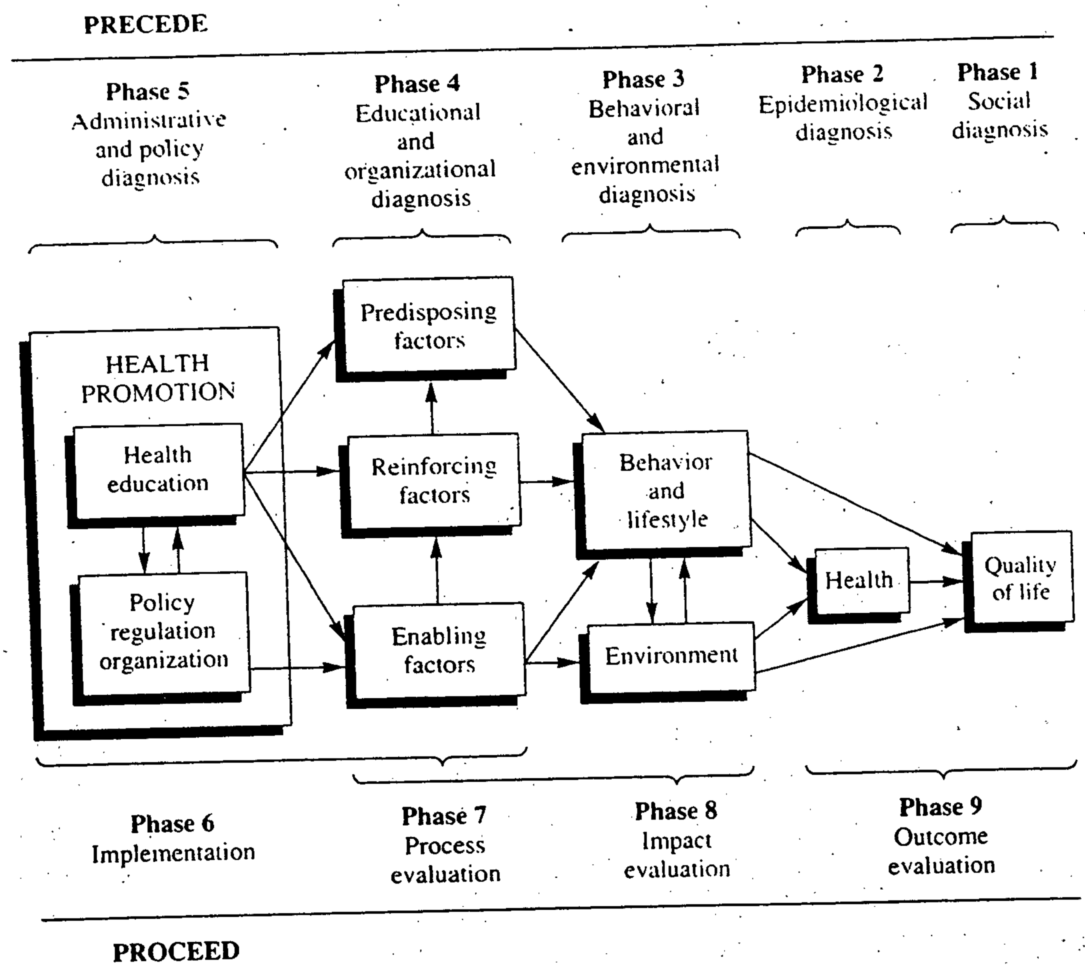
Behavioural Diagnosis: Delineation of the specific health-related actions that most likely affect, or could affect a health outcome.

Environmental Diagnosis: A systematic assessment of the factors in the social and physical environment that interact with behaviour to produce health effects or quality of life outcomes.

Educational and Organizational Diagnosis: Identifies the factors that must be changed to initiate and sustain the process of behavioural and environmental change.

It is Phase 3 of the Model (behavioural and environmental diagnosis) that represents the ecological perspective because it points to a reciprocal relationship between behaviour and lifestyle (behavioural issues) and environment (issues of the social and physical environment). Thus, the model allows the development of relationships important when studying a health problem such as skiing injuries. In employing this model, I will show that the relationship between behaviour and the environment is interactive and bi-directional and is not uni-directional nor does the relationship exhibit the necessary and sufficient conditions of causality. Also, although lifestyle is an important issue in ecological research, it is an issue that has not been emphasized in this research: So this research looks primarily at behaviour and then to specific lifestyle constructs such as peer culture.

Figure 2.1 The Precede-Proceed Health Promotion Planning Model



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The goals and objectives of this thesis requires us to focus on Phases 2, 3, and 4 of the model:

Phase 2 (Epidemiological diagnosis) corresponds in this study to the distribution of ski injuries and their typologies.

Phase 3 (Behavioural and environmental diagnosis) encompasses "environmental" features which are physical (terrain, weather, number of skiers, slope condition, etc.) and social (companions, type of group, pressures created by media stereotyping, etc.).

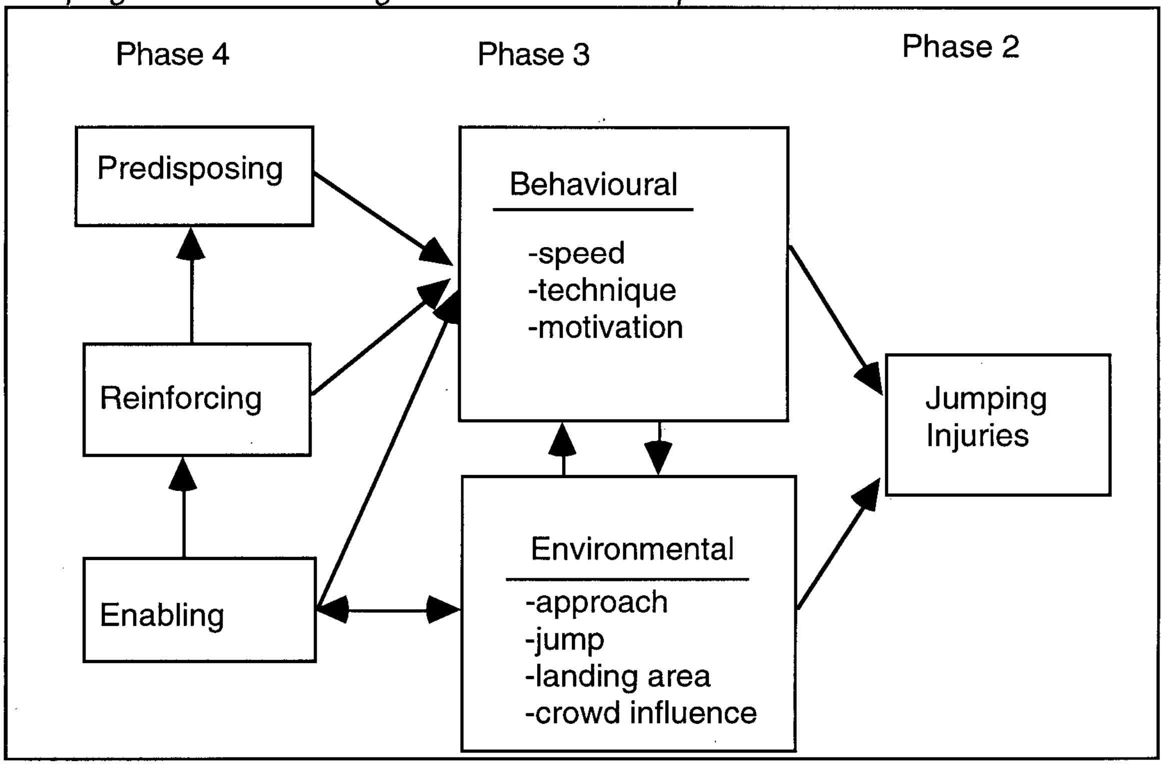
Phase 4 (Educational and organizational diagnosis) relates in this thesis research to issues which must be addressed if the study is to result in understandings which enable the development of injury prevention programs. The three types of factors which, according to the model, should be considered in this phase are the *predisposing factors* (antecedent knowledge, beliefs and attitudes), *reinforcing factors* (rewards or incentives which contribute to its persistence) and *enabling factors* (antecedents or accompaniments to behaviours that enable a motivation to be realized).

Here is an example that illustrates, in an admittedly superficial way, how these three phases of this ecological model can be applied to a particular skiing risk behaviour. A review of the popular literature on alpine skiing and snowboarding indicates that jumping is a favorite behaviour among skiers and contributes to the fun of skiing. Jumping is also a leading factor associated with injury among 15-30 year old skiers. The behavioural and environmental diagnosis (Phase 3) would likely identify three specific behaviours which contribute to injury in jumping: 1) speed of approach, 2) form employed in the jump, and 3) landing the jump. The environmental determinants include: 1) angle of approach, 2) the lift of the jump, 3) the landing zone and 4) the influence of the spectators. The educational and organizational diagnosis, then, would investigate the predisposing, reinforcing and enabling factors of each item identified in the previous Phase. The social environmental factors, which include both intrinsic (internally generated) and extrinsic (externally generated) motivation may or may not be included as a factor in this phase of the model (see Figure 2.2).

It is recognized that the social environmental factors in the Precede-Proceed Model often are not identified in the behavioural and environmental diagnosis because of the tendency of users of the model to defer consideration of these until they are ready to analyze reinforcing factors in the educational and organizational diagnosis. In a sport and recreation situation, I recognize the importance the social environmental factors on behaviour. Social factors are often identified in Phase 3, the educational and organizational diagnosis, especially in connection with reinforcing factors. I would prefer to include the social environment explicitly in the behavioural and environmental diagnosis.

Thus, the model constrains us to consider ecological issues in a manner that is productive of understandings of the determinants of injury and potential points of intervention. It also leads us to recognize effective and feasible interventions. The scope of this thesis allows us to follow this model as far as that recognition of appropriate interventions; but issues of implementation and evaluation implicit in the Proceed component of the model will have to await subsequent research.

Figure 2.2: Three Phases of the Precede Component of the Model with Respect to Jumping Behaviour Among Skiers as an Example



The Host-Agent-Environment Model

Another ecological model that is frequently used in epidemiological investigations is the Host-Agent-Environment Model, also previously discussed in Chapter 1 (Haddon & Baker, 1981; Hennekens & Mayrent, 1987; MacMahon & Pugh, 1970; Sleet, et al., 1991). This model (see Figure 2.3), which arose in disease-based epidemiology, is also clearly ecological in its assumptions because it recognizes emphatically the person (host) and the social as well as the physical environment in the investigation of injury. A third issue of focus, agent, defines the role of equipment in injury events. In comparing the Host-Agent-Environment (HAE) approach to the Precede-Proceed (PP) Model discussed above, I note the following similarities and differences.

Similarities: Issues of person (HAE) are reflected in the behaviour and lifestyle component of Phase 3 (PP). The facts of the social and physical environment (HAE) are explored in the environment component also in Phase 3 (PP).

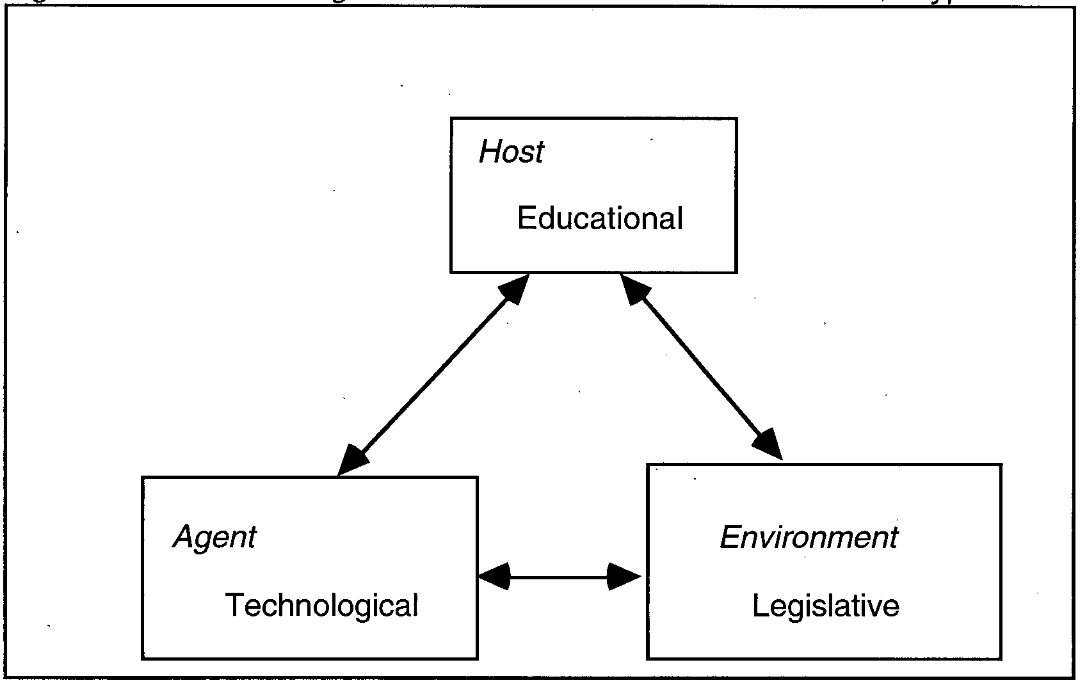
Differences: The agent variable in HAE is not explicitly denoted as a diagnostic issue in (PP), although agency in this sense (equipment) is one of the notions implied under enabling factors in Phase 4 of (PP). Also, a more general observation, the HAE is primarily a diagnostic tool that looks at direct cause and effect relationships, whereas, the PP model includes tactics for the development of ecological interventions and for implementation and evaluation.

So that differences between the assumptions and provisions of these two ecological approaches to injury can be appreciated, ski jumping, explored from the Precede-Proceed perspective above, will now again be analyzed using the Host-Agent-Environment Model.

The skier who wishes to take jumps requires three factors to achieve success. First of all, the skier must have sufficient skill, self-efficacy and knowledge concerning the process of jumping. Secondly, the skier must have adequate and appropriate equipment to execute the manoeuver and finally the environment must be conducive to the act of jumping.

The Host	The Agent	The Environment
-Knowledge	-Proper equipment	-Snow
-Skill		-Angle of approach
-Self-efficacy		-Jump
-Motivation		-Landing area
		-Crowd influence

Figure 2.3: The Host-Agent- Environment Model --Interventions Types



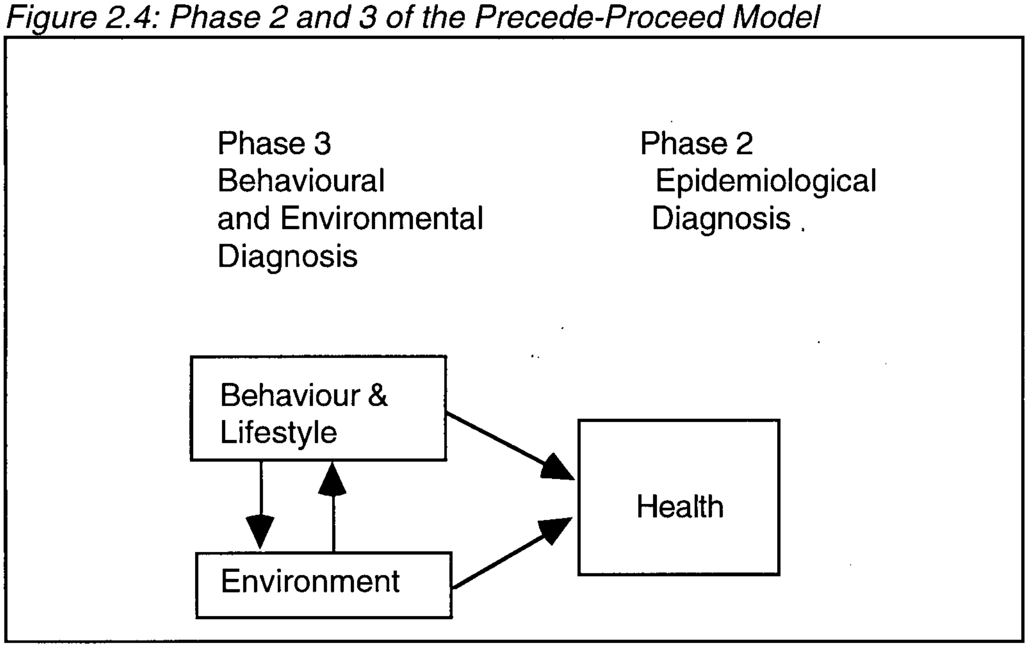
Interventions would, then, likely focus on educating the skier about proper skiing equipment, the use of safety equipment, and recognition of environmental factors which may affect the act of jumping. Technological interventions may include specialized equipment which would absorb the forces incurred in a jump or perhaps the construction of specialized jumps, much like those seen in competitive freestyle events and in snowboard parks. In a recreational skiing environment, a legislative intervention would be to ban jumping from all or part of the ski area, legislating the use of helmets when jumping (as already exists in competitive jumping). The problem with this model is that it does not direct the development of interventions based on identified priorities and objectives but rather on experience, personal intervention preference and intuition.

This treatment, although superficial, allows us to compare how the Precede-Proceed Model and the Host-Agent-Environment Model differ, even though they are similar in assumptions.

Adapting the Precede Component of the Model to Emphasize the Relationship Between Behaviour and the Social and Physical Environments

The Precede-Proceed model recognizes the importance of the behavioural, social-environmental, and physical-environmental determinants of a given health problem. However, in attempting to use this model, I encountered a circularity and imprecision in the model's formulation of "behaviour" which requires greater specificity for rigorous examination of these three factors as they relate to skiing injuries. As behaviour and the social and physical environments are presented in the Precede-Proceed model, they affect each other reciprocally and they are not defined specifically for analyzing causation in sports-related injuries. The circularity that I refer to is this: according to Phase 3 of the model, behaviour and the social and physical environmental factors affect each other reciprocally (*i.e.,* the social environment (setting) and the physical environment (situation) impact on behaviour and behaviour in return affects the social and physical environments). Green diagrams the relationship as in Figure 2.4.

Figure 2.4: Phase 2 and 3 of the Precede-Proceed Model



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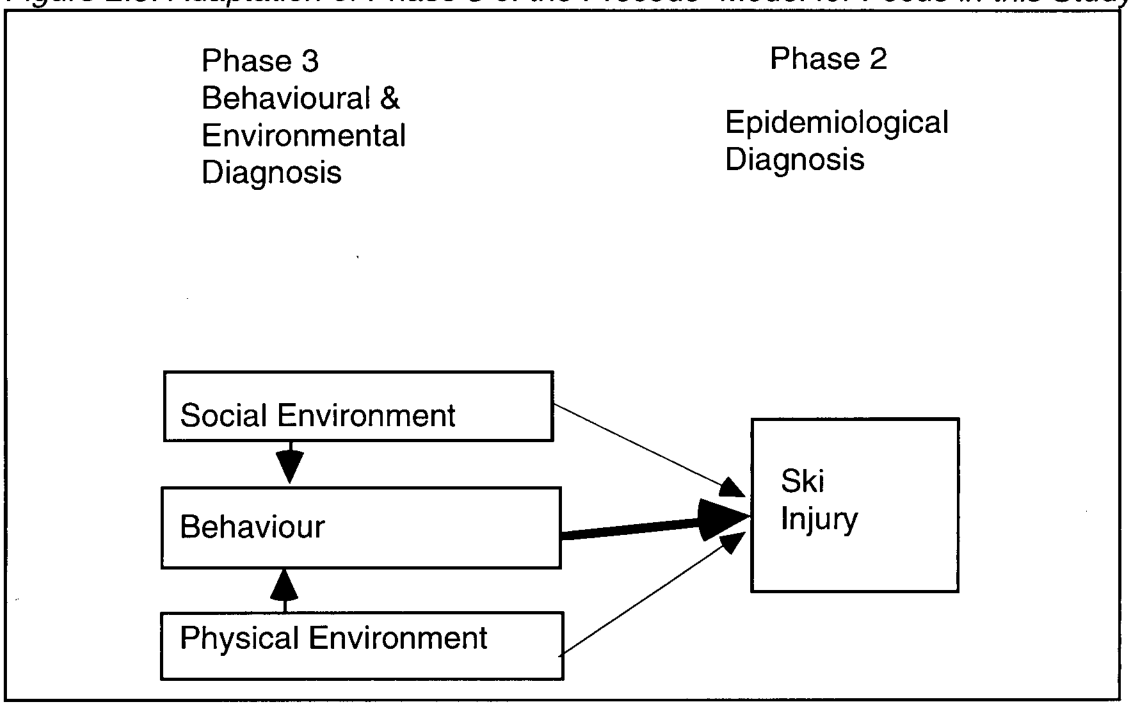
In order to make the model more enabling for analyzing causation in skiing-related injuries, I am defining both the physical and social environments and behaviour in a way that clarifies their relationship to each other in skiing situations, and their causative roles in the epidemiology of skiing injuries. As Green presents it (see Figure 2.3), the model characterizes the environment (*i.e.,* both the social and physical environments) as both affecting and being affected by behaviour and lifestyle in Phase 3. The *social environment*, as I define it for this thesis research, includes the social identities, relationships of participants, and other aspects of the social setting of skiing which influence behaviour. I define the *physical environment* as natural and artificial aspects of the skiing situation, including weather, terrain, facilities and crowding, that influence behaviour. *Behaviour* , on the other hand, is also role-governed or impulse-governed but the roles and impulses may be conditioned by/or the social setting or physical situation. Therefore, behaviour is emphatically affected by both the social and physical environment. Thus, I am adapting Phase 3 to encompass elements of Phase 4 of the Precede-Proceed model to give emphasis to the influence of environments on behaviour rather than the influence of behaviour on environment (see Figure 2.5). All three factors (the social environment, the physical environment and behaviour) impact on the etiology of the specific health problem of ski injuries. In Phase 3, though, behaviour will be examined as it is affected by aspects of the social environment and the physical environment but I will not examine how it reciprocally affects those environments in return. Thus, I am defining behaviour for this study as actions determined by the social and physical environments. This allows me to focus this study on the lines of causation in analyzing ski injuries for which data are available at Blackcomb. It also suggests that ski injuries result primarily from behaviour (Johnson and Pope, 1984; Cadman,1996), which in turn is generated because of the expectations associated with social roles or in response to aspects of the physical environment, such as crowding or weather. And, to a much lesser or more distal extent, the physical (*i.e.,* avalanches, poor visibility, cliffs, and ice) and social (*i.e.,* peer persuasion, media, social norms) environment can be seen to be factors directly influencing the health problem of ski injuries.

Figure 2.5: Adaptation of Phase 3 of the Precede Model for Focus in this Study



Adapted from Green and Kreuter (1991)

These definitions and relationships will enable me to discover and characterize what is most immediately causative in skiing injuries because, if our objective is to develop educational interventions, it is important to be clear about what behavioural factors are most proximally responsible for the injuries.

Summary

Chapter 2 has presented the theoretical assumptions and the methodology which underlie the conceptualization of this thesis. I have succinctly discussed the rationale for the choice of methodological approach used in this research. The theoretical framework, employed to investigate the relationships in Phase 3 of the Precede-Proceed model is Bandura's Social Cognitive Theory. This approach will frame the study and the interventions derived from the findings. Social Cognitive Theory incorporates the interactions between the person, their beliefs and the environment in determining behaviour. I have given arguments for the selection of a micro-analytical case-study approach and for using a quantitative and hypothetico-deductive framework. For the handling of data, two distinct but complementary ecological models have been chosen and described--the Precede-Proceed and Host-Agent-Environment Models. Example treatments of ski jumping using these two models highlights the similarities and differences between models. Finally, I have outlined an adaptation of Phase 3 of the Precede-Proceed model to focus the investigation on immediate (proximal rather than distal) factors affecting skiing injuries and to allow clear characterization of how environmental factors affect injury related-behaviours. This in turn, should allow an analysis of data that leads to recommendations on ways the ski industry and government can structure environments and rules to minimize hazardous environmental conditions

Chapter 3

Hypothesis Development--Literature Review and the Preliminary Study

Introduction

Since this chapter discusses hypothesis development, it may be useful at this point to clarify the distinction between theory and hypothesis. Chapter 2 was about theory (theoretical assumptions underlying the formulation and conduct of research). Chapter 3 is about hypotheses (claims generated deductively to be refined or falsified by research). Thus, hopefully, readers can avoid the confusion in popular usage that results from statements like "I have a theory that sports injuries are more common among left-handed skiers" , which is really a statement of a hypothesis rather than a characterization of the person's theoretical assumptions. Hypotheses, then, are claims with a heuristic value--they help focus one's research on the collection and analysis of data that will confirm or falsify the claims. Hypothesis, as we use it, has much in common with the term "research question" , which is a subset of the larger issues implied by the term "research problem" (*i.e.,* the general topic of a study including scope, methodology, and hypotheses).

This chapter, then, is about hypotheses. It discusses the development of the hypotheses explored in this thesis. These claims arose in response to a review of previous literature in the field and were refined to reflect the results of a preliminary study. Both the literature review and the preliminary research stage and its findings will be discussed in this chapter. Another relevant factor in this process that should be mentioned is that my own intuitions based on years of experience as a professional ski patroller probably influenced the "creative hunches" and the "trial and error" procedure involved in the development and refining of these hypotheses.

The presentation of the material in this chapter allows readers to follow the progression of hypothesis development.

Literature Review

Introduction

The literature review on sports-based injury included over 400 articles and documents with 165 directly related to skiing. The published corpus of studies and reports was dominated by clinically-based epidemiological investigations and reports on specific injury trends from around the world. Both published and unpublished material was sought and reviewed using the following search strategy. A library search was conducted on the following subjects: injury prevention, adolescent health, ski injuries and risk behaviour among adolescents. I also did electronic searches on the following databases: MEDLINE, Psychological Abstracts, ERIC, HEALTH, SOCIOPHILE and SPORT. A review of the American Society of Testing and Materials Special Technical Papers on skiing trauma and safety was also carried out. Personal correspondence with ski areas, with representatives of the CWSAA (Canada West Ski Areas Association) and with the CSIA (Canadian Ski Instructors Alliance) resulted in access to unpublished reports and papers.

Also, since the functional objective of this literature review is to note generalizations from which hypotheses can be generated, the presentation of previous research has been structured into general categories. The overlapping focus of some of these categories (*e.g.*, injury rates, injuries among adolescents and the social environment of adolescent ski behaviours) and because many of the articles discussed in this literature review cover several topics, a few have been mentioned more than once. A discussion of risk and injury in other sporting activities has been placed in Chapter 6 as they pertain directly to the treatment of intervention development and in this way repetition is alleviate.

Injury vs. Accident

Any discussion of sports injury must start out with a definition. Injury can be defined as an insult to the body resulting in hurt, damage or loss. An accident, on the other hand, is a sudden, unintentional event which is apparently unpredictable and which may or may not result in injury. Injury differs from accident in that injury does infer predictable causation and it includes bodily harm.

Mortality Studies

Death in alpine skiing has been well documented but reports of snowboard fatalities are only now being described in the literature. Fatalities on the ski hill are rare events and are most often predictable and preventable events. It is my experience and that of other researchers that more specific data would be generated if death on the ski hills were classified under traumatic and non-traumatic causes. Non-traumatic causes of death would include cardiac arrest, aneurysms, anaphalaxis, etc. It appears that more and more people are being encouraged to maintain an active lifestyle well into their senior years. This, combined with increased numbers of elderly people with the aging population and the improved lift services and well groomed slopes, means that more people at-risk to non-traumatic illness are present in the alpine ski area. The incidence of death, due to non-traumatic events, appears to be climbing at ski areas but this has only begun to be formally investigated (Burtscher, Mittleman, Philadelphy, Likar & Nauchbauer, 1995). These fatalities are not directly related to skiing and should not be included as skiing fatalities.

Estimates indicate that 20-30 people die annually as a result of a traumatic ski injury in the US. This excludes avalanche victims and those fatally injured due to mechanical failure on ski lifts. Two North American studies report the problem of skiing-related fatalities (Morrow, et al., 1988; Shealy, 1985). Both studies represent U.S. populations. The rate of fatal injury is estimated at 0.5/million skier visits (Shealy, 1985). Shealy (1985) found 117 skiing-related fatalities between 1973-1983, of which 71 qualified for this study. The mean age of the fatally injured skier is 27.35 years compared to a control population whose mean age was 25.75 years (median age for fatalities was 22.08 years). Males represented 83.1% of fatal injuries. Brain injury accounted for 59.2% of fatalities and internal injury 33.8%.

The second study on skiing fatalities (Morrow, et al., 1988) investigated fatalities in Vermont between 1979 and 1986 ski seasons. It found similar patterns to Shealy's (1985) study. The male to female ratio was similar with 81% of the fatalities being male and the age range was 15-70 with a median age of 26 years and a mean age of 29.7 years. A rate of 1.5 per million skier visits was established. The likely difference between Shealy's results and Morrows is that one represents a national study while the other investigated only those in one state.

European reports on skiing fatalities are similar to North American traumatic ski injuries. An Austrian study reviewed fatalities over a three- year period. They found that there were 192 traumatic fatalities and 96 non-traumatic fatalities (Berghold, 1989). One case study reports on snowboarding fatalities described three deaths among snowboarders who asphyxiated in deep snow (Kizer, MacQuarrie, Kuhn & Scannell, 1994). The causal factors associated with these three deaths will be discussed below.

Injury Rates

It is difficult to ascertain the seriousness of the problem being studied without incidence rates of injury. Incidence rates of injury are the number of new cases occurring in a defined population during a specified time period. There are, actually, few studies where published incidence rates of ski injury have been based on verifiable data. Instead, rates based on estimates are common and reflect the difficulty of obtaining all of the information necessary for the calculation. The number of injuries is generally easy to acquire, but determining the total number of skiers at risk (the defined population during a specified time period) has been difficult and researchers often resorted to estimates. The "skier visit" (SV) is the common metric for calculating the incidence rate and means the same as skier days(Caldwell, 1984).

Variations in Measures of Ski Injury Rates

Laskowski and Murtaugh's (1992) article on ski injuries among physically disabled skiers at various Colorado ski areas, demonstrated the utility of verifiable data while providing a landmark study on disabled skiers and their subsequent injury patterns. They state that replicability in their study was limited by inconsistencies in data collection methods from one area to another. To ensure replicability, they chose to employ one ski area for a single site case study. This unnamed "large Colorado" ski area provided statistically valid reports of skier visits which enabled the calculation of injury rates for both disabled and able-bodied skiers. Injury data were collected retrospectively from ski patrol records. Of primary interest are the data from able-bodied skiers and their rate of skiing injury per 1000 skier visits (Table 3.1).

Table 3.1 Injury Rates for Skiers in a Large Colorado Ski Area, 1985-1989

	1985-86	1986-87	1987-88	1988-89	Total
Injuries	2,636	2,684	3,030	3,546	11,896
Skier Visits	808,579	796,026	869,231	905,911	3,379,747
Rate /1000SV	3.3	3.4	3.5	3.9	3.5

Readers should note that the methods employed in this thesis are by and large a replication of those used by Laskowski and Murtaugh.

The most extensive of all ski injury studies is the 23-year study (1972 to the present) by Robert Johnson, Carl Ettlinger and Jasper Shealy (1995) at a moderate sized northern Vermont ski area (now known to have been Sugarbush North and South). This longitudinal clinical study provides the most comprehensive investigation of ski injuries presently available and its data have generated numerous publications in the field (Blitzer, Johnson, Ettlinger & Aggeborn, 1984; Ettlinger, Johnson & Shealy, 1995b; Johnson, Ettlinger & Campbell, 1980; Johnson, et al., 1995; Johnson & Pope, 1984; Johnson, Ettlinger & Shealy, 1993; Shealy & Etlinger, 1993). All injuries transported to the clinic by the ski patrol and any walk-in patients presenting themselves within 48 hours of the ski injury were included, amounting to over 8,000 verifiable injury reports. However, the establishment of the at-risk skier population relied on estimates. Nonetheless, the researchers apparently took monumental efforts to ensure that these estimates accurately represent the general skiing population. Over 2,000 skiers in a control population have been interviewed and a further 40,000 respondents participated in a parking lot survey to ensure the representiveness of the control population.

This study provides outstanding data for ski injury trend analysis. For instance, this injury study was done during a major transition time in ski binding technology. They identified that lower leg injuries were reduced by approximately 80% (largely due to technological advances in bindings) and the general incidence of injury declined by approximately 50% over the life of the study. The estimated number of skier visits in the study is 2,750,000. However, due to the technological limitations of the era, statistically valid reporting of incidence rates of injury was difficult, primarily with regard to computing the population at-risk. Their putative figures were based on the total number of skier visits calculated from projected lift ticket sales and corrected for season's pass holders.

The Vermont research team employ an incidence rate procedure which discourages replicability or comparison with other studies. The standard incidence rate measure is defined as:

$$\text{Incidence} = \frac{\text{Number of new cases}}{\text{Total population}} \text{ during a given time}$$

(Hennekens, et al., 1987)

However, Johnson and the Vermont research team (1995) use the inverse of incidence rates, the mean days between injuries (MDBI), and it is calculated as follows:

$$\text{MDBI} = \frac{\text{Skier Days}}{\text{Number of Injuries}}$$

(Johnson, et al., 1995)

The injury incidence rate established by Johnson and his colleagues is one injury for every 408 skiing days or approximately 2.5 per 1000 skier days. This incidence rate is substantially lower than those reported in Australia and New Zealand (page 56) and two factors may be responsible for this. First, the definition of injury may not be the same and two, the Vermont ski area is not nearly as challenging nor as difficult as the other two study sites.

Although I will treat adolescent ski injuries in depth later (see page 51), another study from the Vermont group which is particularly relevant to the general issue of ski injury investigates injuries among children between 1972 and 1981. Blitzer, Johnson, Ettlinger and Aggerborn (1984) demonstrated the treatment of injury rates among children using the same strategies described above. The study investigated injuries among children divided into four age groups: aged 10 years and under, 11 to 13 years, 14-16 years and 17 years and older. However, because of the unique nature of the data, a further discussion of its data collection methods is warranted.

In that study, verified injury reports between 1972-1981 indicated that 22% of injuries to skiers of all ages happened to children under 17 years. The control population established by random sampling in parking lots and in the base lodge was composed of 1,268 skiers, 18% of whom were children. This was supported by 35,000 surveys administered around the ski racks and the parking lot. The number of skier visits in each of the four age groups was determined from the distribution of that age group in the control sample and the survey results. The rates using the MDBI technique were:

17 and older	1 injury for every 254 skier days
14-16	1 injury for every 206 skier days
11-13	1 injury for every 151 skier days
10 and under	1 injury for every 253 skier days

Thus, the 11 to 13 year old skiers had the highest incidence rate of injury. Again, the increased precision in age grouping may be misleading, since their skier visit data are based on estimates taken from sampling strategies and not actual skier visit statistics. Nonetheless, the identification of youths as having increased rates of injury and the fact that these young people have different injury patterns (as will be discussed on page 136) is relevant to my research.

A generalization about previous ski injury research emerges. It appears that in previous studies, rigorous care and attention has been taken in the collection of injury data, but determining the population at risk of injury is often approached with less rigor. Lamont's (1993) treatment of ski injury data in New Zealand demonstrates some of the problems one encounters when relying on ski areas to provide this crucial skier visit data. Five major ski areas agreed to participate in the study. Each provided a very high quality injury database but, because the 1989 season was not a good one, two of the "ski fields" refused to provide skier visit data for fear of loss of trade. Furthermore, Lamont simply doesn't describe how each ski field established its skier visit count, which raises further questions of reliability and replicability of the data. The problems faced in this multi-site investigation do not encourage the practice of leaving record keeping up to the site management. The 1990 phase of the study, however, did not have the same problems since it was a "bumper" ski season. The incidence rates reported only acknowledge the "all skier" category and no attempt to identify age-specific rates is made. The New Zealand national mean rate of ski injuries in 1990 was 3.3 per 1000 SV (Lamont, 1993). The injury patterns in New Zealand are clearly presented and the organization of causes of skier injury have been incorporated in my thesis study and will be discussed below when I treat research on causes of injury (see page 59).

Giddings, McCallum and Duff (1993) report on children's ski injuries in Australia. Their treatment of incidence rates differs from those above in that they have employed the age distinction used in ticket sales at the ski area: Children 12 years and under and adults 13 years and older. This distinction allows replicability for children's injuries but provides a potential over-generalization in that adolescents and adults appear to have the same pattern and rate of injury which I know from other studies to be improbable. Regardless of this, the treatment of children's injuries is good. The injury data are clinical records taken at the local medical facility. This represents good diagnostic data but may underrepresent the actual injury problem as some skiers may not attend the local clinic. The data from the ski area, once again, are not described, which hampers replicability. The authors indicate that the lift company provided the skier visit count in its annual report and also revealed that 7.5% of lift tickets were sold to children, thus enabling a calculation of incidence rates based on ratios of estimates. This rate was 3.34/1000 SV for children 12 years and under and 3.05/1000SV for adults 13 years and older. Injured children represented 8.2% of the injured population and 7.5% of the general skiing population.

A Japanese study by Sugawara, Serita, Takada, Watanabe and Kondo (1987) reported on injuries at a ski area outside of Sapporo, Japan during a five year period (1980-1985). Although rates are not provided, the authors report that 40% of the injured skiers were children aged 6 to 12 years. The next highest group of injured skiers were young adults 19 to 29 years. The adolescent population were notably absent from the injury reports.

The only Canadian findings relating to children's' ski injuries came from Abernathy (1991) who reviewed 11,000 injury reports prepared by the Canadian National Ski Patrol, a volunteer organization who patrol at many Canadian ski areas. Admittedly, Abernathy indicates that precise skier visits are not available and that rates cannot be generated. This study demonstrates the problem of only reporting on the injured population and not recognizing the at-risk population. For instance, Abernathy reports that 60% of the injured were between 11 and 19 years of age and that two-thirds of these involved 11-15 year olds. That would represent 6,600 young people. It is unlikely that young people account for 60% of the skiing population during this time period (1989/90) and are likely to be over-represented by these figures. It would have been beneficial had Abernathy provided more information regarding how many ski areas participated, which provinces were represented, how valid and reliable was the data collection and how these reports were collated and analyzed. Nonetheless, this study does present some interesting findings which will be discussed in the appropriate sections below.

Adolescent Ski Injury Rates Revisited

Although I have discussed studies of adolescent ski injuries above, it is worthwhile to generalize about them clearly here. Adolescent skiers are reported to have an increased incidence of injury. But, due to differences calculating and reporting, it is difficult to compare results. Injury rates differ widely, almost to the point of taxing credibility. Giddings (1993) reports that children 12 and under represent 8.2% of the injured population. Blitzer found 22% of injured skiers being under 17 years of age. A recent paper from the Vermont study indicates that the overall injury rate between 1981-1991 ski seasons was 3.98 per 1000 skier days for children and 3.04 per 1000 skier days from adolescents and that the injury rate for children is 44% higher than it is for adults (Deibert, Aronsson, Johnson, Ettlinger, Shealy, 1995). The Japanese study by Sugawara et al.,(1987) found 40% of injured skiers were between 6 and 12 years. And finally, Abernathy claims that 60% of injuries in a Canadian study involved children under 19 years. Young people may be injured at a higher proportion than their representation among the total skiing population. It is obvious that we need research and studies that tell us to what degree children really **are** more commonly injured.

Previous treatments of ski injury rates differ in terms of data reliability and the conclusions their data allowed the researchers to make. In fact, these studies made important contributions by showing trends in injury incidence even though they were obviously limited by the technology of the day. Fortunately, technological advances, particularly in computerized ticket sales, have recently allowed more replicable and statistically valid data collection strategies. Some of this technology was field tested in the preliminary retrospective component of this thesis and is employed in the prospective study.

General Injury Patterns

It is suggested that injury patterns differ with the age of the individual. Unfortunately, many studies of injuries do not provide for generalizations regarding age and injury patterns. The net result is that comparisons are often difficult because data collection methods are neither replicable nor always statistically reliable. A review of some of the injury trends and patterns already presented and will provide a number of studies which emphasize specific age groups in the skiing population.

The most notable change in injury pattern is the reduction of the lower leg fracture among adults. To reiterate, Johnson et al., (1995) reported that lower leg fractures have declined by approximately 80% during the past 20 years. Spiral fractures were reduced by 83%, bending fractures 37% (in particular, tibia fractures declined 63%) and ankle fractures declined 82% (Schaff & Hausser, 1993; Shealy, 1993a). This has been met with an increase in serious knee sprains (Anterior Cruciate ligament {ACL} injury) and is now the number one debilitating injury in alpine recreational and competitive skiing (Allegra, Fava & Priano, 1993; Berns, Hull & Patterson, 1993; Chiang & Mote Jr., 1993; Johnson, et al., 1993; Potera, 1985; Yee & Mote, 1993). Following the knee injury, other injured parts commonly reported in alpine skiing include the shoulder, the head, the face and the shoulder.

Blitzer et al. (1985) and Deibert et al., (1995) provide an outstanding summary of the ten most common injuries of the four age groups investigated. Table 3.2 and 3.2a show how injury patterns differ among the age groups identified.

Blitzer and Deibert's studies demonstrate the importance of investigating age-specific injury patterns. The injury types are quite different depending on the age of the injured person. Note the high ranking of thumb injuries among those 12 years and older and the high ranking of tibia fractures among the three younger groups in the Blitzer study. Deibert (1995) followed up on this study and presents data from the 1986-1993 ski seasons showing a change in leading injuries (Table 3.2a)

Table 3.2 Ten Most Common Injuries by Age, Presented at the Medical Clinic at Sugarbush North, Vermont(1972-1981)

Adult	14-16	11-13	<11
Thumb MCP[1]	Thumb MCP	Thumb MCP	Grade 1 MCL
Gr1 MCL[2]	Gr1 MCL	Tibia Fx[3]	Tibia fx
Laceration	Tibia fx	Gr1 MCL	Ankle sprain
Shoulder	Boot top cont.[4]	Leg/thigh cont.	Boot top cont.
Ankle sprain	Arm/hand cont.	Ankle sprain	knee cont.
Boot top cont.	Laceration	Boot top cont.	Leg/thigh cont.
Gr2 MCL	Gr 2 MCL	Arm/hand cont.	Arm/hand cont.
Tibia fx	Leg/thigh cont.	Metacarpal fx	Thumb MCP
Shoulder Dislo.[5]	Thumb fx	Head cont.	Gr 2 MCL
Gr 3 MCL	Ankle sprain	Laceration	Laceration

1-metacarpophalangeal joint 2-medial collateral ligament
3-fracture 4-contusion
5-dislocation Adapted from (Blitzer, et al., 1984, p.143)

Table 3.2a Ten Most Common Injuries in Each Age Group Expressed as Percentage of All Injuries, Sugarbush, Vermont, 1986-1993

Child		Adolescent		Adult	
Injury	**Percent**	**Injury**	**Percent**	**Injury**	**Percent**
Knee Cont.	11.2	MCP/UCL	10.2	Gr.3 ACL	18.4
Gr.1 MCL	7.9	Hand Fx	7.0	Gr.1 MCL	8.0
UE Cont.	6.3	UE Cont.	6.5	MCP/UCL	7.9
Leg Cont.	6.3	Knee Cont.	6.1	Laceration	6.7
MCP/UCL	5.9	Gr.1 MCL	6.0	AC/RC	5.6
Concussion	5.3	Laceration	5.5	Shoulder Di	3.8
Tibia Fx	4.6	Gr.3 ACL	4.5	Knee Cont	3.5
Facial	3.9	Concussion	4.4	UE Cont	2.5
Hand Fx	3.9	Shoulder	3.9	Leg cont.	2.5

Cont.=Contussion Fx=Fracture Di=Dislocation
Gr.1,2,3 Ligament Sprains MCL=Medial Collateral Ligament AC/RC=Shoulder
UE=Upper Extremity ACL= Ant. Cruciate Ligament MCP/UEL=Thumb
(Adapted from Deibert et al., 1995)

Serious head injuries are not reported as one of the more common skiing injuries, but the potential for serious brain injury and or death is always present given the behaviours practiced by skiers and the natural skiing environment.
Lamont's (1993) Australian study indicated that lacerations were the leading head injury, ranking as the third most frequent wound. The lacerations were usually caused by alpine skiers being hit by their own equipment or hard objects in the snow (*e.g.,* rocks, ice, branches). Concussions were ranked as the fifth most common injury resulting from skiers hitting their heads on the packed snow.

The shoulder injury (especially shoulder dislocations) according to the literature is a less frequent but serious problem on the hill because of the nerve and soft-tissue damage which often occurs with such joint injuries and the delay often encountered between the injury event and the treatment at a medical facility. A French study by Binet et al., 1985) of skiing-related shoulder dislocations reported that 88% of the dislocations occurred after a direct fall on the shoulder with the arm close to the body. One-third of the dislocations occurred when the arm was in abduction. The remaining 12% occurred without falling but usually involved a ski pole or ski lift causing strong traction on the arm. This injury is by the way, relatively rare for children and yet represents one of the leading injuries for adults according to Blitzer et al., (1984). That observation leads us to consider the injury types and patterns particular to children.

<u>Pediatric Skiing Injuries</u>

Children are not immune to ski injuries and the literature suggests that they are in fact at greater risk of injury than the adult population. Although there are only a few studies specifically dealing with children, the cumulative evidence is that children have a higher rate of injury and have different patterns of injury.

The Blitzer et al.(1984) study is one of the landmark studies of children's injuries. Their list of the top ten injuries in four age groups has not been replicated. Blitzer investigated all 3182 injuries which occurred between the 1972 and 1981 ski seasons. There were 696 children under 16 injured, representing 22% of all injured skiers. Using their data collection strategies, they determined that the overall injury rate decreased during the nine years of the study in all age groups. The decrease is probably attributable to the technological advances made in ski bindings during the study period (1972-1981). The risk factors associated with injury were skiing experience, personal estimate of ability, binding release and equipment ownership. The age group most at risk of injury were the 11-13 year olds followed by the 14-16 year olds. Older children suffered more serious knee sprains than younger ones. Tibia fractures decreased as age increased (13.3% of injuries for 10 and under children and 3.3% for adults) in this study. Deibert et al., (1995) report that ankle and tibia fractures continue to decline among all age groups.

The Sugawara et al., (1987) paper also describes some of the common injuries to Japanese children. This five-year retrospective study reviewed 1276 injury files from one ski area. Children aged 6-12 represented 40% (510) of the injured population. There were 384 males and 114 females in the 6-12 year old injured population. Nearly half of all adult injuries were sustained by intermediate level skiers while approximately 50% of children with fractures or sprains were beginners on slopes of less than 10 degrees. Fractures occurred without binding release in 74% of children, 54% of adolescents and 67% of adults. This suggests that bindings during that era continue to be a major risk factor in skiing, especially for children.

The Giddings et al., (1993) report on Australian ski injuries investigated children's injuries over a three-year period (1988-1990) at the Mt. Hotham ski resort. This retrospective study investigated 2501 skiing injuries presented at a medical clinic near Mt. Hotham. There were 204 injuries involving children 12 years of age and younger. These were compared to those sustained by skiers 13 years and older. No statistical differences were noted regarding the rates of injuries between the two groups. Injury rates of 3.34 per 1000 child ski days and 3.05 per 1000 adult ski days were established. The incidence of lower leg fractures was, however, <u>six</u> times that of the adult population. Giddings and his group feel that lower leg fractures continue to be a major ski injury problem for children as their rate of reduction is not as great as that of the adult population.

A Norwegian study by Ekeland, Nordsletten, Lystad and Holtmoen (1993) investigated children's injuries at four ski areas during the 1985/86 ski season . This study, much smaller than the others, included 59 injured children under age 15 and 63 controls. The most common injury sites were the lower leg 24%, the knee 20%, and the head 14%. Bindings did not release in 56% of cases in children under 10, where 27% did not release for those 10-14 years. Beginner skiers with less than 3 years experience were significantly more at risk than the more experienced skiers. This study found lower leg fractures a serious concern, as well as head injuries among the older children. The authors recommend helmet use and emphasized the importance of having the bindings properly adjusted.

These studies, using a variety of data collection methods, all suggest that children are at greater risk of various kinds of injury than adults. Lower leg fractures, head, knee and thumb injuries are ranked as leading injuries.

An interesting footnote is that children have not seen the same reduction in lower leg fractures as have the adult population despite the modernization of ski bindings. As previously stated by Giddings et. al., lower leg fractures were six times more frequent in children 12 and under than those youth and adults over age 12 and Blitzer (1985) found in his study that tibia fractures occurred in 13.3% of injured children under eleven while only 3.3% of injured adults. Forty-seven percent of children's injuries in Ekeland's study were lower leg equipment-related injuries indicating a problem in the boot-binding release function for children's bindings. There are several hypotheses which may be involved alone or together that may be responsible for this problem. First, that binding adjustment models do not account for the developmental differences in the growing child, resulting in bindings improperly set for the maturation level of the child (Bahniuk & Hulse, 1985; Ekeland, et al., 1993; Potera, 1985; Raas, 1987). Secondly, if the adjustment scales are correct, it may be that many parents choose to make their child's binding adjustment themselves without any form of training, or the children attempt to do so themselves. Another hypothesis may be that the equipment is used and worn and are not of a high or current technological standard.

The findings regarding children's head injuries are not consistent. It appears that young children often suffer less serious head injuries than adults but have increased rates of head contusions, lacerations and concussions. Including the face, as a head injury, explains some of the variation. The head and face were the third leading injury site among children 12 and under in Giddings (1993) study; Ekeland et al. (1993) also reported the head and face as the third leading site in children under 15 years but that head injuries occurred in only 5% of the younger children compared to 18% among the older ones.

Gender-Specific Injury Patterns

Males represent around 75% of the injured snowboarding population and are usually under 30 years of age (Abu-Laban, 1991; Ganong, Heneveld, Beranek & Fry, 1992;

Janes & Fincken, 1993; Pino & Colville, 1989; Shealy, 1993a). Recent papers by Shealy (1993) and Cadman (1993) indicate that wrist injuries are a particular problem of the female snowboarder with nearly twice the frequency as for males. The leading cause for upper extremity injury among snowboarders is falling on the outstretched arm. Beginners are at greatest risk of this injury (Shealy, 1993a). It may well be that females are over-represented in the beginner categories of this relatively new sport.

In studies of fatalities, victims are predominantly male. Morrow, et al. (1988) found 81% of his fatality population were male while Shealy (1985) notes that males represented 83% of fatalities in his study.

Shealy, et al. (1993) found that male skiers had slightly lower rates of injury than female skiers but that among snowboarders this was not the case among intermediate and advanced level riders. Females both in skiing and snowboarding have nearly twice the rate of knee injuries as males. Males tend to injure their head and faces more than females in both sports.

Sport Specific Injury Patterns

The literature on snowboarding injuries is in a state of incipient growth The leading published reports were by Shealy and Sundman (1989)(presented in 1987) and by Pino and Colville (1989). Since then a number of studies have emerged supporting the fact the snowboarders have a different injury pattern than alpine skiers (Abu-Laban, 1991; Cadman, 1994; Ganong, et al., 1992; Janes & Nicholas, 1995; Janes, et al., 1993; Shealy, 1995; Shealy, 1993b). Establishing injury rates in snowboarding has been hampered the same way rates for alpine skiing have been and also because the two sports now share the same terrain and are accounted for in the same way by ski area ticketing procedures and policies. Determining the snowboarder population using reproducible strategies has been made very difficult. A paper by Jasper Shealy estimates injury rates using sampling strategies. His findings suggest injury rates are comparable between the two sports and that male and female rates are proportional between the two sports when controlled for ability (Shealy, 1993b).

Snowboarding equipment continues to change and these changes are reflected in the injury patterns. An estimated rate of injury among snowboarders was 2.99/1000 snowboarding days at 15 ski resorts across the United states. Nine of these 15 centres had large snowboarding populations and subsequently these nine ski areas reported a rate of 3.37/1000 snowboarder days (Shealy, 1993b). It is apparent that the snowboarding injury rate is comparable to the ski injury rate, however, identifying the denominator (total number of snowboarders) is virtually impossible because lift tickets do not differentiate between the two sports. Shealy does not explain how he obtained his rates The leading injury site reported is the lower leg and in particular the ankle joint. The second major injury site is the arm, with wrist fractures predominating (Abu-Laban, 1991; Pino, et al., 1989). The introduction of hard shelled boots may be potentially related to an increase in knee injuries among snowboarders. Snowboarders are reported to have more fractures than skiers with the leading fracture site being the forearm. The more recent studies on snowboarding injuries indicate that the wrist is the leading injury site and not the ankle (Janes, et al., 1993; Shealy, et al., 1996).

Physical Skiing Environment

Another general topic within the literature on skiing injuries is the effect of the physical environment on behaviour. To distinguish behaviour from lifestyle and other forms of action, *behaviour* as defined by Green and Kreuter (1991) as an action that has a specific frequency, duration and purpose, whether conscious or unconscious. In skiing, behaviour is largely dependent on the natural environment. A skier requires a slope and snow in order to be able to ski. However, variations in slope, weather, snow conditions, crowding and snow grooming will affect the skier's behaviour within the context of the skiing environment.

Environmental Factors Leading to Death on the Slopes

The leading cause of death for skiers was a collision with a tree (76%) followed by rock (8%), lift tower (5%), other skier (5%), ski pole (3%) and a fall from a cliff (3%). Speed associated with a loss of control is the leading factor in all of the alpine skiing fatalities reported by Shealy (1985).

Death in alpine skiing is an infrequent event but one which does occur regularly in skiing. The major risk factor identified by researchers was excessive speed combined with a loss of control leading to an impact with a solid object such as a tree or rock. Improved trail design and better grooming of the skiing environment may enable more skiers to access the runs, but they also encourage increased speeds which may result in more serious injury (Scharplatz, Thuhleman & Enderlin, 1985). Educating skiers about the risks of skiing and the need to ski in control may be assumed to help prevent injuries (Fiore, 1994).

Large scale investigations of snowboarding fatalities have not been described in the literature. However, a case study describing three snowboarding fatalities presents a different picture than that generally described for skiers. This study highlighted an unusual occurrence of three snowboarding fatalities in the Lake Tahoe region. In each case, the young (15-22) male victims were found inverted in a tree well with deep powder snow conditions (Kizer, et al., 1994). The victims were all snowboarding off the ski run and were tree skiing. It would be unfair to state that snowboarders are more at risk of deep snow immersion death than skiers engaging in the same activity (Prystay, 1994; Schaefer, 1995).

The physical environment plays a critical role in the incidence and severity of injury among alpine skiers and snowboarders. It is apparent that serious injury often occurs in places where the skier can attain higher speeds and then come into contact with hard objects such as trees, rocks and lift towers. Most injury occurs on beginner and intermediate slopes which are groomed. Good visibility is also a common factor in ski injuries. This suggests that most ski injuries occur under ideal skiing conditions and are more likely dependent on the skier's ability to handle the chosen terrain. The physical environment in skiing presents inherent risks and hazards which attract many skiers who seek to challenge themselves and nature while enjoying the beauty of the outdoor environment and maximizing the health and recreational benefits of outdoor activity.

Environmental Factors Leading to Injuries on the Ski Slopes

To start with a generalization, the published literature on ski injuries does not provide definitive answers with respect to the role of the physical environment on specific injuries and injury rates. The data used to describe the physical environment are usually descriptors noted on injury report forms completed by the attending ski patroller or by a detailed interview with the injury victim at the medical facility. Most epidemiological investigations on ski injuries, located in this review, make reference to both natural and artificial environmental factors which existed at the injury scene. These variables include such quantifiable items as new snow, snow quality, condition of the slope (groomed, moguls, powder, wet, icy), level of run difficulty, lift involvement and visibility are some of the more common descriptors.

Skiing is a winter sport largely dependent on snow, weather and access to prepared slopes. Technological advances in the preparation and maintenance of the ski area have greatly enhanced the natural attributes Mother Nature has provided. Mountain slopes have ski runs cut out from the trees, aerial lifts whisk skiers to the upper elevations with minimal effort, snow-making systems provide improved early and late season conditions and groomed slopes make skiing accessible to all levels of participants. These artificial features, when combined with snowfall, temperature, visibility and wind create a complicated web of interrelated factors which may influence skiing behaviour and injury. Figure 3.1 represents the physical environmental features of a ski area which influence skiing behaviour.

A taxonomy has been generated for each term, so that the reader can understand what factors skiers include under each heading. This list was generated with the assistance of two professionally sponsored snowboarders, three ski patrollers, three adult skiers, two adolescent skiers and the researcher.

Weather: visibility, wind, temperature, powder conditions, new snow, ice, rain, clothing

Slopes: designated ski runs, skiing terrain inside the ski area, ski terrain outside of the ski area but accessed from the ski area, natural and artificial features

Natural: slope angle, snow, ground cover, moguls, terrain features, cut banks, wind lips, on-off piste, alpine/sub-alpine

Artificial: permanent and temporary features of the ski runs and slopes done on purpose to enhance skiing (cutting trails, contouring the ski run, installing snow-making systems, moving and flattening the snow, marking hazards and trails)

Grooming: summer grooming (rock and stump removal, seeding, drainage, contouring), winter grooming (snowcats, winch cats, snowmaking)

Safety: marking (trail signs, specific hazards, Alpine Responsibility Code), lift loading instructions, tower pads, fences, education centres, media, ski patrol

Lifts: technology (high speed four-person lifts compared to T-bars), more on-hill time, fatigue, loading mazes, safety bars, load/unload areas, education in maze area, tower signs

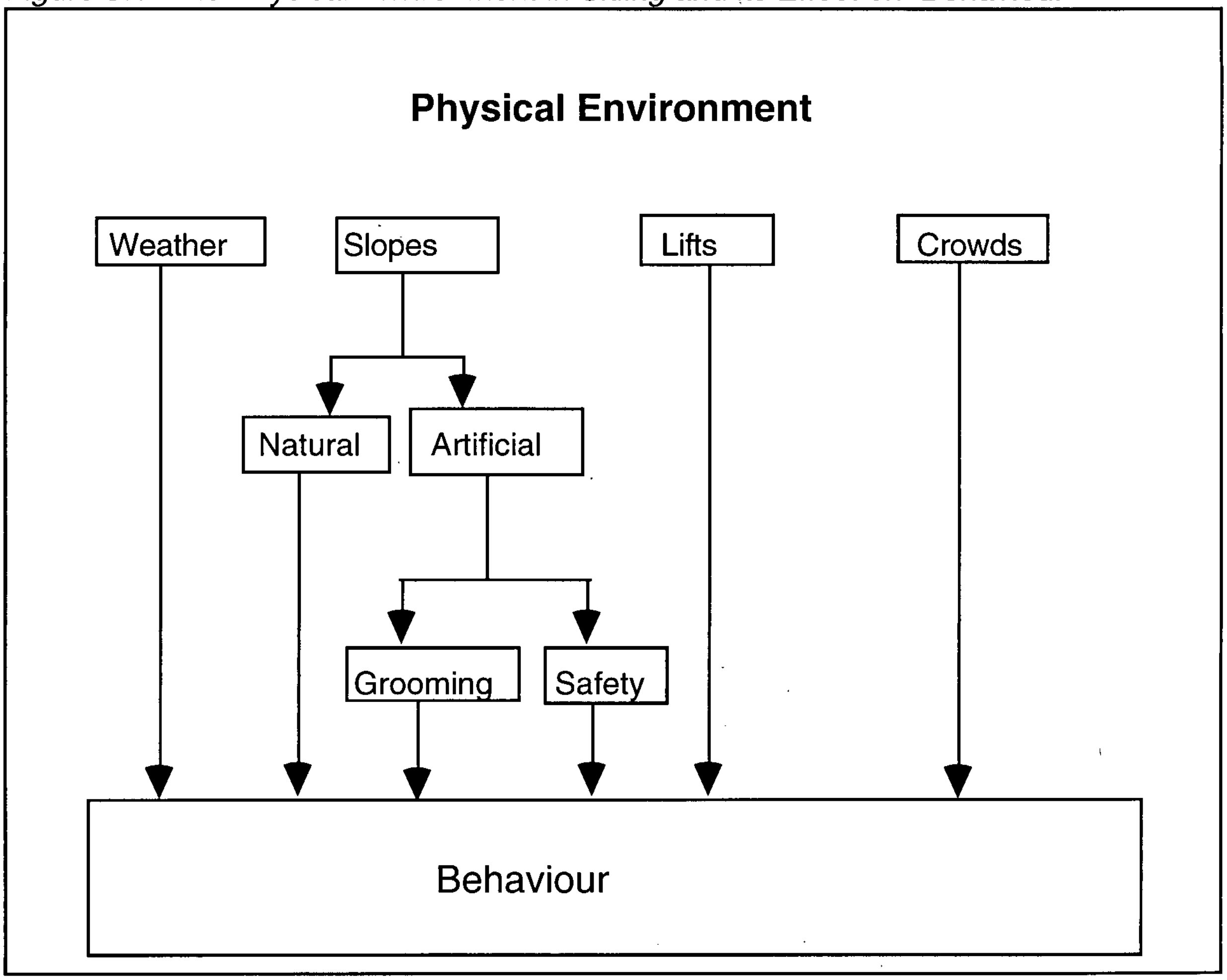
Crowds: congestion, collisions, near collisions, frustration, moguls, delays, run deterioration.

The literature on skiing deals with these factors in isolation more often than not. The following review will attempt to demonstrate how the individual factors influence behaviour and injury as an outcome of skiing.

Weather

Skiers, like mariners, understand that Mother Nature can bring the best and worst of climatic conditions. The effects of weather are of paramount importance for skiers. Such factors as precipitation, temperature, wind, and visibility influence the skiing experience and possibly the incidence of injury. Few systematic investigations of injury take these factors into account, but the literature does suggest that natural environmental factors play a role in injury events.

Figure 3.1: The Physical Environment in Skiing and its Effect on Behaviour



Weather has a major influence on the skiing experience. A sunny, spring day will attract skiers whereas a cold, windy day may dissuade all but the hard core habitués. Researchers have conflicting conclusions. Stephen Wasilewski, is quoted by Dolinar (1991) as believing that skiers tend to get hurt more when skiing in sub optimal conditions, yet evidence suggests that most serious injuries including fatalities occur in good weather. Morrow (1988) concurs that poor visibility was not a factor in any of the fatally injured skiers in his Vermont study. On the other hand, Bouter's (1988) survey of injured European skiers who skied the Alps, found that approximately 20% of injured skiers mentioned limited visibility as a factor. The physical environment may be an aggravating factor since the high mountainous regions of the Alps pose greater threats to skiers (*i.e.,* cliffs, crevasses, open glacier bowls) with impaired visibility than those on the smaller ski hills of Vermont.

An important contribution is Serita's (1987) suggestion that changing temperature was a critical issue in skiing injury. He looked at how temperature affected snow conditions and found that injury incidence was related to changing snow conditions during the course of a day. He believes that warning skiers about changing snow conditions during the day may have a substantial impact on the incidence of injury. Serita indicates that it takes at least 30 minutes for the change of air temperature to affect the snow surface, giving ample time to warn skiers of the impending hazards of changing snow conditions. According to Serita, the number of accidents rose sharply under warm weather and spring-like conditions. However, without rates it may simply be that more people ski during the fine spring-like weather.

A factor which was not mentioned in the reviewed studies was decreased skier performance due to cold. Of interest is whether the daily incidence of injury is greater or lower during periods of colder temperatures.

The importance of understanding the effects of sun, wind and temperature are imperative for advanced skiers, whose decisions to ski a particular double black diamond in the morning or afternoon may make a difference in whether they navigate the run successfully. A case in point is this report of a fatally injured skier who entered a run closed due to icy conditions that would have been safe to ski after two hours of sun exposure (to soften the ice).

BLACKCOMB SKIER DIES
A 23-year old Toronto man has died of injuries suffered on Blackcomb Mountain after ducking through ropes and tumbling down a steep, closed slope...
(Anderson, 1994)

Note: It is important to recognize that this skier, known to me personally, was an advanced-ability skier rather than simply someone who failed to notice the barrier. The skiers last words "You only live once!" indicate poignantly that this young man recognized the risks of skiing this slope but likely failed to recognize the effects of changing weather/slope condition.

Snow Conditions

Injury patterns tend to differ depending on the snow conditions. The Sugawara et al., (1987) study previously mentioned investigated 1276 ski injuries and found that injury patterns varied with snow conditions. They defined the snow conditions as *powder* (it does not lump when grasped), *soft snow* (it lumps when grasped), *wet snow* (the water oozes out when grasped), *hard snow* (packed and hard snow conditions), *icy* (one can hardly pierce it with the tip of the pole). The injury patterns in this study show that fractures occurred on soft snow in 33.1% of children and 33.6% of adults, suggesting that hard snow conditions are more likely to cause fractures than soft snow conditions. The inverse is true for dislocations where 36% occurred on hard snow and 64% on soft snow. Johnson and Pope (1984) observed a significant decrease in lower extremity equipment related (LEER) injuries on icy surfaces with concomitant increase in other injuries. Bouter et al., (1988) reported similar findings regarding snow conditions and injury patterns. They claim that during conditions of icy or hard packed snow, a higher proportion of upper extremity and head injuries exist, while in wet or powder snow lower extremity injuries predominate. The relationship between injury and snow conditions requires and deserves further investigation.

Slopes--Natural Features

Ski runs are classified as to their level of difficulty in relation to other runs on that particular mountain. The standard North American rating is 'green' easiest (beginner), 'blue' more difficult (intermediate), 'black' most difficult (advanced), 'double black' experts only. For example, a green run on one mountain may be quite different from a green run on another mountain (De Billy, 1991).

The literature is vague regarding injury and the difficulty level of the run. The majority of studies emphasize the skier's self-reported ability rather than the difficulty level of the run where the injury occurred. The skier's ability will be discussed below in the section on skiing behaviours. The majority of papers suggest that injuries are more frequent on beginner and intermediate slopes but empirical evidence is lacking. Morrow et al., (1988) is an important paper on skiing fatalities in Vermont (to be further discussed below) which indicated a surprising generalization. Of 16 cases investigated, 11 occurred on beginner or intermediate level slopes by skiers skiing at or below their reported ability .

Thus, one can generalize that previous studies suggest that the level of difficulty of the ski run is a factor but empirical evidence is lacking. Articles commonly focus on the skier's self-reported ability rather than the type of ski run chosen by the skier. Further research on where injuries occur on the ski hill should provide a basis for the development of passive interventions (*e.g.,* design of ski runs and padding of obstacles). This strategy is described by Bergstrom, Askild, Jorgensen and Ekeland (1993) when a new ski area was developed and a ski run injury analysis was performed to determine the most injury prone locations on the mountain. The potential for serious injury is obviously greater on the double-black, expert-only slopes yet the reality is that a majority of cases involving serious injury resulting in death occur on beginner and intermediate level slopes. Admittedly, this is based on a single study and should be explored further.

<u>Slopes--Artificial Environmental Factors</u>

The artificial influence on the ski slopes include the grooming and safety marking. These two factors play a large role in risk management/loss prevention for ski areas and are also important in creating a positive and health promoting skiing experience.

Grooming

The grooming of ski slopes is becoming more and more common as skiers demand more challenging and meticulously prepared surfaces to ski. As ski runs get used, washboard bumps known as moguls are formed, causing the run to become more difficult to ski. A groomed slope, then, is one where tracked grooming machines (snow cats) plow the snow and use a tiller to smooth the surface to carpet-like conditions. It is common practice to eliminate moguls every night by grooming the slopes flat. This enables more people to use the slopes, increasing their enjoyment and generating more revenue for the ski area. The groomed slopes facilitate skiing regardless of ability. Deep snow or slopes with moguls require more skill on the part of the skier. Scharplatz (1985) and Johnson (1984) make the generalizing claim that improved grooming of the skiing environment may enable more skiers to access the runs, but it also encourages increased speeds which may result in more serious injury.

Arne Ekeland of Norway has produced three studies which have included grooming as an evaluated risk factor. His study on children's ski injuries (1993) found that 86% of injuries to children 15 years and younger occurred on groomed slopes Ekeland, et al. (1993). In another study Ekeland, Holtmoen and Lystad (1989) randomly selected more than 750 skiers from lift lines to investigate skiing behaviours and found that 74% of skiers skied on prepared slopes while 25% skied on both groomed and powder snow (generally off piste where the snow is unpacked). This led Ekeland to investigate the different trends between those injured on groomed slopes and those injured in powder snow. Those results were presented at the 11th International Congress on Skiing Trauma and Skiing Safety in Voss, Norway (1995). His findings indicate that ski injuries in powder snow are similar in type as those occurring on groomed slopes and that the risk of injury is about the same, given that more advanced skiers tend to ski in the powder snow (Ekeland, Holtman & Nordsletten, 1995).

Despite indications that the majority of injuries including those to adolescents occur on groomed slopes, it must also be recognized that the majority of skiers ski on these same slopes. Johnson points out that snow grooming, snow making and trail design may have an effect on injury but that "we know of no well-controlled studies which prove the value of these variables in preventing injury" (Johnson, et al., 1984, p.373). Groomed slopes enable increased speeds to be obtained and Blitzer eloquently reminds us that "they *(young people)* are usually of sufficient skill to ski rapidly, yet often show poor judgment and recklessness which all too frequently results in accidents" (Blitzer, et al., 1984, p.146). The treatment for this kind of behaviour according to Fiore (1994) is to educate the skier about the risks and the need to ski in control.

Groomed slopes are a fact of life on the ski hill and the trend is to groom not only beginner and intermediate level runs but advanced runs as well. The technology is available to groom the steepest of slopes using specialized winch cats (snow grooming machines with winches). This trend according to Johnson (1984) will result in more injuries due to more skiers skiing at greater speeds on more and more challenging ski runs. The net result is that the improved environmental conditions are offset by the more reckless skiing behaviour they encourage (*e.g.,* ability to go faster and lose control). Skiers may be led into a false sense of security with the near perfect skiing conditions and not realize how easy it is to lose control.

Safety

Safety is a prime concern for ski areas and efforts to ensure that a consistent quality of signage and marking are present. Penniman (1993) suggests a standard of marking for various types of obstacles. However, the industry maintains that local marking standards should be employed which meet the local needs (B.C Law Reform Commission, 1993). Marking of ski run hazards is an important risk management/loss prevention strategy of the ski area. Ski patrols, as a matter of routine, ski each slope every morning. These trail-checks (as outlined in the Blackcomb Ski Patrol Policy and Procedure Manual, 1994) are performed with the perspective of the lowest level of skier the trail is designed for (*e.g.,* a green trail will be checked from the perspective of the beginner skier, and marked to what is considered a reasonable expectation from their point of view). The trail check includes verifying that appropriate signs are present (*e.g.*, avalanche closure, permanent closure, caution, marginal skiing, slow), marking of hazards (*e.g.,* bare patches, rocks, stumps, creeks, cliffs), evaluating snow conditions (*e.g.,* icy, groomed, wet, powder), and noting the status of the run (*e.g.,* open, closed, marginal skiing).

Even though marking standards vary from ski area to ski area, consistency within an area is of great importance so that skier's expectations are routinely satisfied and the ski area receives maximum protection from litigation from skiers who come in contact with unmarked hazards. The use of crossed bamboos to mark small hazards, vertical bamboo with rope strung between for larger hazards and permanent fencing for large hazards such as cliffs or avalanche prone areas. Ski areas perform a number of tasks intended to increase the safety of the skiing experience. Avalanche control is routinely carried out with ski area boundaries on all slopes which may pose a threat to skiers. Slopes watch or speed control programs are becoming increasingly common in many ski areas and are designed to educate reckless skiers about the Mountain's Alpine Responsibility Code (see page 182 for details). Ski patrols will attend to injured skiers and, at the end of each day, every run is swept by the patrol to ensure that no one is left on the mountain.

No studies relating injury to signage have been identified. However, most ski areas attempt to identify runs clearly by name, number and difficulty level.

<u>Lifts</u>

The potential for injury on or around ski lifts is great because of the mechanical nature of the device. North American ski areas make a concerted effort to reduce the risk of injury at the loading area of ski lifts by providing mazes so that skiers approach the lift in an orderly manner unlike many European ski areas which do not provide such organizational structures. The potential for injury appears to be greatest during the loading and unloading phase (Shealy, 1982). The use of the safety bar (on aerial lifts) should ensure that the ride up the mountain is incident free. There were only two recent studies located which investigate injuries associated with ski lifts. Lindsjo, Hellquist, Engkwist and Balkfors (1985) investigated injuries to Swedish skiers using a surface lift known as the T-Bar. This three year study investigated 168 lift-related injuries representing 7.5% of all injuries in the ski area. The authors claim that the injury rate for riding the T-bar was 1/80,000 rides. The majority of injuries were minor in nature and only four required hospitalization while the rest were treated at the local clinic or by ski patrol staff.

The second study by Bouter, Knipschild and Volovics (1988) reported that 6% of injuries were lift-related but little information describing the circumstances. Developments in ski lift design has been tremendous and the impact of these lifts on the ski area and the risk of injury loading, unloading and riding high speed lifts should receive further assessment.

Crowding

Crowding is a factor which is often considered by the skiing public to be highly correlated to injury. Measures investigating crowding usually revert to studies of skier collisions. Increased skier density is likely to result in a greater number of injury-producing collisions. However, Jenkins, Johnson and Pope (1985) found no direct correlations when they compared the incidence of injury producing collisions and ticket sales. On the other hand, a very interesting diachronic Norwegian study by Lystad (1989) was designed to investigate the effects of a ski area which was doubling the lift capacity without enlarging the skiable terrain. This study proved useful in understanding the effects of crowding. At the start of a new season, a double chair was installed doubling the lift capacity of the ski area. That season, the incidence of injury-related collisions increased by 70% to a high of 0.27/1000SV. The rates continued to be high for three years until new trails were opened and the rate then declined to 0.11/1000SV. Lystad found that victims of skier collisions were usually children and beginner skiers. He suggests that it is important to have slopes which can separate skiers by ability so that novices and children do not have to share the slopes with more aggressive skiers.

It would be most useful to investigate high and low skier volume and injury rates. Technology is available that would allow researchers to monitor daily injury rates and the general effects of crowding could easily be determined.

In conclusion, skiing behaviours are determined largely by the physical environment. The combined influence of both natural and artificial environmental factors will dictate not only what behaviours skiers engage in but to a certain extent how much pleasure they may derive from the experience. Skiing on slopes above one's ability or skiing in the fog will influence the success of the experience and subsequently the enjoyment of the activity. The most frequently noted physical environmental factors are weather, slope conditions, ski lifts and crowding. The literature is inconclusive as to the effect of physical environmental factors upon skiing behaviours, let alone skiing injuries.

The Social Environmental of Skiing

The issue of the social environment of ski injuries is an aspect of the Precede-Proceed Model and therefore important background for this thesis. The behaviour of skiers is not only influenced by the physical environment but by the social environment as well and is influenced by role, co-participants, skills and knowledge, activities and equipment (see Figure 3.2).

Much like with the physical environment, a taxonomy has been generated to define the above terms from a skier's perspective.

Role: There are several clearly defined groups in skiing who share similar beliefs and patterns of behaviour.

-Freestylers, who are also known as soft booters, aerialists, jibbers and bonkers.

-Hard plate riders who are known as hard booters, free riders, carvers, race boarders,

-Professional skiers who include instructors, ski patrollers, coaches and sponsored skiers.

-Adults tend to make up the rest of the unclassified groups on the ski hill, but it is evident that other distinctions such as locals, tourists, destination skiers, foreign skiers and special clubs also contribute to the various roles played by skiers.

Co-Participants: All people who share the ski area with you but most importantly are your friends who you ski with and family.

Adults: The adult population tends to include parents, professionals skiers (ski patrollers, instructors, lift operators), coaches as well as the general adult skiing population.

Peers: Generally speaking the peer group is the group which exerts the most influence on an individual. In skiing, older kids, pro-sponsored alpine skiers and snowboarders, innovators (new moves), racers, same-age friends who have similar beliefs tend to form the individuals peer group.

Instruction: Instruction is the transmission of knowledge and or skills which will enhance a skier's experience directly or indirectly. Formal instruction usually occurs with the ski school, race teams, freestyle training, children's programs, school programs, adult camps, guided tours, signage, education centres, magazines, books and media. Informal instruction may simply include watching others or practicing a move with a friend.

Activities: Planned or unplanned activities skiers undertake while skiing. These may include formal programs or spur-of-the-moment actions.

Organized: This includes all organized activities which may occur at a ski area such as recreational race series, kids/youth camps, public race centres, halfpipe competitions, competitive racing (Pro-Am, World Cup, Provincial, League), bordercross, extreme, ski school, summer training, powder 8 competitions.

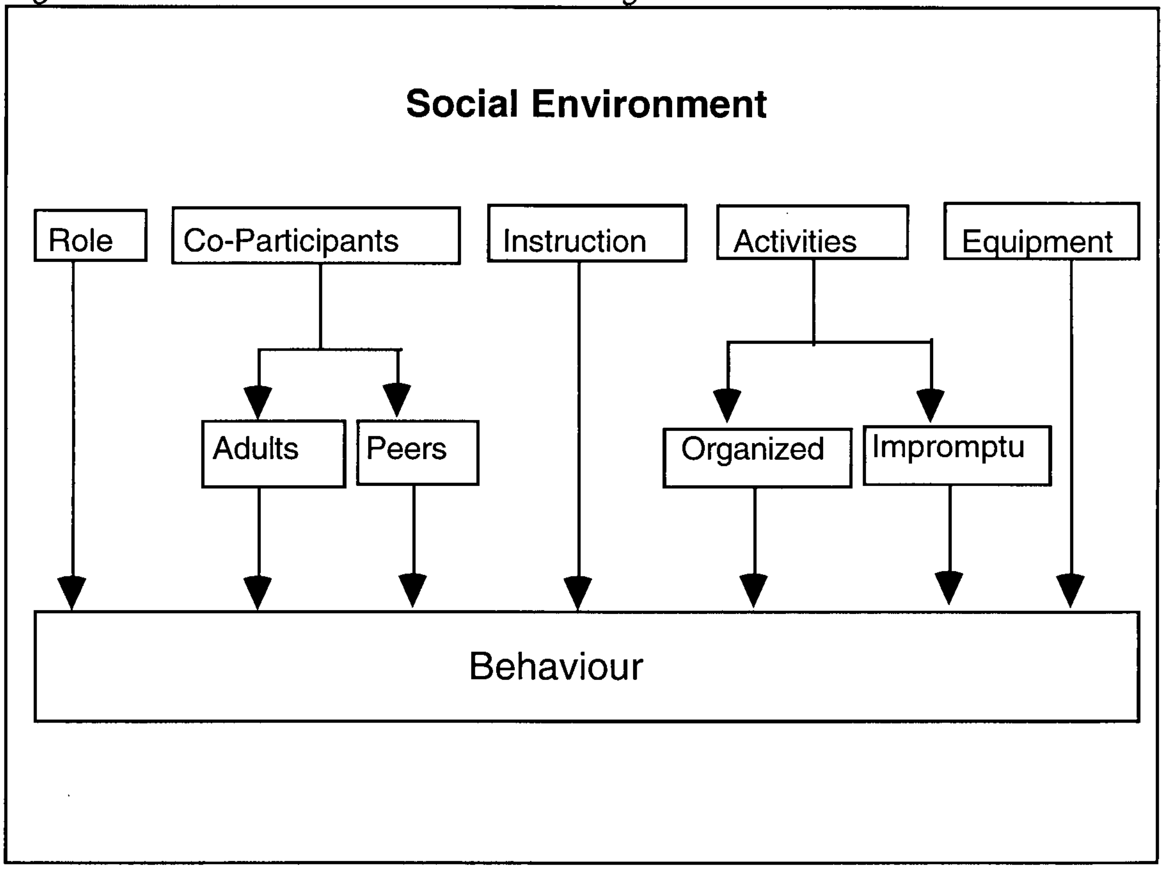
Impromptu: Any activity done by one or more people while skiing. This may occur anywhere, but common sites are in the snowboard park, the halfpipe, at unique terrain features (wind lips, cliffs, etc.)

Equipment: Equipment may or may not be a social environmental factor but choice of equipment is largely influenced by social marketing factors. Professionals, corporate sponsors and the media influence equipment choice and how equipment is perceived to be used. Also, a persons equipment may limit a skier's ability to perform optimally (*e.g.,* slalom skis for slalom racing).

Role

In considering the important social-ecological issue of skiers' role, I am essentially looking at the effects of expectations on skier behaviour. To return to the most basic definitions of behavioural sociology, a "*role* " is defined as the behaviours considered by insiders to be appropriate to a social identity. Thus, the "skier", "snowboarder", "members of the Cadman High School ski club","Hot Doggers", "new schoolers", "old schoolers", "hard booters" and "jibbers" are all social identities with associated roles that impact on behaviour.

Figure 3.2: The Social Environment in Skiing and its Effect on Behaviour



Although, I did not locate any peer reviewed studies which investigate the issue of role expectations, the popular skiing and snowboarding literature was helpful.

Bruce Edgerly (1995) wrote in *Snow Country* magazine that "ski cults, ski gangs, ski clans or rat packs" are simply informal groups or friends who ski together under a common name. He claims that pack skiers invariably share the same values: a passion for skiing, no matter what the conditions; a love of camaraderie and an intense desire to push their limits. He says that when skiers share this mind-set, skiing becomes synergistic and supercharged, and a frenzy can erupt at any time. These groups with names like 'the Jackson Hole Air Force, The Dogs of Bell Mountain (Aspen), Ridge Hippies (Bridger Bowl), Face Rats (Heavenly Valley)' are often comprised of members well into their 50's who seek to push their limits and to be part of a group.

Also clear in the popular literature is that snowboarders are stereotyped as having their unique identifying features. Clearly an issue of role-governed behaviour, snowboarder's have their own ethos and slang. Snowboarding has been dubbed the adolescent sport of baggy pants, bad attitudes and jib-bonking (striking objects with the snowboard while riding).

Stereotyped behaviour among adolescents is not uncommon. Many young people experiment with different social groups in order to experience being a member of the group and sharing the values, aspirations and goals of the group. In skiing, stereotyped behaviour is again not uncommon. As we have seen above, adult skiers have been seeking insider status in ski groups or fraternities.

Snowboarder's have received a great deal of attention in recent years by the media and the adult skiing population. It is uncertain whether the snowboarder's behaviour is the cause or the result of attention paid to it by non-snowboarders. Lee Crane's 1993 *Snow Country* magazine article describes some of the features that distinguish the sub-groups within the snowboarding culture. Despite her humourous attempt at distinguishing these groups, the role expectations are evident. The terms employed to denote the various groups are extinct but the examples serve to demonstrate the point that role expectations are present even if we do not know how they developed.

<u>Snow-skaters/Yo-Boarders</u>

Visuals: Like their gang member, skateboarding cousins, Yo-boarders tend to ride in large packs and spend most of their day sitting smack-dab in the middle of the most crowded ski runs. Dressed like their favorite rapper, they typically outfit themselves in baggy denim trousers, Paul Bunyan-size flannel shirts and pierced body parts.

Auditory clues: " Dude, I f__ing jibbed that f__ing stump and f__ing bonked that f__ing piece of s___ lift tower with the tail of my F__ing board".

Demeanor: Yo-boarders are the most obnoxious, sarcastic, belligerent, adolescent, anarchistic, foul mouthed destructive creatures allowed to purchase a ski pass.

<u>Ski-Boarders</u>

Visuals: ski-boarders dress like skiers. They wear similar boots; the same $600 padded racing sweaters with matching pants... ski-boarder to keep their boards on the snow and arc big turns, leaning so far over it looks as if they're falling.

Auditory clues: "I'm not happy with the carving characteristics of this asymmetrical-core/symmetrical-sidecut race board because the flex pattern is too soft in the tail...

Demeanor: With a heavy dose of faux-friendliness, ski-boarders are the most receptive to questions about the sport...

<u>Snow Surfers or snurfers</u>

Visuals: snurfers believe their prowess in the ocean translates directly to the snow, so they often head for the gnarliest cliff they can find and hurl themselves over its edge.

Auditory clues: "Duuuuude, that was sooo gnarleee. Did you see that hiddie (hideous) chute?... I just charged right over the dude and I almost biffed.

Demeanor: Despite their foggy mental state, snurfers are friendly.

(Olfactory clues: The smell of marijuana permeates nearly everything a snurfer owns.)

The national snowboard scene is reported to be divergent and difficult to characterize with a single label. The *Snow Country* staff (Oct., 1994) researched the controversy between skiers and snowboarders and came up with the following analogy. "Like many of its practitioners, the sport is a teenager, with all the tantrums, desire to shock and Igotta-be-me yearnings the word implies. Skiers, of course, are the hapless parents, forced to watch with bemusement or outrage as the innocuous toddler becomes a near-adult with a nose-ring, green Mohawk and mercurial attitude". (Page 154)

There is certainly a relationship between the behaviour of snowboarders and the media portrayals. Without speculating as to whether the magazines reflect or mold snowboarder behaviour (or both), I note that insider clothing and riding behaviour reflect what is depicted in the magazines. For example, a careful review of contents of one randomly selected snowboard magazine (*Transworld Snowboard* Magazine, Volume 5, Number 5, February 1995) taken from the shelf of an avid 16-year-old snowboarder showed all of the snowboarders wearing baggy pants, most wearing wool hats or baseball caps worn backwards and some idiosyncratic haircuts. Among the 280 pages in which a clearly defined photograph could be evaluated (sequence shots count as one) there were 61 photographs of "BIG AIR" jumps off cliffs, cornices, and among trees where the rider is at least 6 meters from the snow, 29 photos of riders in deep powder snow, most of which is avalanche prone terrain, there were 5 photos of riders bonking (hitting off objects), 18 involving jumps in a half-pipe. There was not a single photograph of a helmet, avalanche beacon, avalanche shovel or other safety/rescue equipment. Snowboard leashes were not apparent but may have been hidden by clothing. The only reference to an avalanche transceiver was in a large print headline "I haven't shaved for ten days. I just bought a quilted flannel shirt and a dual-frequency avalanche transceiver. I ride a 172, and it feels small. I eat steak for breakfast. I am Mr. Alaska."

From all of the above discussion on role, we can generalize that skier roles do exist and that particular behaviours are consistent with those roles. Furthermore, it appears from the popular literature that shared insider perceptions of role are an important factor in determining the social norms of skier behaviour. Social norms are the accepted beliefs, values and practices shared among group members. Many young skiers take on a role when they step into their skiing equipment and along with that they adopt many or all of the accepted social norms.

Co-Participants

The influence of co-participants has not been evaluated with respect to skiing behaviour. Two primary groups have been targeted which are likely to have an influence on the adolescent skier, the adults and the peer group. The academic literature on skiing has not identified either of these as recognized factors influencing injury or skiing behaviour for that matter. However, it is widely accepted elsewhere that they do play an important role in determining behavioural patterns and possibly with injury as an outcome of that behaviour.

Adults

It is evident that adults have a greater influence on young children's behaviour than they do on adolescent behaviour which is strongly associated with the peer culture. The influence of the family and other adults is not nearly as strong as that of the peer group (Jessor, 1991; Tonkin, 1987). Neither the popular not the academic ski literature describes the inter-relationship between adult and youth behaviour.

Peer Group

Evidence suggests that the peer group does affect skiing behaviour. Located in the popular literature were numerous references to peer persuasion between skiers. Several examples documented in snowboard magazines will be discussed. The first from *Transworld Snowboarding* magazine Vol. 5, No. 5, Feb. 1995, p. 90 .

> "The first attempt I got at least a 40-foot drop...I didn't realize it at the time, but I landed only six feet from a rock on the left hand side, if I had been just a tad off I could have been really hurt... I'd never done a backflip off a cliff, but *Joe Curtis said to go for it.* So I did this huge backflip shifty... The butterflies were going hard. I mean, if you land on your head from 35 feet, your dead." quote from Jim Rippey (italics for emphasis)

A second example by Mark Gallup in *Snowboarder* magazine (Dec. 1994) describes several injury producing events where the peer group encouraged extreme jumping behaviours. Gallup (a photographer) describes how his pro-riders go about snowboarding when it's time to play rather than do photo-shoots. "Anyway, I've seen it before, a group of bros getting together on their home turf and pushing each other's abilities just a bit too far.". One rider went off a 25 foot rock and injured his shoulder. His friends decided on the home-remedy method of putting a board against his chest and tugging on his arm. When the collar bone poked 3 inches into the air, threatening to rip the skin, we all backed off... it was separated and not dislocated. On a second site, a jumper went off a 40 foot cliff. He couldn't see the landing zone and went for it on the advice and encouragement of his friends. He landed on a rock, imbedding a softball size rock into his backside (pictures included in the magazine).

The influence of peer persuasion in alpine skiing has not been investigated scientifically but evidence of its existence permeates the popular literature. In the January, 1995 issue of *Snowboarder* magazine, we find a discussion regarding the hidden spots of Mount Baker and how snowboarders need to be introduced to hidden terrain by their peers: "I didn't know any of the secret spots until people showed me. But I did pay my dues."... "People see a little patch of untouched snow and they forget that it's untouched for a reason. They end up with broken backs, tibias, rotated hips... and they deserve it!".

The general theme among the articles in the snowboard magazines is that injury is a form of status which is inevitable and that you have to push hard to make gains and get a "rush" from the sport. Whether you're snowboarding or alpine skiing, it takes two to tango. According to Ken Achenback (*Transworld Snowboarding* Magazine, February 1994) snowboarding is more fun in groups of two or more. It doesn't matter how much vertical or how many lifts an area has, if your with a friend, you can make the most of anything a ski area has. As far as snowboarding is concerned, a recent survey showed that most snowboarders do not ride alone and that riding with the peer group is important. The Canadian Ski Council (1994) reported on a snowboarding survey which indicated that at administration time 18% were riding alone, 32% were in pairs, 18% in a threesome, 11% in a foursome, 7% were in a group of 5 and 15% were in a group of six or more. The mean snowboarding group was 3.2 people.

The review of the academic literature did not locate any studies which investigated or identified the social environment of the skier, as a predisposing, reinforcing or enabling factor influencing injury or general skiing behaviours. The skiing experience encourages a great deal of social interaction. It provides a forum for friends and family to engage in a fun recreational activity and an opportunity to meet new people on the lifts and in the restaurants. Recreational skiing is rarely described as an individual activity and it is obvious when observing skiers that social interactions have a significant contribution to the pleasures derived from the sport.

<u>Instruction: Skill and Knowledge Development</u>

Ski instruction for children and adults enables people to acquire new skills and develop a specialized knowledge base. Some authors suggest that ski instruction is under-utilized for skill development and subsequently may incur a greater risk of injury. Ekeland et al. (1989), report that only 38% of respondents in their survey had received any skiing instruction. He found that ski lessons were taken by only 9% of population that season, 29% had taken previous instruction at some point whereas, 62% of respondents had never had formal skiing instruction. Bouter et al., (1988) identified that 10% of all injured male skiers and 17% of all injured female skiers as being injured during a formal ski lesson.

The skier's ability, which is usually linked with experience and skill, has been a recognized factor in ski injuries for some time. Johnson et al.,(1984) indicate that as early as 1974 they recognized that the single most important factor affecting the ski injury rate was the skier's ability. Less skilled skiers have a higher rate of injury than advanced level skiers. The authors argue that rapid skill development in lessons with low hours of experience may increase the incidence of injury. The important determinant is experience, the skier needs both skill and experience so that he/she can recognize hazards in the ski area, can interpret subtle changes in the snow conditions and be able to alter one's skiing manner to remain in control on all kinds of terrain.

Shealy (1993a) points out that lessons may not be responsible for reducing ski injuries but rather it is the experience gained by practice. He finds it frustrating that no demonstrable beneficial effect for lessons has been proven when the effect of lessons is controlled for experience. Shealy states that if the behaviour of the advanced skier could be transferred to the entry level skier, the potential exists for dramatic reductions in the injury rate. My concern, on the other hand questions the frequency and rate of ski injuries while people are participating in lessons , this is especially so among young people. The premise of the argument is then a question of supervision of the young skier rather than acquired skill and knowledge.

Skiing out of control is the most common behavioural factor reported in the summaries of fatally injured skiers. Fifteen of the 16 fatalities reported by Morrow (1988) were witnessed and the skiers' were said to be "out-of-control" at the time of the injury event. Five of the fatally injured were engaged in informal racing on public ski runs. Only two skiers were reported on runs above their ability while the others were at or below their ability level as previously stated above.

There have been several fatalities reported in the media involving children on school sponsored ski trips. These instructional outings have not received any attention in the literature yet media reports suggest that a problem exists.

> Collision with sign kills skier
> An inexperienced skier from southern Alberta died instantly when she collided head-on with a sign post on a ski hill near Fernie...
> ...13 year girl... died just before 10 a.m. Saturday... with school group...
> ...she was skiing with two school friends who were more experienced skiers. It was the second descent of the day and all three were on an intermediate-level ski run called the Lower Bear, which had frozen, hard-packed snow. Based on witnesses' reports, (the girl) stood rigidly upright and pointed her skis downhill and didn't appear to try to slow down or stop.
>
> (Staff, 1994)

> Student falls to death in drama at Cypress
> (Fraser, 1993)

> Skier who hit teen - airborn, jury told
> A skier who collided in mid-air with an Oakville teen... was skiing in "a crazy fashion" an inquest has heard. Ryan Rattray, 16, was tucked into a racing crouch and was air-born over a small ridge when he struck Jeremy Burbidge who had earlier fallen and was stooped over to collect his equipment... Rattray, an experienced ski racer and a member of the resort's ski team, also sustained head injuries...The inquest heard that signs were posted at the resort forbidding tucking, racing and jumping and outlining safety rules and a skier's code...
> (Swainson, 1992)

School programs are by intent instructional programs, however, it is generally viewed that students only receive between one and two hours of instruction per ski day. No formal evaluation of school sponsored ski programs was identified in the literature search. The school, with its unique culture requires further investigation regarding skiing behaviours and injuries.

Media and Knowledge about Skiing Risks

Skiing fatalities do not get a large amount of media attention. The under reporting of skiing deaths among the general skiing population may result in an underestimation of the dangerousness associated with skiing (Levine, et al., 1994). This study reports that knowledge of fatalities rather than less serious injuries is crucial in increasing skier's rating of the danger inherent in the sport and for decreasing self-reported risky behaviour. I would assume that ski areas would prefer to keep this sort of information as low profile as possible for fear of scaring away potential clients. However, the increased awareness regarding motor vehicle crashes and bicycle related injuries has not deterred many individuals but may promote a greater respect for the risks involved.

One study found that skiers perceptions of the dangerousness of skiing to be related to the perception of injury severity common to the sport (Levine, et al., 1994). The researchers found that the knowledge of skiing deaths as an injury outcome was an important factor in the perception of dangerousness. The study involved 542 subjects who completed a questionnaire to determine their knowledge of serious ski injuries (deaths) at the ski area and how this knowledge affected their perceptions and behaviours. The results indicate that knowledge of fatalities (as opposed to less serious injuries) was crucial in increasing skiers' ratings of the danger inherent in the sport and decreasing risky behaviour (by self-reports).

In the survey, only about 50% were cognizant of the fatalities through the usual grapevine (informal communication) and news reports. The remainder of the sample were unaware of these serious injuries. This information may be crucial in altering risk underestimation. Levine suggest that young skiers who have advanced skill, should be considered as targets for this sort of information because they lack life experience and detailed information.

Activities

A ski area provides a wide range of recreational and competitive activities for skiers. The very nature of skiing enables impromptu events to occur where two people challenge one another to a race or a jump. But more importantly in a ski area, a major effort is given to provide skiers the opportunity to spend money on organized activities within the ski area. There are ski clubs, ski teams, race camps, mogul camps, children's camps, adult camps, day programs, weekly programs and a host of special events. Each designed so that the participants have fun, perhaps learn new skill and interact with others with similar interest.

Of the many reasons why skiers engage in organized activities at the ski hill, the most common is to have fun. Competitive racers, regardless of age and ability, state that fun is a major motivating factor for participation. In a 1987 paper, Jerry May outlines two critical psychological components of ski racing, fun and feelings. The author concludes that fun and feelings are one and that the emotions experienced in an activity make it fun. Play is another important concept which allows one to experience emotion and hence to experience fun. Competitive ski racing and other organized activities need to be fun, otherwise interest and performance would deteriorate (May, 1987). Although May does not define the notion of fun, young skiers may refer to fun as some combination of a sense of accomplishment, an adrenaline rush from the high speeds, social acceptance and perhaps the diversion from school and home life.

<u>Equipment</u>

The choice of equipment is not easily placed in the Precede-Proceed Model but does have a key role in the Host-Agent-Environment Model. Having the right equipment, correctly fitted and adjusted for its intended use and user will minimize the potential for injury. In skiing, cost can be a major barrier to having the right equipment. Many skiers will enter activities or perform manoeuvers that their equipment is not designed for. How equipment becomes a social environmental factor is that its selection is largely dependent on social influences.

Marketing for ski fashion, ski resorts and ski equipment (including snowboarding) is big business. Of the nine snowboard and 3 ski magazines selected for review, every page contained some form of advertisement of a skiing product or ski area destination. The brand names are highlighted in every picture and on the ski hill it is evident that specific brand names are important "trade marks" for participants and their position within their groups. The clothes and equipment help identify their roles.

Steven Threndyle in *Ski Canada* (November, 1994) reports that *extreme skiing* (skiing off-piste on extremely steep slopes and performing daring stunts far from medical aid or support) is increasing in popularity, at least as a spectator sport among the recreational skiing crowd. He notes that ski equipment manufacturers have realized that ski racers are no longer the heroes of the recreational skier, but extreme skiers have taken on that role. Upon this realization, it didn't take long for the term "extreme" to appear on all sorts of ski products. It is clearly presented in the text that having the right equipment is not enough. "That kind of stimulation (extreme skiing videos and equipment promotionals) can be a dangerous thing, since viewers often take the action scenes out of context and think ' hey, anybody can jump cliffs if they've got the balls'. There is a lot of preparation involved that isn't shown on camera" (p.126). The key point here, is that marketing strategies and the media often sensationalize these extreme behaviours not realizing the influence the behaviours have on untrained viewers.

This review did not identify any studies investigating how equipment influenced behaviour. Having ski bindings properly adjusted has been discussed and programs which encourage skiers to have their bindings checked will be described on page 87.

In conclusion, readers will have noted that the literature relating to the social environment of skiing is largely popular rather than empirical. It seems that our intuitions about the social environment of skiing injuries are conditioned more by folklore than by empirical studies. By folklore, I am referring to generally held stereotypes about skiing behaviour, stereotypes which have not been examined or documented in empirical studies.

Research Findings and Suggestions for Program Development

The literature on ski injuries does not emphasize program development nor evaluation of existing programs. There are essentially two papers which describe how ski programs ought to be developed, two which describe the effectiveness of educational campaigns for binding testing and one paper which describes a new educational program aimed at anterior cruciate ligament injury prevention. There have also been some technological advancements which have influenced particular injuries which will be discussed below.

Lex Bouter and Gerjo Kok (1990,1991) co-authored two papers which describe a process for planning health education programs for skiers. The process description is an adaptation of the Precede portion of Green and Kreuter's Precede model described previously. These authors point out that many health education programs aimed at preventing ski injuries are often poorly planned and evaluation is essentially non-existent.

The ten steps identified are:

1)How serious is the problem?
2)What behaviour is involved?
3)What are the determinants of the behaviour?
4)What options are there for change?
5)How can that be implemented?
6)Has the implementation been carried out as planned?
7)Has the intervention been received as planned?
8)Have the determinants of behaviour changed?
9)Has the behaviour changed?
10)Has the problem been lessened?

The authors also identify three sets of factors which influence behaviour. These are a) attitude of the skier, b) social influences, and c) self-efficacy. Bouter and Kok strongly encourage that sports injury specialists and health educators join forces to effective design interventions which work.

Damoiseaux, deJongh, Bouter and Jan Hosper (1991) performed a randomized intervention study of Dutch skiers to see what strategy encouraged skiers to have their bindings tested. The researchers recruited subjects from a ski fair resulting in a high participation rate. There were eight experimental groups in the study. Three conditions were tested: 1) the moment (one week before or three weeks before the planned holiday), 2) the medium (audio cassette or leaflet), and 3) the approach (fear arousing or neutral) and a control group was included that received no intervention). The study demonstrated rigor and a representative control population. The major findings were: 1) the cassettes made the strongest impression, 2) significantly increased knowledge of binding safety was achieved by the experimental group, 3) cassettes with strong fear-arousing message presented 3 weeks before the trip produced the greatest effect on knowledge and intention to have bindings checked (the three week period allowed participants the time to discuss the cassette with others and take action regarding their bindings), 4) irrespective of time and medium, behaviour was most affected by information with a high degree of fear.

A Swedish research group comprised of Dannielsson, Erickson, Jonsson, Lind and Lundkvist (1985) evaluated a ski safety initiative which was launched in 1974. Several organization participated in the campaign which included media presentations, the banishment of old bindings and ski binding tests on the slopes. In 1983, the group carried out a cost-benefit analysis of the program. Apart from the humanitarian gains, the annual sum saved by the community amounted to almost 4 million crowns or a savings of five crowns on each crown invested in the campaign. The authors indicated that lower leg injuries were greatly reduced as a result of campaign. The authors estimated that the risk of injury-producing falls could be reduced by at least 50% when bindings release properly. They believe the safety campaign to have been worthwhile.

Evidence such as this should encourage government agencies to consider seriously educational interventions to reduce ski injuries. It must also be acknowledged that binding technology was entering the ski market at the time and would likely have contributed to the savings in health care regardless of the program.

Ettlinger, Johnson and Shealy (1995a,b) reported on the Vermont Safety Research group's educational ACL Awareness '95 program. This program is designed to teach skiers to avoid specific behaviours which have been attributed in combination to serious ACL injury. The group evaluated some 20 videotape recordings of actual knee injuries in progress and interviewed over 1400 ACL injured skiers over a 22 year period. Their program was field tested with professional skiers (ski patrollers and instructors) from 42 ski areas with 22 being part of the control group. Serious knee sprains declined by 62%

among on-duty patrollers and instructors subjected to training compared with two previous seasons, while no decline was observed in the control group.

This program is now available for the general skiing public and demonstrates how epidemiological research can provide valuable data for developing educational interventions.

Technological innovations have made significant contributions in reducing injuries in skiing. The most notable advance was in binding technology during the 1970's and 1980's. Johnson et al., (1993) reports that lower leg injuries were reduced by 83% over the 20 years of their study. This reduction was largely in lower leg fractures which were prevented by the release binding. However, serious knee sprains have seen a 209% increase. Ski bindings are not designed to prevent this sort of injury and a great deal of research is occurring in this area (Caldwell, Landry & Hull, 1993; Crawford & Mote, 1995; Eseltine & Hull, 1993; Potera, 1985; Quinn & Mote Jr., 1993). Over 25 papers were presented on ski binding research at the 11 th International Congress on Ski Trauma and Skiing Safety held in Voss, Norway, 1995.

The leading alpine skiing injury noted in the literature is the 'skier's thumb' which is either a sprain or fracture. The leading mechanism for this injury is falling on the outstretched arm with the ski pole firmly held in the hand. Improved grip design, in the different skiing sports, is making progress at reducing this sort of injury (Bovard, 1994; Johnson, et al., 1984; Hauser, W.,1991).

Among snowboarders, injury prevention efforts have been the result of technological advancements in the snowboard, binding and boots. The soft snowboot common to those who pioneered snowboarding have been replaced by a firmer boot, also known as a soft boot which is much more rigid in construction with firm ankle supports than its predecessor. This technological advancement is likely responsible for the reduction of ankle injuries in recent reports (Ganong, et al., 1992; Janes, et al., 1993; Pino, et al., 1989; Shealy & Sundman, 1989; Shealy, 1993b; Vincenten & Yacoub, 1993). The introduction of the hard shelled boot for snowboarders who like to 'carve' a turning skill which resembles skiing more than 'free riding" on a snowboard. These changes are influencing the injury patterns by reducing lower leg/ankle injuries and creating knee injuries similar to that of alpine skiers. Lacerations are not as common among snowboarders as alpine skiers because the snowboard is attached to the riders feet without a release binding mechanism. Without a release binding and without poles, snowboarders experience few equipment-related lacerations (Shealy, et al., 1993). The leading injury, the wrist, has not been addressed but protective wrist guards would likely reduce the incidence of wrist fractures (Ganong, et al., 1992).

As with alpine skiing, the injury risk among snowboarders decreases with increased ability. However, investigation of the social environment and the predisposing, reinforcing and enabling factors associated with snowboard injury have yet to be investigated. The knowledge patterns between skiers who become snowboarders and skateboarders who become snowboarders are different according to four groups of adolescents and young adult snowboarders who participated in focus groups using a semi-directive approach (Cadman & Wyne, 1994; Stewart & Shamdasani, 1990). Apparently, the alpine skier turned snowboarder has a greater appreciation of the "acceptable behaviour patterns" practiced on the ski hill whereas respondents felt that skateboarders turned snowboarders were more rebellious and didn't conform to established behaviour patterns identified by the Alpine Responsibility Code.

Limitations of Previous Research Methods

There are certain limitations identified in the literature review which need to be addressed. This thesis research will attempt to address some of these limitations and propose new standards for data collection and analysis. First of all, studies which describe only injury patterns without defining the at-risk population or include incidence measures hamper replicability and subsequent comparisons between ski areas. The standard in epidemiology is a rate "per unit of time" and in skiing a rate "per 1000 Skier Visits" is an appropriate measure. The MDBI metric used by Johnson should not be used by itself but with standard rates so that comparisons with other researchers and other sporting activities can be compared.

Secondly, it is obvious that different age groups sustain distinct injury patterns and rates. Because few studies employ the same units, it is difficult to compare rates and injury patterns when comparable groupings do not exist. A review of ticket prices indicate that three groups are identified. These are children under 13 years, youth 13-17 years, adults 18-64 years and seniors 65 years and older. Many ski areas provide free lift tickets to children six years and under. Ideally a smaller unit among adults would be ideal but given the difficulty involved in establishing different ticket products, it is unlikely that the adult age group will be divided.

Third, the social environment in skiing has been recognized in the popular literature but has not been evaluated in the academic literature. The literature review has identified this as a major limitation since it is becoming increasingly apparent that the social environment plays a large role in determining skiing behaviour and subsequently skiing injury.

Another problem that several authors point out is that approximately 25% of ski injuries go unreported to ski patrols and local medical centres (Garrick & Kurland, 1971; Johnson, et al., 1993). All injury rates should, therefore, be considered an under representation of the actual problem. At present there is no procedure for identifying these injuries.

Because health researchers tend to emphasized micro-level analysis of particular problems, many issues which influence injury have been neglected. This ecological investigation has already identified numerous social and physical environmental factors not previously studied which may influence skiing behaviours and possibly the ski injury problem.

Conclusions from the Literature Review

The literature review has highlighted some of the behavioural, social and environmental determinants which may affect skiing injuries. It is evident that behaviours are affected by both the physical and the social environment. The review of the literature has provided both the reader and the researcher with a good understanding of the current knowledge base surrounding skiing injuries and their prevention. Based on this review, a preliminary retrospective study was performed to provide a basis for planning a prospective study.

Preliminary Retrospective Study

Introduction

Having completed a survey of the literature relating to sports injury and using the generalizations and trends noted in the published literature on skiing injuries, I developed a series of preliminary hypotheses to be to tested against a body of data. This was undertaken in order to: a) explore and refine the hypotheses I had generated, based on previous research and personal experience, b) refine data collection strategies, c) test and explore the validity of data available as a result of computerized technology which previous researchers did not have access to, and d) to gain research experience requisite to developing a defensible proposal for the prospective study which would comprise the focus of my dissertation.

Focus, Scope and Objective of the Preliminary Research

I refer to this phase of the research as both "the preliminary study" and "the retrospective study". It is preliminary in that it allows me to accomplish various incipient goals; and it is retrospective in that it is based on data that had been collected previously. There was a body of data composed of approximately 2500 injury report forms generated by the Blackcomb ski patrol during the 1992 ski season that was available for analysis. In fact, as a member of the patrol, I had been involved in the generation of this corpus of data. The written injury report forms represented a record of all patients treated by the patrol against the possibility of legal action by the injured parties against the Mountain. The forms were stored numerically (92-1, 92-2, etc.) but were not collated, computerized or analyzed in any way. This was an ideal opportunity for me at this point in my thesis research. Not surprisingly, Blackcomb recognized my research as consistent with their corporate goal of becoming a leader in the ski industry and, when I approached them for approval, the management encouraged me to use the data to discover anything that might help them achieve that objective.

Thus, this preliminary, retrospective phase of the research project is an exploratory analysis of that previously collected corpus of 2500 ski injury reports in order to effectively plan a prospective study with refined hypotheses and field tested procedures.

Theoretical Value and Practical Importance of the Preliminary Research

This preliminary research was intended to identify statistical trends and quantitative evidence upon which to base generalizations for the prospective study. The retrospective study was not informed by any particular theoretical perspective. It is recognized that theoretical assumptions are of great utility in structuring research projects if one is to achieve anything more than observationally adequate generalizations. A second theoretical aspect of the retrospective research was that it allowed a quantitative test of trends in skiing injury abstracted from the published sports medicine literature.

Practical contributions of the preliminary study included : a) the production of verifiable rates of skiing injuries at a Canadian ski area, b) the development of replicable means for using computers to determine the population at risk, a statistical template that could be used in subsequent studies, and c) most importantly in light of this thesis, it served as a foundation upon which the prospective study was based.

Conduct of the Research (Methods)

This preliminary study can be described as a descriptive retrospective case-series analysis of reported ski injuries collected between November 22,1991, and May 24, 1992. The injury pattern data for this study were clearly framed on injury report forms that provided descriptions of the patient and the injury. Although the form was designed to record the patient demographics and particulars of the injury event, the form does not elicit information on the ecological aspects of the injury setting and situations. The data were generated by members of the Blackcomb ski patrol who treated the injured individual. The ski patrol management took every reasonable step to ensure that all injuries were documented and on file in sequential order. Missing injury reports were substituted by the researcher with the dispatcher's log, which provided a record of the patient's name, age, gender, injury and disposition. All of these data were analyzed quantitatively to explore and further refine the stated hypotheses.

Treatment of the Data and Findings

At the end of the 1992 ski season, there were 2,139 verifiable injury reports completed by the Blackcomb ski patrol. Thirty-nine variables were coded from each injury report and the data were entered for computer analysis using Systat 5.2 for the Macintosh computer (Wilkinson, Hill & Vang, 1992). The following 25 headings were identified on the injury report and from them the 39 variables were derived:

Injury Number
Date of injury
Time of injury
City of injured
Age of injured
Gender of injured
Run name where injury occurred
Run Difficulty
MTF (Minor Treatment Form) designates minor injuries
Transportation on hill
Transportation from hill
Snow quality
Snow surface
Sport type
Activity (racing, lesson, free skiing/snowboarding)
Ability (self reported)
Equipment (owned/rented)
Patient description of accident
Chief complaint
Mechanism of injury
Injury type
Injury site
Immobilization equipment
Drugs used on site
Attendant qualifications

Data were divided into five age groups representing the age divisions of the lift ticket products. The age groups were 0-6 years, 7-12 years, 13-17 years, 18-64 years and 65+ years. The ticket products at Blackcomb were all computerized and bar-coded.

Each skier was scanned at the base of the mountain. Repeated scans were discarded by the Ticket Scanning software ensuring that each skier was only recognized as one skier visit regardless of how many times the skier was scanned. Complimentary tickets as well as multi-day tickets are bar-coded and recorded. All staff who ski as part of their job are required to have their passes scanned before loading lifts. Summary reports for each product were generated at the end of the season. Collation of the various products by age groups had to be done manually by the investigator due to limitations in the software. This replicable and reliable skier visit data enabled incidence rates to be calculated with unprecedented accuracy and specificity.

Results of the Retrospective Study

A total of 720,066 skier visits were recorded on Blackcomb Mountain during the preliminary study. Two categories of injury were included in the incidence rate calculations. The first injury rate included all reported injury to the ski patrol and the second, those injured who were referred to medical aid (RTMA). This distinction regarding injury severity in ski patrol records should be noted as a first time datum in this type of study. Table 3.3 summarizes the age specific injury rates.

Table 3.3: Age-Specific Skier Injury Rates at Blackcomb Mountain During the 1992 Winter Ski Season (unit of measure skier day visits)

Age (years)	Number of Injured	Population (day-visits)	All injured Rate /1000	Number of injured referred*	RTMA Rate /1000
0-6	35	9,182	3.81	16	1.74
7-12	221	46,487	4.75	148	3.18
13-17	376	86,429	4.35	289	3.34
18-64	1441	569,423	2.53	1062	1.87
65+	19	8,545	2.22	15	1.75
All	2139	720,066	2.97	1559	2.17

*referred to medical aid off-site and excludes minor treatments. (42 files had no age indication and were included in the section "all" but not in age-specific groups)

The injury rate among these sub-groups is not proportional to the number of skiers in each age group using the mountain. Adults, who represent 79% of the skier population, have 67% of the injuries; whereas children under 18, who make up 20% of the skiing population, sustain 29% of the injuries.

These data relate to my first hypothesis: that young people are at greater risk of injury than the adult population. I amalgamated the five age sets into two groups: the first including the three younger age sets and the second composed of the two older sets. I then calculated the relative risk of injury to adolescents (17 years and under) as opposed to adults (18 years and older). Table 3.4 sets up a 2x2 table for calculating Relative Risk (RR):

Table 3.4: Relative Risk of Skiing Injury (RTMA) Between Children and Adults, Blackcomb, 1992

	RTMA	Uninjured	Total
17 and under	488	141,610	142,098
18 and older	1077	576,891	577,968

$$RR = \frac{488/142{,}098 = .00343}{1077/577{,}968 = .00186} = 1.84$$

Statistically significant p=0.002

Table 3.5 Age and the Three Leading Injured Body Parts: Number, Frequency and Rate of all Injured Skiers, 1992

Age (in years), number of injured	Most Injured Part	#2 Injured Part	#3 Injured Part
0-6 n=35	head & face n=13 37% 1.42	knee n=5 14% 0.54	back n=3 8.5% 0.32
7-12 n=221	knee n=51 22% 1.63	head & face n=38 17% 0.82	ankle n=18 9% 0.32
13-17 n=376	knee n=86 23% 0.99	head & face n=80 22% 0.93	wrist n=39 10% 0.45
18-30 n=780	knee n=213 27% n/a	head & face n=178 23% n/a	shoulder n=86 11% n/a)
31-42 n=375	knee n=132 36% n/a)	head & face n=63 17% n/a	shoulder n=59 16% n/a
43-64 n=309	knee n=106 34% n/a	shoulder n=50 16% n/a	head & face n=48 16% n/a
18-64 n=1441	knee n=442 31% 0.74	head & face n=286 20% 0.48	shoulder n=193 13% 0.32
65+ n=19	head & face n=8 42% 0.94	knee n=5 26% 0.59	shoulder n=4 17% 0.47
All n=2139	knee n=546 28% 0.76	head & face n=442 17% 0.61)	shoulder n=255 11% 0.35

-42 files had no age indication and were included in the section "all" but not in age-specific groups
-Figures represent a) number of specific injuries, b) percentage of all injuries and c) incidence rate of injury per 1000SV during 1 ski season.
-Rates are not available for shaded sections

The relative risk of injury requiring medical attention between adults and children under 18 years is 1.84 (*i.e.,* children have a 84% greater risk of injury than adults), and this difference is statistically significant.

Thus, the investigation of age-specific injury patterns indicates that differences do exist. This study reflects the general injury types identified in the literature review (Table 3.5). The frequency and rate of these specific injuries contradict some of the trends found in the literature and, in fact, indicate higher values (greater frequency) than those stated elsewhere.

The knee is consistently found to be the leading injury among most age groups with the exception of young children and senior citizens. The head and face are other high proportion injury site among skiers.

A second review of head/face injury report forms allowed for a more specific evaluation of this problem (Table 3.6).

Table 3.6 Head and Face Injury Rates Among Skiers at Blackcomb, 1992.

Age (in years)	No. of injuries	Population day visits	Rate /1000 day visits
0-6	13	9,182	1.42
7-12	38	46,487	0.82
13-17	80	86,429	0.93
18-64	286	596,423	0.48
65+	8	8,545	0.94
All	442	720,066	0.61

-because 42 files had no age indication the category "all" includes more injuries than the sum of the 5 groups

Head and facial injury rates have not been described in the literature but the frequency and percentage of reported injury indicates that this is a problem of greater magnitude than we are led to expect from other studies.

Personal error (is an all-encompassing term that includes any reported cause that does not include an external factor) is the leading cause of self-reported injury (*i.e.,* it is the main cause that injured parties of all age groups give as their assessment of the reason of the injury). Of particular interest to us in this study, though, are the second and third leading causes of injury because, whereas personal error is a non-specific characterization, the second and third causes identify quite specific activities (see Table 3.7).

The preliminary retrospective study provided an opportunity to field test the procedures and methods of data collection and analysis and provided a data set upon which preliminary hypotheses could be tested. The refined hypotheses are presented below.

Hypotheses

Based on the literature review and the preliminary retrospective study the following hypotheses were developed.

Hypothesis 1) Ski injury patterns are population specific, in the following ways:

a) Ski injury patterns vary significantly with age,

b) Ski injury patterns vary significantly by gender,

c)Injury patterns vary significantly between alpine skiing and snowboarding populations.

Hypothesis 2) Adolescents are a population at risk of injury in skiing in the following ways:

a)Adolescent age groups demonstrate an elevated incidence of risk taking behaviours in skiing over population norms.

b)Adolescent age groups demonstrate an elevated incidence of injury from skiing over population norms.

Table 3.7: Age-Specific Self-Reported Cause of Injury Among Injured Skiers at Blackcomb, 1992.

Age (years) n=number of injured	Cause #1	Cause #2	Cause #3	Misc.
0-6 n=35	PE* n=15 43% 1.63	Impact* n=6 17% 0.65	Jump* n=3 8.5% 0.33)	PC * n=3 8.5% 0.33
7-12 n=221	PE n=125 57% 2.7	Jump n=18 7.7% 0.65	PC n=17 8.4% 0.37	--
13-17 n=376	PE n=222 59% 2.5	Jump n=44 12% 0.50	CSC * n=32 8.5% 0.37	PC n=9 2.4% 0.10
18-30 n=780	PE n=429 55% n/a	Jump n=73 9% n/a	Impact n=63 8% n/a	PC n=35 4.5% n/a
31-42 n=375	PE n=244 65% n/a	CSC n=32 8% n/a	PC n=22 6% n/a	--
43-64 n=309	PE n=210 68% n/a	CSC n=28 9% n/a	Impact n=19 6% n/a	PC n=13 4% n/a
18-64 n=1441	PE n=869 60% 1.5	CSC n=124 9% 0.21	Impact n=105 7% 0.18	PC n=68 5% 0.12
65+ n=19	PE n=11 58% 1.28	Impact n=3 16% 0.35	CSC n=3 16% 0.35	PC n=1-= 5% 0.11
All n=2139	PE n=1273 60% 1.7	CSC n=179 8.3% 0.24	Impact n=155 7% 0.22	PC n=102 4.8% 0.14

* PE: Personal Error   Impact: Person to object collision   Jump: Fall Jumping
PC: Person to Person Collision CSC: Change of Snow Conditions
-42 files had no age indication and were included in the section "all" but not in age-specific groups
-The figures represent a) number of individuals reporting this cause, b) percentage of people reporting this cause and c) incidence rate of cause per 1000SV during 1 ski season)
-Rates not available for shaded sections

Hypothesis 3) The physical environment in skiing significantly affects injury in the following ways:

a) Groomed slopes are associated with more injuries than non-groomed slopes,

b) Weather variables such as new snow, visibility and temperature affect injury rates in a significant manner,

c) Higher skier visit/days in the ski area will result with significantly more skiing related injuries,

d) Lift related injuries are most frequent during the loading and unloading procedure.

Hypothesis 4) The social environment of the skier is associated demonstrably with ski injury patterns and behaviours in the following ways:

a) Adolescents on school sponsored ski programs will be injured significantly more than same age population norms,

b) Skiing behaviour is affected by the social relationship of the skiing partners.

Hypothesis 5) Youth engage in many higher risk skiing behaviours and lack experience with skiing-related injury.

a) Reported causes of injury differ according to the age of the skier,

b) A large number of youth participate in higher risk skiing behaviours such as improper binding adjustments, skiing closed areas and tree skiing,

c) Adolescents do not practice or use active safety oriented behaviours like wearing helmets and using the safety bar on chairlifts,

d) Many children have little experience with injury related events skiing,

e) Safety oriented behaviours (safety instruction, ski lessons) are affected by barriers (e.g. economic and social).

Summary

Chapter 3 included the literature review and a preliminary retrospective study that enable the researcher to field test procedures and refine hypotheses. The process of refining the hypotheses can be understood more clearly when seen in a continuous progression. The hypothetico-deductive strategy, outlined in Chapter 2, was effective in that it allowed me to combine the findings generated by the literature review, the results of the retrospective study and my own personal experience in this important phase of the research. Chapter 4 describes the prospective study, starting with the methods used in data collection, collation and analysis.

Chapter 4

Methods--Conduct of the Research in the Prospective Study

Introduction

In Chapter 4, the focal research on which this dissertation is based will be presented. Heretofore, this part of the research has been referred to as "the prospective study" because it is based on anticipated data and because it allows the reader to distinguish it from the preliminary study which was retrospective.

This chapter presents a discussion of the methods used in eliciting, collating, and analyzing data on adolescent ski injuries at Blackcomb Mountain during the 1993 ski season. As described in Chapter 2, methods are the particular procedures and strategies employed here to investigate the problem of adolescent ski injuries. This investigation involves four kinds of methods (3 major kinds and a minor one):

a) *Discovery methods*--questionnaires and forms for eliciting information formally; the format of informal interviews and semi-directed group discussions; and accessing computerized data reflecting Blackcomb ticket sales and ski patrol injury reports.

b) *Collation methods*-- statistical collating of injury report forms and questionnaire responses; transcription of tape-recorded focus group discussions and qualitative entries in the questionnaire; and collating weather information from Blackcomb's weather observations.

c) *Analytical methods*--descriptive statistical methods (means, rates and proportions, Chi Square tests) are employed to analyze trends and develop applications based on identified generalizations; and content analysis (computer assisted inventory of recurrent key words in transcripts) to summarize findings from qualitative responses.

and d) *Presentation methods*--a minor aspect of methods in research has to do with the conventions and tactics used in presenting one's conclusions. Various charts, graphs, tables and taxonomic diagrams to illustrate the facts and findings of this research.

Characterization of the Study

Focus, Scope and Objective of the Study

This is a quantitative prospective case study of a single skiing site based on data collected both by the investigator and the management of the facility. The epidemiological goals and objectives of the study are to identify and explain injury patterns, determine populations affected and generate implementable interventions.

Conduct of the Research (Methods)

The following table of the research project offers the reader a clear picture of the planning, preparation and execution of this study. Although it emphasizes issues having to do with methods, the reader will note that it includes a discussion of preliminary administrative activities (consultations, liaisons with the ski area and the important details of funding and ethics).

The Research Project--An Outline

Preparation	a) consultation with thesis committee b) ethics application c) liaison with Blackcomb's administration d) application for funding	
Data Collection		
Personnel	a) ski patrollers (recorders of injury reports)-train/supervise b) research assistant (questionnaire administration)-train/ supervise	
Methods	a) Injury Report Form	i) verify for completeness and accuracy ii) follow-up missing reports iii) compiling youth forms iv) list of injured youth for mail-out
	b) Questionnaire (Injured skiers & Uninjured skiers)	i) develop questions based on hypotheses ii) solicit questions from experts iii) field test questionnaire iv) revise questionnaire v) duplicate vi) prepare intro. letter, consent form Vii) administer on-hill questionnaire viii) mail-out to injured skiers ix) follow-up non-returns
	c) Tabulation of Skier Visits	i) liaison with ticket office ii) review monthly skier visits reports iii) review end-of-season reports iv) verify hard copy summaries v) spot check ticket product prints-outs vi) extract age-specific figures from particular ticket products
	d) Weather and Daily Injury Rates	i) verify daily entries into weather log ii) verify dispatch summary sheets are completed for each day iii) obtain weekly bulletins regarding daily skier visits

Data Collation

Personnel	a) University Data Entry Services	i) train data entry personnel
Methods	a) Injury Report Form	i) develop computer codes for variables ii) code each variable on every form iii) enter codes into computer iv) spot checks entries
	b) Questionnaire	i) develop computer code for variables ii) code each form iii) enter data into computer iv) verification by data entry personnel
	c) Weather and Daily Incidence Rates	i) obtain weather log ii) develop code for variables iii) enter coded responses into computer iv) enter daily RTMA from dispatch summary sheets into database v) enter daily skier visit log into database
Data Analysis	Methods	i) frequency distributions ii) incidence rates iii) chi square vi) relative risk
Data Presentation	a) Findings	i) tables, graphs, charts ii) written descriptors and discussion

Preparatory Issues

Having identified a dissertation topic in consultation with my committee, an interdisciplinary perspective was selected for this research. The first draft of the thesis proposal profited from the input of the faculty committee and external consultation including the senior administration at Blackcomb Mountain. Prior to commencing formal data collection, the research group submitted an application for review to the U.B.C. Screening Committee for Research Involving Human Subjects. The proposal was deemed acceptable with two stipulations: 1) confidentiality of the participants must be assured and maintained, and 2) all subjects under the age of 18 must have active parental consent. These ethical stipulations were followed meticulously, particularly in the administration of the injured and uninjured skier questionnaire.

It was clear that research funding would be extremely helpful. I applied for and received funding ($5,000) from the Royal Bank Injury Prevention Program in conjunction with the B.C. Children's Hospital. This grant defrayed the expenses of hiring a research assistant to administer the questionnaire and the cost of duplicating the forms.

Finally, Blackcomb's senior management was consulted at various phases of the project. They supported the study, made a few suggestions as to details of data collection and consented to have their name publicly associated with the research and its findings.

Data Collection Phase of the Project

Planning

It is important that the methods employed in data collection be responsive to the hypotheses and consistent with the chosen methodological framework. Therefore, in planning this important aspect of the research, I was careful to keep in mind that the data elicited must be both sufficient and suitable to confirm or falsify the hypotheses that were developed as research questions. This planning stage was critical. If I did not correctly anticipate the information needed to support the hypotheses, I would not be able to design the research schedule, methods, or instruments in a way that would allow the research objectives to be met. It was also apparent that the data collection had to be scheduled in a way that was responsive to the timing of the ski season and to my academic program. (See Figure 1.1, page 9, for the timing of the schedule as it actually transpired).

Personnel

Ski Patrol--In order to accomplish the research, the field recorders and data collectors required training. This was done by the approximately 70 ski patrollers who treat and report ski injuries at Blackcomb--an average of nearly 2,500 each season. It is the responsibility of a researcher to build internal validity into the data collection instruments and procedure. Internal validity refers to the control of extraneous variables by the researcher, in this aspect of the study internal validity would require that all of the patrollers operated with the same definitions and procedures in completing the form. To ensure this internal validity, steps were taken to train the ski patrollers regarding the Injury Report Form (IRF). Prior to the commencement of the ski season, I met with the ski patrol and discussed the objectives of the study and the importance of consistent and accurate recording on the IRF. As a group, we arrived at a consensus regarding minimum standards of recording information and we clarified ambiguous terms on the form. For example, in the preliminary study, I found that some patrollers would only circle one item per category. It was made clear to the patrollers that it was appropriate to circle all relevant items and, if necessary, to make additional comments in the space provided. For example, in the box providing environment-related data several combinations could be selected to represent the injury site (*e.g.,* injury site conditions: 0-15 cm new, dry and groomed); or under the activity-when-injured section several responses may be relevant (*i.e.,* "snowboarding", "racing" and "lift-related" would all be checked to describe a snowboarder involved in a race who hits a lift tower). Also, we defined all of the terms listed on the injury report form to ensure consistent understanding and use. For example, the terms dry, wet and moist snow are sometimes difficult to distinguish. After some discussion, it was agreed upon that it would be useful to use the industry accepted definitions employed by the Canadian Avalanche Association (Associate Committee on Geotechnical Research, 1989).

Research Assistant-- A research assistant was hired to administer the Skier's Knowledge Initiative Questionnaire (a questionnaire designed to solicit information regarding skier practices and knowledge from young skiers under 18 years of age). A female research assistant (RA) was hired and trained. This required both pre-administration training and on-site training while the instrument was being field tested. The protocol for administering the questionnaire included:

a) a smile;
b) a warm welcome from both Blackcomb and the BC Children's Hospital (the RA wore clothing that identified her as representing both Blackcomb and Children's Hospital);
c) explaining the study's objective;
d) encouraging that parent(s) read the introductory letter and review the questionnaire;
e) explaining the questionnaire and its importance to the children: telling them about assurances of anonymity;
f) upon agreement, the RA leaves the packages (introductory letter, consent form, questionnaire and a pencil);
g) after 15 minutes the RA returns to collect the completed package and check the questionnaires quickly for completeness;
h) responding to any questions;
i) thanking both the children and the parents for their participation.

The RA was paid a fee for each completed questionnaire. I monitored the RA on a regular basis to ensure that a consistent administration procedure was followed.

Data Collection

The Injury Report Form (IRF)

The IRF, as previously discussed in Chapter 3, proved to be an ideal instrument for collecting data on ski injuries for this study. All ski areas have similar forms. The form used by Blackcomb has been refined through periodic review by management, pre-hospital care consultants (ambulance service), physicians and the Mountain's attorneys to ensure that it continues to meet its objective. That objective is to record information about the injured person, the injury and the injury site (the form was not altered in any way by the researcher for research purposes). The IRF is the only official record of an injury on the Mountain. Hence, ski patrollers are comfortable with its use and recognize completing the form is a part of their job. In addition to completing the standard form, each patroller was asked to describe fully any head-injured patient so that a more detailed analysis of head injuries could be attempted. As well, patrollers were asked to note on the form whether the child was with a school group or not. As a matter of routine, dispatchers inquired regarding school group status when patrollers radioed regarding any injury to a patient under 18 years and this information was recorded in the dispatch record.

Once a week, a copy of the IRF of children under 18 years was collected (the IRF consists of an original page and 3 carbonless copies). I verified with the dispatch log whether all injury forms were accounted for and tracked down any missing forms. Sometimes it required interviewing a ski patrollers who failed to file an IRF. In the rare event that no information was located, details were taken from the dispatch log which included the following information: name, age, gender, suspected injury, transportation, destination and school group status.

A mailing-list of injured skiers who required medical attention was compiled from the names and addresses on the IRFs. It was later used for distribution of the questionnaires.

Skier's Knowledge Initiative (SKI) Questionnaire

Development

Having identified the preliminary hypotheses from the literature review and consulted with the research committee and experts in the field, a questionnaire was designed with the intention of collecting hypothesis-driven data not available from the IRF. There were no previously developed instruments that collected the type of information I required to meet my research objectives. A group of experts was assembled to assist in the development of appropriate questions. The experts included ski patrollers, physicians, ski instructors and skiers (parents and youth). The final questionnaire consisted of questions intended to elicit data which related to the stated hypotheses. Its organization is as follows (the actual questions can be found in Appendix A):

Number of Questions	Hypothesis reference
2	Hypothesis #2 (Injury frequency)
4	Hypothesis #3 (Physical environment and injury patterns)
7	Hypothesis #4 (Social environment and injury patterns)
15	Hypothesis #5 (Behaviour affects injury patterns)
3	Hypothesis #6 (Intervention strategies)
4	Qualitative-Hypotheses #1,#5
12	Demographic-Hypothesis #1 (Demographics-injury trends)

Field Testing

The first drafts of the questionnaire were field tested with the children of the secretarial staff at BC Children's Hospital (who typed the questionnaire), and then with 25 young recreational and competitive skiers belonging to a local ski club. A debriefing session was conducted with a subset of this group of 25. Also, as each respondent submitted their completed questionnaire, respondent's were asked if there were any ambiguous or confusing questions. For example, question 26, Have you ever skied into someone else? required clarification as many of these youth play games where they run into each other on purpose. Our intention was to inquire regarding unintentional collision; therefore, we added "(not on purpose)" to the question.

Parents of younger children encouraged me to remove questions regarding alcohol and drug consumption. Since it was decided to have only one questionnaire for the three age groups, the questionnaire development team felt that it prudent to omit this line of questioning. The final questionnaire consisted of 43 multiple questions and four open-ended questions.

Questionnaire Assessment

Some readers may note that a detailed psychometric analysis of the questionnaire is not provided. After carefully reviewing the questionnaire and the objectives of this study, it was felt that such an evaluation would not necessarily provide any added strength to the study. The rationale for this decision was based on two factors. First, the questionnaire was purposefully composed of single-item self-reported measures not intended to elicit underlying concepts; and, secondly, since the investigation was not designed as a case-control study (where injured respondents would be rigorously matched with uninjured controls), the questionnaire was not intended to look quantitatively at differences between injured and uninjured skiers. The intention of this component of the research was to identify behaviours and experiences of young skiers without limiting the scope to a particular underlying concept. The decision not to undertake a case control study was based on the fact that matching individuals with regards to age, gender, ability, sport, socio-economic status, etc. would have proven too overwhelming in a research endeavour of this scope. It was felt that before effective case studies could be accomplished, it was necessary to have a first look at the lay of the land before dissecting it, hence a descriptive social epidemiological investigation was selected without case controls.

Questionnaire Administration

The SKI questionnaire was administered to two groups: a) injured skiers as identified on the IRF, and b) a sampling of uninjured skiers taken at an on-hill restaurant. The administration of the questionnaire to these two groups required different techniques and considerations.

Injured Sample

As mentioned above, at the end of the ski season all of the ski patrol injury report forms which referred patients to a medical doctor (RTMA = referred to medical aid) were collated and a SKI questionnaire was sent out to them. The questionnaire package included an introductory letter, the questionnaire, a consent form, a supplemental injury information sheet and a stamped self-addressed envelope. Parents were asked to review the questionnaire and either to assist the child in completing it or to give the entire package to the child for him/her to complete in private.

This package was mailed out to the parents of nearly 300 children. A phone reminder was made to non-responders and, if requested, a second package was sent. For administrative reasons, the questionnaire was sent out at the end of the ski season. Development of the mailing list had been ongoing throughout the season, and as a result, the mail-out was planned to coincide with the conclusion of the ski season. Although data on an "injured group" in contra-distinction to an "uninjured group" is not required by the hypotheses as stated, nonetheless, it was felt that the study would be weakened if this population was excluded from the study. This population of injured skiers has not been included for the purpose of creating a case-control study. Injured and uninjured skiers will not be compared but, will be treated in a parallel fashion.

In considering the potential for bias which might affect this component of the study, I noted two minor issues which may warrant mentioning. First of all, the participation of those who responded rested purely on their goodwill and motivation to contribute to the study. Rosenthal and Rosnow (1975) were one of the first to discover that participants who volunteer, have predictable differences from people who do not volunteer. They found that volunteers tended to be better educated, of higher socio-economic standing, more intelligent, more sociable and less conforming than non-volunteers. Thus, the group who responded (*i.e.,* volunteered) may not be representative of all injured skiers. A second potential source of bias may result from the delay in canvassing this injured group. Some respondents may have had a delay of up to five months from the injury event and the questionnaire administration. Their responses may be affected by *recall bias*, which is the tendency for recollection to be skewed by the reaction of others and the passage of time. For example, someone injured while skiing out-of-bounds, who was later told again and again that this behaviour was "dumb and dangerous", might not recall or recount the events as they actually happened.

Uninjured Sample

The questionnaire was also distributed to a second, larger group of uninjured skiers. These data was collected from 863 young skiers (aged 5-17 years) during the months of March and April, 1993 on Blackcomb Mountain. A letter of introduction, a consent form and the questionnaire formed "the package" given to each participant in the uninjured sample. Due to ethical considerations (requiring active parental consent), a random sample appeared to be impossible considering the resources available to this study. A purposive sampling strategy was employed. This strategy was to obtain the largest possible sample of young skiers who entered the Rendezvous Restaurant (a mid-mountain restaurant) with a parent or guardian. Choosing the end of the season ensured that respondents would probably have had an opportunity to have skied or snowboarded that year prior to the administration of the questionnaire.

As suggested above, obtaining a random sample of children in a ski area seemed impossible given the ethical constraints imposed by the UBC ethics committee (*i.e.,* the need for active parental consent limited data collection to children accompanied by a parent who gave their consent). Possibly the data collection of eligible respondents could have been randomized by interviewing in a patterned sequence (*e.g.,* every fourth group with children who entered the restaurant). But, this would still have only achieved a representative sample of young people who eat with their parents, not of the population being studied (all children). Hence, I chose to obtain as large a sample as possible sacrificing mechanical randomness for magnitude (750 respondents) because of limited time and resources.

The questionnaire was administered at the Rendezvous restaurant, a mid-mountain restaurant, on 30 skiing days between 10:00 and 14:00 hrs. The rationale for this time frame was that eating at a ski area is often a hectic event and experienced skiing families either eat early or late to avoid the noon-hour crowd. Hence, this research by design successfully obtained input from both experienced and inexperienced skiers. To further increase the representiveness of the sample, data were strategically collected during 4 days of each week, using weekends and holidays (when more children are out of school and able to ski) and alternating the mid-week day so as to reduce sampling bias.

To increase internal validity, a similar environment was ensured for all respondents in the administration of this instrument. The testing conditions included: a) the same person administering the questionnaire, b) to all of the subjects, c) using the same administration protocols. It occurred in the same environment at the same time of day so that all subjects experienced similar environmental factors (building colors, windows facing the ski area and the hustle and bustle of people in a restaurant). Controlling all variables is not possible, but the protocols undertook to ensure that each individual shared a similar experience while completing the form.

Limitations of the Questionnaire Results

The questionnaire results have certain limitations in their generalizability. The sample of uninjured and injured skiers may not necessarily be generalizable to the entire youth skiing population. The reason for this limitation lies principally with the ethical concerns of the study. Statistically rigorous random sampling of young skiers was not possible because active parental consent was required to survey these young subjects. Secondly, the sample may be a large one but nonetheless it represents skiers from one site (Blackcomb Mountain). The sampling strategy limited by resources, ethical considerations and the reality of accessing young skiers and their parents in the skiing environment proved a challenge.

Tabulation of Skier Visits

Having collaborated with the ticket office in the preliminary study, the collection of prospective data was made much simpler. However, it should be noted that the ticket office did not normally generate age-specific accounting for each ticket product. The existing software did not always enable these data to be extracted in the manner needed for this research (*e.g.,* credit card purchases from automated ticket booths). In most instances, ticket product summaries were available by age group, in others I had to inspect computer print-outs manually to obtain age-specific data.

Blackcomb was a leader in computerized ski ticket distribution and provided a replicable and reliable system for tabulating skier visits. The researcher's role was to ensure that each skier visit was accounted for and that age-specific tabulations were correct. Ticket data on skier visits should be considered reliable, replicable and valid. With regard to reliability at the corporate level, the computerized package employed by Blackcomb was monitored on a daily basis for any anomalies and hard copy reports were generated and verified for accuracy. Also, at the individual level, each skier was checked with a bar-code scanner in the lift maze at the base of the mountain. Skiers returning to the base lifts later in the day were re-checked and the computer ignored repeat visits on the same day when down-loaded into the main computer. Half-day tickets were included in the study but it required two half-day tickets to make one skier visit day. Indeed technology can be beaten when individuals cheat the ticket system and slight discrepancies may exist when people on the cusp of the age groups misrepresent their age to pay cheaper rates. For example, a parent may acquire a Tot ticket for their seven year old, or a 13 year old may purchase a child's ticket to save money. It is also possible, that a person can access the mountain without a ticket by hiking 350 vertical meters in the woods to the mid-mountain lifts where no ticket validation occurs. But such skewing of the data must be considered both negligible and uncontrollable.

Weather and Daily Injury Rates

In order to consider the fourth hypotheses (regarding the relationship between the physical environment and injury patterns), specific information was needed about weather patterns. Neither the Injury Report Form nor the SKI Questionnaire (as used in the injured skier survey) elicited specific information about the prevailing weather at the time of the injury event. This component of the study required the coordination of three components: a) frequency of injured skiers, b) replicable daily skier visit count, c) replicable daily weather observations.

a. Frequency of Injured Skiers: To obtain the frequency of injured skiers during the 1994-95 ski season, the most reliable and efficacious source was the dispatch record. Because detailed patient information was not required, the dispatch record provided the most accurate and reliable source of injured skier information. The dispatch log is maintained by three full time dispatchers who monitor all injured skier reports by radio. Each reported injury received a file number and the following information: a) for responses with no injury, a no treatment indication was made and b) in cases involving an injury the dispatcher would note who was the attending patroller, the patient's name, age and injury, the disposition of the injured skier, whether or not the patient was referred to medical aid and whether or not patients under 18 were with a school group or not.

b. Skier Visit Records: Replicable daily skier visit records prior to 1994 were difficult to obtain during the ski season because of the existing computer software. To analyze the data on skier visits, all of the bar code readers had to be downloaded and interpreted by the computer. This had to be done at night due to the seven day a week operation and did not permit technicians to perform anything but verification routines let alone summary analysis. Technological advances planned for the 1994-95 season which facilitated daily skier visit analysis prompted a delay of one year in collecting this data. During the 1994-95 ski season, replicable next day skier visit data was available from the Blackcomb management.

c. Weather data: Weather data on Blackcomb is recorded by trained field observers at 06:00 and 14:00 using both computerized weather sensing instruments and field observations. I chose the 14:00 weather observation because it most likely represented the days weather pattern when skiers would be on the slopes. Weather data on Blackcomb is recorded at four different elevations. I chose to use the 1850m weather plot (main mid-mountain restaurant level) because of the high skier traffic in this area. New snow accumulation was taken from the 1550m weather plot because it was less wind-affected and provided a more accurate reporting of the new snowfall and snow base. Weather variables recorded include:

-air temperature: maximum, minimum and present
-wind: speed and direction
-depth of snow: seasonal base, 12 hour, 24 hour and storm accumulations
-humidity
-barometric pressure
-precipitation type and intensity
-sky conditions
-visibility

There were 121 observation days in this component of the study and daily weather and injury rate data were collected and recorded.

Data Collation

Data entry personnel--The University of British Columbia maintained a professional data-entry department which entered raw data into a database. The data-entry plan was reviewed with the manager of the department, who deemed it appropriate and consistent with standard entry protocols of her department. This service has built-in reliability procedures to ensure replicable and valid data-entry.

Injury Report Forms

As standard operating procedure, ski patrollers were requested to complete the injury report form within 24 hours of attending to an injured skier. The patroller completed the form on site with the injured skier if time, weather and the patient's condition permitted.

Otherwise, the information was noted in the patroller's notebook and the form completed as soon as possible. Each injury report form was submitted to the dispatcher and checked off as submitted . At this point one copy of the forms was collected and verified for completeness.

These copies of the IRF were stored until sufficient numbers warranted entering the data into the computer. Missing forms became apparent and were tracked down and obtained where possible; otherwise basic information from the dispatch log was substituted for the actual report (obviously with some information missing). The injury report forms consisted of 39 variables. Each variable was coded with a numerical figure and entered it into a data management and statistical computer package (Systat 5.2 for the Macintosh (Wilkinson, et al., 1992)). For example, the injured body part (item 'u' below) was coded from the injury report and entered into the computerized database; *e.g.,* Injured part: 1) thigh, 2) knee, 3) lower leg, 4) ankle, 5) foot, 6) abdomen, 7) chest, etc. The computerized statistical codes were:

Statistics Data entry

a) Accident number:
b) Date: month, day
c) Time of accident:
d) Sex: 1) male, 2) female
e) Age:
f) Trail number:
g) Difficulty: 1) easiest 2) more difficult 3) most difficult 4) experts only
h) Form: 1) regular 2) minor treatment form 3) 10-49 (investigation)
i) Destination: 1)clinic 2) home 3) own doctor 4) hospital (directly) 5) return to skiing

j) New Snow Depth: 1) 0-15 cm 2)+15 cm
k) Snow texture: 1) dry 2) moist 3) wet 4) n/a
l) Hill surface: 1) groomed 2) bumps
m) Snow surface: 1)hard 2) frozen granular 3) powder 0)n/a
n) Activity: 1) skiing 2) snowboarding 3) monoboarding 4) other
o) Task: 1) recreational 2) competitive 3) lift 4) group lesson, 5) private lesson
p)Ability: 1) beginner 2) intermediate 3) advanced
q) Equipment : 1) owned 2) rental 3) borrowed 4) other

r) Collision: 0)no 1) person 2) tree 3) rock 4) other natural object 5) lift tower 6) vehicle 7) snowgun 8)other man-made object
s) Non collision: 0) no 1) near skier collision 2) near vehicle collision 3) fall jumping 4) fall change of snow 5) fall change of terrain 6) skied off trail 7) skier error 8) fatigue 9) other

t) Injury Zone 1: 1) left 2) right
u) Injured part 1: 1) thigh 2) knee 3) lower leg 4) ankle 5) foot 6) abdomen 7) chest 8) back 9) head 10) neck 11) shoulder 12) arm 13) wrist 14) hand 15) thumb 16) face 17) hip

v) Injury Zone 2: 1) left 2)right
w) Injured part 2: 1) thigh 2) knee 3) lower leg 4) ankle 5) foot 6) abdomen 7) chest 8) back 9) head 10) neck 11) shoulder 12) arm 13) wrist 14) hand 15) thumb 16 face 17) hip

x) Medication: 0)none 1) o2 3) entonox 4) analgesic 5) anti nausea 6) anti nausea and analgesic 7)#6 + O2 8) #6 and Entonox 9) other

y) Splints: 0) none 1) cardboard 2) sagar 3) wood 4) metal
z) Board and Collar: 0) none 1) yes 2) board only
Aa) Highest level of attendant : 1)IFA* 2) EMA1* 3) EMA2 4) ALS 5) MD* 6) RN*

Bb) Referral to MD: 1) yes 2) no
Cc) Transport from hill: 0) none 1) EHS* 2) comapny 3) private 4) helicopter
Dd) Transportation on hill: 0) none 1) t-bog 2) ski doo 3) snow cat 4) download walk 5) download stretcher 6) t-bog & download

Ee) Lift related: 0) no 1) struck by carrier 2) fall with restraining bar (rb) 3) fall no (rb) 4) fall loading 5) fall unloading 6) tower, 7) maze

Ff) Head injury: 1) concussion, 2) laceration, 3) 1+2, 4) eye injury, 5) unconscious, 6) combat, 7) epilepsy, 8) contusion, 9) headache 0)none

Gg) School group 0) no 1) yes

*EHS-Emergency Health Services (Ambulance Service)
IFA-Industrial First Aid
EMA-Emergency Medical attendant
MD-Medical Doctor
RN- registered Nurse

Patients with multiple injuries had the most serious injury listed first, followed by secondary injuries. In the final analysis, all injuries were combined resulting in more injured parts than injured skiers. Frequent spot checks were conducted to verify data entry with the actual injury report form, data entry and verification were done by the researcher. The patient's name and address were omitted from the working data to ensure anonymity, but a separate form was made which included the injured person's name, address and telephone number for the injured skier questionnaire mail-out.

The SKI Questionnaire

The completed questionnaires were returned to the researcher who coded the responses with numerical values and the University's data entry personnel entered the data into a database using a standard spot verification strategy. These were then transferred to a computerized statistical package for analysis.

Each questionnaire had been screened by the RA in the field and the majority of questionnaires were completed correctly. Twelve forms were largely incomplete and were discarded; forms missing only a few items were entered noting "missing data" which were not included in the analysis. I reviewed the questionnaires and wrote codes adjacent to the question number in order to minimize error by the data entry personnel who would otherwise have to count down the items then enter it. An example of this procedure is listed below:

31. How often do you ski the trees?
() never
2 () 1 run per day
() 2-5 runs per day

Although data-entry personal regularly do reliability checks, I also verified randomly selected entries against the original data.

Weather and Daily Injury Rates

In collating the data relating to weather and injury rates, the weather observations were coded and a database created for future statistical analysis. Codes for weather observations were as follows:

Sky Conditions
1) Clear: no clouds
2) Scattered Clouds: the sky is half or less covered with clouds
3) Broken Clouds: more than half but not all of the sky is covered with clouds
4) Overcast: the sky is completely covered with clouds
5) Obscured: A non-cloud layer (fog or snowfall) prevents the observer from seeing the sky

Visibility
0) Unlimited
1) Variable
2) Limited

Temperature
As recorded to the nearest degree (-5°C, 2°C)

Precipitation 24 hours
0) 0 cm
1) 1-10 cm
2) 11-20 cm
3) 21-30 cm
4) 31-40 cm
5) 41+ cm

Wind
0) Calm
1) Light (1-25 Km/h)
2) Moderate (26-40 Km/h)
3) Strong (41+ Km/h)

The mountain was able to provide next day tabulations of skier visits during the 1994-95 ski season. These figures were entered into the data base. The injured skier data included only patients referred to medical aid and were collected from the dispatch log. This data source is limited to providing general injury rates of those referred to medical aid by the ski patrol rather than injury specific rates.

Analysis of Data

Quantitative and Statistical Analysis

My research, as previously discussed, is predominantly a quantitative investigation. The study can be defined as a *descriptive research study*, which means that it implies a survey research design and seeks to answer questions of the "what is" type. For example, what is the distribution of injury between males and females? *Descriptive statistics* are those used to transform a set of observations into indices that describe or characterize the data and are used to summarize and organize large data sets into manageable and meaningful observations. Predominant in the analysis are *measures of central tendency*, which are statistical strategies to define what the typical or average response or observation might be. The term *frequency distributions* is an important descriptive analytic tool because it shows the most and least frequently occurring observations and the general shape of the distribution.

In addition to presenting the frequency distributions and measures of central tendency, one of the major contributions of this study is the presentation of replicable and reliable incidence rates of injury. Again, *incidence rates* are those new cases of injury in a determined population over a defined period of time. The distinction between injury incidence rates and injury frequency can be seen clearly by this example from the preliminary study. Young skiers under 18 years recorded 488 injuries requiring medical aid whereas the adults recorded 1077 injuries requiring medical attention. At face value, adults have the more serious injury problem because more of them are injured. However, when we consider how many skiers were skiing and at-risk of injury, we can determine the proportion of injured skiers to the total skiing population under study. Among young people there were 488 injuries out of 141,610 skier visits (*i.e.,* 0.34% or 3.4 /1000SV) and among adults there were 1077 injuries out of 576,891 skier visits(*i.e.*

0.18% or 1.8/1000SV). Injury frequency suggests that adults had the more serious problem, but injury rates indicate that youth had almost twice the risk of injury (0.34% vs. 0.18%).

Much of the analysis which follows will focus on comparing injury and behaviour patterns by age groups, the two gender groups and sport (alpine skiing and snowboarding). Injury incidence rates (rather than frequency) will prove to be more valuable in these comparisons; but to ensure that the differences are not simply due to chance, the Chi Square test with an alpha level of 0.05 will be used to test statistical significance of the results. The alpha level or probability level of 0.05 has been selected for rejecting the null hypothesis and enabling the result to be considered statistically significant. It is important to note that differences that are not statistically significant may in fact still be important but that the analysis was not sensitive enough to detect it at the predetermined probability level. In this research, the Chi-Square test was employed because it designed to test relationships based on comparing proportions.

Where appropriate the relative risk ratio (RR) has been used to compare the proportion of injury between two populations of skiers. Here is an example of how the relative risk ratio discussed previously (page 96) is computed below:

	Injured skiers	Uninjured skiers
Risk factor present	A	B
Risk factor absent	C	D

$$RR = \frac{A/(A+B)}{C/(C+D)}$$

The statistical analysis was assisted by the computerized statistical package Systat 5.2 for the Macintosh computer (Wilkinson, et al., 1992). Qualitative responses from both the IRF, the questionnaire, the supplementary injury information sheet and the focus group sessions were analyzed using computer assisted content analysis of key words and concepts.

Summary Overview of the Data as Collated

In summation of the discussion of the data collection and collation, the following concise overview of database is provided.

Injury Report Form

There were 540 injured skiers under 18 years of age during the study period with 354 people being referred to medical aid. Further discussion of the results will be presented later in Chapter 5 as they are directly relevant to the hypotheses under investigation.

SKI Questionnaire

A total of 981 questionnaires were analyzed. The basic demographic information is presented below in Table 4.0:

Table 4.0: Demographic Data on the SKI Questionnaire Respondents

Age	Uninjured n=863/(%)	Injured n=118/(%)
5	11/1.3	2/1.7
6	52/6.3	3/2.5
7	55/6.4	1/0.9
8	68/7.9	4/3.4
9	72/8.3	6/5.1
10	85/9.9	5/4.3
11	90/10.4	8/6.8
12	107/12.4	16/13.6
13	78/9.0	9/7.6
14	89/10.3	12/10.2
15	71/8.2	12/10.2
16	46/5.3	22/18.6
17	39/4.5	18/15.3

Gender	Uninjured n=863/(%)	Injured n=118/(%)
male	489/56.7	63/53.9
female	374/43.3	55/46.6

The questionnaire demographics are similar to those found from the IRF, indicating that the sample is comprised of a similar proportions as those found in the injured population. It is important to note that approximately one-third of injured skiers responded to the questionnaire limiting its representiveness and generalizability.

Skier Visit Data-1993

The replicable skier visit data provided by Blackcomb Mountain demonstrated that during the study period there were:

77,802 Youth (13-17 years) skier visits;

54,336 Child (7-12 years) skier visits;

14,215 Tot (0-6) skier visits

<u>Supplementary Data on Environmental Factors</u>

Weather data

The four month period during the 1994-95 ski season included 121 weather observations taken at 14:00 on Blackcomb Mountain.

Injured Skiers

The dispatch log provided data for the 121 days of this component of the study. There were 2017 reported injuries and 1535 patients referred to medical aid.

Skier Visits Data-1995

During the 121 day period of data collection the replicable skier visit count was 757,171 skiers.

The various data sources have been detailed here allowing the reader a concise picture of how many respondents participated, the basic demographics and other related statistical information regarding the database and which is not treated in the analysis chapter.

Focus Group Discussions--An Unplanned Data Collection Opportunity

An invitation by the Blackcomb administration provided an unexpected opportunity to collect qualitative data from young snowboarders. With the education coordinator at Blackcomb, a series of four Focus Group meetings were organized on the topic of Snowboarding at Blackcomb in early April, 1994. The purpose of this focus group was to attempt to better understand the needs of snowboarders and to possibly find strategies to examine alpine skier and snowboarder tension reported in the popular literature. Although, this data collection was not planned as part of the research, this data source would prove useful in better understanding the behaviours and beliefs of young snowboarders as they interact with the social and physical environment at Blackcomb. There were four groups, two which were purposefully selected and two which attempted a more random selection process. The two purposefully selected groups consisted of professional snowboarders (instructors, sales-persons) and members of a snowboard racing club, all who were invited to participate. To obtain a more representative sample of the average snowboarder, the two other groups were selected by chance by three ski patrollers who were asked to invite 10 snowboarders, three at least who were female but not more than five. Two main age divisions needed representation, those under 18 years and those 18 and over. The patroller's sought their subjects from three different regions of the mountain. The goal was to invite 15 people per session and have a turn-out of six to ten persons. The participants were enticed with food, beverages and gift certificates for their one hour participation of a same day focus group (at the end of the ski day, at the base of the hill).

The semi-directed focus groups were led by the same patroller and were tape-recorded and later analyzed. The purpose of the focus group was to:

A. Identify the major concerns of snowboarders regarding their sport;

B. Explore the reasons why snowboarder's are being perceived negatively by some skiers and the media;
C. To better understand from a snowboarder's perspective what makes a good snowboarding area;
D. Solicit recommendations regarding potential corporate sponsors for snowboard facilities

The tapes were transcribed using a content analysis procedure using key words and constructs. A summary report was produced for Blackcomb and access to this data source was granted for this research..

Data Presentation

The results will be presented in Chapter 5.

Summary

Chapter 4 has presented the methods and procedures employed in the prospective study. This was done in some detail to help the reader visualize the sequential conduct of the research, to show how the methods are consistent with the theoretical assumptions of the study, and to provide defined procedures that will facilitate replication. The study was based on defined hypotheses requiring instruments and procedures which can confirm or falsify these heuristic claims.

In retrospect, some of these methods can be recognized as not totally successful in composition or statistical formulation. However, it will also be apparent that these design imperfections have not compromised the study nor have they produced inconclusive nor demonstrably faulty data.

In many ways, methods can be seen to be the most crucial aspect of any research project. They must be responsive to the issue under study and they are responsible for the outcome in that they are so clearly linked to the quality of the data that will be collected. This certainly was the case with my research in this study. These issues lead up to Chapter 5, which will present the results and findings of the study.

Chapter 5--Results and Findings

Chapter 5 presents the analysis and findings of the study. The preceding chapters have directed the reader towards a clear understanding of the issues, the methodology, the development of hypotheses and the particular methods employed in obtaining reliable and replicable data in this study. In this chapter, the analysis of data will be presented followed by a discussion of the results as they relate to the five hypotheses which this study explores. Also a discussion of some of the inductively generated findings identified during the course of the analysis will be introduced.

Hypothesis Driven Analysis and Findings

The following section of the chapter will present analyses relating to my first two research hypotheses and will discuss the findings and their significance.

Hypothesis #1 and Hypothesis # 2

Hypothesis 1) Ski injury patterns are population specific, in the following ways:

a) Ski injury patterns vary significantly with age,

b) Ski injury patterns vary significantly by gender,

c)Injury patterns vary significantly between alpine skiing and snowboarding populations.

Hypothesis 2) Adolescents are a population at risk of injury in skiing in the following ways:

a)Adolescent age groups demonstrate an elevated incidence of risk taking behaviours in skiing over population norms.

b)Adolescent age groups demonstrate an elevated incidence of injury from skiing over population norms.

Injury Patterns

The data from Blackcomb's Injury Report Form provide a reliable and replicable Canadian ski injury database that can be used to substantiate the first two hypotheses. Injury among the youth skiing population is not evenly distributed. Table 5.0 indicates that adolescents have more ski injuries (*i.e.,* greater injury frequency distribution) than do younger children.

Table 5.0: Age and Frequency of Injured at Blackcomb 1993

Age	Number of Injured	Percent (%)
2	1	0.2
3	0	0.0
4	2	0.4
5	9	1.7
6	15	2.8
7	20	3.7
8	28	5.2
9	33	6.1
10	31	5.7
11	45	8.3
12	42	7.8
13	43	8.0
14	79	14.6
15	61	11.3
16	72	13.3
17	59	10.9

Fourteen year old children had the highest frequency of injuries in both the preliminary study and in this one. As previously discussed, the frequency of injury is not a useful method of reporting data because it cannot be compared easily with other ski areas or sports.

To facilitate comparisons and to establish the extent of the ski injury problem among young skiers, I have provided age-specific incidence rates of ski injury. The importance of replicable incidence rates of injury cannot be overstated. Injury frequency in skiing is largely governed by the total number of participants. As we have seen above in the age frequency distribution of injured skiers, we know that more 14-year olds were injured than children of any other age. But we cannot determine the seriousness nor the extent of the problem by looking at injury frequency distributions alone. Statements of injury rates on the other hand, take into account the total number of participants skiing (*i.e.,* the population at-risk of injury). In this study three age groups have been defined based on the ticket products.

Remember that we noted in the literature review and, closer to home, in the preliminary study that young skiers have a higher risk of injury than other groups in the skiing population. The injury rates among young skiers in this study ranged from a high of 4.03/1000 Skier Visits (SV) to a low of 0.91/1000 SV as seen in Table 5.1. These rates are important for two reasons. First, they will define the extent or seriousness of the problem in commonly understood epidemiological terms. Secondly, they provide baseline data for measuring the effectiveness of future interventions designed to reduce the incidence of injury.

During the 1993 ski season at Blackcomb, reliable and replicable computer-generated skier visit tabulations were established for three age groups of skiers under 18 years of age: a) 0-6 years (14,215 skier visits), b) 7-12 years (54,336 skier visits), and 13-17 years (77,802 skier visits). Two incidence rates of injury were calculated for each of these age groups based on injury severity. The two classifications of the ski patrol data are: 1) "all reported injury" and, 2) those injured skiers who were "referred to medical aid" (RTMA). Table 5.1 reports these data.

Table 5.1: Injury Rates for Children at Blackcomb, 1993

Age (years)	No. of Injuries	Injury rate /1000 SV	No. of injured RTMA	Injury rate RTMA /1000 SV
0-6	27	**1.90**	13	**0.91**
7-12	199	**3.66**	121	**2.22**
13-17	314	**4.03**	220	**2.86**
All (0-17)	540	**3.69**	354	**2.42**

The relative risk of RTMA injury shows that adolescents have a 28%(RR=1.28) greater risk of injury than children (7-12 years).

The data on adolescent injuries also allow me to determine patterns of injury, generalizations about what types of injuries occur (usually in terms of the body parts affected). Table 5.2 reports in descending order of frequency the leading injured body parts for children under 18 years of age. Knowing the total number of injured children (146,353), I am able to provide rates of injury for each these categories .

Table 5.2: Injured Body Parts of Children 0-17 Years in Descending Order of Occurrence at Blackcomb, 1993

Body part injured	Number of injuries	Percent of Injuries	Rate /1000SV
Knee	121	22.4	0.83
Face	64	11.9	0.44
Head	52	9.6	0.36
Thumb	48	8.9	0.33
Wrist	42	7.8	0.29
Ankle	35	6.5	0.24
Back	33	6.1	0.23
Shoulder	30	5.6	0.21
Thigh	26	4.8	0.18
Arm	21	3.9	0.14
Lower leg	20	3.7	0.14
Hip	19	3.5	0.13
Chest	18	3.3	0.12
Abdomen	16	3.0	0.11
Hand	15	2.8	0.10
Neck	7	1.3	0.04
Foot	4	0.7	0.03

My results regarding injury sites are consistent with the findings of others as discussed in the literature review. A notable difference in my data is that lower leg injuries are not as common as what others have reported and that head and face injuries are significantly more common. Head and facial injuries, when combined, are nearly equal to knee injuries, the leading injury site. In 96% of the injury report forms describing head and facial injuries (111 of 116 cases), supplementary information was provided by the ski patroller detailing the injury. Thus, I have been able to generalize about the types of injuries (contusions, lacerations, etc.) to the head and face rather than simply identifying the location of the injury(see Table 5.3 below). These injuries or illnesses were described by the ski patrol and represent reported chief complaints in more detail that normally reported on the IRF.

Table 5.3: Injury Types Among Children 0-17 with Head/face Injury at Blackcomb, 1993

Injury	Number of injuries	Percent of head and face injuries	Percent of all injuries (%)
Laceration	48	43.2	8.9
Contusion	28	25.2	5.2
Concussion	19	17.1	3.5
Unconsciousness	5	4.5	0.9
Eye injury	4	3.6	0.7
Laceration and concussion	3	2.7	0.6
Combative patient	2	1.8	0.4
Epileptic seizure	1	0.9	0.2
Headache	1	0.9	0.2

Head injuries, excluding the face, represent 52 incidents. It should be noted that a protective helmet would probably have prevented or at least reduced the severity of injury in almost all head injuries resulting from a fall or collision.

These data also demonstrate the extent of the injury problem among children under 18 years and, again, are consistent with the general findings of other international researchers. When the data are arranged according to our three age groups, we can identify the leading injury sites according to age group (Table 5.4).

Table 5.4: Age and Leading Injured Body Part: Number, Frequency and Rate of all Injured Children 0-17, at Blackcomb, 1993

Age Group, n=number of injured	Most Injured Part	#2 Injured Part	#3 Injured Part
0-6 n=27	head & face* n=11 41% 0.77	knee n=6 22% 0.42	ankle/wrist n=2 7% 0.14
7-12 n=199	head & face n=46 23% 0.85	knee n=45 23% 0.83	thumb n=16 8% 0.29
13-17 n=314	knee n=70 22% 0.90	head & face n=59 19% 0.76	thumb n=32 10% 0.41
all (0-17) n=540	knee n-121 22% 0.82	head & face n=116 22% 0.79	thumb n=48 9% 0.33

*children 0-6 years had significantly more head and face injuries than knee injuries and significantly more head and face injuries than the other two age groups ($p<0.05$)
-Figures indicate a)number of specific injuries, b)percentage of injuries and c)incidence rate per 1000 Skier Visits during 1 ski season)
-

Few statistically significant relationships can be found in the above data. Young children (0-6 years of age) had significantly more head and face injuries than knee injuries. Also, this age group (0-6 years) also had significantly more head and face injuries than the two older age groups.

Using Canadian data here also presents an injury pattern similar to other studies; but, the frequency of these injuries is quite different. For example among injured skiers, the proportion of young children (0-6 years) who injure their head and face (41%) is substantially higher than those identified by Ekeland (1993) who reported that head injuries accounted for 15% of injuries in his injured population of children under 15 and Giddings (1993) who found head and face injuries represented in 14.1% of his injured population of children 12 years and under. The importance of demonstrating rates of injury rather than simply identifying the frequency of injuries is that the two data sources can be equitably compared. Giddings (1993) estimated the skier visits for children 12 years and younger to be 61,083 and reported 29 head and face injuries; the rate of head and face injury was 0.47/1000 SV. On Blackcomb, the head & face injury rates are 0.77/1000SV for children 0-6 years, 0.84/1000SV for children 7-12 years and 0.75 for children 13-17 years. To compare with the Giddings study, I combined the two younger groups in my study and obtained a head and face injury rate of 0.83/1000SV for children 12 years and under. The relative-risk ratio was 0.57, meaning that the Australian youth have approximately half the risk of head and facial injury "faced" by Canadian children. It is obvious, then, that the increased frequency in reported head and face trauma is not just a factor of a greater at-risk population but that children at this Canadian site have nearly double the rate of head and face injuries than that reported by Giddings 1993 (the only other study which provided enough information to establish rates). A cautionary remark to note is that it is uncertain whether the two data sets define head and face injury in the same way which may account for some of the difference mentioned.

Gender Differences

Gender differences in ski injury patterns are readily apparent and have been documented using US and European data. The Canadian data, once again, are consistent with the trends noted in the literature. The gender distribution among injured skiers (0-17 years) is 54.6% male and 45.4% female and the difference is not statistically significant. This result is comparable to the gender distribution of the entire injured population identified in the preliminary study where males represented 57% of the injured population and females 43% and the under 18 gender distribution was 56% male and 44% female. Table 5.5 identifies the 10 leading injured body parts for males and females under 18 years.

Table 5.5: Gender and the Ten Leading Types of Injuries Recorded on Blackcomb Mountain, 1993

Males (%)	**Female (%)**
1- Head/face (26.5)*	1- Knee (32.0)*
2- Knee (15.2)	2- Head/face (15.7)
3- Thumb (9.5)	3- Ankle (9.0)
4- Shoulder (9.5)	4- Thumb (8.2)
5- Wrist (9.2)	5- Wrist (6.1)
6- Back (6.4)	6- Back (5.7)
7- Lower leg (4.7)	7- Thigh (5.3)
8- Ankle (4.4)	8- Hip (3.7)
9- Thigh (4.4)	9- Arm (3.7)
10- Arm (4.1)	10-Chest (3.3)/Hand (3.3)

*Males had significantly more head and face injuries than females and females had significantly more knee injuries than the males ($p<0.05$)

Thus, statistically significant gender differences were noted for both knee and head & face injuries. As previously discussed in the preliminary study, males had significantly more head & face injuries than females while females had significantly more knee injuries than the males. Because the gender distribution in the skiing population has not been established, it is impossible to provide gender-specific rates of injury.

<u>Sport Specific Injury Patterns</u>

Previous reports on the injury patterns between alpine skiers and snowboarders have demonstrated that the two groups have different injury patterns. Canadian researchers were one of the first to report on the snowboard injury problem (Abu-Laban, 1991). The data presented below (Table 5.6) describes the ten leading injuries of alpine skiers and snowboarders reported on Blackcomb during the study.

Table 5.6: The Ten Leading Sport Specific Injuries Reported on Blackcomb Mountain, 1993

Alpine Skier (%)	**Snowboarder (%)**
1- Knee (24.9)*	1- Wrist (26.8)*
2- Head/face (21.4)	2- Knee (15.5)
3- Thumb (10.6)	3- Head/face (15.5)
4- Lower leg (6.9)	4- Shoulder (11.3)
5- Back (6.5)	5- Arm (7.0)
6- Wrist (5.3)	6- Back (5.6)
7- Shoulder (4.9)	7- Thigh (5.6)
8- Hip (4.4)	8- Chest (2.8)
9- Ankle (4.2)	9- Hand (2.8)
10- Arm (3.5)	10- Thumb (2.8)

* Alpine skiers had significantly more knee injuries than snowboarders while snowboarders had significantly more wrist injuries than alpine skiers ($p<0.05$)

Skiers had significantly more knee injuries than snowboarders while snowboarders had significantly more wrist injuries than the skiers. A further investigation of gender with the two sports indicate other statistically significant results. With regards to alpine skiers, females have significantly more knee injuries than males and males have significantly more head and face injuries than female skiers. There were no statistically significant gender differences among the snowboarders (due to the small number of cases, detection of statistically significant results was not possible). Once again, because the distribution of alpine skiers and snowboarders is not known, it is impossible to establish rates of injury for these two groups.

Summary of Findings Regarding Hypotheses # 1 and #2

The following summarizes the findings of the first two hypotheses. According to this study adolescents have the highest risk of injury of any of the three groups of children studied (0-6, 7-12 and 13-17 years). It is apparent that injury patterns are governed by age, gender and sport. Statistically significant differences were noted for male head and face injuries, female knee injuries, and wrist injuries among snowboarders. In comparing head and facial ski injury data for children 12 years and younger, it was evident that those injured at Blackcomb had nearly twice the injury rate of their same-age Australian counterparts.

The data reported above confirm the hypothesis that Canadian ski injury data can provide verifiable injury patterns regarding age, gender and sport-specific activities and that these Canadian results are comparable to data from studies elsewhere. The importance of this finding is that we now know that Canadian data (at least those from this study site) indicate trends which are consistent with those identified by researchers in other sites around the world.

Hypothesis #3

The physical environment in skiing significantly affects injury in the following ways:

a) Groomed slopes are associated with more injuries than non-groomed slopes,

b) Weather variables such as new snow, visibility and temperature affect injury rates in a significant manner,

c) Higher skier visit/days in the ski area will result with significantly more skiing related injuries,

d) Lift related injuries are most frequent during the loading and unloading procedure.

Terrain

Data employed in the investigation of hypothesis #3 are based on Blackcomb's IRF and its weather and skier visit accounting. The slope conditions reported on the IRF by the attending ski patroller provide an accurate description of the physical terrain where the injury occurred. The first factor commonly used to describe the physical skiing environment is the ski run. Because ski runs differ from one hill to the next, let alone from one state/province or country to the next, a standardized criterion for run designation is impossible. However, the North American ski industry attempts to standardize the ski run designations within each ski area. These include:

> green circle = easiest,
> blue square = more difficult,
> black diamond = most difficult,
> double black diamond = experts only.

Many skiers may not recognize, though, that the designations are mountain-specific and relative to the other runs at that ski facility. For example, green denotes an "easiest" run for that ski area and that ski area alone. It could be more difficult than a blue run at another ski area.

Looking back to those injured in the 1992 preliminary study involving all skiers, 29% were injured on runs designated easiest, 46% on more difficult and 14% on most difficult, with the remaining 10% not having any indication on the form. In that same study, those under 18 were injured on the following run designations; easiest 38%, more difficult 41%, most difficult 10%, and no response 11%. There are no estimates available regarding the number of skiers using the different types of ski runs at this ski area.

In the 1993 prospective study a fourth designation "experts only" was included on the trail map to render greater precision to the "most difficult" category from the preceding year. Table 5.7 shows the age group and the level of difficulty of the run where the injury occurred. The data support the internationally noted trend that skiing injuries occur most frequently on runs designated easiest or more difficult but not necessarily at a higher rate per 1000 skier visits on those runs.

Table 5.7: Age Group and Slope Difficulty where Injury Occurred, Blackcomb,1993

Slope Difficulty	0-6	7-12	13-17	0-17 all
Not Stated*	7 (26%)	25 (18%)	58 (19%)	100 (19%)
Easiest	13 (48%)	82 (41%)	100 (32%)	195 (36%)
More Difficult	7 (26%)	78 (39%)	126 (40%)	211 (39%)
Most Difficult	-------	3 (1.5%)	25 (8%)	28 (5%)
Expert	--------	1 (0.5%)	5 (2%)	6 (1%)

*indicates injuries occurred somewhere other than the attending patroller found them and the patient could not recall the name of the run.

Results from the IRF indicate that most injuries occur under what experienced skiers would consider good skiing conditions. Among those injured, the majority (78.5%) were skiing on new snow less than 15 cm in depth. Only 3.2% of the injuries occurred in fresh snow greater than 15 cm. The extensive grooming of the slopes at the study site ensured that the majority of "easiest" and "more difficult" runs were groomed every night providing soft packed snow and not loose powder snow or moguls. In 68% of the injury events, the snow was dry (too loose to make good snowballs), moist (good snowball making snow) for 11.1%, and wet (water oozes out when making snowballs) in 1.7%. Groomed slopes accounted for 67.2% of the injury locations whereas mogul runs were noted for only 14.3%. The snow surface was hard (boot penetration of 5 cm) in 70.7% of the injury events, soft packed (boot penetration 10-15 cm) in 6.3% of injuries and powder snow (walking is difficult) in 2.2% of the injuries. One can then generalize that the conditions in which most skiing injuries occur is on beginner and intermediate runs that are groomed and have hard packed snow conditions.

<u>Changing Weather Patterns</u>

Data regarding changing weather patterns and injury were collected from the 1994-95 component of the study where daily incidence rates of injury were prepared and then were compared with the weather conditions present at 14:00 that day. (Note, these data represents all skiers who were injured during the four month study period and are not limited to children under 18 years.)

It has been suggested that poor visibility, new snowfall and temperature are factors positively associated with injury (Bouter, 1988). Analysis using injury frequency showed that more injuries occurred on days with more skier volume (*e.g.,* Saturdays had more injured skiers than Wednesdays). Thus, variations caused by weather were not detectable due to differences in skier visits which tended to skew the results (*e.g.,* "powder snow days" often attracted more skiers and more skiers usually results in more injuries). To compensate, daily injury rates were used and compared with the weather data. This type of analysis has not been previously reported in the literature. The skier injury information is represented in Table 5.8.

Table 5.8: Summary of Daily Injury Statistics over a 4 Month Period, Blackcomb, 1995

	Injuries	RTMA	Skier Visits
# of days	121	121	121
Minimum	0	0	1,503
Maximum	39	32	13,484
Mean	16.67	12.69	6,258
Median	15	12	6,059
Total number	2,017	1,535	757,171

The incidence rates for the summary above revealed that the category of all injury ranged from between 0/1000 SV to 7.12/1000 SV with a mean rate of 2.70/1000 SV. The RTMA rates ranged between 0 and 3.96/1000 SV and had a mean of 2.05/1000 SV. The RTMA mean rate will be used in the analysis which compares injury and existing weather conditions. The weather data that will be used in the previously mentioned analysis is summarized in Table 5.9 and represents the daily weather observations at 14:00.

Table 5.9: Summary of Daily Weather Observations, Blackcomb, 1995

	Temperature °C	New Snow (cm)	Visibility
# of days	121	121	121
Minimum	-18	0	0
Maximum	6	42	2
Mean	-2.8	5.71	0.63
Median	-3	1	---
Total number	------	691	---

Visibility scale

0= clear, unlimited visibility

1= variable, the sky is cloudy but visibility is generally good allowing the skier to see 25-50 meters ahead

2= limited, the sky is obscured and the skier can see less than 25m ahead

The analysis consisted of a comparison between the three weather conditions and the mean RTMA incidence rate of injury. The RTMA mean rate (2.05/1000SV) represented the cut-off point between higher and lower incidence of injury (*e.g.,* days with RTMA rates below 2.05/1000SV were considered low incidence of injury days and days with rates 2.05/1000SV and above were considered higher incidence of injury days). The temperature variable was divided into two categories, warm days when temperatures were -5°C and warmer and cold days when the temperatures were colder than -5°C. Visibility employed its existing criteria (describe in Table 5.11); and new snowfall/storm cycles used the following criteria (in a 24 hour period):

1) less than 11 cm,

2) 11-19 cm and,

3) greater than 19 cm.

Table 5.10 indicates the test results performed relating injury rates to environmental conditions.

Table 5.10: Environmental Conditions and Injury Rate Relationships, Blackcomb, 1995

Variable 1	Variable 2	p value*
Temperature ≤-5 and >-5	above/below 2.05/1000SV	.573
New Snow <11 cm 11-19 cm >19 cm	above/below 2.05/1000SV	.317
Visibility 1-unlimited 2-variable 3-limited	above/below 2.05/1000SV	.279

*Statistical significance $p<0.05$

It was suggested that poor visibility could be problematic to skiers and lead to increased incidence of injury because of the inability to see clearly. Evidence suggests that injury rates are, in fact, not affected in a statistically significant way by visibility in a ski area.

The belief of some skiers that larger accumulations for new snow is responsible for an increase in injury rates was also tested. Injury rates were found not to be affected in a statistically significant manner by the amount of new snow that falls each day in a ski area.

Temperature, as well, failed to be a statistically significant factor influencing injury.

The failure to reject these hypotheses suggests that the common belief that these physical environmental factors influence injury rates is false. However, it is recommended that further investigation using specific injury rates rather than general incidence rates should be pursued. For example, the overall injury rate may not change as a result of different weather conditions but the frequency and rate of specific injuries may vary (*e.g.,* deep snow is sometimes associated with medial collateral knee ligament injuries while head injuries are often associated with hard and icy conditions).

It was noted that the injury rates in the preliminary study and in the prospective study were substantially different (Table 5.11). Incidence rates from the retrospective study were higher than those in the prospective study for reasons that could include different programs, different conditions or different composition of the skiing population between the two periods.

Table 5.11 Comparing Injury Rates- the Retrospective and the Prospective Studies, Blackcomb ,1992-93

Age group	Retrospective Injury Rate/1000SV	Prospective Injury Rate/1000SV	Retrospective RTMA Rate/1000SV	Prospective RTMA Rate/1000SV
0-6	3.81	1.90	1.74	0.91
7-12	4.75	3.66	3.18	2.22
13-17	4.35	4.03	3.34	2.86
18-64	2.53	-------*	1.87	-------
65+	2.22	-------	1.75	-------
All	2.97	-------	2.17	-------

* the dashes indicate that data for this age group was not collected in the Phase 2 prospective data collection

A careful review of the data, followed by an analysis of the educational and promotional activities sponsored by the mountain, indicated that the data were sound and that there were no new programs implemented between the two seasons which may have contributed to this reduction in injury rates. This finding, then, is probably attributable to natural environmental factors (weather) that reportedly affect ski injury patterns. By this I mean that the entire season's weather was better than the preceding year- more snow, less ice, better snow coverage. This finding demonstrates the importance of maintaining longitudinal records so that seasonal and other variations are understood in relation to changes in injury trends and patterns.

The weather as a physical environment factor does not appear to play as significant a role as it is sometimes suggested in the literature. However, at the more individual level, it is likely that improved understanding of the environmental influences on skiing behaviour would contribute to reducing an individual's potential for injury. For example, the skier who died after attempting to ski a shaded icy slope may not have recognized the temporary hazard of that slope (see page 65 for further information); the skier who recognizes icier conditions might have avoided the run until such time as conditions changed.

Crowding

Crowding is a term defined as a higher number of skier visit/days than the mean number of skier visit/days of the study period. The only reliable measure of crowding is skier visits at the ski area. The following comparison investigates a) those ski days with less than 6000 skier visits, b) those days with 5,999-10,000 skiers and c) days with over 10,000 skier visits. It is obvious that more skiers are injured on days with more skier visits. However, note that the RTMA injury rate is inversely related to skier visits. The more skier visits the smaller the RTMA incidence rate.

Table 5.12: Injury and Crowding, Blackcomb,1995

Measure	Less than 6000SV	6000 to 10,000SV	Over 10,000SV
No. of Days	57	55	9
No. of Injured-mean	12.07	19.85	26.33
No. of Injured-max.	25	39	34
No. of Injured-total	688	1092	237
Rate of All Injured	**2.82/1000 SV**	**2.64/1000SV**	**2.87/1000SV**
No. of RTMA-mean	9.32	14.9	20.44
No. of RTMA-max.	21	32	26
No. of RTMA-total	531	820	184
Rate of RTMA Skiers	**2.16/1000SV**	**1.97/1000SV**	**1.81/1000SV**
Mean New Snowfall	6.39 cm	5.20 cm	4.56 cm
Mean Temperature	-2.65°C	-3.05°C	-3.22°C

As a matter of fact, the relative risk of injury on days with more than 6000 is 0.92 or, in other words, there is a greater chance of injury on days with less skier traffic. Evidence presented here suggests that injury rates for injuries requiring medical attention at Blackcomb are in fact, lessened by larger crowds.

Loading and Unloading Lifts

Although the literature did not provide a great deal of information regarding lift related injuries, it was suspected that most of these injuries occurred in the loading and unloading procedure. The injury report form provided the following data.

Table 5.13: Injury Involving Lifts, Blackcomb, 1993

Cause	7-12 years	13-17 years	All 0-17 years
Struck by carrier	6 (3%)*	3 (1%)	9 (1.7%)
Fall loading	1 (0.5%)	1(.3%)	2 (.37%)
Fall unloading	4 (2%)	2 (.6%)	6 (1.1%)
Collision with tower	---	2 (.6%)	3 (.56%)
Collision with maze	4 (2%)	---	2 (.37%)

* percent value represents the percentage of all injured children in that age group
No injuries were reported among children 0-6 years

The frequency of lift-related injury is rather small with 24 injured children during the study. The rate of lift-related injury among children is 0.01/1000SV. The majority of injuries did occur in the loading and unloading area. If being struck by the carrier (the chair) is included in loading, then this category should be considered the danger area as 11 of 24 injuries occurred at this phase of the lift ride. Falls in the unload area need further investigation. My personal experience suggests that the injury frequency is related to the incline of the off-load ramp. The steeper the ramp the greater the injury frequency and rate. However, this would have to be evaluated in a future study. The frequency of young skiers falling from the lift is very small with only a few instances occurring during the course of a season, if at all. The injuries resulting from such falls, however, are usually significant. This type of fall can be prevented with the use of the restraining bar and this behaviour will be discussed on page 175.

Summary of Findings Regarding Hypothesis #3

Ski injuries are influenced by the physical environment, but perhaps not to the extent commonly believed. While it is true that the natural physical environment (*i.e.,* steep slopes, rock outcrops, cliffs, avalanche prone slopes, trees) will determine the potential for injury (*i.e.,* contusions, abrasions, fractures, concussion, quadriplegia, and perhaps death), not all skiers will expose themselves to these sorts of physical environmental features. Ski runs designated "most difficult" or for "experts only" have a great potential to do harm to a skier who loses control and falls on the steep slopes. One such case was a 16 year old female who fell and slid down an icy mogul run like a rag doll. She crossed under a closed sign and went under a rope. The fall resulted in her jacket and shirt to be peeled from her body, she fractured her arm and had a serious concussion resulting in prolonged unconsciousness (2 hours). However, few injuries occur on these slopes either because fewer skiers are attracted to them or that they attract a higher ability type skier who is less inclined to fall . Ski injuries as seen in this study and elsewhere, appear to occur most often on beginner and intermediate level slopes under what experienced skiers would consider ideal conditions. There were no statistically significant findings indicating that weather variables had an effect on higher or lower incidence rates of injury.

The artificial physical environment includes such things as ski lifts and grooming of slopes. The majority of injuries occurred on groomed slopes. It is quite possible that the reason most injuries occur on these slopes is because more people ski on them. On the other hand, it may be that the smooth surfaces provide an opportunity for greater speed despite one's ability level. With regard to lift-related injury, the loading procedure is responsible for nearly half of all these types of incidents. Injuries resulting from collisions with the lift towers, the maze in the loading area and falls from the chair are infrequent.

The features of the physical environment identified in the literature review have not all proven in this study to co-exist with increased incidence of injury. As a matter of fact, other than run designation and slope preparation, the majority of variables were not related in a significant way to an increase in injury.

Hypothesis #4

The social environment of the skier impacts significantly on the incidence of injury and skiing behaviours in the following ways:

a) Adolescents on school sponsored ski programs will be injured significantly more than same age population norms;

b) Skiing behaviour is affected by the social relationship of the skiing partners.

Data used to investigate this hypothesis were collected from the Injury Report Form and the Skier's Knowledge Initiative questionnaire. It is also important to note that the investigation of skiing injuries specific to school children has not been reported previously in literature.

School Children as a Special Youth Population

As part of the study population, I was able to distinguish between youth who were injured skiing with their school and those who were not. There were 22,752 verifiable skier visits by students attending school sponsored ski programs (SP) on Blackcomb Mountain during the 1993 ski season. These students, aged 7-17 years, were enrolled in a registered school, were transported by bus to the ski area, received a one-and-one half-hour ski lesson followed by free skiing time. Table 5.14 reports the age specific frequency of injury between school groups and the general youth population (GYP).

Table 5.14: Number and Proportion of Injuries to Children in School Groups Compared to those in the General Youth Population, Blackcomb, 1993

Age	SP	GYP
0-6	--	27 (100%)
7-12	20 (10%)	179 (90%)
13-17	105 (33%)	209 (67%)
0-17 all	125 (23%)	415 (77%)

To match the school group population SP and the GYP, the 0-6 year olds were eliminated from the analysis (because they haven't attained school age) and the age distribution, then became 7-17 years in each category. The incidence rates of injury for school groups and the GYP are presented in Table 5.15.

Table 5.15: Incidence of Injury among the School Population and the General Youth Population using Injury Report Data at Blackcomb, 1993

	No. of injured	Population at risk	Rate of injury /1000 SV	No. RTMA	RTMA rate /1000 SV
School	125	22,752	5.49	95	4.17*
GYP	388	109,386	3.55	246	2.25

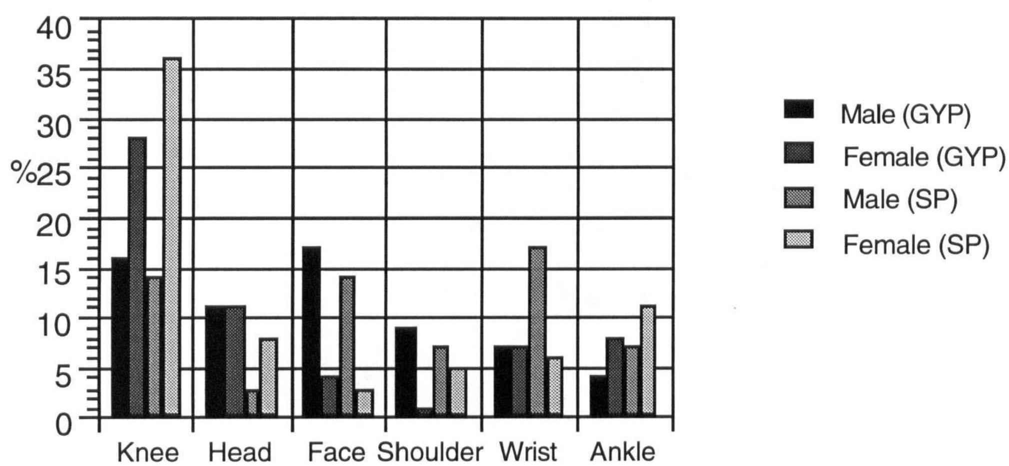
GYP = children aged 7-17 and excludes children on school ski trips
*RTMA rates between GYP and SP are statistically significant ($p<0.05$)

It is obvious that children on school-sponsored ski trips sustain a greater proportion of injuries than the GYP, with an RTMA incidence rate of injury nearly double that of the GYP. The relative risk (RR) ratio between the two groups is 1.55 for all injury and 1.85 for RTMA. The Chi Square tests for statistical significance indicates that a significant difference exists between the two populations ($p=.003$). The school population incurred 33% of the injuries yet represented only 17% of the skier visits. The importance of this finding is noteworthy as no other published report has ever identified this population, let alone demonstrated a significantly different injury risk than children not on school ski programs. The over representation of school children among injured youth is a red flag for ski injury researchers, educators and parents.

Injury Patterns Between the School Population and General Youth Population

The injury patterns between the school population and the general youth population are very similar but not identical. Figure 5.0 demonstrates using a histogram the similarities between the two groups with to respect to gender-based injury patterns.

Figure 5.0: Comparing the Distribution of Specific Injuries and Gender using the Proportion of those who Sustained an Injury Between the General Youth Population and the School Population at Blackcomb, 1993



-Significant difference between SP and GYP: the wrist (p<0.05)

-Significant differences between males and females GYP:
females had more knee injuries, males had more head, face and shoulder injuries (p.<0.05)
-Significant differences between males and females SP:
females had more knee injuires than males and males had more head and face injuries(p<0.05)

The only statistically significant difference identified between the SP and GYP was the wrist injury (p=.016). Several significant differences were identified between the gender groups within each study population. In the GYP, females had significantly more knee injuries than males (p=.004), the males had significantly more facial injuries than the females (p=.000) and males had significantly more shoulder injuries than females (p=.030). In the school population, females had significantly more knee injuries than males (p=.004) and males had significantly more facial injuries than females (p=.030). Statistical comparisons of skiers and snowboarders in the school population was not feasible because of the small number of snowboarders in the population.

Introduction to Skiing

How skiers were introduced to skiing activities has yet to be reported in the literature. Since early skiing experience may influence skiing behaviour, I surveyed skiers about their first experiences skiing. The vast majority (82%) of the uninjured subjects began skiing with their families, likewise 75.4% of injured skiers did as well. Friends and relatives introduced about 7% of both groups to skiing, while the school introduced 7.3% of uninjured respondents to skiing and 15.3% of injured respondents. Although comparisons can't be made, further research into the school as a social environmental factor should be encouraged. It would be helpful to attempt to determine whether the school "culture" influences injury or whether it is simply that school groups include more novices (who are more likely to injure themselves than advanced level skiers). In this study, it is evident that injuries to school children included more novice skiers than those injured in the GYP (see figure 5.1 on page 156).

According to both groups of questionnaire respondents, the vast majority of older children participate in school-sponsored ski trips. Tables 5.16 and 5.16a show the increased participation in school ski trips among older children.

Table 5.16: Skiing Participation in School Sponsored Ski Programs, Uninjured SKI Sample, Blackcomb, 1993

	0-6	7-12	13-17	all 0-17
yes	14.3%	37.3%	78%	50.9%
no	85.7%	62.7%	22.1%	49.1%

Table 5.16a: Skiing Participation in School Sponsored Ski Programs, Injured SKI Sample, Blackcomb, 1993

	0-6	7-12	13-17	all 0-17
yes	0%	50%	90.4%	72.9%
no	100%	50%	9.6%	27.1%

This high level of participation in school programs suggests that the school may be an appropriate venue for presenting an effective educational intervention in skiing safety. However, when asked where skiing safety ought to be taught, both groups of respondents overwhelmingly (over 80%) identified the ski hill as the ideal teaching environment. About 11% of the 13-17 year olds identified the school as being a good place to teach skiing safety.

Gender Differences

Unlike the majority of published reports on ski injury gender differences, females in the school population outnumbered the injured males. Table 5.17 indicates that the school population had more injured females than males which is an anomaly in the ski injury literature. The differences are not statistically significant (P=.064) but should be noted nonetheless because it is the first findings of females having had a greater proportion of injuries than males in the skiing literature. Further research is required to identify the reasons why this finding is so.

Table 5.17 Gender Differences among the Injured in the General Youth Population and the School Population at Blackcomb, 1993

	Boys	Girls
GYP	220/56.7%*	168/43.3%
SP	59/47.2%	66/52.8%

*gender differences between groups are not statistically significant

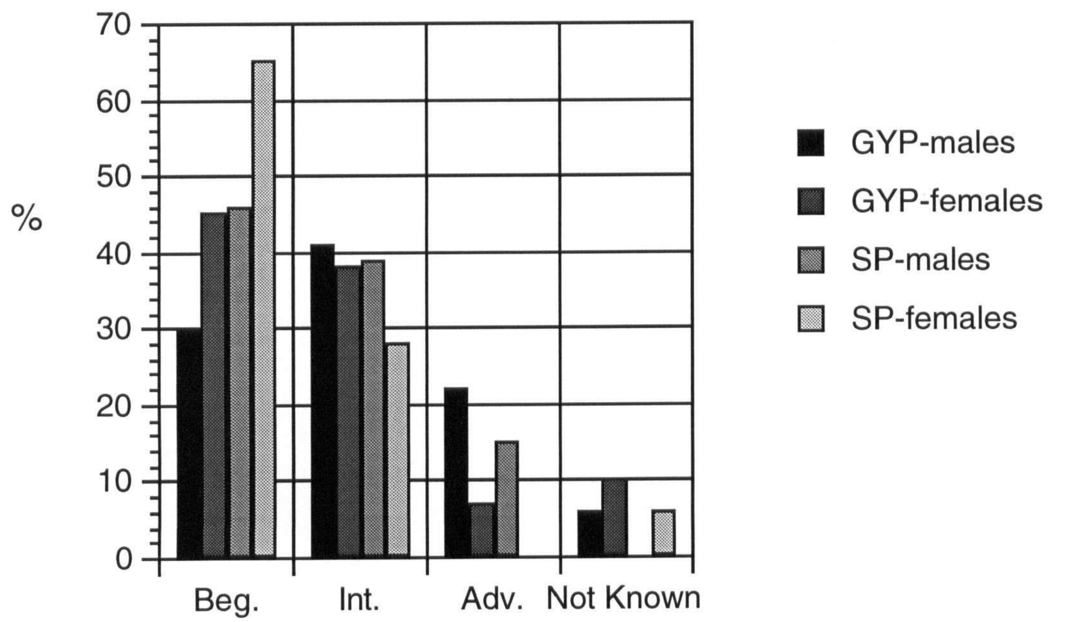
Skiing Ability

The skiing literature suggests that beginners and intermediate level skiers have a higher risk of injury than experienced skiers. Figure 5.1 (following page) shows the self-reported ability level and gender of the injured skiers. It is obvious that injury frequency is greater among beginners and intermediate level skiers. Significant differences existed between the GYP and SP with regards to ability for both boys and girls. Only in the beginner category were there significant differences between boys in the SP and GYP ($p=.027$) and girls in the SP and GYP ($p=.006$). In the other ability groups no significant differences were detected between the two gender groups.

When comparing the injured body part and the skiers ability in Figure 5.2 , the results show that knee injuries diminish with experience while head and shoulder injuries increase as the person gains experience. Statistically significant differences existed between abilities with respect to knee injuries ($p=0.013$)This is especially apparent among the GYP .

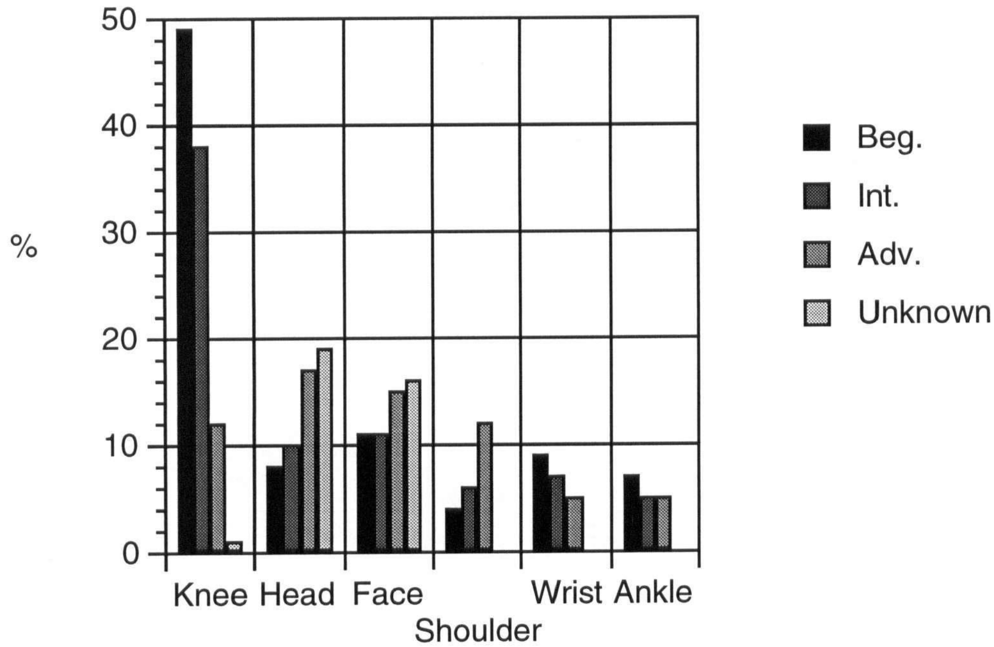
Among the SP, a similar pattern exists but it is less pronounced (Figure 5.3). An interesting finding is the percentage of shoulder injuries among the advanced SP skiers, this difference is statistically significant ($p<0.001$).

Figure 5.1: Comparing Gender, Group and Self-reported Skiing Ability of those Injured at Blackcomb, 1993



SP and GYP have significantly different skiing abilities ($p<0.05$)
Beginner category: sig. dif. between SP and GYP males and between SP and GYP females ($p<0.05$)

Figure 5.2: Comparing the Injured Body Part and Self-Reported Ability of those who Sustained an Injury in the General Youth Population as Identified by the Injury Report Form at Blackcomb, 1993



Significant difference between abilities and the knee injury (p<0.05)

Figure 5.3: Comparing Proportions among the Injured School Population using Self-Reported Ability and Injured Body Part at Blackcomb, 1993

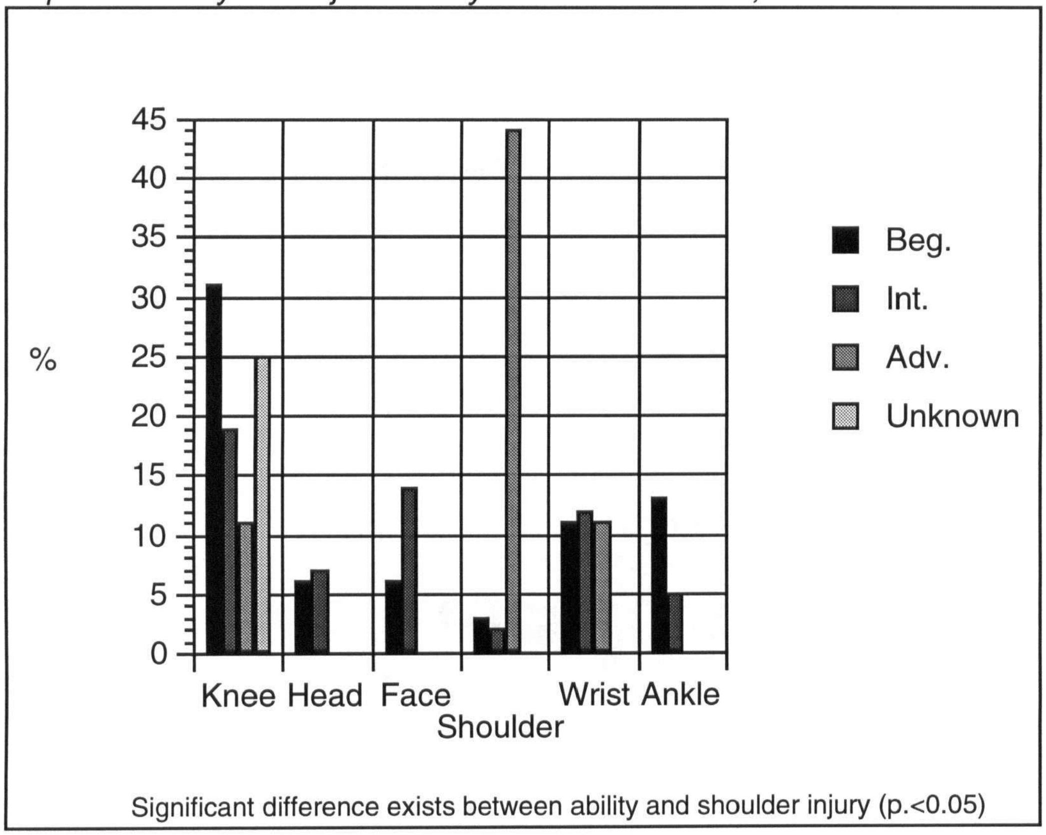
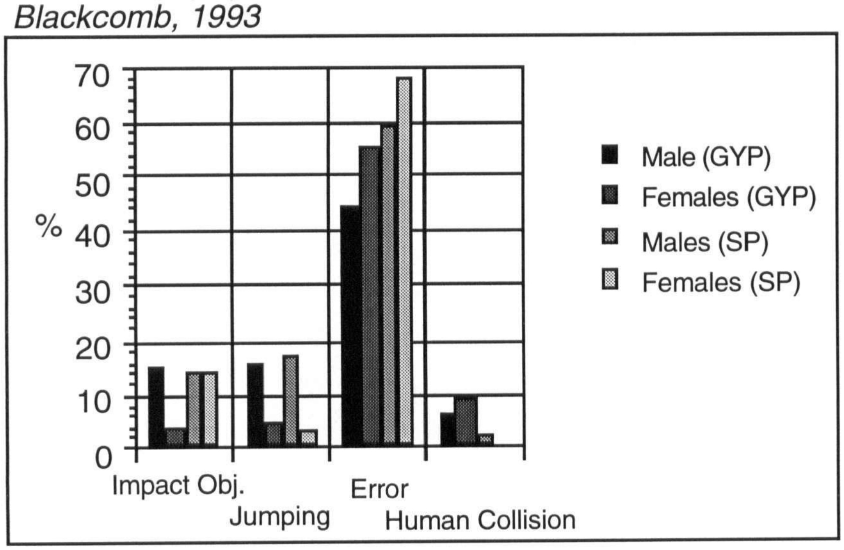


Figure 5.4 : Comparing Percentages of those Injured using Gender and Reported Causes of Injury between the General Youth Population and the School Population at Blackcomb, 1993



Self-Reported Cause of Injury

The mechanism leading to the injury event is often difficult to identify. Personal error is the leading reported cause among the injured skier population. This is usually interpreted by ski patrollers as a skill-based error where the skier lost control and was injured in or after the fall. Figure 5.4 (above) shows the self-reported causes of injury among the four categories investigated.

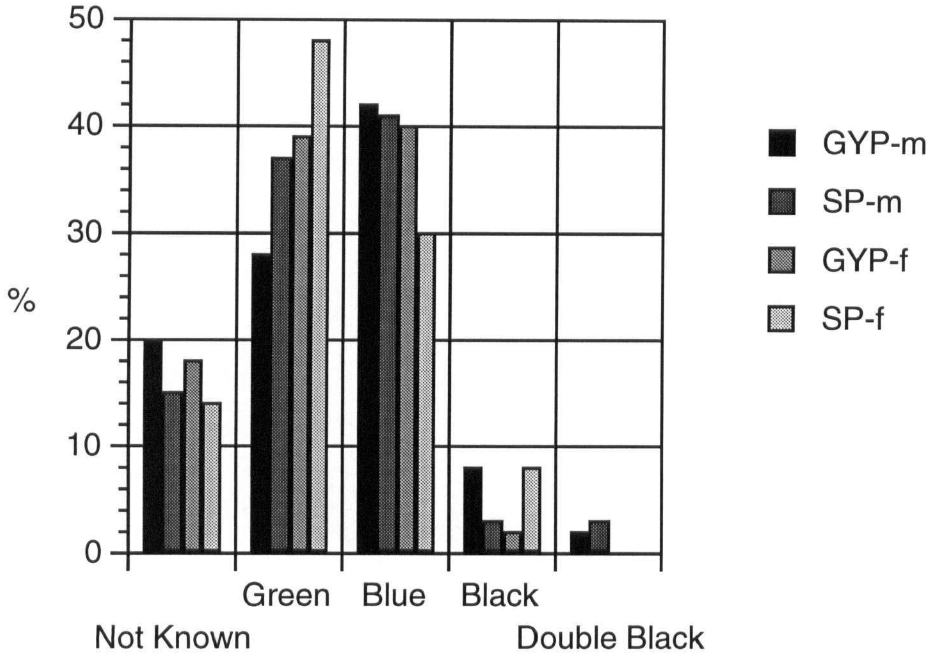
Significant results were found between genders in both the GYP and the SP. With respect to jumping, males were injured significantly more than females in both the GYP ($p=.001$) and the SP ($p=.008$). Other significant results were found among the GYP where males were injured more than females when injuries involved an impact with an object ($p=.001$) and more females reported personal error as the cause of injury than males ($p=.037$).

The injuries occurred on runs with similar difficulty levels in both the GYP and SP. The international designations for run difficulty have been previously described on page 140. Figure 5.5 (below) shows the level of difficulty where the injury occurred.

The majority of injuries for both the GYP and SP occurred on beginner and Intermediate runs. Further investigation showed that the environmental conditions for the majority of the injuries were on groomed hard packed snow of less than 15 cm of new snow and the visibility was good.

With respect to ski lessons only one child in a school program was injured while taking a lesson. The remainder of the injuries occurred while students were free skiing.

Figure 5.5: Comparing the Percentages of those Injured in the General Youth Population and the School Population using the Level of Difficulty of the Terrain where the Injury Occurred for Males and Females at Blackcomb, 1993



Who the child was skiing with does influence behaviour. The higher incidence of injury among children in school-sponsored ski trips begs the question, why? My personal experience suggests that direct adult supervision is minimal for most school children on the ski hills. The SKI questionnaire included a question regarding how the child's skiing behaviour changed when he/she was skiing with a parent rather than a friend. Tables 5.18 and 5.18a show that many young people reported that they ski differently when they are with friends than when they are with parents. Some of the reasons are presented and are based on a selection of qualitative answers provided by respondents.

Table 5.18: Age and Skiing Behaviour with Friends, Uninjured SKI Sample at Blackcomb, 1993

	0-6	7-12	13-17	all 0-17
I ski differently with parents than with friends	16.1%	30.0%	51.4%	37.0%

Table 5.18a: Age and Skiing Behaviour with Friends, Injured SKI Sample at Blackcomb, 1993

	0-6	7-12	13-17	all 0-17
I ski differently with parents than with friends	20%	27.5%	39.4%	34.5%

The qualitative responses provide suggestions as to why they ski differently with friends than with parents. Their responses suggest that parents ski more slowly, don't go off jumps and only ski "easy" runs. A selection of their qualitative responses are listed below: (Age and gender are listed at the beginning of the quote)

16F My parents will get mad if I ski the way I do with my friends.
15F Because it seems I have to impress my parents.
15M My parents are boring
15F Friends are closer to my ability.
14M Parents slow me down.
13F I like to impress my friends.
13M I can do more jumps and go faster.
15M I go faster.
15F I ski faster with friends.
10M My friends go faster so I go faster.
12F Adults ski too slowly
14F I like to show my friends I'm good
13F I am an expert skier and I like to show off.
15F because I work at skill more than fun when I'm with adults.
14M I'm worried about scaring my parents.
13M My parents worry about me when I ski with them.
15F With friends I'm more reckless.
15M I like to show off with my friends.
8M Because I want to show off.

The younger respondents (those under 13 years) indicated that they tended to ski the same with either parents or friends because they don't have to show off. Also, for many of the young respondents (under 7 years), they have never had the opportunity to ski without direct parental supervision.

On the other hand, a few of the older respondents indicated that they skied the same regardless of who they were with. Some of their comments were:

15M I don't have to prove myself.
15F When I am with adults I feel safer so I am more confident.
13M There is no point in skiing like an idiot with your friends.
10F I have to be a responsible skier all of the time.
8F I am not a show off.
10M I know how well I ski and don't have to impress.

The social environment, as measured by self-reported behaviour, indicates that these young people are influenced by who they ski with. The majority of very young children appear content with skiing and developing skills in the company of adults or under the direct supervision of an adult (*e.g.,* ski instructor). But as the child ages and gains increased skills, he/she wishes to go faster and engage in more daring activities. These qualitative responses indicate that skiing behaviour is influenced by the co-participants in the social environment.

<u>Summary of the Findings</u>

The social environment does play a role in skiing behaviour and on the incidence of skiing injury. The social environment may not have a definitive causal relationship with the injury or health outcome, but it certainly does have an influence on behaviour (which, in turn, has a causal relationship with injury outcomes).

Each year it is estimated that tens of thousands of young people ski with their schools in British Columbia. The incidence of injury is much greater among children on school programs than among those not on a school program. The risk ratio of 1.55 indicates that children on school programs have a 55% greater chance of injury than the GYP.

Despite the fact that a large proportion of the injured school children are beginners and intermediate level skiers, the rate of injury is unacceptable. It is evident that students who are being supervised in a ski lesson are rarely injured. However, as Blitzer (1985) indicated, young people often have sufficient skill to ski rapidly, yet still show poor judgment and recklessness which can often result in injury. All this indicates that children in school programs should have educational interventions designed to increase their skill level rapidly while at the same time ensuring that they do not compromise their health by engaging in behaviours exceeding their ability level (increased supervision). This may include skiing out-of-control, high speed skiing, skiing runs far exceeding their ability, jumping inappropriately and skiing off-piste (out-of-bounds).

Skiing fatalities involving school children are rare. In the sixteen years this ski area has been operational, only one fatality among the SP has been reported. It occurred during the study period; a 16 year old female was skiing along the side of a ski run and collided with a tree. She was free skiing at the time.

Finally, the evidence from the questionnaire indicates that nearly half of the uninjured teenagers ski differently when they are with parents than with friends. This suggests that the social environmental factors (role, co-participants, activities, media, etc.) are important contributors to the behaviours practiced by these young skiers and subsequent skiing injuries. These behaviours will be discussed in detail under hypothesis #5 below.

Hypothesis #5

Youth engage in many higher risk skiing behaviours and lack experience with skiing related injury.

a) Reported causes of injury differ according to the age of the skier,

b) A large number of youth participate in higher risk skiing behaviours such as improper binding adjustments, skiing closed areas and tree skiing,

c) Adolescents do not practice or use active safety oriented behaviours like wearing helmets and using the safety bar on chairlifts,

d) Many children have little experience with injury related events skiing,

e) Safety oriented behaviours (safety instruction, ski lessons) are affected by barriers (e.g. economic and social).

Data generated to respond to this hypothesis were collected from the IRF, the SKI questionnaire and the SKI questionnaire supplement (an extra question that asks the person to described the injury event in as much detail as possible) for injured skiers.

Behaviours Derived from the Environment

It is apparent from both the popular and academic literature that skiing behaviours are influenced to varying degrees by both the social and the physical environment. A ski area with a 200 meter vertical rise without any steep grades will not provide the same opportunities for skiers to engage in high risk skiing behaviours as will a large skiing facility located in a high mountainous region. Despite the physical environmental features, there appear to be social influences which will encourage young people to push their limits and perhaps engage in higher-risk skiing behaviours.

Young alpine skiers and snowboarders engage in a wide variety of skiing behaviours which range from health promoting ones (*e.g.,* helmet use) to potentially health compromising ones (*e.g.,* skiing out-of-bounds). Other health compromising behaviours investigated here include jumping, skiing among trees, entering closed areas and not having the release bindings properly adjusted. It is recognized that these factors are influenced by the degree to which they are practiced. For example, the risk level between jumping off a mogul and jumping off a 20 meter high cliff present different degrees of risk. Skiing behaviours, like any others, are affected by some combination of intrinsic or extrinsic motivation. By *intrinsic motivation*, I mean those influences on behaviour which are derived from within the person; and *extrinsic motivation* are those influences on behaviour which come more directly from the social and physical environment.

Regardless of the motivation, most skiers accept the majority of the responsibility for their injury. This is based on patients' statements of what happened and the obvious fact that every injury does not result in litigation. For the most part, the skier failed to maintain control given the environmental (usually physical) conditions present. On the IRF, the patient's statement usually indicates that a personal error occurred which resulted in the injury event. Personal error, as seen in Table 5.19, is the leading self reported cause of injury found in the study, followed by or accompanied by a range of personal or physical environmental factors to which the individual did not adapt. Response figures in the 60% range for personal error are not unusual in the literature (Lamont, 1993). Typically, the patient's statement taken at the time of injury, shows that most had no recollection of the incident other than of losing control and falling. This indicates either they don't remember the events or they don't have the experience to be able to describe what happened. In other circumstances, such as a skier collision, the cause is often the result of both behavioural factors (skiing out of control, standing in the center of the run, etc.) and environmental conditions (crowding, groomed runs and intersecting ski runs).

Among the young skiers injured during the 1993 data collection period, personal error was considered the reason for injury in more than half of the injured children. Table 5.19 shows that jumping among youth 13-17 appears to be a frequently reported injury cause while person-to-person collisions among 0-12 year olds is also noted.

The general category of personal error encompasses a range far too vast to be of any real value to researchers and requires greater precision in describing what the personal error was. This may be achieved by ski patrollers who, when interviewing injured skiers, could attempt to identify more precisely the mechanism of injury. For instance, crossing one's ski tips, catching an inside-edge, and not being able to hold a ski edge on ice are just a few causes which would provide specific information regarding the ski injury event. Greater accuracy in determining what happened is necessary so that effective interventions can be tailored to reduce or eliminate the high frequency reported causes of injury.

Recall that skier error (or personal error) is often used to describe an injury event where the skier misjudged the environmental conditions or their own ability and then lost control. Distinguishing the moment of injury is also important. Knowing whether the injury occurred before the fall or as the result of the fall has important implications in prevention (*e.g.* , a twisting motion which tears a ligament and causes a person to fall, as opposed to losing control and tearing ligaments in the fall).

Table 5.19: Number and Proportion of Injury Attributed to Eight Causes by Injured Skiers at Blackcomb, 1993

Self-reported cause	0-6 n=27	7-12 n=199	13-17 n=314	0-17 all n=540
Skier Error	12/44.4*	105/52.8	164/52.2	281/52.0
Fall Jumping	---	15/7.5	41/13.1	56/10.4
Person to person collision	4/14.8	21/10.6	9/2.9	34/6.3
Fall change of snow	4/14.8	12/6.0	22/7.0	38/7.0
Collision with a rock	--	2/1.0	13/4.1	15/2.8
Collision with a tree	--	1/0.5	10/3.2	11/2.0
Collision with a lift tower	--	6/3.0	3/1.0	9/1.7
Near skier collision	--	4/2.0	4/1.3	8/1.5
Skied off trail	--	--	6/1.9	6/1.1
Collision with a snowgun	1/3.7	--	1/0.3	2/0.4
Collision with other man-made objects	1/3.7	8/5.0	8/2.6	17/3.2

*First value is the frequency followed by the percentage

Detailed questioning by the ski patroller may encourage guided reflection on and clearer recollection of the injury event. The significance of this could be immense because, if the injury occurred during or after a fall, then teaching skiers how to fall properly could reduce injury. This approach is the basis of a new skier education program called the ACL Awareness '95 program developed by a Vermont ski injury research group (Ettlinger, et al., 1995a) that attempts to focus on injury control in place of accident prevention.

<u>Jumping</u>

Jumping is a behaviour practiced by most skiers and is one of the leading causes of injury among young people, as seen in Table 5.19 above. In the preliminary study, it was found that jumping was a major factor in a large proportion of injuries involving 13-30 year olds. As previously discussed, jumping is performed by many skiers and is reported in the popular literature to add considerable challenge and fun to the sports of alpine skiing and snowboarding. In many cases, a ski jump can simply be a mogul while, on the other extreme, it may be a leap from a cliff-top with a10 meter drop or more. It is often the case that the landing area of the jump is not visible to the jumper. In this situation, for the safety of the jumper and any potential person who might inadvertently be hidden from view. This was the case of Jeremy Burbidge, aged 14 years, who was killed at Mount St. Moonstone near Barrie, Ontario by another skier getting air off a knoll (Swainson, 1992). It is important to use a *spotter,* a person who can see both the skier and the landing area and who ensures that the landing area is clear. Tables 5.20 and 5.20a show that a spotter is commonly used at this ski area.

Table 5.20 Use of Spotters by Different Age Groups when Jumping, Uninjured SKI Sample, Blackcomb, 1993

Spotter use	0-6	7-12	13-17	All 0-17
always	35.7%	39%	35.1%	37.3%
50% of the time	16.1%	34.8%	45.1%	37.5%
never	48.2%	26.2%	19.8%	25.2%

Table 5.20a: Use of Spotters by Different Age Groups when Jumping, Injured SKI Sample, Blackcomb, 1993

Spotter use	0-6	7-12	13-17	All 0-17
always	20%	44.4%	39.1%	39.5%
50% of the time	20%	30.6%	42%	37.6%
never	60%	25%	18.8%	22.9%

Jumping is a behaviour which places a skier in a position where they are unable to stop or turn in order to avoid a skier below. It is essential that all skiers understand the importance of using spotters and know when to use them.

To continue with the jumping behaviour discussed above, the jump itself must be recognized as a complex skill. It is a skill-based activity practiced by many but few skiers have ever received any formal instruction on jumping by ski school instructors or aerial freestyle coaches. This activity requires a good understanding of one's own ability and sufficient experience to judge both the jump and the landing area. Planning is essential in performing a jump. In some instances highly trained skiers will carefully plan a jump by checking the approach, the jump and the landing zone and then trying it at slow speeds until the jumper is fully prepared to take the jump. More often for the average recreational skier, however, jumping is a spur of the moment decision and formal preparation is nonexistent. In this case, the processing of information must be accomplished nearly instantaneously and the successful completion is often based on luck rather than skill and planning. Stopping and considering the jump for a moment and ensuring that a spotter can see both the jumper and the landing area will provide sufficient time for an individual to reflect upon the jump, the landing area, one's own skill level and the potential consequences of an unsuccessful jump. The following comments are from skiers who sustained injuries jumping.

> I was skiing with a friend in the trees. We decided to go off a cliff... I rammed my knee into my face breaking my cheekbone.
> (12 year old male)

> I crushed a vertebrae in my back going off a thirty foot high cliff. I landed wrong and hurt my back. My friend checked the landing area but I just landed wrong.
> (16 year old male)

> My ski class was going off jumps. I didn't really want to do it but I did it anyways because the others were. (8 year old girl)

> I was snowboarding in a closed area and was "blind" jumping and landed on some rocks which I didn't see. (12 year old girl)
>
> I went off a jump which was too steep and I was going too fast. I went really high and landed flat. (10 year old boy)
>
> None of us realized how flat the landing was. I realized when I was in the air above my Dad's head that I was in trouble.
> (12 year old boy)

Most of the injuries sustained by these children are the result of not adequately assessing the jump site due to a lack of experience or judgment which then placed them in a compromising position resulting in injury.

<u>Unsafe Skiing Practices</u>

The SKI questionnaire administered to young skiers provided a great deal of information concerning the knowledge and behaviours practiced by young skiers. Practices commonly considered unsafe in skiing are self adjustments of the binding, skiing out-of-control, skiing closed areas, skiing among the trees, and as previously discussed not using a spotter when jumping. Despite these recognized hazardous behaviours which have regularly been identified by experts, parents, children and ski area operators, only ski binding adjustment behaviours have been extensively investigated (Damoiseaux, de Jongh, Bouter & Hosper, 1991; Danielsson, Erickson, Jonsson, Lind & Lundkvist, 1985; Potera, 1985; Quinn, et al., 1993).

<u>Binding Adjustment</u>

The vast majority of young skiers, in this study, have had their bindings adjusted in a ski shop by trained technicians. Nevertheless, as seen in Tables 5.21 and 5.21a, many young people in this sample report using ski bindings which have been adjusted by their parents or by some other non-certified person (ski technicians are trained and certified to adjust bindings). It appears that parents are involved in adjusting the binding more with young children than with older ones. A future study should investigate whether or not a relationship exists between the high incidence of lower leg fractures among children (Ekeland, et al., 1993; Giddings, et al., 1993) and parental adjustment of bindings.

Table 5.21: Binding Adjustments Made on Uninjured SKI Respondent's Skis, at Blackcomb, 1993

Binding adjuster	0-6	7-12	13-17	All 0-17
Ski shop	68.3%	73.5%	64.1%	68.5%
Friend	8.0%	1.7%	3.4%	2.8%
Parent	23.8%	20.6%	13.0%	18%
Ski coach/ instructor	0.0%	2.3%	2.5%	2.2%
Other	0.0%	4.0%	17.0%	8.6%

Table 5.21a: Binding Adjustments Made on Injured SKI Respondent's Skis at Blackcomb, 1993

Binding adjuster	0-6	7-12	13-17	All
Ski shop	100%	76.9%	62.5%	69%
Friend	0%	0%	5.6%	3.5%
Parent	0%	15.4%	9.7%	11.2%
Ski coach/ instructor	0%	5.1%	5.6%	5.2%
Other	0%	2.6%	16.7%	11.2%

<u>Skiing Closures</u>

One of the more dangerous behaviours practiced by skiers is *skiing in closed areas.* Areas are designated closed because of an existing hazard which may be temporary or permanent. A *temporary closure*, as an example, might be a run closed due to a lack of snow resulting in ski conditions so marginal (*e.g.,* exposed rocks) that the run is hazardous at this time but may not be after another major snowfall. *Permanent closures* include uncontrollable and unstable avalanche prone slopes or extremely dangerous terrain such as cliffs. Hence, these areas are deemed too dangerous for skiers and are not open for skiing. Run closures are marked with rope and signs indicating their closed status. Tables 5.22 and 5.22a report the behaviour of ducking under a closure fence and skiing a closed run. The figures indicate that a large proportion of respondents engage in this behaviour and place themselves at an increased risk of injury.

Table 5.22 Age and Experience Skiing a Closed Run, Uninjured SKI Sample at Blackcomb, 1993

Have skied a closed run	0-6	7-12	13-17	all 0-17
yes	7.9%	16.8%	53.6%	30%
no	92.1%	83.2%	46.4%	70%

Table 5.22a: Age and Experience Skiing a Closed Run, Injured SKI Sample at Blackcomb, 1993

Have skied a closed run	0-6	7-12	13-17	all 0-17
yes	0%	12.5%	43.1%	30.8%
no	100%	87.5%	56.9%	69.2%

Tree Skiing

Tree skiing (defined as an activity when the skier leaves the designated run and enters a forested area where trees can be in close proximity to the skier) is an activity which many alpine skiers and snowboarders enjoy as it enables them to experience loose powder snow without having to hike or leave the ski area. Technically, tree skiing is considered skiing out-of-bounds because the skier purposefully leaves the designated runs which is different from skiing a closed area because it is not marked off and not policed by the ski patrol or other ski area employees). Skiers are discouraged from skiing out-of-bounds because of the inherent dangers and because the area is not patrolled and any rescue becomes the responsibility of the injured. Unfortunately, tree skiing increases the skier's exposure to hazards such as collisions with trees and rocks, falling into deep tree wells, creeks and deep snow. Despite the fact that these areas are not designated runs and considered out-of-bounds, many skiers explore these treed areas to some extent. Tables 5.23 and 5.23a indicate how frequently young skiers ski the trees.

Table 5.23: Age and Experience Skiing the Trees, Uninjured SKI Sample at Blackcomb, 1993

Tree skiing experience	0-6	7-12	13-17	all 0-17
never	47.6%	38.6%	20.7%	32.6%
1 run/day	25.4%	33.1%	44.9%	37.0%
2-5 runs/day	27.0%	23.9%	26.9%	25.3%
most all of the time	0.0%	4.4%	7.4%	5.2%

Table 5.23a: Age and Experience Skiing the Trees, Injured SKI Sample at Blackcomb, 1993

Tree skiing experience	0-6	7-12	13-17	all 0-17
never	100%	47.5%	33.3%	40.2%
1 run/day	0%	32.5%	26.4%	27.4%
2-5 runs/day	0%	20%	37.5%	30.8%
most all of the time	0%	0%	2.8%	1.7%

Many people ski the trees, but because these areas are not patrolled, an injured skier may not be found for a considerable amount of time. A future study might investigate the preparedness of skiers who ski out-of-bounds. It would be useful to know whether these individuals ski with partners, have whistles, or stay in sight of one another, and to what degree they consider their personal safety. A recent fatality at this ski area (1994) involved a skier who fell head first into a tree well. His partners were not in view of him and when he did not show up at the lift, they assumed he had gone ahead on his own. This scenario is not uncommon as three other similar cases have recently been reported in the medical journals (Kizer, et al., 1994) . This skier's death would probably have been prevented had he been skiing with a partner close at hand.

<u>Use of Safety Equipment</u>

The proper use of safety equipment requires an individual's motivation to act (such as in the case of having bindings properly adjusted or wearing a ski helmet). Apart from binding adjustment, as previously discussed, the helmet is one of the most widely recognized safety devices and has an impressive record for preventing serious and costly head injuries in the sporting community (Brown & Farley, 1989; Cushman, 1992; Cushman, James & Waclawick, 1991; DiGuiseppi & Koepseli, 1989; Parkin, Spence, Hu & Wesson, 1992; Sacks, 1991; Snively & Becker, 1991; Soininen & Hantula, 1992; Stewart, 1992; Weiss, 1991). Yet, in skiing the helmet has not been widely accepted among recreational participants. In the competitive world of ski racing, the helmet is a mandatory piece of equipment for most competitive events (May, 1987; Raas, 1987). Helmet use among young children is more common in skiing but still underutilized (Abernathy, 1993; De Billy, 1991; Dolinar, 1991; Ekeland, et al., 1993; Giddings, et al., 1993). Approximately 60% of children 0-6 years, in both groups questioned, wear a helmet all of the time when skiing. This figure then drops by half for children 7-12 and then down to 1% among teenagers. The incidence of injury to the head is quite small (1.42/1000SV for 0-6 year olds, 0.78/1000SV for children 7-12 years and 0.97/1000SV for teens) yet in terms of numbers, it is the second leading injury site of young skiers. Helmet use among children is often encouraged in the ski injury literature as it has the potential to virtually eliminate most head injuries (Abernathy, 1993; De Billy, 1991; Dolinar, 1991; Snively, et al., 1991; Young, 1991).

Helmet Use

Among the uninjured children, 36.1% have worn a helmet skiing at one time or another. The younger the child, the greater the likelihood that a helmet will be worn. Tables 5.24 and 5.24a show current reported helmet use among the two samples.

Table 5.24: Helmet Use among Three Age Groups, Uninjured SKI Sample at Blackcomb, 1993

	0-6	7-12	13-17	All
never	20.6%	54.7%	85.7%	63.8%
sometimes	15.9%	15.4%	13.0%	14.5%
always	63.5%	29.9%	1.2%	21.6%

Table 5.24a: Helmet Use among Three Age Groups, Injured SKI Sample at Blackcomb, 1993

	0-6	7-12	13-17	All
never	20%	55%	91.7%	76.1%
sometimes	20%	12.5%	8.3%	10.3%
always	60%	32.5%	0%	13.7%

As seen here, once the child reaches 13 years of age, helmets are no longer worn regularly. Injured children 13-17 reported considerably less helmet use than those in the uninjured sample. When asked if they had ever worn a helmet on a regular basis, uninjured skiers reported 74.6%,47.8% and 28.8% for tots, child and youth respectively, and injured respondents replied similarly. The category "sometimes", especially among 13-17 year olds may be attributed to racers who must wear helmets in training and competition but not during recreational skiing. In any event, the use of helmets may be beneficial in reducing one of the most common ski injuries among children 0-17, much like it has been demonstrated in cycling (Stewart,1992).

The increased use of helmets in skiing among young children may be the result of a carry-over effect from the effective bicycle helmet programs. Among the uninjured sample, the use of bicycle helmets when cycling was 72% of tots, 56% for children 7-12 and 23% of teens. The skiing culture which includes both alpine skiing and snowboarding does not actively encourage helmet use. To get ahead of ourselves, the social environment, which includes the marketing strategies of ski equipment manufacturers, rarely promotes helmets in their product lines and media portrayals seldom include or highlight subjects wearing helmets. It will be necessary for equipment manufacturers to take a bold step and design a helmet that people will wear. Ski fashions are such that style is very important and including helmets as a fashion statement as well as a safety device will facilitate its adoption.

Safety Bar on Chairlifts

The use of the safety bar prevents skiers from falling out of the lift and in many instances also provides a foot rest. This device is often underutilized. Many skiers do not recognize the potential to be jettisoned from the chair in the event of an emergency stop. The resulting bounce in the middle of a tower span can be significant when riding on high speed chairs which often travel at 4 or 5 meters per second. When asked about using the safety bar, 47.5% of uninjured respondents 0-17 indicated that they used it all of the time. Eleven percent use them only on chairs with foot-rests while another 11% will use them only if another person pulls it down. Twenty-six percent said they used it most of the time. The greatest use of the safety bar is by young children 0-12 and decreases by about half among 13-17 year olds.

Experience with Injury

Another factor which detracts from safe skiing behaviours is the fact that most young skiers have little personal experience with serious skiing injuries. As well, because the incidence of serious injury is quite small in skiing, it is unlikely that many children will have known someone seriously injured while skiing. It is much more likely that the young skier knows of someone who has received a minor injury such as contusions, sprains or minor fractures.

One of the important behavioural determinants identified in the more general injury literature is the perceived susceptibility of being injured in a given situation. Since most young skiers do not have direct experience with skiing injuries it is likely that their perception of injury susceptibility is lower than those who have experience with injury. Table 5.25 indicates that the younger the child, the less experience they have regarding skiing injuries .

Among the injured skier sample, it was reported that 56.8% had experienced a friend or family member being tobogganed off the ski hill while 78.8% reported having a near miss where they just escaped injury.

Table 5.25: Age and Experience with Skiing Injuries, Uninjured SKI Sample at Blackcomb, 1993

	0-6	7-12	13-17	all 0-17
Have been injured skiing	9.5%	21%	39.3%	27.1%
Have seen a Doctor because of a skiing injury	1.6%	13.2%	30.3%	18.8%
A friend or family member has been in a ski patrol toboggan	30.2%	36.8%	54.2%	42.9%
I've had a near miss where I just escaped injury	36.5%	64.4%	81.4%	68.7%

Note that the above table includes data from more than one item on the questionnaire, thus tabulating results will not equal 100%

The Social Environment

The social environment was presented in Chapter 3 (page 73) and included five components of social interaction: role, co-participants, instruction, activities and the social issues pertaining to equipment. In this discussion of factors which influence behaviour, the following three issues (safety instruction, the ski lesson and social interactions) are described using collected data.

Safety Instruction

Learning about skiing and skiing safety requires instruction. When asked who taught the respondents the most about skiing safety, the responses varied with age but parents played an important role in developing safe skiing knowledge among uninjured children

(Table 5.26). It appears that the group of injured respondents have had considerably less parental participation in developing safe skiing behaviours (Table 5.26a).

Table 5.26: Who Taught the Child Most about Skiing Safety by Age Group, Uninjured SKI Sample at Blackcomb, 1993

	0-6	7-12	13-17	all 0-17
myself	0.0%	4.8%	24.8%	12.0%
parents	50.8%	42%	31.3%	38.6%
friends	1.6%	2.1%	7.7%	4.2%
ski instructor	44.4%	47.1%	32.2%	41.3%
ski patroller	3.2%	3.9%	4.0%	4.0%

Table 5.26a: Who Taught the Child Most about Skiing Safety by Age Group, Injured SKI Sample at Blackcomb, 1993

	0-6	7-12	13-17	all 0-17
myself	0%	2.5%	30.6%	19.7%
parents	60%	20%	20.8%	22.2%
friends	0%	2.5%	11.1%	7.7%
ski instructor	40%	72.5%	33.3%	47%
ski patroller	0%	2.5%	4.2%	3.4%

Interestingly enough, when asked who they would most likely listen to regarding skiing safety, several changes occurred in the pattern. Tables 5.27 and 5.27a show that parents are one of the least likely people respondents say they would listen to, while the ski patroller moved up to be adjacent to ski instructors.

Table 5.27: Who Each Age Group Would Listen to More about Skiing Safety, Uninjured SKI Sample at Blackcomb, 1993

	0-6	7-12	13-17	all 0-17
ski instructor	44.4%	43.5%	33.9%	40.0%
school teacher	3.2%	0.4%	0.9%	0.8%
ski patroller	23.8%	37.0%	49.1%	40.5%
parents	28.6%	18.3%	8.1%	15.5%
other	0.0%	0.8%	7.5%	3.3%

Table 5.27a: Who Each Age Group Would Listen to More about Skiing Safety? Injured SKI Sample at Blackcomb, 1993

	0-6	7-12	13-17	all 0-17
ski instructor	80.0%	50%	37.5%	43.6%
school teacher	0%	0%	0%	0%
ski patroller	20.0%	45.2%	47.2%	44.4%
parents	0%	7.5%	5.6%	6.0%
other	0%	0%	9.7%	6.0%

It would seem that ski instructors and ski patrollers would be most listened to regarding skiing safety. School teachers, it would seem have the least credibility for instructing students regarding skiing safety and this point is an important one for the development of future school-based interventions. The children's ski school program at Blackcomb includes instruction regarding safety and the Alpine Responsibility Code. As well ski patrollers meet school buses and provide school programs that deal with safety issues.

Ski Lessons

We saw in the epidemiological diagnosis that very few injuries occur during ski lessons. It would seem obvious that the ski lesson would be the place where young people learned the most about skiing. However, ski lessons are very much under-utilized, leaving the question "Where do young skiers learn how to ski?". Two questions were asked of respondents regarding ski lessons. How many lesson had they taken last season and how many had they taken this ski season? Tables 5.28 (a) and 5.29 (a) indicate the results. Interestingly, despite the fact that some of the injured skiers in Table 5.30a may have been injured early in the season (thus having less opportunity to have lessons), the difference between the two groups is inconsequential.

Table 5.28: Ski Lesson Taken the Previous Year from the Questionnaire Date, Uninjured SKI Sample at Blackcomb, 1993

Lessons	0-6	7-12	13-17	all 0-17
none	34.9%	36.1%	57.3%	43.9%
one	7.9%	13.8%	15.6%	13.7%
2-9	38.1%	31.9%	18.9%	27.5%
10+	19.1%	18.2%	9.3%	15.0%

Table 5.28a: Ski Lesson Taken the Previous Year from the Questionnaire Date, Injured SKI Sample at Blackcomb, 1993

Lessons	0-6	7-12	13-17	all 0-17
none	40%	30.8%	71.2%	56.4%
one	0%	10.3%	12.3%	11.1%
2-9	20%	33.3%	13.7%	20.5%
10+	40%	25.6%	2.7%	12.0%

Table 5.29: Ski Lessons Taken this Year up to the Questionnaire Date, Uninjured SKI Sample at Blackcomb, 1993

Lessons	0-6	7-12	13-17	all 0-17
none	36.5%	45.9%	68.4%	53.7%
one	7.9%	11.5%	14.2%	12.3%
2-9	31.8%	27.3%	12.1%	21.9%
10+	23.8%	15.3%	5.3%	12.2%

Table 5.29a: Ski Lessons Taken this Year up to the Questionnaire Date, Injured SKI Sample at Blackcomb, 1993

Lessons	0-6	7-12	13-17	all 0-17
none	20%	28.2%	65.8%	51.3%
one	20%	12.8%	16.4%	15.4%
2-9	40%	25.6%	12.3%	18%
10+	20%	33.3%	5.5%	15.4%

Ski lessons are obviously not the place where the majority of young people acquire their skiing skills and knowledge. As young people continue to improve, they must be acquiring the skills from either a trial and error process and or from vicarious sources in the environment. With very little injury occurring during ski lessons, it is obvious that under the supervision of an experienced instructor, progress is made in a safe manner. Injury seems to be associated with free skiing and trial and error practice.

Social Interaction

The ski area encourages social interaction using both natural and man-made settings. For instance restaurants, ski school meeting places, light boards that show lift-line status, snowboard parks and lift lines are fabricated meeting places where people congregate in a ski area. Natural places are crest of hills, long flat sections of runs and naturally formed jump sites to name but a few. The natural jump sites are probably the most interesting places to observe behaviour because people (especially young ones) congregate and watch others perform jumps and then often try them themselves. It is my experience at one jump site that even after someone seriously injures him/herself, the jumping continues once the patient has been extricated. This particular jump site to which I am referring has become known to patrollers' of this ski area as "Lemming's Leap" as young people continue to jump regardless of the hazard and knowledge of its injury history.

Skiing is a social activity and many individual behaviours are influenced by those in the surrounding environment. It is evident that the majority of young alpine skier and snowboarders do not take lessons with any great regularity. Children under 13 are more likely to take lessons but once the teen years arrive few individuals take lessons with any regular basis. Modeling by others in the environment is a likely factor in the learning of skiing skills. How skiing safety and knowledge of appropriate conduct is learned remains vague.

Summary of Findings for Hypothesis #5

The behavioural, social and physical environmental factors form a complex web which appear to influence skiing safety and enjoyment. The evidence presented here suggests that jumping, a specific skiing behaviour is associated with an increase in injury. Other behaviours considered likely to increase the potential for injury (skiing the trees, skiing closed areas, not having the bindings properly adjusted) were noted among the respondents. Safety equipment is often underutilized. Helmet use decreases with age and the lowering of the restraint bar on chairlifts is often not performed by young skiers. The education of young skiers regarding safety has been influenced largely by the parents of the child and then by the professional groups working in the ski area (ski patrol and ski school). It is suggested by the data that the ski area is the best place to teach skiing safety and that school teachers are probably the least likely person young people would listen to regarding skiing safety. The individual's experience with injury is limited. Young skiers are reportedly more aware of minor injuries and are not cognizant of more serious injuries which occur in the ski area. This lack of experience with injury may be an important factor in determining the perceived susceptibility of injury- which may affect skiing behaviours. Based on the findings, numerous interventions become apparent when reviewing the evidence.

Inductively Derived Findings

The analysis of the data collected for this study has identified inductively some interesting findings. These will be presented here, because they too lend themselves to the development of interventions to be discussed in Chapter 6.

Knowledge

Much like driving, skiers need to understand "the rules of the road" so that they can interact safely with the other people on the ski slopes. The Alpine Responsibility Code (ARC) defines the basic safety and behavioural expectations of skiers. It is usually defined as a partial list of six major points:

> i) When skiing downhill or overtaking another skier, a skier shall choose a course and speed which assures the safety of other skiers ahead or below;
> ii) A skier shall not stop in any location which obstructs a ski run or where he is not visible from above;
> iii) When entering a ski run or starting to ski downhill, a skier shall yield to other skiers on the ski run;
> iv) A skier shall wear retention straps or other devices which prevent runaway skis;
> v) A skier shall keep off closed ski runs and shall observe all posted signs within the ski area;
> vi) A skier shall not ski within any ski area when his ability to do so is impaired by alcohol, drugs, or other substances;
> vii) A skier involved in a collision with another skier shall as soon as practicable identify himself to the other skier, or to a representative of the ski area operator and shall render all possible assistance to the other skier, pending the arrival of the ski patrol or emergency first aid personnel.
>
> (B.C Law Reform Commission, 1993)

The Ski questionnaire found that 31% of uninjured children claimed that they had never heard of the ARC and that 66% claimed that they could not list the six main points of the code. It may be that they practice the intentions of the code intuitively but this cannot be ascertained. Only 80.4% of the uninjured sample could correctly state who had the right of way when skiing down a slope. Regarding run designation, 6% of the uninjured sample and 10% of the injured sample chose incorrectly the meaning of a blue square run. The lack of knowledge has the potential to put some skiers at considerable risk of injury.

Punishing Reckless Skiers

Reckless skiing is defined as skiers who flagrantly disobey the ARC and place the lives of other skiers in danger, let alone their personal safety. The ski questionnaire respondents were asked what should be done to punish and/or educate reckless skiers. The combined results of the two samples (which were nearly identical) indicated that 29% of respondents believed a stern warning was an appropriate penalty for reckless skiing, 37% believed a two week suspension was appropriate, while 21% thought the viewing of a safety video would be suitable. The remaining respondents suggested qualitatively that there should be an incremental penalty for repeat violators with increasing severity.

Self-Description as a Skier

The SKI questionnaire respondents were asked to characterize themselves as a skier from a list of six items. Tables 5.30 and 5.30a indicate that the majority believe themselves to be safe skiers.

Table 5.30: Personal Description as a Skier, Uninjured SKI Sample at Blackcomb, 1993

Skier Quality	Frequency and Percent
Fast	171 (19.8%)
In-control	406 (47.1)
Reckless	13 (1.5%)
Cautious	113 (13.1%)
Scared	17 (2%)
Daring	143 (16.6%)

Table 5.30a: Personal Description as a skier, Injured SKI Sample at Blackcomb, 1993

Skier Quality	Frequency and Percent
Fast	21 (17.8%)
In-control	45 (38.1%)
Reckless	0 (-)
Cautious	29 (24.6%)
Scared	5 (4.2%)
Daring	18 (15.3%)

These personal descriptions must be interpreted carefully. Many of the skiers who indicated in-control may still be fast and reckless skiers but believe that they are doing so while in-control. It is the ski patrol's experience that at the end of the day, on the ski out where skier congestion is greatest, it is the advanced level skier who poses the greatest threat as they ski rapidly without consideration for the other skiers, in other words they may be in control but are skiing recklessly for the given conditions.

<u>Most Common Cause for Ski Injuries-The Respondent's Perspective</u>

Respondents, when asked what is the most common cause of ski injuries, reported that speed and skiing terrain above one's ability as the two leading causes. Interestingly enough one of the most noted factors mentioned in the literature, the binding setting, was not a consideration for many of the skiers.

Table 31: SKI Questionnaire Respondent's Belief Regarding the Most Common Cause of Ski Injury, Blackcomb, 1993

Cause	Uninjured Sample	Injured sample
Too much speed	420 (48.85)	64 (54.2%)
Skiing terrain above ability	149 (17.3%)	23 (19.5%)
Skier collisions	100 (11.6%)	9 (7.6%)
Overcrowded runs	82 (9.5%)	11 (9.3%)
Other	40 (4.7%)	8 (8.6%)
Blind air-jumping	33 (3.8%)	2 (1.7%)
Falls-unloading chair	23 (2.7%)	0 (-)
Bindings set too tight	14 (1.6%)	1 (0.9%)

Skier Collisions

The problem of skier collisions is often believed to be a more serious problem than it is. The actual incidence of injury resulting from a skier collision is quite small. In the preliminary study person to person collisions were reported as the cause for 4.8% of the injuries. The incidence rate for skier collisions resulting in reported injury was 0.14 per 1000 SV during the 1992 ski season. It may well be that skier collisions not resulting in injury are much higher. Among the uninjured sample of respondents to the SKI questionnaire 72% claim to have been struck by another skier. It is perhaps the case that these incidents are not reported to the ski patrol and hence not reported on. Further research will be required to investigate this problem, however, the injury report data will be accurate for serious injury resulting from collisions.

Snowboard Focus Group Results

The snowboard focus groups provided some important insight into the issue of role among snowboarders and the behavioural norms. The respondents indicated that there was a difference between snowboarders who learned to ski first and those who are new to the sport and who came from a skateboarding background. Indications were that the street attitude of skateboard riders was carried over into the skiing environment and to exacerbate the issue they were not cognizant of skiing etiquette. The participants overwhelmingly indicated that a snowboard park would attract many participants and help reduce the perceived tension between skiers and snowboarders. They also stated that complete integration of the two sports was required. They strong suggested that all ski area managers try snowboarding and gain an appreciation of both the fun and some of the problems snowboarders encounter in a ski area (*e.g.*, flat roads).

Summary

Chapter 5 presented five hypotheses developed from the literature review and the preliminary retrospective study. The data not only confirm existing international ski injury trends but lends further precision on the age specific distribution of injury and the determinants of injury. Adolescents have a higher risk of ski injury than other age groups studied and engage in many higher risk skiing behaviours. The influence of the physical environment did not appear as significant as it is commonly believed to be. It may well be that the use of overall injury rates is too general and specific injuries need to be examined with respect to environmental factors. The social environment, namely the school population, appears to have a significant relationship with increased incidence of ski injuries. Further investigation will be required to identify specific factors that may influence injury rates among children in school sponsored ski programs.

Chapter 6 will focus on the conclusions and implications of this research to both the academic and professional practice of skiing safety.

Chapter 6

Conclusions and Implications

Chapter 6 presents the conclusions and implications of the study. The preceding chapters have investigated major issues regarding alpine skiing and snowboarding, explored issues of methodology and hypothesis development and presented the research findings. In this chapter, the focus will be on the identification of interventions based on the findings. A brief overview of risk behaviour and injury in other sports will demonstrate how this research may impact upon other sport and recreational activities. Finally, suggestions and implications for future research will be discussed.

Injury in Child and Adolescent Populations -The Big Picture

In Canada, as in other developed countries, the leading cause of death among young people (under 18 years) is injury (Health Canada, 1995). The literature on preventive programs for young people is large, with much of the research on adolescent driving behaviour, suicide, smoking, drugs and alcohol, sexual behaviour, violence, school dropout, and to a lesser extent on sport and recreation (Frankish, et al., 1994). Most of this research has emphasized unintentional injury and its prevention using strategies which affect the predisposing, reinforcing and/or enabling determinants of behaviour or of the environment (Anonymous, 1989; Anonymous, 1992; Bradstock, et al., 1987; Child Accident Prevention Trust, 1993; Curley, 1991; NHTSA, 1990; Spivak, Prothrow-Stith & Hausman, 1988; Zobeck, Stinson, Grant & Bertolucci, 1993).

Sports Injury

It is estimated that between 20 and 35 million US children between the ages of 6 and 21 years participate in recreational and competitive sporting events (Landry, 1992; Smith & Smoll, 1991). The potential for injury is always present in sports and "anything that makes the agents of injury more available or the duration of exposure greater will increase the risk of injury" (Tonkin, 1987, p.214). The extent of the injury problem is unknown in the majority of sports and recreational activities because existing surveillance systems are not sensitive enough to distinguish between individual sports and leisure time activities. As well, for many sports and recreational activities, identifying exposure time is difficult. (Vimpani, 1989; Waxweiler, Harel & O'Carroll, 1993).

Data are available regarding some youth sports and improved surveillance is beginning to shed more light on the problem. Some of the existing hospital surveillance systems provide sport specific injury frequencies that include basic patient demographics and injury severity scores. For example, the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP) monitors emergency rooms (Ellison & Mackenzie, 1993). In 1991 with 10 hospitals participating, there were 37,169 injury records among children 5-19 years. Of those, 9,514 were sports-related and males represented 68.7% of this specific population of injured children. The sports with the greatest proportion of reported injuries in the CHIRPP data base were in descending order, basketball, ice hockey, soccer, snow skiing, baseball, football, ice skating, gymnastics, street hockey and volleyball. Individual sport-specific epidemiological and etiological investigations are required to understand fully the determinants associated with the injury patterns. Comparisons between sports are extremely difficult as exposure is difficult to standardize, especially when the sports are not always played in a formal supervised arena and the diverse physical demands each sport presents are diverse. Snow skiing is listed as the fourth highest injury producing sport in this data base. It should be noted that CHIRPP includes only major pediatric trauma centres and excludes many of the regional hospitals located near ski areas.

Certain sports have been well documented in the literature with regards to injury patterns, determinants of injury and preventive interventions. Sport specific epidemiological investigations have identified patterns of injury and have influenced changes in equipment, rules and playing surfaces. Between 1973 and 1980, for example, there were 40 baseball- or softball-related deaths in the US in players 5-14 years of age. There was an average of 5 deaths per year, mainly from head and neck injuries and blunt trauma to the chest. Rules and equipment modifications including the mandatory use of batting helmets has had a positive impact on the sport, and fatal injuries by 1990 were in the range of 3 per year (Anonymous, 1994b). Soccer, a sport played by over 6 million American children under 17 years has its own sport-specific injuries. Increased efforts to reduce soccer injuries include, improved coaching, rule changes and modifying playing surfaces (Kibler, 1993; Sullivan & Gross, 1980).

Basketball has become one of the most popular sports among young people. This sport is not only played in competitive leagues but is played a great deal in school yards, driveways and in open gyms (Sickles & Lombardo, 1993). Sickles and Lombardo (1993) go a step further and note that adolescent basketball players are different from the adult ball player. Adolescent athletes in general are different from adults because of physical, emotional, social and psychological changes that occur in adolescence. They also suggest that the perception of invincibility and the increased desire to explore their physical limits results in risk-taking behaviors (p.207). Training, conditioning and rule enforcement are key to preventing injuries among competitive players. The authors offer no suggestions for recreational play. This is similar to skiing where recreational participants are without coaches to provide training regimes and the skiing environment is not supervised by race officials.

Recreational sporting activities and competitive sports all have the potential for injury and require sport-specific solutions. Other competitive team sports like football, hockey and rugby have been extensively studied by injury researchers (Caine & Lindner, 1990; Chalmers, 1994; Egger, 1991; Ellison, et al., 1993; Gallagher, Finison, Guyer & Goodenough, 1984; Kochncke, 1992; Kraus & Conroy, 1984; Landry, 1992; Murray & Livingston, 1995; Tursz & Crost, 1986; Zakariya, 1988; Zaricznyj, Shattuck, Mast, Robertson & D'Elia, 1980) and changes in rules, training techniques and playing surfaces have succeeded in reducing injury. Other activities such as recreational bike riding, skateboarding, and roller blading provide numerous opportunities for injury and require further study. The introduction of safety equipment, legislation, and media campaigns have impacted on the negative health outcomes sometimes associated with these individual sporting activities (Bouvier, 1991; Brown, et al., 1989; Cushman, 1992; DiGuiseppi, et al., 1989; Jacques & Grzesiak, 1994; Kingma, 1994; Morris & Trimble, 1991; Sacks, 1991; Snively, et al., 1991; U.S. Dept. of Transportation, 1993; Wishon & Oreskovich, 1986). Recreational skiing has received a considerable amount of attention from researchers but little emphasis has been on the development of behavioural interventions. The ARC, the ACL Awareness program and a few evaluation studies of binding adjustment constitute the main body of the active prevention efforts. Despite the many organizations that represents various bodies within the skiing industry (ski instructors, racers, patrollers, trades, and ski areas) the recreational skier has yet to obtain a voice and representation.

<u>Risk Behaviour</u>

The sport and recreation environment provides a wide range of experiences that promote adolescent development. Smith echoes the widely held assumption that the participation in sporting activities is relevant to the formation of important behaviours such as cooperation, unselfishness, attitudes towards achievement, stress management skills, risk-taking, and the abilities to tolerate frustration and delay gratification (Smith, et al., 1991). Risk is considered an essential component of adolescent development as it enables the young person to engage in social, physical and emotional experimentation in the quest of developing a personal sense of independence (Zuckerman & Duby, 1985). Traditionally the epidemiological view of risk has been biomedical in nature. The biomedical model identifies agents or factors in the environment that correlates with an increased probability of health compromising outcomes (Jessor, 1991). In recent years, the movement towards understanding chronic diseases has directed researchers to look at behaviour as a risk factor. Risk factors then not only affect biomedical outcomes but influence the antecedents and outcomes in a psychosocial dimension. This is especially important during adolescence (Tonkin, 1987).

Jessor (1991) describes the differences between risk behaviour and risk-taking behaviour.

> Risk behaviors can jeopardize the accomplishment of normal developmental tasks, the fulfillment of expected social roles, the acquisition of essential skills, the achievement of a sense of adequacy and competence, and the appropriate preparation for the transition to the next stage in the life trajectory, young adulthood. The term risk behavior refers, then, to any behavior that can compromise these psychosocial aspects of successful adolescent development. (p.599)

The notion of risk-taking behaviour is more in line with the conscious taking of risks, "the satisfaction or thrill of engaging in something risky where there is a conscious awareness of the risk or danger involved and a deliberate seeking for the thrill that issues from the uncertainty of beating the odds" (p.599). Jessor strongly suggests that risk behaviour is a better term than risk-taking behaviour because most adolescents are unaware of the many risks associated with their behaviours. It appears that adolescents need to take risks in order to develop into young adults but the question always remains as to which risks are acceptable to society and which are not. What is often seen by adults as risk-taking behaviour in youth is seen by youth as exploratory or adventurous for which the magnitude and potential consequences of the risk are unknown to them.

Young people tend to be more interested in interacting with their environment than just being passive observers. This desire to do things is encouraged from other people or models in the environment who provide vicarious reinforcement to the young participants and often encourage children to engage in activities in which they may or may not have the physical ability to accomplish (Bandura, 1977a; Zuckerman, et al., 1985). For the most part schools provide a wide range of age- and ability-appropriate activities for young people to engage in with respect to sports and recreation. Similarly, the health opportunities offered by recreational and competitive sports and recreation are many (Breitenstein & Ewert, 1990; Cronin, 1991; Landry, 1992; Levenson, 1990). However, injury is always a possible outcome for athletes and injury is often related to exposure (Tonkin, 1987)

Intervention Strategies Derived from the Research

Data derived from the Injury Report Forms and the Skier's Knowledge Initiative Questionnaire have provided some direction for intervention development that may contribute to the reduction of the number and severity of ski injuries. Intervention strategies can be classified in two general categories: a) behavioural and b) environmental. Based on the findings of this research and on the review of the literature, numerous intervention strategies emerged . The behaviour of skiers is largely influenced by aspects of the social and physical environment (*e.g.,* peer pressure, jumping, skiing the trees, having bindings checked). The second group of interventions deal with modifying the physical skiing environment in ways that eliminate or reduce injuries caused by people coming into contact with the physical environment while skiing (*e.g.,* use of the safety bar on chair lifts, retention devices on skis, padded lift towers). The two theoretical approaches, Social Cognitive Theory and Haddon's countermeasures described in Chapter 2, are indeed relevant to the development of interventions based on the findings.

Interventions Based on Social Cognitive Theory

Skiing interventions derived from SCT emphasize a more population-based orientation than an individual-based focus. By *population based interventions*, I mean strategies designed to modify the behaviour of skiers using policy changes, organizational changes that are facilitated by mass media and large group techniques. In this approach, the change in behaviour may be quite small but, because of the large numbers involved, it may have a significant impact on increasing health promoting behaviours while reducing injuries and lessening health care costs. For example, if a population-based intervention succeeded in increasing by 20% the attention and care of advanced skiers on high traffic beginner and intermediate runs , then perhaps, some 50,000 skiers may have changed their behaviour. That will have the important effect of reducing the incidence of collision and near collision injuries and making these slopes that much safer for everyone. *Individual-based interventions* are those which focus on changing the behaviour of individuals, usually in response to misbehaviour (e.g., skiing while under the influence of alcohol, fast and reckless skiing). For example, an intervention designed to reduce reckless skiing on the slopes might require that 100 reckless skiers be identified: and then if intensive counseling (*i.e.,* personal intervention) were successful, only 100 skiers would have changed their behaviour (a mere subset of the hundreds of thousands who frequent the ski slopes). The objective of ski injury interventions is to reduce the frequency and rate of injury among skiers while increasing the enjoyment and health benefits of all skiers.

The respondents of the SKI questionnaire overwhelmingly stated that the ski area is the primary locale for implementing skiing safety and ski injury prevention programs. However, to achieve a successful intervention or prevention program designed to reduce the incidence and severity of skiing injuries, a concerted effort by the entire skiing community is recommended. The *skiing community* is composed of:

a) the ski industry (including manufacturers, retail shops, provincial and national organizations representing ski areas and their employees),
b) the ski area (employees, signage, ski schools, ski patrols, marketing departments, race clubs),
c) the medical community (including physicians, surgeons, physiotherapists and public health departments),
d) schools (administrators, teachers, students, and parents),
e) the media (print, film, radio and TV) and,
f) the skiing population itself.

The injury prevention literature suggests that an intervention should be as narrowly defined as possible with specific target behaviours selected so that a clear message is presented. For example, the "buckle up" campaigns on vehicle seat belt use focus on that one behaviour and do not include speed reduction, drinking and driving, unsafe lane changes, etc. Furthermore, the more widely the message is broadcasted, and with more members of the community involved in the intervention program, the more likely it is that behaviours will change and be reinforced. A widely broadcast message, however, does not ensure that hard-to-reach populations will receive the message and multiple strategies may be required to reach the specifically targeted populations or groups. Because of the nature of recreational skiing and its social and physical environment, interventions based on behaviour change theories seem appropriate. The principles and constructs of Social Cognitive Theory provide a foundation for many approaches designed to affect health-related behaviours. They may have the potential for influencing skiing behaviour and ski injury events.

Interventions Based on Changing the Physical Environment

William Haddon Jr. was one of the first to investigate injuries from an environmental perspective and whose injury countermeasures were designed to reduce injury by modifying the physical environment. In skiing, it is apparent that this influence has a long history. Ski areas once used bales of hay at the base of ski lift towers and in front of other obstacles to lessen the effects of an impact with the object. Modern ski lift towers are padded with plastic covered open-cell foam at the base so that the force of a skier colliding with the tower is dissipated and injury lessened.

In the skiing environment, not all of Haddon's countermeasures are relevant but do provide an opportunity to investigate thoroughly features of the physical environment..

1) Prevent the creation of hazards in the first place,
(prevent skiers from skiing, release the ski so that it does not act as a lever on the tibia);

2) Reduce the amount of hazard brought into being,
(modify skis so that higher speeds cannot be achieved, reduce release values, do not make slopes steep);

3) Prevent the release of the hazard,
(Use of fences and railings to keep skiers from going over cliffs and steep embankments);

4) Modify the rate of release of the hazard from its source,
(explosives to release avalanches during non-ski periods, padding towers)

5) Separate the hazard from that which is to be protected by time and space,
(barriers around hazardous areas; no night skiing in dark areas)

6) Separate the hazard from that which is to be protected by a physical barrier,
(padded lift towers, trees, rocks, buildings ,etc.);

7) Modify relevant basic qualities of the hazard,
(plant trees with lots of low branches to reduce impact with the trunk, slope design, removal of rocks, stumps);

8) Make resistant what is to be protected,
(padded ski suits, improved physical conditioning, use of helmets, wrist guards);

9) Begin to counter damage done by the hazard,
(ski patrol, first aid knowledge of skiing public, educate skiers as to hazards);

10) Stabilize, repair and rehabilitate the object of the damage,
(medical facilities nearby, emergency transport from the hill, etc.).

At present, the most common environmental countermeasure is padding the hazards, followed by marking hazards so that skiers avoid them, and having trained medical and paramedical personnel to extricate and apply basic life support care rapidly to injured skiers.

It is obvious that injury prevention strategies incorporate both *active interventions* which require some sort of action on the part of the individual and *passive interventions* such as creating barriers between the skier and solid objects in the ski area. Some interventions like wearing a helmet require an action to put the helmet on correctly; then it becomes a passive intervention because it is there, ready to absorb an impact, if such a condition arises.

Finally, health promotion and injury prevention programs cannot be all things to all people. Kotler and Zaltman (1971) indicate the importance of targeting behaviour change interventions to a population defined as narrowly as possible. Within the skiing population there are numerous subgroups based on age, gender, income, sport practiced, etc. A cost-benefit analysis is often required to determine which of the specific target populations would yield the greatest results. Epidemiological and behavioural analyses on populations identify which actions of which target populations will be most productive to isolate and emphasize in a program plan.

Implications for Practice

The following issues arose in the literature review and in the findings of this research. Four groups of problems have been identified: specific injuries, determinants of behaviour, behaviours and environmental issues. Some of these have been suggested previously by other researchers but are also relevant to the findings in this study. The potential interventions listed are not exhaustive and are presented to demonstrate what behavioural and environmental interventions or combination thereof are suited to the identified problem. The list itself, is not an exhaustive one and only represents the issues raised in this study. Items are not organized in order of importance.

Injuries
1) increased injury rates among adolescents
2) knee injuries
3) thumb injuries
4) head injuries
5) wrist injuries-snowboarders
6) lower leg fractures-alpine skiers
7) shoulder injuries among advanced skiers

Determinants of Behaviours
1) role expectations (gender, alpine skier, snowboarder)
2) social norms
3) school programs
4) knowledge of the Alpine Responsibility Code
5) experience (with injury, different skiing conditions, etc.)

Skiing Behaviours
1) jumping
2) skiing the trees

3) skiing closed areas
4) fast and reckless skiing
5) taking lessons
6) practicing safe skiing strategies (e.g., ski with a buddy, prepared for self-rescue when out-of-bounds)

Environment

1) slope preparation (grooming)
2) safety of the slopes (signage, trail rating)
3) lift related injuries (loading, unloading, falls from the lift)
4) high traffic zones and congestion
5) effects of weather on ski injuries
6) injuries resulting from impact with objects

Based on these identified issues that affect skiing safety and skiing-related injuries several potential interventions are raised. The list is not exhaustive by any means but is an attempt to open further discussion and encourage others to consider the problems and reflect on potential solutions.

Injuries

1) Increased injury rates among adolescents

The majority of the issues raised above stem from this study and the literature review which emphasized adolescents. Hence, dealing effectively with these issues should affect the injury rates of adolescents. One of the key findings in this research is that an injury problem exists. In light of this conclusion, members of the skiing community can begin to plan, develop and implement appropriate interventions for and by community members.

2) Knee injuries

The literature clearly indicates that knee injuries are a problem for all skiers and an especially noted problem of female skiers. Behavioural interventions such as the one suggested by Ettlinger, Johnson and Shealy called ACL Awareness '95 teaches skiers to recognize six behaviours or movements which are known to cause serious anterior cruciate ligament damage. They teach skiers how to fall so that they do not compromise their knees to the forces of the fall. Ski bindings, regardless of the setting are not designed to prevent soft-tissue knee injuries and technological improvements have not yet identified a way for the binding to reconcile both soft and hard tissue injuries.

3) Thumb injuries

Thumb injuries are one of the most common yet under-reported ski injuries according to numerous studies described in the literature review. Experiments with pole grip design have had positive outcomes in reducing injury among Nordic (cross-country) skiers. Falls with or without the ski pole in hand can cause injury. Taping the thumb or designing thumb guards in gloves may be a potential solution. However, since the thumb is often an under-valued injury by skiers and one that is considered often as simply an annoying problem is not likely to receive a great deal of research attention.

4) Head injuries

Head injuries as previously stated are more or less completely preventable. If all skiers wore a helmet all of the time, then the likelihood of sustaining a head injury would be virtually eliminated. It must be cautioned that helmet use may affect the potential for cervical injury. Further research is required to determine what sort of helmet might best protect the skier from injury. Helmet manufacturers need to develop stylish helmets that will meet the protective, comfort and fashion needs of skiers. The media and most certainly the popular skiing magazines should develop policies to promote helmet use among their models and stunt personnel. Parents will have to encourage their children to wear helmets and should model the desired behaviour as well. Legislation similar to bike helmet laws may be necessary to support the community efforts.

5) Wrist injuries-snowboarders

Wrist injuries, in the snowboard population, are a serious problem especially among novices. As a matter of fact, more than half of the wrist injuries I have personally treated on the slopes in the past few years were first time snowboarders on their first day. Clothing manufacturers have recognized this injury problem and some products have built in protective devices to prevent the wrist from injury. The cost of high quality gloves with wrist protection are considerably more expensive than those without the protective devices-- a serious barrier to implementation. Further research to determine what standard of wrist protection, if any, should be encouraged is still required.

6) Lower leg fractures-alpine skiers

Although not recognized as a serious problem in this study, the literature review indicated that younger children have rates of lower leg fractures up to six times that of adults. Parents must be educated regarding children's skiing equipment and ensure that their children receive good equipment which meets or exceeds basic standards. Old and worn equipment should not be recycled with other children. Ski boots and bindings form a system and this system only works effectively when they are mounted and adjusted by a professionally trained technician. It is evident from the results of this study that many children ski on skis which have not been adjusted by trained personnel. Incorrectly set bindings can result in serious leg fractures. As well, further researcher regarding the existing standards for children's bindings may have to be reviewed in light of current findings on lower leg fractures. The benefits resulting from the use of the release binding by adults have not been achieved with children. It may be that the immature bone structures of the child require a different method for determining binding settings (current North American tables are based on self-reported height, weight and skiing style). Skiing style refers to the type of terrain to be skied and how the skier perceives his/her ability in that terrain

7) Shoulder injuries among advanced skiers

Shoulder injuries among advanced level skiers may be related to increased use of the ski pole. A French study (Binet,1985) indicated that most shoulder dislocations occur when the skier plants the ski pole in a turn and rotates the arm externally. Many skiers use pole straps (which attach the pole to the wrist) and these may aggravate the potential for shoulder injuries because if the arm is pulled back behind the body, a simple release of the grip will not release the pole and the abducted shoulder may dislocate anteriorly. Skiers should be discouraged from wearing the ski pole retention straps or they should use break-away straps which release under tension. Proper poling technique would also help to reduce the incidence of shoulder injury.

<u>Determinants of Behaviours</u>

1) Role Expectations and Norms (gender, alpine skier, snowboarder)

Issues dealing with role and role expectations will require a long term effort by the skiing community for change to occur. It is difficult to determine whether the media creates or simply reports current role expectations and norms in skiing. It is probably a combination of both. This circularity is not necessarily a productive one because it can encourage anti-establishment codes of conduct and create friction between alpine skiers and snowboarders. Noting that the alpine skier - snowboarder conflict is more a generational issue than a sport-specific problem, resolution may include sensitizing adults to the needs of young people and their desire for independence. This can only help to reduce the tension between the two groups. Both the adult and adolescent skiers need to be sensitized to the behavioural expectations of one another in the skiing environment.

It is generally agreed that many adolescents engage in higher risk behaviours or activities and push their personal limits to excessive levels. Skiing is generally considered a pro-social activity (meaning that participants are engaging themselves in socially acceptable ways) unlike engaging in high risk anti-social behaviour like vandalizing cars or defacing buildings. The higher risk activities in skiing, such as skiing avalanche prone slopes or skiing the trees should not be condemned but tolerated. Young people should be taught, encouraged and be reinforced for adopting health promoting behaviours that will counter the higher risk activities in which they engage (*e.g.,* always skiing within sight of a buddy when skiing in the trees). It may be that the skiing community needs to find ways to challenge young people with appropriate pro-social activities which incorporate training and competition. For example, the facility might schedule regular half-pipe snowboard competitions, jump competitions and various racing opportunities with as many barriers removed as possible so that it attracts young people. Incorporating safety training with a recognized carding system (a personal identification which states what courses and training the individual has accomplished) would ensure that individuals meet the criteria to compete at a particular level of difficulty *(e.g.* a level 3 jumper could enter a level 3 jump competition, but a level 1 jumper could only enter a level 1 jump competition, with progression achieved through training and education).

2) School Programs

The school ski program is in need of a great deal of attention by teachers and school administrators. The identified injury problem is such that children on school sponsored ski trips have nearly twice the rate of injury as those youths not skiing with their school. Despite the injury problem, the health benefits from this sort of activity are numerous and the school should encourage student participation (Breitenstein et al., 1990).

Parents, ski areas and schools need to ensure that all skiers, especially new recruits have the necessary knowledge to ski safely within the ski area boundaries. However, all too often the school ski program is not planned as an instructional activity but rather as an experiential one. As such, the health of many students is compromised because they are placed in a potentially dangerous environment (*i.e.,* have access to runs above their ability, gain access to lifts in which they have no training) without the necessary enabling skills and knowledge base required for a safe skiing experience. Students require a great deal of *pre-instruction* so that they can maximize learning at the ski hill and understand the potential consequences of their on-hill decisions. Students must be taught: proper winter clothing and eye protection, the Alpine Responsibility Code, what to do in the event of an injury, how their equipment works, behavioural expectations regarding jumping and skiing off-piste, and to understand what the different signs in a ski area mean. At the ski hill, skiing instruction should be mandatory because this will be the only opportunity students will have to be exposed to a professionally trained role model. Ski instructors will have to tailor their instruction to meet the skill and safety needs of their students while recognizing the realities of adolescent skiing behaviours.

At the same time, *supervision* is a major issue which needs to be addressed. Of the 125 injuries reported among school children only one was injured in a ski lesson. The rest were injured free skiing. Student-adult ratios are mandated by law for school extra-curricular activities, but for many this extends only to the site. Many parents and teachers ski together and meet the children at the end of the day, leaving them unsupervised for most of the day. Groups of students should be skiing with a responsible adult who can help teach safe skiing practices and keep the higher risk-taking behaviours at an appropriate level. Teachers also need to be prepared for the eventuality of an injury and have a system in place for evacuating the child from the ski area or local medical facility. Following each skiing session, a debriefing should be held to discuss problems, and concerns and to reinforce the positive aspects of the experience.

Ski areas should consider lengthening ski instruction and perhaps including half-day or all day ski instruction/guiding so that students can maximize learning and be supervised by professionally trained instructors.

3) *Knowledge and Practice of the Alpine Responsibility Code (ARC)*

The Alpine Responsibility Code described on page 181 (formerly known as the Skier's Responsibility Code) is a set of rules or more appropriately the responsibilities of skiers designed to ensure that all skiers have a safe and enjoyable time. These responsibilities, or rules of the road, parallel the laws that govern driving. However, unlike driving, skiers are never tested on the rules of the ski hill. It is evident from the results of this study that many skiers are ignorant of the code and even those who are aware of it are largely unable to define the six major responsibilities of skiers. Posting the responsibilities of skiers in restaurants, on lift towers, washroom stall doors and on trail maps is an attempt by the ski area to increase awareness of the ARC. Children on school ski programs and in ski school classes should not only be taught the code and be tested on it but, more importantly, it should be discussed and applied in the field so that young skiers understand not only the words but the intentions of this code.

4) *Experience*

Experience is an invaluable resource for skiers. The skills applied to the sport of skiing are dependent on environmental factors and experience with different conditions will enable the skier to engage in appropriate skiing behaviours for the given situation. For example, in cloudy weather the skier should slow down, in icy conditions the skier must concentrate on edge control, in deep snow the skier's weight should be further back than usual. Experience coupled with practice and instruction will enable the skier to react correctly to almost any circumstance. Experience with injury, on the other hand may caution a skier from engaging in a particularly risky behaviour if he or she has prior knowledge or personal experience of injury resulting from that behaviour. For example, knowing that a friend fractured a leg jumping off cliff "A" may discourage similar high risk behaviour at that same location and possibly others.

Skiing Behaviours

1) Jumping

Jumping in skiing requires skill, knowledge and motivation. Some ski areas have tried to ban jumping but because the skiing environment is so conducive to jumping, skiers will leap off cliffs, tree stumps, rocks, moguls, wind lips, and if these are not sufficient they will often construct jumps on the sides of ski runs. Many ski areas have snowboard parks where artificial jumps are provided for the snowboarders. Ski instruction should include jumping as a topic for instruction because it is a behaviour practiced by so many people. It may provide young people with the basic training to evaluate a jump, the landing site and their ability. In particular, efforts should be made to educate skiers to use spotters when the landing site is not completely visible to the jumper.

Jumps designed by ski areas, namely those in snowboard parks, need to be monitored closely to evaluate jumps producing high numbers of injuries, (for example "gap jumps", those which have a ramp to get lift followed by another ramp for landing with a gap in between). It is not uncommon for this sort of jump to injure a snowboarder who does not have sufficient speed to clear the gap and crashes into the opposing wall. On the other hand, snowboarders who approach the jump at excessive speed can sustain a fall as a result of clearing not only the gap but the landing area as well. Both environmental and behavioural interventions are required in this situation.

2) Skiing the Trees

Skiing off-piste and among the trees provides skiers with an opportunity to ski untracked snow. Many skiers, however, do not recognize the increased risks associated with skiing in this terrain. Buried logs, covered creeks, trees, low level branches, snow laden tree crowns and tree wells are all hazards which can cause injury to the best of skiers. An injury occurring alone in this environment could be fatal because the area is infrequently skied and not patrolled. A broken leg on a designated run is serious, but a broken leg on the side of a mountain, by yourself, in below freezing temperatures and in waist deep snow is beyond what most individuals can deal with. Despite this, skiing the trees is fun and will be practiced by many skiers.

Awareness and knowledge are key to reducing injury. Skiers must be taught to recognize the risks and must know how to take steps to minimize those risks: skiing with a partner in view at all times, having a whistle, keeping pole straps undone, advising others where you are planning to ski, having spare clothing and being prepared for self-rescue. Many ski areas are now encouraging "gladed skiing", these are ski runs where the trees have been thinned out and are patrolled. The intention is to provide tree skiing experiences in a patrolled area. The risk of a collision with a tree, however, is always present.

3) Skiing Closed Areas

To many skiers closed doesn't really mean closed, it means "if I go there I do so at my own risk and recognizing that I may have to pay for a rescue". There are numerous types of closures in a ski area. The two which are most heavily policed are Avalanche Closures (ski runs closed due to unstable snow and/or active avalanche control work being done) and Permanent Closures (areas where the terrain is not skiable due to cliffs or other terrain features). These areas have ropes and signs indicating their status yet many skiers choose to ignore them because they believe the areas to be safe and within <u>their</u> ability. However, they don't always realize that they are not just jeopardizing their own health but that of the rescuers and of those who will follow their ski tracks--ignorant of what lies ahead.

Regular run closures are common in early and late season due to insufficient snow. These are closed with ropes and signs, yet many skiers feel that they can ski on these marginal slopes with exposed rocks, creeks and other debris. Skiers need to gain an appreciation of why these areas are closed and why the ski area has a duty of care to prevent or discourage them from using unsafe slopes where the minimum safety standards for skiing cannot be achieved.

4) Fast and reckless skiing

Speed is one of the key factors that makes skiing fun, however, excessive speed in crowded areas can be dangerous to the skier and to others in the immediate area. More and more ski areas are providing speed control personnel whose responsibility is to slow skiers down. Often a reminder that they are in a slow skiing zone or that because of high skier traffic they should slow down so as not to scare less able skiers. Sometimes, a ticket will have to be revoked and skiing privileges suspended if repeat infractions occur. Some ski areas will require fast and reckless skiers to view an educational video on skiing safety. Many ski areas provide recreational race courses for those who want speed. In this case the skier can obtain high speeds in a separated area that will likely have increased protection (e.g., padded trees, netting and physical barriers from the rest of the skiing population).

5) *Taking lessons*

Most every ski area has a professional ski school that will provide skiing or snowboarding instruction. These programs present a significant financial barrier for many skiers resulting in many skiers learning skills vicariously and by trial and error. The skills, with time and patience can often be acquired but the safety instruction is often missed. The research literature indicated that rapid skill development alone does not reduce injury but that when combined with experience may in fact reduce injury incidence. Injury rates among beginner and intermediate level skiers is reported to be higher than advanced level participants and instruction can help accelerate skill acquisition and experience. Some ski areas provide free on-slope clinics for skiers, others have camps and a wide variety of products designed to increase the skiers skill level. Many ski lessons do not provide safety training and further efforts to increase the skiers knowledge as well as skill is an important consideration for ski schools interested in providing a comprehensive skier education package. Unfortunately many skiers either don't have the financial resources for lessons or simply don't believe that a lesson can help them. In fact many young respondents in this study felt that lessons detracted from having fun on the slopes.

6) Safe Skiing Practices

There are several simple safe skiing practices that all skiers should follow. Some of these include: skiing with a buddy, carrying a whistle, having a predetermined meeting place in the event you loose your group, have self-rescue equipment if you are skiing out-of-bounds, ensure that people know where you plan on skiing, carry any medications you may need while on the slopes. A few simple precautions can prevent needless tragedies. Financial barriers are again a factor here. Helmets, avalanche beacons, probes and portable shovels are expensive and pose a significant barrier to practicing safe skiing. For the casual recreational skier who skis only a few times a year, having proper clothing and eye wear is a challenge let alone more expensive safety devices.

Environment

1) Slope Preparation (grooming)

The grooming of ski slopes has not been linked directly to ski injuries as a causative factor. It is true that these well manicured slopes are the site of the majority of injuries but they are also the same slopes where the majority of skiers ski. Increased speed and increased skier traffic are two factors which may also be linked to increases in injury rates on these slopes. The grooming of slopes enables more skiers to ski, as the skill level necessary to ski these surfaces is lower than for ungroomed slopes. The main problem with grooming slopes is that it facilitates higher speeds. The studies on skiing-related fatalities list speed as one of the major causative factors. The increased speed is often associated with a loss of control resulting in a collision with an object (known as a rapid deceleration injury). Efforts to slow skiers down requires awareness, education and enforcement so that the skiing environment is as safe as possible for all users.

2) Safety of the Slopes (signage, trail rating)

Ski areas must ensure that ski runs are adequately marked with the run name and number, and the level of difficulty using both the recognized industry standards of colour and shape. These should coincide with trail maps as well. The design of the ski runs should ensure that runs do not lead to more difficult slopes (*e.g.*, an intermediate level slope becoming and advanced level slope without due warning or alternate route around the difficult section). All skiers should be aware of and understand the run designations and how the scale works; realizing that the designations are for that mountain alone (a beginner slope at one mountain may not be a beginner slope at another).

3) Lift related Injuries (loading, unloading, falls from the lift)

Injury occurring at or on the ski lifts are rather infrequent events considering the number of people who are moved on these devices. North American ski areas have for the most part accepted lift lines and maze system to funnel skiers to the lift in a fair and systematic way. Signage is evident and directions are clearly stated. Despite this, some skiers still manage to be distracted at loading and are struck by the carrier (moreso on fixed grip chairs where the chair remains attached to the cable rather than on high speed lifts where the chair detaches from the cable). Lift attendants are stationed at the top and bottom of the lifts to ensure that if a miss-load occurs they can stop the lift as quickly as possible.

While riding aerial lifts, it is strongly encouraged that riders lower the restraining device. All chairlifts in Canada are required to have a restraining device. However, many skiers choose not to lower the device. Children are particularly susceptible to falling from the chair because of their small size. Also, in the event of an emergency stop, the cable brake is applied and the stop can be very sudden, causing the chair to have a significant bounce, especially between tower spans. Anecdotal reports indicate that many skiers believe the restraining device is a foot rest. Although it often does serve this function, its primary function is to keep people from falling from the lift. Off-loading from the chair is where many lift-related injuries occur. It is my experience that the steeper the off-load ramp the more injuries there are. An environmental solution to this would be to flatten out the off-load ramp so that skiers can unload safely and move away from the lift without gaining a great deal of speed on the downhill slope.

4) High traffic zones and congestion

The design of ski areas should consider high traffic zones and skier congestion. It appears from the literature that many congestion problems occur when ski areas expand and modernize the lift system without increasing the skiing terrain. Increasing skier volume increases congestion and adversely affects the skiing surface due to the increased volume (more bare patches, more moguls, etc.). Skiers should be encouraged to slow down in these areas and ski areas should attempt to design lifts stations and restaurants with open areas around them to accommodate the runs that converge in these places.

5) Effects of Weather on Ski Injuries

There were no statistically significant findings regarding weather and general injury rates but the literature does suggest that specific injury types are affected by weather. Since weather cannot be changed, then skiers must be taught to recognize how weather affects the skiing and their performance. The changing weather conditions do affect the skiing surface in the course of the day and skiers should be aware of how these changes affect their skiing.

6) Injuries Resulting from Impact with Objects Among Young Children

It is suggested that young children (0-6 years) have a higher rate of collisions with objects than do other age groups. Since many of these children ski on specially configured low angle ski slopes away from the main ski runs, every effort to render that physical environment safe should be undertaken. For example, trees, lift towers, rocks and buildings should be removed, padded or placed behind an appropriate barrier. One creative solution to prevent children from skiing into ski racks and the buildings at the base of a low-angle slope was to create a small burm (a pile of snow 30-40 cm high) along the length of the building so that children would be deflected from crashing into the racks. Another possible solution would be to treat the ski base so that higher speeds could not be achieved. Lastly, mandatory helmet use would reduce the incidence of head injuries.

7) Congestion

Children under 13 years of age were identified as having a high number of injuries caused by skier collisions. Because these young skiers ski the same slopes as everyone else, there is probably not an exclusive environmental factor at play. More likely is that these children are venturing onto more aggressive slopes and being smaller and less skilled are being overtaken by adult skiers who may or may not have seen them. Younger children tend to stop where they want to, unaware of other skier traffic. Stopping below a knoll or on a crowded break-over in the center of a run is hazardous. Educating children as to how and where to position themselves is important but parents need to be taught how to protect their children on the ski slopes by acting as a more visible rear guard (tail-gunner). Another factor is that small children are simply not being seen by skiers moving at a high rate of speed. Ensuring that children have contrasting colours may also help to reduce the incidence of collisions.

<u>Summary</u>

Skiing is a complex task that incorporates numerous variables including equipment, the environment, the behaviours practiced and the skier's individual state of being. Ski areas provide numerous services to their guests to ensure that the skier has an enjoyable day. Skiing has numerous inherent risks which may result in injury. Inherent risks can be defined as risks that are incidental to and inseparable from the sport. It is easy to blame the skier for every misfortune that may arise while skiing but victim-blaming serves little purpose in developing a safer recreational activity. The ski area can only do so much to render the natural environment and the fabricated skiing environment safe. Skiers need to become more involved in issues concerning their sport and community based interventions need to be developed. At present the recreational skier has no organization that represents the millions of skiers who visit

British Columbia ski resorts. Nearly every other group associated with skiing has representation of some sort. For example, there are representative bodies for ski areas, ski patrollers, ski instructors, ski racers, etc.

Reducing the incidence and severity of injury will require further technological advances, educational interventions and legislation. It is still unclear as to who and what should be addressed in order to make skiing a safer activity. However, as the body of literature continues to grow and more health professionals take on issues concerning skiers and skiing, the potential to reduce injury further will become apparent. Personal error is the leading cause of injury. Increasing skill, knowledge and practice of skiing safety will likely result in fewer injuries on the slopes.

Skiing Injuries among Young People

Young skiers have a significantly greater risk of injury and their behaviour is influenced by both the social and physical environments. The results of skiing behaviours can range from death on the one hand to exhilaration and ecstasy on the other. It is evident that ski injuries can have enormous personal costs for a young person (loss of mobility, loss of employment, loss of quality of life) and significant social costs (hospital treatment and rehabilitation, loss of productivity and long-term nursing care). The research goal, here, was to investigate ski injuries among an adolescent population of skiers and to explore the distribution and determinants of skiing-related injury.

In the skiing situation, it is obvious that injury prevention requires both environmental and behavioural interventions. The age-specific rates of injury combined with the distribution of injuries and the identified determinants have allowed for specific interventions and prevention initiatives to be recognized. The evidence at this ski area indicates that children under 18 years of age have a significantly higher rate of injury than the adult population. The injury problem among adolescents (13-17 years) is most distinguishable, followed by children 7-12 years and then by young children 0-6 years. Also noted was the fact that children on school-sponsored ski programs had significantly more injuries than those children of the same age not skiing with their school. The argument that the school population is composed of more beginners (hence a greater likelihood of injury) is relevant only to the point that it reinforces the fact that this population requires some special attention.

The injury patterns for the three age groups highlight different distributions and determinants of injury. Based on the findings, interventive strategies have been identified which may have the potential to reduce the incidence and/or severity of injury producing events. Personal error is the leading reported cause of injury but does not provide sufficient information to help develop specific interventions. Hence, personal error is not discussed below as a factor for interventive strategies.

Young children (0-6 years) are particularly susceptible to craniofacial injuries (41% of all injuries) and one of the more common causes (17%) of injury noted in the preliminary study were collisions with other skiers and with inanimate objects in the skiing environment (and skier-object collisions was particularly noteworthy in the prospective study). Knee injuries, followed by those to the ankle, were the next two leading injuries. Helmets have been identified as the primary means of reducing head injuries among this age group. Parental awareness and incentives to encourage helmet use among these small skiers is recommended. Many of these young skiers ski on special children's slopes and ensuring that the environment is free of obstacles or equipped with appropriate barriers to dissipate forces of a skier-object collision is an intervention that seems warranted. Another injury cause identified was the skier collision, where one skier is struck by another. As these young children increase in skill, they proceed towards the open slopes and must interact with the entire skiing population. Their small size, lack of skill and experience (and developmental stage does not easily accommodate abstract thought) may be factors in this higher frequency of skier collisions (Gage, 1979). Slow skiing zones may provide a suitable transition for both young and novice skiers. Other possible interventions may be to increase the visibility of the young child, to teach parents to ski behind young children, and to teach young children what are safe places to stop and rest. The frequency of ankle injuries suggests that ski boots for these young children are inadequate, either too large or designed with insufficient support. The knee injury problem is not related to the boot-binding system nor the binding-release setting. The ski binding is designed to prevent tibia fractures and to keep the ski attached to the foot until unsafe forces are achieved which may injure the tibia. The soft tissue of the knee is not factored into the binding mechanism.

Children 7 to 12 years injure their knees and sustain craniofacial injuries at the same frequency (23% of injuries) and the leading causes of injury that have been identified are skier collisions (10.6%) and jumping (7.5%). Once again, helmet use can prevent the majority of head injuries but with this age group, social norms and peer pressure are forces which must be dealt with in the development of interventions. Injuries caused by jumping require increased skill training and knowledge development as well as some form of social inoculation to help reduce the peer persuasion to engage in inappropriate risk. Ensuring that a responsible spotter be in place for the jump will ensure that the landing area is clear an safe.

The leading injury site among adolescents (13-17 years) is the knee followed by craniofacial injuries and the thumb. The leading causes of injury after personal error are jumping (13.1%), collisions with objects (11.2%) and changes in snow texture (7%). Knee injuries can be reduced by teaching skiers how to avoid certain falling movements or behaviours which have been found to lead to serious knee injuries. The ACL Awareness '95 program is one such program (Ettlinger, et al., 1995a). Another tactic might be to encourage pre-season training to increase hamstring and quadriceps strength (Morrissey, Seto, Brewster & Kerland, 1987). Collisions with objects can be dealt with in two ways: a) increased use of barriers where appropriate, although many of these collisions involve rocks and trees along the side of ski runs and the collision is precede by a loss of control, and b) increased skill development and a greater awareness of the potential hazards of skiing in higher risk areas (*e.g.,* closed areas, avalanche prone areas, and tree skiing).

The issue of role is a crucial social factor involved in the injury pre-event. Role and social norms guide behaviour among young skiers and evidence from the popular literature described on page 71 show that engaging in higher risk skiing activities is the norm. Role expectations are developed from various external sources and often adopted as normative behaviours (*i.e.,* clothing, speech, mannerisms). The health compromising behaviours reported (aerials, deep powder and tree skiing) do not reveal the planning nor the safety precautions taken by the professional models used in the photo-documentaries. Risk taking in skiing provides many adolescents an opportunity to engage in risk activity that is socially acceptable. However, interventions are needed to educate young skiers how to reduce the risk of injury or death by adopting safe skiing strategies (*e.g.,* skiing in pairs, having self-rescue equipment, using spotters, getting information from experts, etc.).

To date the majority of interventions designed to reduce injury within a ski area have been initiated by the ski area management as loss prevention strategies. These strategies focus on providing a positive experience for the skier by reducing confusion and creating a problem-free skiing experience. To this end, ski areas for the most part provide excellent signage (*i.e.,* run names, level of difficulty, directions and instructions for lift riders), the grooming of slopes is meticulous, lift personnel are highly trained and maintenance is usually a top priority.

With respect to school-sponsored ski programs, both the school and the ski area require a great deal of attention. These programs have the potential to provide a three-way benefit. 1) The ski area attracts clients and a loyalty to the mountain among the young and impressionable skiers. 2) The school meets its educational obligations to provide students with life-long recreational interests and opportunities to enhance personal health and well-being. And 3) the student acquires skill, confidence, self-esteem, and physical fitness and may adopt the sport as a life-long recreational pursuit. However, the school-sponsored ski program is not meeting the needs of students. Skiing instruction using Canadian Ski Instructors Alliance guidelines meet skill development needs in the skiing community but is under-utilized or not used at all by students. Supervision is lacking, which has a direct bearing on the incidence of injury (one injured skier of a total of 125 was injured in a supervised ski lesson), pre-instruction is non-existent for the majority of school groups and post-injury planning is often ignored, causing delays and inconvenience to all concerned. School-sponsored ski programs provide a valuable service to all concerned. It does, however, require planning so that an optimal yet safe learning experience can be achieved by the students.

Contributions of this Research

This research has resulted in several theoretical and practical contributions. The research represents a departure from the traditional technological approach to ski injury prevention. It recognizes that even with technological provisions, behaviour plays a role in most ski injuries, and that technological interventions alone are not meeting the injury preventive needs of skiers. The emphasis on behaviour and the psychosocial determinants that influence behaviour is of paramount importance in developing interventions to reduce the incidence and severity of skiing injuries.

On the theoretical level the research confirms and elaborates elements of Phase 3 of the Green and Kreuter Precede-Proceed model, emphasizing the relationships between environment and consequent behaviour. It is from this and other research evidence that, in sport and recreational settings, behaviour seems to have the most direct impact on the injury problem. The physical environment enables the behaviour to occur but it is rare for the physical environment to cause injury by itself. Even avalanche occurrences, a natural physical environmental threat to skiers, requires skiers to seek powder snow on or beneath steep slopes. The social environment helps to create or to perpetuate the behaviours, fashions and beliefs of young skiers. *It is unlikely that a direct link can be made between the social environment and an injury without incorporating behaviour.* In essence then, the skiing behaviour is influenced by both the social and physical environment.

This model incorporates well the notion of behaviour and environment but does not pay equal attention to issues of vector (*i.e.,* equipment). In the epidemiological model Host-Agent-Environment, the agent or vector receives equal representation whereas in the Precede-Proceed Model, it is imbedded in the environment and it surfaces in Phase 4 of the model as an enabling factor linked to the environmental factors normally listed in Phase 3. As a result, equipment-related issues were not as prominent in this study as they have been in the general ski injury literature.

Another theoretical contribution of this thesis is the application of Social Cognitive Theory to the identified intervention strategies. Specific skiing behaviours and physical and social environments have been associated with an increased risk of injury. The planning or design of interventions to reduce the incidence and severity of ski injuries can use SCT to identify and target the interaction of elements in the Precede-Proceed Models' "predisposing factors" (the person), enabling and reinforcing factors (environment) and the person's behaviour. An approach which includes constructs from SCT such as expectancies about environmental cues, consequences of specific actions and one's own competence to perform the behaviour (self-efficacy) may contribute to reducing injury in skiing and in other domains. In addition, SCT proposes that skiers learn vicariously and that models and reinforcements in the skiing environment may encourage or discourage higher risk behaviours or reinforce the adoption of health promoting behaviours (safety) which may reduce the potential harm incurred by practicing high-risk behaviour (*e.g.,* skiing with a buddy in the trees, having self-rescue gear when skiing avalanche prone slopes). Findings in this study suggest that adolescent skiers are influenced to a greater extent by peers than by adults, that many young skiers engage in behaviours that place them (possibly unknowingly) at greater risk of injury. Although SCT was not employed directly in the formation of hypotheses, it is evident that constructs of SCT will be applicable in the development of educational programs for skiers and on any ski injury reduction intervention. Approaches to understanding behaviour change including the Health Belief Model, the Social Norms Approach, and the Social Influence Approach, all previously described in Chapter 2 can be seen to fit the profile of those at greater or lesser risk of ski injury and be applied in Phase 4 of the Precede-Proceed model in planning injury prevention programs for specific populations in specific settings.

At a more practical level, this research has identified children under 18 years as having a significantly greater incidence rate of injury than the adult population. Adolescents have the highest rate of injury followed by the 7-12 year olds and the young children under 6. Craniofacial injuries were considerably more problematic in this study than those reported elsewhere. This may be the result of a more challenging physical environment at the study site or issues dealing with injury definitions and data collection methods.

The distribution and determinants of injury among the three age groups have been clearly defined. The injury patterns are not identical among the three groups and interventions are reported to be most successful when the specificity of the intervention and its target population have been matched.

Many of the behaviours practiced by skiers have not been well described in the academic literature. It is obvious that many young people engage in higher risk skiing activities such as jumping, skiing the trees, and skiing closed areas. These activities have the potential to increase the incidence and severity of skiing related injury.

The majority of school-age skiers have skied on school-sponsored ski programs. This provides a possible intervention site that would not only help to reduce injury among this school-based population but among most of the general youth population at the same time. Respondents of the questionnaire overwhelmingly indicated that the ski area was the ideal place to teach skiing safety. It might be suggested that some pre-instruction occur in the school environment followed by on-hill instruction.

Implications for Future Research

Skiing behaviour has only recently become an active area of research. Only a handful of studies have looked at skiing behaviours {the ACL Awareness '95 program (Ettlinger, et al., 1995a), and binding adjustment studies (Bouter & Knipschild, 1991a; Danielsson, 1976; Danielsson, et al., 1985)}. The majority of the emphasis in ski injury research has been in injury epidemiology and equipment design. The modifications to ski equipment have been most successful in bringing down injury rates but this technology appears to have reached a plateau or a point of diminishing returns. Issues concerning future research have been identified from issues raised in a) the literature review, b) the research data, and c) professional and personal field experience in ski patrolling and pre-hospital care of injured skiers and snowboarders.

Issues Derived from the Literature Review

As the sport of snowboarding continues to grow, it is necessary to explore the problem of snowboarding-related mortality. It is suggested that snowboarder's have the same risk factors as alpine skiers yet the few references made to snowboarding deaths in the literature suggest that deep snow immersion is the leading single factor causing death. A detailed review of snowboarding fatalities is required on a national scale to explore the distribution and determinants of snowboarding mortality.

With regard to lower leg fractures among children, the literature suggests that it is a significant problem. However, the ski patrol data employed in this study did not reinforce this hypothesis one way or the other because of diagnostic limitations. A further investigation that tracks lower leg injuries of both adults and children is required. Blitzer (1984), Gidings (1993) and Ekeland (1993) all suggest that lower leg fractures are overrepresented among young skiers.

The research literature concerning head injuries is not consistent. Despite being one of the leading injuries among children, the majority of head injuries are reportedly minor in nature. With increased interests in promoting helmet use for children, it is imperative that the distribution and determinants of head injuries be explored in greater detail. Also missing in the literature are cost-benefit analyses of helmet use and of helmet wearing behaviours. At this point there are only helmet sales records to indicate the number that may be in use. Many helmets are worn by competitive racers and not recreational skiers suggesting that sales records are not a good indicator of helmet use.

Research is required to define further the determinants affecting skiing behaviour. These would include the sociological factors influencing skiing behaviours and the importance role and norms have on individuals and on groups, and the psychological factors that affect one's susceptibility to engage in high-risk behaviour.

Several theoretical perspectives should be tested for empirical utility in this line of investigation. For example, the Health Belief Model appears to be a practical perspective to use in investigating the predisposing factors of perceived susceptibility and severity of injury among skiers. As well, one would assume that learning theory and marketing research may be incorporated to teach and reinforce health promoting behaviours that would contribute to improved health.

Issues Derived from the Research Data

It is obvious from the findings that there are gender differences in injury patterns of skiers. However, further research that investigates non-injured males and females is required. Exploring behaviour patterns among male and female skiers would provide valuable information for developing health promotion interventions. A crucial factor that is required is a combined age- and gender-specific ticketing system that would provide further precision in determining incidence rates of morbidity and mortality.

On the same lines as above, if ticket sales could discriminate between alpine skiers and snowboarders, accurate incidence rates of injury could be determined rather than the estimates currently being made using sampling strategies.

The injury report forms used by ski areas are the primary data source for ski injury analysis and can be used as a information gathering system. The specifics of the form should provide the ski patroller with a means of recording data regarding the injured person, the specific injury and the environmental conditions. Ideally, the IRF as a surveillance system should be nationally based so that inter-regional comparisons can be generated and interventions targeted to specific regional problems as well as to more global issues regarding skiing safety and binding adjustment.

It is imperative that the major self-reported cause of injury, personal error, be more narrowly defined. Forms and questions designed to elicit details regarding injury events need to be improved. At present more than half of all injuries are classified as skier error. With little or no knowledge as to what happened, prevention efforts cannot be generated.

Due to ethical limitations regarding research access to children under 19 years of age, it is necessary that strategies be developed that can meet ethical considerations yet enable randomization of samples in the skiing environment.

The focus group provided considerable insight into the social roles and norms of the various groups represented in a ski area. This largely untapped resource using a qualitative approach has great potential to guide future research. Issues regarding beliefs, values and knowledge development can be effectively explored using qualitative methods.

Injuries in this study tended to occur more often on ski runs designated beginner or intermediate, but this could not be assessed against denominators to allow rates of injury to be calculated. It is important to acquire baseline data regarding the frequency skiers use various types of ski runs. With this information, generalizations about injury patterns could be further explored with greater precision.

Natural environmental factors such as weather, demonstrated little effect on the incidence of injury. Regardless of the weather, injuries occurred at about the same rate. The next phase of this line of investigation is to investigate specific injuries and the environmental factors. For example, are knee injuries more prevalent during periods of new snowfall or during icy conditions. It is the experience of ski patrollers that specific weather patterns result in different injury patterns. This needs to be explored further so that skiers could be made aware of the specific injury threats that may be present during specific weather conditions.

The obvious overrepresentation of children on school sponsored ski trips is alarming and in need of further investigation. It is important to look at the distribution of beginner, intermediate and advanced level participants to see if the differences identified in this study are simply naturally occurring ones, that is the increased incidence of injury is due to a greater number of beginners. This would direct the interventions towards rapid skill development rather than towards more safety oriented education. Another factor may be the equipment used by students. It may be that their equipment is worn and of a lesser quality that one might see in the general youth population. Ski rental equipment usually meet and exceed basic industry standards but the use of non-rental equipment among students may require further investigation. In any event the ski area and the school need to explore safety-related issues concerning school populations.

The Ski Questionnaire probed young skiers for information regarding behaviours. The evidence requires further substantiation to ensure accuracy of the self-reported data. Studies that attempt to observe and quantify many of the behaviours practiced by young skiers are needed. For example, determining the frequency to which skiers use a spotter at a jump site, the number and personal information of closure violators and those who ski the trees are needed.

Issues Derived from Professional and Personal Field Experience

Skiing safety is, at present, largely based on loss prevention strategies by ski area operators. There are several issue that need to be addressed regarding the pre-hospital care of injured skiers and disaster planning on multi-casualty injury events that may arise in a ski area.

As ski areas become more conscious of patient care, the general level of care increases. It is not uncommon for ski areas to have emergency physicians on skis, paramedics as well as trained first aid attendants (ski patrollers). Relative to Haddon's countermeasures, the care one receives immediately post injury can impact on recovery. Cost-benefit analyses are needed to see if the increased level of pre-hospital medical care is warranted and under which circumstances. For example, the final outcome of a patient with a knee sprain may not be changed as a result of an on-hill examination from a physician but a medical intervention on a pneumothorax (puncture lung) can be significant, in fact life-saving.

Physicians at many ski areas are tending to skiers with dislocated shoulders and under some circumstances attempting on-hill reductions. This procedure in the absence of x-rays poses certain risks to both the patient and the physician and the long term outcome of reducing the shoulder on the ski hill is unknown. A key question is whether or not shoulder reductions performed on the ski hill result in better long term outcomes than those treated in a clinical setting?

On the larger scale, ski areas for the most part practice and plan for single injury events and rarely attend to large scale disasters with multiple victims. For example, a recent tragedy at Whistler Mountain, December 23, 1995, challenged not only that Mountain's resources but that of the entire community when four loaded four-person chairs fell from the lift line. The final result included two fatalities and numerous seriously injured skiers. Research into incidents such as this are required so that other ski areas and resort communities can develop action plans and disaster scenarios so that in the event of an unfortunate multi-casualty event, the ski patrol can react in an efficient manner and mobilize both internal and external resources to minimize losses and ascertain the best care possible for the injured

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Summary of Conclusions and Implications

Ski injuries are predictable and preventable events. Children are seen to be at greater risk of injury than adults and the social and physical environment play an important role in determining the potential for injury and injury severity. The social environment, as we know, influences behaviour and this behaviour can be directly linked to injuries. Skiing, like many other sports, is being recognized as an activity where injury can be and should be reduced. Cycling education and helmet laws are making great strides in reducing cycling-related head injuries. In skiing, helmet use, as an example, is on the rise but numerous barriers exist to discourage not only the use of helmets but of other prevention and health-promoting behaviours. Those barriers include high costs of safety equipment and instruction, lack of appropriate role models in the media, inappropriate social norms and role expectations, lack of educational opportunities and maintenance of individual rights and freedom. This research, a social epidemiological study, has provided a foundation that will direct future research in ski injury prevention towards a more psychosocial approach than the technological and regulatory approaches that have dominated the recent injury prevention literature.

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Appendix A

Skier's Knowledge Initiative (SKI) Questionnaire

SKIERS KNOWLEDGE INITIATIVE QUESTIONNAIRE

Participant No: ________ Age: ________ Female ☐ Male ☐

PART I

1. *What alpine activity (downhill) do you do?*
- ☐ always ski
- ☐ always snowboard
- ☐ mostly ski with the occasional snowboarding day
- ☐ mostly snowboard with the occasional ski day

For all participants - skiing and snowboarding represent the same thing in this questionnaire.

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2. *What level of skier do you describe yourself as?*
- ☐ beginner
- ☐ intermediate
- ☐ advanced

3. *How many hours do you usually ski during one day?*
- ☐ 0-2
- ☐ 3-5
- ☐ 6+

4. *Approximately how many days have you skied this season?*
- ☐ 1
- ☐ 2-9
- ☐ 10-20
- ☐ 21+

5. *Approximately how many days did you ski last year?*
- ☐ None
- ☐ 1
- ☐ 2-9
- ☐ 10-20
- ☐ 21+

6. *How many ski lessons have you had this year?*
- ☐ None
- ☐ 1
- ☐ 2-9
- ☐ 10+

7. *How many ski lessons did you have last year?*
- ☐ None
- ☐ 1
- ☐ 2-9
- ☐ 10+

8. *How many years have you been skiing, including this one?*
- ☐ 1
- ☐ 2-5
- ☐ 5-7
- ☐ 8+

9. *Have you ever gone skiing with a school group?*
- ☐ Yes
- ☐ No

10. *The first time you went skiing, who did you go with?*
- ☐ family
- ☐ school
- ☐ friends/relatives
- ☐ I don't remember

11. *Have you ever worn, on a regular basis, a helmet skiing?*
- ☐ Yes
- ☐ No

12. *Who do you think you would listen to more about skier safety?*
- ☐ a ski instructor
- ☐ a school teacher
- ☐ a ski patroller
- ☐ parents

other ___________

13. *Where do you think the best place to teach young people about skiing safety and responsibility is?*
- ☐ home
- ☐ school
- ☐ at the ski hill

other ___________

Questionnaire - Part I (cont'd)

14. *Have you ever heard of the Skier's Responsibility Code?*
☐ Yes
☐ No

15. *Do you always wear a seatbelt when driving (being driven) to the ski hill?*
☐ Yes
☐ No

16. *How often do you wear a helmet skiing?*
☐ never
☐ some of the time
☐ all of the time

17. *How often do you wear a helmet bicycling?*
☐ never
☐ some of the time
☐ all of the time

18. *What does a blue square run mean?*
☐ beginner
☐ intermediate
☐ advanced

19. *Have you ever ducked under a closed sign and rope?*
☐ Yes
☐ No

20. *Have you ever adjusted your bindings on your own?*
☐ Yes
☐ No

21. *Do you ski differently when you are with friends than when you are with your parents or other adults?*
☐ Yes
☐ No
Why?

____

____

22. *Who has taught you the most about skiing safety?*
☐ myself
☐ parents
☐ friends
☐ ski instructor
☐ ski patrol

23. *What do you think is the main reason why people hurt themselves skiing?*

____

____

24. *When jumping, do you always use a spotter when you can't see the landing zone?*
☐ all the time
☐ half of the time
☐ never

25. *Have you ever looked down a run and decided not to ski it?*
☐ Yes
☐ No

26. *Have you ever skied into someone else (not on purpose)?*
☐ Yes
☐ No

27. *Have you ever been hit by another skier?*
☐ Yes
☐ No

28. *Who adjusted your bindings last?*
☐ ski shop
☐ friend
☐ parent
☐ ski instructor/coach
☐ other

29. *Have you ever had to see a doctor because of a skiing injury?*
☐ Yes
☐ No

30. *Have you ever had to see a doctor because of a bicycling injury?*
☐ Yes
☐ No

31. *How often do you ski in the trees?*
☐ never
☐ 1 run per day
☐ 2-5 runs per day
☐ I ski in the trees almost all of the time

Questionnaire - Part I (cont'd)

32. *Have any of your friends or family members ever been taken off the hill in a ski patrol toboggan?*
- ☐ Yes
- ☐ No

33. *Do you have a seasons pass to Blackcomb?*
- ☐ Yes
- ☐ No

34. *Do you have a seasons pass to another mountain?*
- ☐ Yes
- ☐ No

35. *Have you every had a near-miss, where you think you just escaped from getting hurt skiing?*
- ☐ Yes
- ☐ No

36. *How would you describe yourself as a skier? (choose one)*
- ☐ fast
- ☐ in-control
- ☐ reckless
- ☐ cautious
- ☐ scared
- ☐ daring

37. *Could you list the 6 main points of the Skier's Responsibility Code?*
- ☐ Yes
- ☐ No

38. *What sort of punishment should there be for skiers who ski recklessly?*
- ☐ stern warning
- ☐ nothing
- ☐ skiing suspension: 2 weeks
- ☐ view a ski safety video

other

____

____

39. *When you are skiing down a run, who has the right of way?*
- ☐ the skier who is above you
- ☐ the skier below you
- ☐ the skier in the centre of the run

40. *What sort of snow conditions do you prefer?*
- ☐ freshly groomed
- ☐ moguls
- ☐ 10 cm powder
- ☐ 30 cm powder

41. *Have you ever had a ski injury?*
- ☐ Yes
- ☐ No

42. *If yes, what was (were) the injury (injuries)?*

____

____

____

43. *What do you like the most about skiing?*

____

____

44. *What, if anything, scares you the most skiing?*

____

____

45. *What do you think is the most common cause of ski injuries?*
- ☐ too much speed
- ☐ overcrowded runs
- ☐ bindings set too tight
- ☐ blind air while jumping
- ☐ falls unloading chair
- ☐ skiing terrain above ability
- ☐ skier collisions

other

____

____

46. *Do you use the safety bar on the chair lifts?*
- ☐ all of the time
- ☐ only on chairs with foot rests
- ☐ only if someone else pulls it down
- ☐ most of the time
- ☐ never on my own

47. *Are you left or right handed?*
- ☐ Left
- ☐ Right