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Profiling Australian Snowsport Injuries: A Snapshot from the Snowy Mountains

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Snowsport tourism provides a major economic contribution to the rural and regional areas surrounding the major resorts in Australia. One of the barriers to snowsport participation is that people perceive snowsports as dangerous and so fear being injured. Understanding snowsport injuries will help managers to diminish the risk of injuries, and marketers to address perceptions of danger. This study explored snowsport-related injuries to participants aged 18 years and older in the Snowy Mountains, Australia, over 31 days during winter 2006. Of 497 injured snowsport participants surveyed, 76.3% were visiting the area for a holiday, while 16.9% were working in the area for the snow season; 45% were women, 55% were men; 33.2% were aged 18–24 years; with 49.3% being alpine skiers and 46.1% snowboarders. For skiers the main injury was to the knee (75.6%), while for snowboarders the wrist was the main injury location (84.6%). The primary location where injuries occurred was on-piste at the resort (47.5%) with the main mechanism of injury being falling over (38.2%). Most injuries, as reported by the respondents, were either bruises or sprains (72%). Most people did not wear any protective equipment while participating (73.2%). Of the two main activity groups, skiers had the highest proportion who did not wear any protective equipment (78.8%) while snowboarders were most likely to wear helmets (18.8%). Results from this study will be useful to inform future snowsport safety messages and strategies that target various factors that may contribute to snowsport injuries including behaviours and attitudes before and during participation.

Keywords: Snowsport Injuries; Skiing; Snowboarding; Protective Equipment; Visitor Safety; Social Factors

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Introduction

In the face of a constantly changing natural, economic and social environment, tourism destinations and providers need to be vigilant in seeking to better manage their products and services in order to ensure their ongoing viability. Understanding what may be limiting their potential and managing any perceived barriers to growth is one aspect of their broader strategic management. Snowsports, as one section of sports tourism, has additional challenges presented by the very real threat of climate change, and thus must continue to look for ways to retain current participants and introduce new participants. The research presented here explores ways of combating one barrier to participation, that of fear of injury, as part of the overall management of industry sustainability.

'Sport tourism' has been defined in a variety of ways depending upon the emphasis given to factors such as travel motives, level of participant activity, and the time allocated to sport-related activities (Gibson, 2004; Hinch & Higham, 2001). Although researchers may disagree how much participation in sport makes one a 'sports tourist,' a consensus is that this industry segment is growing. Just as there are differences in how sports tourism is defined there are also differences as to how specific activities may be categorized. For example, skiing has been incorporated under the 'soft definition' of sports tourism because tourists are extensively involved in their sport activity for recreational purposes only (Gammon & Robinson, 1997), active sport tourism (Gibson, 2002) and even resort or adventure tourism (Kurtzman, 2000). Whichever definition is used, skiing has certainly received significant attention in the broader sport tourism literature (Gibson, 2004; Higham, 2005; Ritchie & Adair, 2004; Standeven & De Knop, 1999; Weed & Bull, 2004).

However, with the rise of interest in snowboarding, and the re-emergence of older activities, such as snowshoeing and telemarking, research on snow-based tourism may be better termed 'snowsport tourism' as the activities involved are broader than just skiing. Snowsport tourism thus would include physical activities such as skiing, snowboarding, cross-country skiing and snowshoeing, but the term could be flexible enough to include other activities, such as snowmobiling, sleigh rides, snowplay and even après ski. Despite what may be portrayed in the media, most snowsport activities are not extreme sports; they are activities that people of all ages and many abilities are able to participate in throughout their lives. By adopting a broader term such as 'snowsport tourism' and avoiding a sport-discipline label such as 'ski tourism', we also avoid definitional concerns, such as whether the discussion is about a tourism destination (as with a winter resort), an activity (such as skiing) or should include off-snow activity such as après ski. The focus in the research presented here is upon active snowsport participants who have injured themselves while participating in a variety of snowsports.

Internationally, alpine skiing, snowboarding and cross-country skiing are popular sports, both at the competitive and recreational level, for individuals, families and groups. Worldwide, an estimated 65 million people participate in snowsports (Hudson, 2000a). In Australia in 2006 – which was a poor snow season due to

weather – an estimated 177,700 people over the age of 14 participated in ice and snowsports, a participation rate of 1.1% across the whole population (Australian Sports Commission, 2007). In the same year, participants reportedly engaged in 1,713,584 skier-days in the snowsport resorts where a 'skier-day' is the equivalent of a one-day lift pass (Australian Ski Areas Association, 2006). Snowsport participation in 2006 was down 22% from the previous year, when 228,000 people participated, resulting in a national participation rate of 1.4% (Australian Sports Commission, 2005). This decline in participant numbers was reflected in a 16% decrease in skier-day figures, down from 2,034,000 in 2005. In 2007, with improved snow conditions, the skier-days returned to over 2,000,000 (Australian Ski Areas Association, 2007). The economic impact of the Australian snowsport industry, measured as the gross state product, was estimated to be $987 million in 2005, and the industry generated 12,759 jobs during the winter season (National Institute of Economic and Industry Research, 2006). All of these figures collectively indicate that snowsport tourism is an important contributor to those communities that provide the support for the industry.

In light of the importance of this industry, regionally and internationally, the retention and growth of snowsport participants are vital. Ensuring the growth of the market is even more important where seasonality is an ongoing challenge for resorts (Hudson & Cross, 2005; Ismert & Petrick, 2004), and in a time when many alpine areas are under threat from the effects of climate change (König, 1997; König & Abegg, 1997; Moen & Fredman, 2007; Scott *et al.*, 2006). For example, in Australia, the projections are that by 2020 the area under snow for 60 days or more could be reduced by 18–60% as a result of global warming (Hennessy *et al.*, 2003). The Australian domestic snowsport industry is further threatened by the emergence of competing snowsport destinations in the region, such as in Japan, Korea and China, areas that are becoming commercially viable because of low-cost air carriers. In this environment, the Australian snowsport tourism industry must address any controllable barriers or constraints that may be limiting people's introduction to, and ongoing participation in, these activities.

Hudson (2000a) summarized research into the motivations for participating in snowsports, which included enjoyment of the unique environment, the social benefits of being with others who enjoyed the same activity, and a form of release. Hudson (2000a, p. 74) noted that 'a high percentage of the skiing population is more concerned with safety and ambience than athletic challenge or risk'. Although participants willingly run some risks for the sake of adventure, none of them seek to be injured. The word 'Adventure', comes from *ad venio*, or 'whatever comes' (Zweig, 1974), whether that be positive or negative, thus adventure is about uncertainty of outcome (Dickson, 2004). Risk is used here from the perspective of risk management, which it is about promoting positive outcomes, such as enjoyment and engagement, whilst minimizing the potential negative outcomes, such as injury and loss of potential participants (Standards Australia and Standards New Zealand, 2004).

Two studies of over 1800 non-skiing respondents identified a range of barriers to participation in snowsports, which included media image; costs and time

commitments (Williams & Fidgeon, 2000); perceptions of crowding; difficulty in accessing the slopes; and the physical demand (Hudson, 2000b). One deterrent to participation common to both studies was the fear of injury. This fear may be further exaggerated by the culture and marketing messages surrounding snowsports (Dickson, 2006; Dickson *et al.*, 2006; Hudson, 2000b). Using the leisure constraints model (Crawford *et al.*, 1991) in a snow skiing context, Hudson (2000b) identified two interpersonal constraints categories that were related to people's perceptions of physical safety: people were 'afraid of injury' and perceived skiing as being 'too dangerous'. The perception that snowsport is dangerous is also confirmed by an Australian study that demonstrated that even active snowsport participants overestimated the risk of injury (Dickson, 2008). Strategically addressing these perceptions requires better understanding of the real physical risks in snowsports, including the types of injuries, factors contributing to injuries, as well as any injury prevention measures, in order to better inform future marketing and visitor safety strategies.

Risk is often construed as having negative outcomes (Eitzinger & Wiedemann, 2007; Sonmez & Graefe, 1998; Williams & Fidgeon, 2000), yet the Australian and New Zealand Risk Management Standard defines risk as 'the chance of something happening that will have an impact on objectives' where the impact may be either positive or negative (Standards Australia and Standards New Zealand, 2004, p. 4). As suggested by Bernstein (1996, p. 12), 'nobody takes a risk with the expectation that it will fail'. How people perceive risks may differ from the actual or objective risk, as measured by injury rates, yet their perception still influences how they behave in response to perceived negative risks. Perceptions may vary as a result of 'differences in values, needs, assumptions, concepts and concerns' (Standards Australia and Standards New Zealand, 2004, p. 11).

Investigating perceptions of risk, fear and safety is not new to tourism research. Previous studies have examined how perceived travel risks may influence travel decisions (Dolnicar, 2005; Roehl & Fesenmaier, 1992; Sonmez & Graefe, 1998). Other tourism researchers have explored the actual rate of death or injury to international tourists while travelling (Bauer *et al.*, 2005; Dickson & Hurrell, 2007; McInnes *et al.*, 2002). Adventure tourism has also developed a stream of research related to injuries that may contribute to improved safety management and more accurate marketing messages (Bentley *et al.*, 2007; Morgan, 2006). International snowsport injury research has been conducted over several decades, but rarely within the context of tourism development and industry sustainability.

Previous international studies of snowsport injuries have explored the:

- types of snowsport injuries (Ekeland *et al.*, 2005; Idzikowski *et al.*, 2000);
- role of protective equipment, such as helmets and wrist guards, in injury prevention (Hagel *et al.*, 2005a, 2005b; Machold *et al.*, 2002; Sulheim *et al.*, 2006);
- impact of the environment and resort design on injuries (Bergstrom & Ekeland, 2004; O'Brien & Frykman, 2003; Sherry & Richards, 1986); and
- development of more effective binding and equipment design upon injury prevention (Natri *et al.*, 1999; St-Onge *et al.*, 2004).

Key findings from this research indicate that:

- the most common skiing injuries are to the knees (Ekeland *et al.*, 2005; Hentschel *et al.*, 2001; Johnson & Ettlinger, 1982);
- wrist injuries are the most common snowboarding injury (Idzikowski *et al.*, 2000; Machold *et al.*, 2000);
- some snowsport injuries, particularly wrist injuries in snowboarders, would benefit from the use of protective equipment such a wrist guards (Machold *et al.*, 2002; O'Neill, 2003); and
- trail design and the effectiveness of grooming of the slopes both influence rates of injury (Bergstrom & Ekeland, 2004).

This international research, driven predominantly by medical and engineering paradigms, is mostly from Europe and North America where snow and snowsports are part of the broader experience of many people, in contrast to the predominance of beaches and warm environments in Australia. The research focus has been upon the equipment and environment, with little consideration of the role of behaviour and social factors in accidents and safety (Reason, 1997; Zhang *et al.*, 2002). While previous research has helped illuminate each of the specific areas explored, less effort has been exerted to integrate this research into a broader sport tourism context. In this context, fear of injury and perceptions that snowsports are dangerous need to be addressed as they limit potential participation levels, and thus restrict enjoyment of the activity by a larger segment of the population, as well as the economic contribution of snowsport tourism to surrounding communities.

Despite this research tradition, few scholars have examined Australian snowsports injuries even though there are more than 200,000 ice and snowsport participants aged over 14 years. Over the last 20 years, only a few Australian studies on snowsport injuries have been published (Bladin & Giddings, 1993; Bladin & McCrory, 1995; Bladin *et al.*, 2004; Schneider, 2003; Sherry & Fenelon, 1991; Sherry & Richards, 1986), none of which consider the relationship with tourism sustainability.

The exploratory study reported here provides a snapshot of the injured population and the types of injuries they sustain. This research explores the range of factors that may play a role in snowsport injuries and thus contributes to a broader understanding of snowsport injuries, the perception of injuries, and the effect of this on snowsports as a social phenomenon. This paper focuses upon the demographics of the injured population, their activity and snowsport experience as well as the mechanism of injury, location within the resort and the use of protective equipment. The results from this study may be used to develop additional research projects as part of a broader snowsport research agenda (Dickson & Ritchie, 2007). This deeper knowledge may assist in developing effective visitor safety strategies, both on and off the snow. More specifically, this information will assist in the creation of effective snowsport visitor safety messages that target a range of behaviours and attitudes towards injury prevention and will influence marketing messages to address non-participants' perceptions of the dangers in snowsports.

Methods

This research was conducted in collaboration with doctors and physiotherapists in the Snowy Mountains of Australia across four of the five medical practices in the region. These practices provide the medical services in two communities that support three snowsport resorts in New South Wales. Together, these resorts represent an estimated 55–60% of all Australian skier days (Australian Ski Areas Association, 2006). All non-critical patients, 18 years or over, who presented to any of the four practices with an injury from an on-snow incident were informed of the research and invited to participate. Respondents completed an anonymous and confidential two-page self-report questionnaire. Completed questionnaires were placed in envelopes and sealed before being returned to the research assistants to maintain confidentiality and to encourage accuracy in reporting. This research was conducted in accordance with the National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Research Involving Humans* and approved by the Committee for Ethics in Human Research at the University of Canberra.

The survey investigated the patients' previous snowsport experience, mechanism of injury, and context of the incident. Events in the previous 24 hours leading up to the injury, such as the injured participants' reports of fatigue, hydration, alcohol consumption and drug taking were investigated, as influence of time of day, social context, and whether glasses or contact lenses were being used by injured skiers. Slips or trips while walking across the car park were excluded, though slips or trips while walking across the slopes were included. Data were collected during the peak period, over 31 consecutive days from early August to early September 2006. As an exploratory study, the statistical methods employed were primarily descriptive with some use of independent samples *t*-tests and chi-squared tests to compare groups.

Several limitations to this study are a result of the research design and the available research funding. The first limitation is that only those people 18 years of age or older were included due to the difficulty in obtaining ethics clearance for working with children, as well as obtaining informed consent from children. In many cases, children are brought into resort-based medical practices by ski patrol and may not have a parent or adult guardian who could provide consent. Using a self-completion questionnaire raises several problems that affect the potential sample as well as the accuracy of results: firstly, not all children (or critical patients) are capable of completing a self-report questionnaire, thus they were excluded from the research. Second, self-reporting may result in a less-accurate diagnosis or affect the reported severity of the injury (Briggs, 1986; Keats, 1993). However, the advantage of self-reporting is that it is substantially cheaper than other methods, and thus a larger sample is possible in the data collection period. While no records were kept of refusals to participate, or the numbers of critical patients, the anecdotal evidence provided by the research assistants was that refusals were minimal. A further limitation is the lack of injury rates; calculating these rates would require estimates of participant numbers during the data collection period. The resorts in the region do not, for commercial reasons, share information on lift ticket sales (or skier days). Additionally, as

respondents could be participating outside in non-lifted activities (such as cross-country skiing), both within and outside the resorts at the time of their injury, resort ticket sales would not necessarily be sufficient to get a precise indication of injury rates.

Results

Demographics

Of the 497 responses, 76.3% of subjects were visiting the area while on holiday, while 16.9% were working in the area for the winter season. The remainder were local residents. As summarized in Table 1, 549 injuries were reported, with an average of 1.1 injuries per person. The age range was 18–83 years ($\bar{x} = 33.36$ years, mode = 21 years) with 45.0% female and 55.0% males. An independent sample *t*-test was conducted to compare the ages of women and men. There was no significant difference in the mean ages between women ($\bar{x} = 33.48$, $\sigma = 13.05$) and men ($\bar{x} = 33.59$, $\sigma = 13.29$; $t(480) = -0.09$, $p = 0.93$). The largest age group was 18–24 years (33.2%), followed by 25–34 years (31.2%), which together accounted for 64.4% of respondents. Alpine skiing was the main activity at the time of the injury (49.3%) followed by snowboarding (46.1%), cross-country skiing (1%), telemarking (0.6%), snow play or snowball fights (0.6%) and tobogganing (0.4%). A further 2.0% indicated they were participating in other on-snow activities, though it is unclear from the responses what these might have included (see also Table 2).

Prior experience in snowsports was grouped into six categories based upon the number of days the respondents had participated in the snowsport activity they were doing at the time of their injury. The six categories included beginners, with up to six days experience, through to experienced participants with more than 16 weeks experience. A total of 60.9% of respondents had either less than 7 days experience (28.1%) or more than 16 weeks experience (32.8%). A chi-squared test exploring the differences between the experience levels in the two main snowsport activities, alpine skiing and snowboarding, indicated a significant difference ($p = 0.009$). For the alpine skiers, the more experienced participants were the largest experience group among the injured (38.8%), while for snowboarders, the beginners (34.8%) constituted the largest group seeking medical care. Without participation data, it is not possible to conclude whether particular activity, age or experience groups are most at risk of injury (Table 1).

Anatomical Location of Injury and Type of Injury

Previous Australian research (Bladin & Giddings, 1993) indicated that the main injury location for alpine skiers is the knee, and for snowboarders the ankle and foot or the knee, though most recent international studies indicate that injuries to wrists are the most frequent injury for snowboarders (Machold *et al.*, 2000; Sutherland *et al.*, 1996). This previous research also highlighted that the predominant types of injuries were

Table 1 Profile of respondents

	Alpine skiing $n = 273$ (54.9%)	Snowboarding $n = 250$ (50.3%)	All snowsport activities* $n = 497$
	% of snowsport activity		
Females ($n = 217$)	50.0%	40.1%	45.4%
18–24 years	13.4%	60.9%	34.1%
25–34 years	23.5%	33.3%	27.6%
35–44 years	22.7%	4.6%	15.2%
45–54 years	23.5%	1.1%	13.4%
55–64 years	16.0%	0.0%	8.8%
65 years and over	0.8%	0.0%	0.9%
Males ($n = 265$)	50.0%	59.9%	55.0%
18–24 years	15.0%	50.4%	32.8%
25–34 years	23.3%	39.1%	32.1%
35–44 years	16.7%	6.8%	12.1%
45–54 years	27.5%	3.8%	15.1%
55–64 years	10.0%	0.0%	4.5%
65 years and over	7.5%	0.0%	3.4%
Total ($n = 497$)			
18–24 years	13.9%	54.1%	33.2%
25–34 years	24.9%	37.6%	31.2%
35–44 years	19.6%	5.7%	13.3%
45–54 years	24.9%	2.6%	13.9%
55–64 years	12.7%	0.0%	6.2%
65 years and over	4.1%	0.0%	2.2%
Snowsport Experience			
Up to 6 days	21.2%	34.8%	28.1%
7–13 days	9.8%	10.6%	10.1%
14–27 days	11.0%	7.5%	9.5%
28 days up to 8 weeks	9.8%	11.9%	10.5%
8–16 weeks	9.4%	8.8%	8.9%
More than 16 weeks	38.8%	26.4%	32.8%
Total	100.0%	100.0%	100.0%

* Includes telemarking, cross country skiing, tobogganing and snow play.

contusions and sprains, which together made up 72% of skiers' and 65% of snowboarders' injuries.

Tables 2 and 3 summarize the types of injury and the top six locations of injury, from a list of 19, as reported by the respondents. Not withstanding the limits of self-reporting, the information on location of injury is telling with the top six injury locations accounting for 65% of all reported injuries. For all respondents, the knee was the main injury location (21.7%), followed by the shoulder (13.3%) and the wrist (11.8%). Looked at from the perspective of the proportion of each injury type sustained by each group, most knee injuries were reported by alpine skiers (75.6%), compared with 20.2% suffered by snowboarders. In contrast, 84.6% of people with wrist injuries were snowboarders, compared with 12.3% of the total contributed by alpine skiers.

Table 2 Type of Injury and Top Six Injury Locations – Percentage of Cases

	n	Alpine skiing *n* = 273	Snowboarding *n* = 250	Other *n* = 26	Total
			% of snowsport activity		
All injuries	549	49.7%	45.5%	4.7%	
Type of injury					
Bruise	55	9.2%	13.5%	11.5%	11.4%
Sprain	292	69.0%	51.8%	3.8%	60.6%
Laceration	23	2.9%	6.8%	46.2%	4.8%
Dislocation	37	9.2%	6.3%	3.8%	7.7%
Fracture	104	13.8%	29.3%	23.1%	21.6%
Other	38	10.0%	5.0%	3.8%	7.9%
			% of injury location		
Location (top 6)					
Knee	119	75.6%	20.2%	1.6%	21.7%
Shoulder	73	56.2%	42.5%	1.4%	13.3%
Wrist	65	12.3%	84.6%	3.0%	11.8%
Lower leg	34	58.8%	32.4%	8.8%	6.2%
Back / spine	33	24.2%	72.7%	3.0%	6.0%
Hand / finger	33	69.7%	27.3%	3.0%	6.0%

The main types of injury reported were sprains (60.6%), followed by fractures (21.6%), bruising (11.4%), dislocations (7.7%) and lacerations (4.8%). Together, bruises and sprains, the least severe injuries, accounted for 72% of reported injuries. Among the more serious injuries, snowboarders reported 63.7% of all fractures ($n = 65$, 28.4%), which is 2.1 times the rate for alpine skiers ($n = 33$, 13.5%). As previously noted, this is self-reported data, so the diagnoses may not be completely accurate.

Lower body injuries

There were 119 reported knee injuries, with 102 identified as a knee sprain (85.7%) (Table 3). Of the 102 knee sprains, 50 (49.0%) were experienced by female alpine skiers and 22 (21.6%) by male alpine skiers. Of the 50 women who experienced knee

Table 3 Location of Injury and Type of Injury – Percent of Cases

	n	Bruise *n* = 55	Sprain *n* = 292	Laceration *n* = 23	Dislocation *n* = 37	Fracture *n* = 104	Other *n* = 38
				% of injury location			
Body location:							
Knee	119	2.5%	85.7%	0.8%	2.5%	0.8%	7.6%
Shoulder	73	1.4%	49.3%	0.0%	32.9%	8.2%	8.2%
Wrist	65	0.0%	32.3%	1.5%	0.0%	61.5%	4.6%
Lower leg	34	11.8%	38.2%	29.4%	0.0%	20.6%	0.0%
Back / spine	33	27.3%	57.6%	0.0%	0.0%	6.1%*	9.1%
Hand / finger	33	6.1%	36.4%	0.0%	21.2%	30.3%	6.1%

sprains, 15 (30% or 14.7% of all knee sprains) had less than 7 days experience and 16 (32% or 15.7% of all knee sprains) had 16 weeks or more experience. Of the 22 males who suffered knee sprains, eight (36.4% or 7.8% of all knee sprains) had less than 7 days experience and nine (40.9% or 8.8% of all knee sprains) had 16 weeks or more experience. Lower leg injuries, below the knee and excluding the foot, were 6.2% of all injuries, with the main diagnosis being a sprain (38.2%). While it would be beneficial to compare these and following results to the broader snowsport population, there is no suitable national data on experience levels to support a comparative analysis.

Upper body injuries

Of the 65 wrist injuries, 61.5% were fractures; of these, 87.5% were snowboarders, who contributed 38.5% of the 104 reported fractures. Of the 35 snowboarders with wrist injuries, 14 (40%) were beginners with less then 7 days experience (females, $n = 9$, males, $n = 5$). In contrast, snowboarders with less than 7 days experience were only 34.8% of all snowboarders, and thus beginners appear over-represented in the wrist fracture data. Sprains were the most commonly reported injury to both shoulders (49.3%) and hands or fingers (36.4%). Back and spinal injuries accounted for 6% of all injuries with the predominant reported injury being a sprain (57.6%).

Resort Location and Mechanism of Injury

As snowsports are conducted on steep and slippery terrain, certain inherent risks cannot be removed. All snowsport resorts have a diversity of terrain and a variety in the amount of grooming and trail preparation. Previous research suggests that trail design and grooming can contribute to snowsport safety (Bergstrom & Ekeland, 2004). Additional fun and challenge are presented to participants through the building of terrain parks and half-pipes; leaving areas ungroomed after fresh snowfalls; and with individuals building their own 'kickers' or jumps out of the snow.

As indicated in Table 4, the predominant location within the resort where injuries occurred was on-piste, that is, on the groomed runs (47.5% of injuries): this location accounted for substantially more injuries than the next most common location or activity, which was going over a 'kicker' or a jump (10.4%). Falling over was the most common mechanism of injury (38.2%), followed by being out of control (10%) and being hit by another person (9.8%). Together, all forms of terrain parks, built jumps or rails, combined, accounted for 13.1% of the locations in which respondents were injured.

Protective Equipment Use

The type of protective equipment that may be used in snowsports includes helmets, wrist guards, knee guards, back and butt protection. Protective equipment may ameliorate the risk or severity of injury (Hagel *et al.*, 2005a, 2005b; Levy *et al.*, 2007;

Table 4 Experience in Snowsport Activity Compared with Resort Location and Mechanism of Injury

		Experience in snowsport activity						
	N	Up to 6 days	7–13 days	14–27 days	28 days up to 8 weeks	8–16 weeks	More than 16 weeks	Total
All who indicated experience	494	28.1%	10.1%	9.5%	10.5%	8.9%	32.8%	100.0%
		% of snowsport activity						
Snowsport activity (top 4)								
Alpine skiing	245	21.2	9.8	11.0	9.8	9.4	38.8	100.0
Snowboarding	227	34.8	10.6	7.5	11.9	8.8	26.4	100.0
Cross country skiing	5	40.0	20.0	20.0	0.0	0.0	20.0	100.0
Telemarking	3	66.7	0.0	0.0	0.0	0.0	33.3	100.0
		% of all						
Resort location								
On piste	229	14.9	3.9	5.4	4.2	3.9	14.9	47.5
Kicker or jump	50	0.4	0.6	0.8	1.2	1.7	5.6	10.4
Off piste	38	0.6	0.8	0.8	1.2	0.2	3.9	7.9
Terrain park	34	0.6	1.2	0.2	1.0	0.8	0.0	7.1
Slopestyle	21	1.2	0.6	0.2	0.2	0.2	1.9	4.4
Halfpipe	6	0.2	0.0	0.2	0.2	0.0	0.6	1.2
Box or rail	2	0.0	0.0	0.0	0.0	0.0	0.4	0.4
Mechanism of injury								
Fell over	184	14.9	5.0	3.7	3.9	2.3	8.3	38.2
Out of control	48	5.8	0.8	0.6	0.6	0.2	1.9	10.0
Hit by someone	47	1.2	0.6	0.4	1.2	1.5	4.8	9.8
Riding or getting off lift	34	2.7	0.0	0.6	0.4	0.8	2.3	7.1
Equipment failure	8	0.2	0.0	0.0	0.2	0.4	0.8	1.7
Hit tree or lift	6	0.2	0.0	0.0	0.4	0.2	0.4	1.2

O'Neill, 2003; Sulheim *et al.*, 2006). As shown in Table 5, 73.2% of all respondents were not wearing any protective equipment at the time of their injury. There is little difference in the rates of protective equipment use between genders, with 74.7% of women and 71.3% of men not wearing any protective equipment. Of note is the difference between the percentage of alpine skiers who do not wear any protective equipment (78.8%) compared with that of snowboarders (65.1%), even though snowboarders may be perceived as the higher risk-takers given that many of them are 18–24 year old males. Snowboarders reported the highest level of helmet use at 18.8%.

From the perspective of snowsport experience, beginners had one of the lowest levels of helmet use of any experience category (7.2%). In contrast, they had the highest rate of wrist guard usage (12.9%). In terms of the location of injury, 83% of those experiencing a head or face injury were not wearing any protective equipment, with only 10% wearing a helmet. This rate is much lower than the 17.1% for all respondents.

Table 5 Protective Equipment Usage

	Valid responses *n*	No protective equipment	Protective equipment used			
			Helmets	Wrist guards	Back/butt protection	Other
Total	497	73.2%	17.1%	7.0%	3.8%	0.8%
Females	217	74.7%	15.7%	6.9%	2.8%	1.5%
Males	265	71.3%	18.5%	7.2%	4.9%	0.4%
Snowsport activity:						
Alpine skiing	245	78.8%	16.7%	0.0%	2.9%	0.4%
Snowboarding	229	65.1%	18.8%	15.3%	5.2%	1.2%
Snowsport experience:						
Up to 6 days	139	76.3%	7.2%	12.9%	2.9%	0.7%
7–13 days	50	78.0%	12.0%	6.0%	0.0%	0.0%
14–27 days	47	87.2%	6.4%	4.3%	0.0%	0.0%
28 days-less 8 weeks	52	78.8%	17.3%	5.8%	3.8%	0.0%
8-less than 16 weeks	44	65.9%	27.3%	9.1%	0.0%	2.3%
16 weeks or more	162	64.8%	27.8%	3.1%	8.0%	1.2%
Specific injuries						
Head/face injury	30	83.3%	10.0%	6.7%	3.3%	N/A
Wrist injury	65	72.3%	15.4%	7.7%	6.2%	N/A
Back/spine injury	33	72.7%	18.2%	9.1%	3.0%	N/A

Of the 34 snowboarders who experienced wrist fractures (Table 6), 29 (85.3%) were not wearing wrist guards (Table 6). Of those 29, 20 had less than 7 days experience snowboarding, or 58.8% of snowboarders with wrist fractures were beginners who did not wear wrist guards.

Social Factors in Injuries

Our survey of injured snowsport participants explored a number of issues affecting the likelihood and severity of injury. Although ascribing a clear cause to an injury is difficult, if not impossible, certain patterns of injury do help us to understand better the

Table 6 Snowboarders' Wrist Injuries and Wrist Guard Usage

		Experience in snowsport activity					
	n	Up to 6 days	7–13 days	14–27 days	28 days up to 8 weeks	8–16 weeks	More than 16 weeks
No wrist guard used							
Sprain	17	5	3	1	2	2	4
Fracture	29	20	4	2	1	2	0
Other	3	0	2	0	1	2	0
Wrist guard used							
Fracture	5	1	0	1	1	1	1

risks to skiers, snowboarders, and other people engaged in snowsports. The following results and discussion focus upon the social factors at the time of the injury.

Time of Injury

The actual time of the injury was recoded into one-hour time-frames, which revealed that 19.6% occurred in the hour from 11 am to noon, followed by 17.4% from noon to 1:00 pm, 14.1% in the hour starting with 10 am, and 13.7% from 3:00 to 4:00 pm.

Fatigue

Respondents were asked to indicate how much sleep they would normally have, to report how much sleep they had had in the 24 hours before their injury, and to rate the quality of that sleep on a four-point Likert scale. The normal sleep patterns ranged from four to 11 hours, with a mean of 7.57 hours and a mode of eight hours. In the 24 hours prior to the injury, respondents indicated that they had slept from between one and 16 hours, with a mean of 7.40 hours and a mode of eight hours. Most indicated that the quality of sleep was good (44.0%), followed by fair (30.3%), poor (13.1%) and excellent (12.7%).

The difference from normal sleep ranged from −9.0 hours to +8.0 hours with a mean of −0.187 hours (11.2 minutes). The groups with the greatest sleep deficit were those with seven to 13 days experience (mean = −0.48 hours), less than seven days experience (mean = −0.39 hours) and those with 14 to 27 days experience (mean = −0.33 hours). The experience group most likely to sleep more than normal were those people with more than 16 weeks experience (mean = +0.12 hours). Grouping by activity and experience levels indicated that snowboarders with seven to 13 days experience had the greatest sleep deficit ($n = 24$, mean = −0.71 hours) followed by snowboarders with less than seven days experience ($n = 77$, mean = −0.55 hours) and alpine skiers with 14 to 27 days experience ($n = 26$, mean = −0.42 hours). When categorised by snowsport activity, age and gender, those groups with the greatest sleep deficit were: 18- to 24-year-old male snowboarders ($n = 67$, mean = −0.66 hours); 18- to 24-year-old female snowboarders ($n = 50$, mean = −0.54 hours); 25- to 34-year-old female alpine skiers ($n = 26$, mean = −0.46 hours); and 18- to 24-year-old male alpine skiers ($n = 17$, mean = −0.32 hours).

Hydration and Alcohol

Hydration was investigated by asking respondents to indicate fluid intake in the 24 hours prior to their injury. Intake was explored across three categories: alcohol, caffeinated drinks including coffee, tea, energy drinks and soft drinks, and other fluids such as water and milk. Charts showing the number of standard drinks for different types of alcohol were provided to aid calculation. Secondly, respondents were asked to indicate whether their fluid intake for each category was different from their normal intake.

The number of standard alcoholic drinks consumed in the previous 24 hours ranged from nil ($n = 129$) to 24 ($n = 2$) with a mean of 3.1 and mode of nil. For 36.3%, their alcohol intake was more than normal while 48.4% indicated that it was normal. Of those who indicated that they had drunk more alcohol than normal, 15.1% drank ten or more standard alcoholic drinks; 59.8% were alpine skiers and 37.6% were snowboarders; 29.9% had less than seven days experience and 32.5% had more than sixteen weeks experience; and 60.5% were males.

The total intake of caffeinated drinks ranged from nil to 12 litres with a mean of 1.7 litres and a mode of two litres. For 77.0% this was a normal intake of caffeinated drinks while for 15.1% this was less than normal. For other fluids, the range was from nil to 20 litres, with a mean of 4.9 litres and a mode of two litres. For 72%, this was their normal level of other fluids, while 17.1% indicated that it was less than normal.

An independent samples *t*-test was conducted to compare the quantity of alcohol, caffeinated drinks (e.g. tea, coffee, cola) and other drinks (e.g. water) consumed by alpine skiers and snowboarders. There was a significant difference in consumption of alcohol for alpine skiers ($\bar{x} = 2.59$, σ=3.155) and snowboarders ($\bar{x} = 3.65$, $\sigma = 4.544$; $t(338) = -2.718$, $p = 0.007$) and caffeinated drinks for alpine skiers ($\bar{x} = 1.97$, $\sigma = 1.519$) and snowboarders ($\bar{x} = 1.40$, $\sigma = 1.507$; $t(411) = 3.864$, $p = 0.000$), but no significant difference in the consumption of other drinks.

Nutrition and Recent Meals or Snacks

Nutrition during the previous week was self-assessed against a four-point Likert scale from poor to excellent. To assist, meal suggestions were provided to indicate what might be considered poor, fair, good or excellent nutrition. Respondents were also asked to indicate the time when they last had had a meal or snack. Fifty-eight percent indicated that their nutrition was good, 24.2% excellent, 16% fair and 1.8% poor. The time since the respondent had a meal or snack prior the injury ranged from 30 minutes to 14 hours, with a mean of 3.08 hours, and a mode of 3.0 hours. Of those people injured between 11 am and noon, 72.9% had not eaten for three or more hours, while 71.6% of those injured between noon and 1 pm had not eaten for the same period.

Drugs

The use of drugs such as marijuana, heroin and ecstasy was investigated by asking if people had used those drugs, or others in the previous 24 hours, and if so, was the amount used normal for them. Of the 403 who responded to these questions, 3% ($n = 14$) indicated that they had used marijuana, 0.4% had used ecstasy and no one reported using heroin. A further 0.2% indicated using cocaine and 0.4% used speed. Of the 14 who used marijuana, six indicated that they had used more than normal, and four (0.8% of all) reported both using more marijuana than usual and drinking more alcohol than usual.

Fitness

Fitness was self-assessed on a four-point Likert scale ranging from poor to excellent. Only 2% indicated that they had a poor level of fitness, 27.4% indicated a fair fitness level, 54.4% claimed to have a good fitness level and 16.1% suggested that they had an excellent fitness level.

Social Context

Of the 497 people who were surveyed, 95 (19.1%) indicted that they were alone at the time of their injury; 258 were with friends (51.9%), 124 (25%) with family members and 48 (9.7%) with others, which could included fellow workers or school groups or within a lesson. The number of friends with the respondent at the time of the injury ranged from one to 30, with a mean of 3.0 and a mode of one. The number of family members ranged from one to 12, with a mean of 1.8 and a mode of one. The number of others ranged from one to 24 with a mean of 4.5 and also a mode of one.

Corrective Eye Wear

Of the 157 injured participants who needed glasses or contacts for long distance vision (31.6% of all), 71 (45.2%, or 14.3% of all) indicated they were not wearing them at the time of their injury. Of those 71, 45.1% were alpine skiers and 50.7% snowboarders; 31% had less than 7 days snowsport experience, and 23.9% had more than 16 weeks experience; 39.4% were aged 18–24 years, 28.2% were from 25 to 34 years; 43.5% females, 56.5% were males. The largest sub-group was female snowboarders with less than 7 days experience ($n = 9$, or 12.7% of those not wearing glasses).

Discussion

While the focus of this research has been upon snowsport participants as tourists, the fact that 16.9% of those injured were in the Snowy Mountains area to work for the season highlights a human resource management issue for an industry that is already facing skill shortages and the demands of seasonal employment. While it is not possible to determine from these data whether people were working at the time of their injury, for example, as instructors and lift operators, the possibility that the data include a number of workplace injuries would also raise issues related to occupational health and safety (OHS). For example, the relevant OHS legislation where this study was conducted stipulates that:

> An employer must ensure the health, safety and welfare at work of all the employees of the employer, [and that] an employer must ensure that people (other than the employees of the employer) are not exposed to risks to their health or safety arising from the conduct of the employer's undertaking while they are at the employer's place of work. (New South Wales Government, 2000)

Although limited accurate participation data prevent calculating injury rates (Dickson *et al.*, 2006), some comparison with general patterns in the data can suggest trends. For example, data in an annual exercise and sport participation study consistently shows that the average proportion of women (15 years and over) consistently make up 33% of the participants in ice and snowsports over five years (this includes ice skating and ice hockey along with skiing and snowboarding) (Australian Sports Commission, 2000, 2004, 2005, and 2007). With 45% of injuries in this study being reported by women, they may be over-represented in the injured population presented here. Further investigation is needed to explore whether this apparent discrepancy is a result of an anomaly in participation rates, whether women are more likely to report a non-critical injury than men, or whether women, in fact, have a higher injury rate than men in snowsports. This may require conducting a case control study in the future.

With the large proportion of injuries occurring to novice snowboarders and the groups of alpine skiers with the most experience, these may be two important target groups for future snowsport safety messages. With snowboarders having the higher proportion of fractures, most of which are to their wrists, further efforts needs to be made both to understand the mechanism of injury and also to better inform people of injury prevention strategies. Knees, shoulders and wrists remain the most prevalent location of all snowsport injuries, with falling over, being out of control and being hit by someone else the main catalysts for these injuries. Again, further exploring the mechanisms of injury, including the role of equipment design and maintenance, participant skill and fitness, hydration and fatigue will help inform future snowsport safety strategies.

The low levels of protective equipment usage among the injured respondents show that current safety messages promoting its use may not be effective. Future campaigns need to be informed by research exploring areas such as, risk-taking behaviours, attitudes towards equipment use and motives for disregarding safety messages. This may also include exploring sub-cultural effects among snowsport participants, role modelling, and transference of safety attitudes from other sport and recreation pursuits.

The results presented here from the 497 responses raise further questions about snowsport injury rates and injury prevention given the large proportion of both beginner and experienced participants and the apparent over-representation of women in the data. Further investigation of the behaviours and attitudes towards snowsport safety of participants, including the use of protective equipment, will assist in the development of effective snowsport safety strategies. These strategies will also be better shaped by exploring the main mechanisms of injury, particularly falling over, and the potential influence of others factors such as equipment design and maintenance; participant skill and fitness; and the role of fatigue and hydration on injury risk. For example, the discrepancy in the skill levels of those injured while snowboarding and alpine skiing may point to differing injury mechanisms, with safety messages needing to target over-confident experienced alpine skiers and focusing on the need to improve participants' skill levels or awareness of implicit 'rules of the slope' in snowboarding.

Social Factors

The results of this study highlight other issues that might be addressed in safety campaigns. For example, with 51.1% of accidents occurring between 10 am and 1 pm, future research should explore the combined effect of fatigue and low blood sugar on injury risks. These factors may be even more significant given that the mean time since the injured person last ate a meal or snack was more than three hours. Fatigue may have been exacerbated by the fact that injured participants were often sleeping less even though they were probably exercising more than usual. As the younger snowboarders are most likely to sleep less, along with the youngest alpine skiers, this provides a target group for a fatigue-oriented snowsport safety message.

Fatigue can also be compounded by dehydration, which will affect a person's performance. Maintaining hydration in a cold environment where on-snow facilities may be limited, can be a severe challenge (Seifert *et al.*, 2006). Even though people were exercising at altitude, they had not increased their intake of fluids, which may help with hydration, and one in three were drinking more alcohol than normal, which would add to any dehydration. In the context of demanding physical activity, dehydration clearly might contribute to the likelihood of injury.

While self-reported use of drugs in the 24 hours before the injury was lower than expected, the fact that some people were using multiple illegal drugs as well as drinking more than usual raises concerns about their potential behaviours on the slopes. In addition, we do not know if drug use or intoxication among other skiers who did not present at the clinics were contributing to injuries, such as through on-slope collisions.

Fitness levels were generally rated as good or excellent, but a question exists as to whether participants' fitness regimes were appropriate for the activity they were undertaking.

In terms of social context, many of the accidents were primarily in smaller groups of about two people; less than 20% of snowsport participants were alone when they were injured. What cannot be explored here was whether there was any impact of the social group upon the risk-taking behaviour of the injured participants, their alertness to slope conditions, or the likelihood of distraction.

The final area considered was that of corrective eyewear. With 14% of all injuries involving people who need corrective eyewear for distance vision and who were not wearing their glasses or contacts at the time of injury, this is an area for further exploration. Questions that need further consideration include: were they able to see changes in the terrain? And did they not wear their corrective eyewear as their goggles didn't fit over them? If incompatibility of goggles with corrective eyewear is a persistent problem, then making specialised equipment available might be one way to diminish the incidence of injury.

As noted in the outdoor literature, it is the interrelationship between contributing factors that increases the likelihood of people being injured. Thus, the combination of low experience levels, along with poor sleep and dehydration, may raise the risk of injury quite substantially, as could the impact of alcohol or not wearing corrective eyewear.

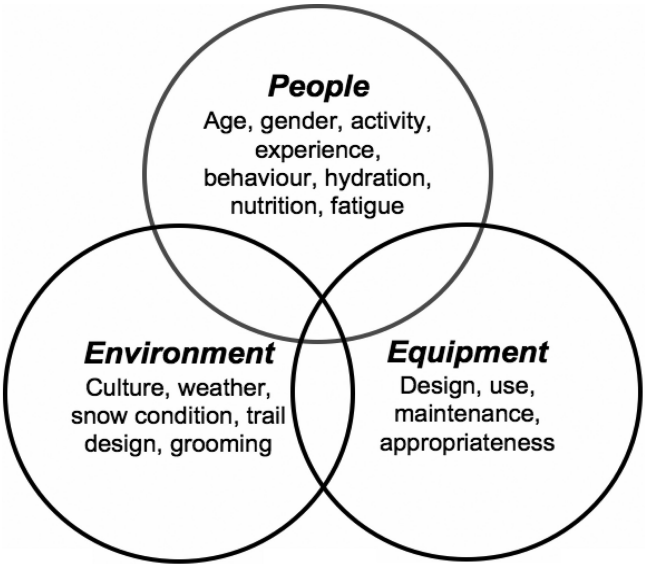

Figure 1 Snowsport Injury Research Framework Adapted from Haddock (2004).

What this research points to is the need for a broader holistic research approach to snowsport safety that addresses all factors that might contribute to snowsport injuries. Figure 1 presents a suggested research framework drawing upon a model used in outdoor risk management literature which also suggests the need to consider the interactions between risk factors (Haddock, 2004). In the snowsport context, *people* includes general demographic factors such as age and gender, but also activity-specific variables such as snowsport experience, hydration levels, nutrition and fatigue. This category may be extended to incorporate the choices and decisions a person makes as part of their participation (Meyer & Williamson, 2003). *Equipment* covers all aspects of the equipment in use (e.g. clothing, boots, skis and lifts), such as design, maintenance, use, as well as the appropriateness of the equipment to the person and situation. Finally, *environment* can be considered not only the physical environment, both natural and man-made, but also the cultural context of the activity, including such elements as the media, sub-cultural values, and interactions on the snow.

Conclusion

Snowsport tourism is a major economic contributor in regional Australia. With the threat of climate change and the impact of regional overseas snowsport competitors, the snowsport industry is facing the prospect of a difficult future. With the participation rate for people over the age of 14 years estimated at only 1.4% of the total population, substantial opportunities to grow the industry exist if barriers to participation are effectively managed. Perceiving snowsports as dangerous and fearing injury is one obstacle to some people participating. Thus, exploring ways both to reduce the actual injuries and to influence people's perceptions of snowsport injury is important for

those concerned about the safety of people participating in Australian snowsports, as well as for those seeking to grow the Australian snowsport industry.

While it is not possible to generalise from this data to the broader population, this study helps to illuminate the extent and nature of snowsports injuries in the Australian context. The key findings of this research and the implications for future research and practice are as follows.

- The majority of reported injuries were of low severity, either sprains or bruises.
- Beginners were least likely to wear protective equipment, yet appear to be most at risk of injury. Thus, they should be clearly informed of the risk of injury and the value of wearing protective equipment. This also has implications for equipment rental facilities in terms of what they stock and how they package their rental products. For example, rental packages could be discounted for participants who agree to wear protective equipment.
- Although public perception may be that young men are most likely to engage in risk-taking behaviour, women may disproportionately be presenting with injuries at clinics in Australian snowsport resorts. Safety strategies specifically tailored to women will need to take into account a better understanding of the mechanisms that most often lead to their injury.
- Future visitor safety strategies should focus upon those groups who form the greatest proportion of reported injuries, both beginners and experienced participants, and focus differentiated messages and tactics on each group depending upon their attitudes, behaviours, and predominant injury mechanisms.
- Skiers have the highest number of knee injuries and snowboarders the most wrist injuries; these remain two important activity groups and injury locations to focus and evaluate future snowsport safety efforts.
- Future snowsport injury research would benefit from having accurate data in areas such as participation levels (for all ages), gender splits, age distribution, experience levels in snowsport, and preferred snowsport activities.

As an exploratory study, this research provides insights into snowsport injuries in the main snowsport region of Australia, generating a range of future research questions. From this research, further studies may emerge to explore injury rates as well as investigating how changing visitor safety messages may affect the rates, types and severity of injury in different participant groups. Additionally, from the perspective of participation and growth of the snowsport industry, this research suggests that marketing messages may influence people's fear of injury and perceptions of snowsports as being dangerous. Understanding the factors that contribute to injury may allow the snowsport tourism industry to better prevent injuries and also to better inform the public about the actual risks present in snowsports.

While it is not possible to conclude from this research whether any of these factors have specifically contributed to the actual injury rate or severity, this study does bring to the fore a wider range of variables than those normally considered when investigating factors that contribute to snowsport injuries and highlights a number of

unanticipated patterns in the data from Australia. These results suggest focus areas for future snowsport safety messages and snowsport injury research.

Three key foci for snowsport safety messages suggested by this study are:

- encourage people to be well rested for their snowsport activity;
- encourage proper hydration and nutrition suitable for exercising for prolonged periods at altitude in cold climates; and
- highlight the importance of wearing corrective eyewear while participating in snowsport activities.

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