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This edition of Hazard provides an overview of fatal and hospital-treated injuries in snow and ice sports in Victoria over the 3-year period January 2004 to December 2006. The National Coroners Information System (NCIS) provided data on fatalities and hospital-treated cases were extracted from two datasets held by VISU: the Victorian Admitted Episode Dataset (VAED) and the Victorian Emergency Minimum Dataset (VEMD). Recommended preventive measures should be considered for implementation in the 2008 season.

Injury in snow and ice sports

Karen Ashby & Erin Cassell

Summary

Injury in snow sports

Over the study period, there were 2 deaths related to skiing and 817 hospital admissions and 587 emergency department presentations (non-admissions) for injuries related to snow sports.

- The two fatalities occurred in downhill skiing. Both deaths were due to head injuries that occurred when the skier lost control and collided with a tree lining the slope.
- Among hospital admissions there were more injured skiers (62%, n=504) than snowboarders (32%, n=264), whereas among ED presentations (non-admissions) there were more injured snowboarders (58%, n=340) than skiers (37%, n=218).
- A small proportion (5%) of snow sports hospital admissions and ED presentations were for injuries that occurred in tobogganing.
- Two-thirds of hospital-treated snow sports injury cases were males.
- 46% of snow sports hospital admissions and 61% of ED presentations (non-admissions) were aged 15-29 years.
- Falls caused approximately three-quarters of hospital-treated snow sports injuries. Around 8% of injuries were caused by collisions with objects (tree, log, ski lift etc.) and 3% by collisions with another person (a skier, snowboarder or bystander).
- Among admissions, the lower limb, particularly the knee/lower leg, was the most commonly injured body site accounting for 41% of cases. Among ED presentations the most frequently injured body site was the upper limb (46%), mostly involving the wrist and shoulder.
- More than half (53%) of admissions were fracture cases, most commonly to the lower leg (27% of fractures) and forearm/wrist (23%). Sprains/strains were the most common injury among ED presentations (36%), followed closely by fractures (32%).
- The most common specific serious injury in skiers was knee dislocation (25%), followed by tibial fracture (20%) and intracranial injury (8%, mostly concussion).
- The most common specific serious injuries in snowboarders were: forearm/wrist fracture (27%), lower leg fracture (11%) and intracranial injury (9%, mostly concussion)

The full injury profile of skiers, snowboarders and tobogganers are presented separately in the report.

A separate article on ***Injury in ice sports*** covering ice skating, ice hockey and sledding is included in this *Hazard* issue, starting page 14.

Preventive measures with fair-to-good research evidence supporting their effectiveness are: helmet wearing (for skiers and snowboarders); wristguard use (for snowboarders); falls training for advanced skiers; and identification (mapping) and treatment of injury blackspots on slopes/trails.

Other measures recommended by researchers/experts that should be implemented with a strong evaluation component are: pre-season conditioning programs for skiers and snowboarders that focus on the physical attributes needed for the specific sport; skier safety education and skills training; speed and collision control measures on slopes; separation of skiers and snowboarders and beginners/novices from other slope users; interventions that support careful progression from easier to harder runs by novice participants based on skills development; identification and mitigation of environmental hazards by resort/park operators; regular grooming of slopes; and the provision of active and well-trained ski patrollers who have a high level of training in first aid. Research should concentrate on improving ski boot and ski pole design and ski binding design to reduce ACL injury in skiing.

Common sense dictates that skiers and snowboarders should wear appropriate clothing and protective equipment including eyewear and sun protection, pay careful attention to their nutrition and hydration needs, abstain from or limit their alcohol intake and take a snow safety course, especially if intending to ski or snowboard in unpatrolled areas.

Injury in snow sports

Introduction

Skiing and snowboarding are physically demanding sports that require strength, flexibility, endurance, fitness, good anticipation and reflexes. The participant, their equipment and the environment all contribute to the occurrence of injury.

This edition of *Hazard* provides an overview of unintentional fatal and non-fatal injuries in snow sports utilising data from the National Coroners Information System (NCIS) and the Victorian hospital-based injury surveillance datasets (the Victorian Admitted Episodes Dataset and the Victorian Emergency Minimum Dataset). Activities covered by this report include snow skiing (alpine, Nordic, cross country, aerial and ski jumping), snowboarding and tobogganing. Other snow activities such as snowmobiling, and curling were included in the search criteria but only one relevant case (an injury to a snowmobiler) was identified.

Injury in ice sports is covered in a separate article starting on page 14.

Method

Data on deaths registered by the Victorian Coroners Office over the period January 2004-December 2006 were extracted from the National Coroner's Information System.

Non-fatal injury data were extracted from two hospital datasets held by VISU:

- Victorian Admitted Episodes Dataset (VAED) – Victorian public and private hospital injury admissions (January 2004 to December 2006); and
- Victorian Emergency Minimum Dataset (VEMD) – Victorian public hospital emergency department (ED) injury presentations (January 2004 to December 2006)

Analysis of VAED and VEMD data indicate that 79-89% of hospital-treated injuries for snow sport and recreation activities occur in a 3-month period from July to September (inclusive).

The method for extracting data is described in Box 1 (page 18).

Fatal skiing injury case scenarios, Victoria, January 2004 to December 2006 (n=2) **Table 1**

Activity	Scenario
Skiing	• *Deceased male aged in his 30s fell while downhill skiing on an out-of-bounds track, and collided with a tree.* • *Downhill skiing death - under investigation by the Coroner.*

Results

Deaths

Fatality data were extracted from the NCIS database for the 3-year period January 2004 to December 2006. In 2005, within a 10-day period, there were two fatalities directly related to snow sports participation. Both skiers died from head injuries that occurred when the skier lost control and collided with a tree lining the slope. The cause of death of one of the skiers (a 12 year-old boy) is from newspaper reports and is not confirmed as the case is still under investigation by the Coroner.

Hospital-treated injury

Over the 3-year period January 2004 to December 2006, there were 1,404 hospital-treated snow sports injuries, 817 hospital admissions and 587 ED presentations (non-admissions). ED presentations are underestimated because none of the small rural hospitals in the immediate vicinity of the snowfields contribute data to the VEMD, whereas the VAED covers all public and private hospitals.

In table 2 the pattern of injury for admissions and ED presentations (non-admissions) are compared. The different types of skiing (downhill, cross country etc.) were not well specified in the data so a breakdown of skiing cases is not included.

- Overall, two-thirds of hospital-treated snow sports injury cases were males.
- 46% of admissions and 61% of ED presentations (non-admissions) were aged 15-29 years.
- Most snow sports hospital admissions were for skiing injuries (62%). By contrast, non-admitted ED presentations were most commonly snowboarding injuries (58%).
- Approximately three-quarters of hospital-treated injuries (admissions and non-admitted ED presentations) were caused by falls. A further 8% of injuries were caused by collisions with objects and 3% by collisions with another person i.e. a skier, snowboarder or bystander.

- Among admissions, the lower limb (particularly the knee/lower leg) was the most commonly injured body site accounting for 41% of cases. By contrast, among ED presentations injuries to the upper limb, mostly to the wrist and shoulder, were most common (46%).
- More than half (53%) of admissions were fracture cases, most commonly lower leg fracture (27%) and forearm/wrist fracture (23%). Sprains and strains were the most common injury among ED presentations (36%), followed closely by fractures (32%).

Hospital admissions (n = 817)

Frequency

Over the 3-year study period, there were 817 hospital admissions for snow sports injuries. The frequency of cases declined from 360 in 2004 to 273 in 2005 and further to 184 in 2006. These figures are related to the amount of snow cover in each season. Almost two-thirds of admitted cases occurred in skiing, mostly alpine, a further 32% in snowboarding and 5% in tobogganing. The pattern of injury among hospital admissions is summarised in table 2.

Gender and age

Figure 1 shows injury frequency by gender and age group. The highest injury frequencies were observed among male adolescents and young adults in the 5-year age groups from age 15-19 to 30-34 years. Participation and exposure (time-at-risk) data are not available so rates cannot be calculated.

The major causes (mechanisms), body sites injured and the nature of injury are shown in Table 2.

Causes of injury

Most injuries (72%) were fall-related.

Nature and site of injury

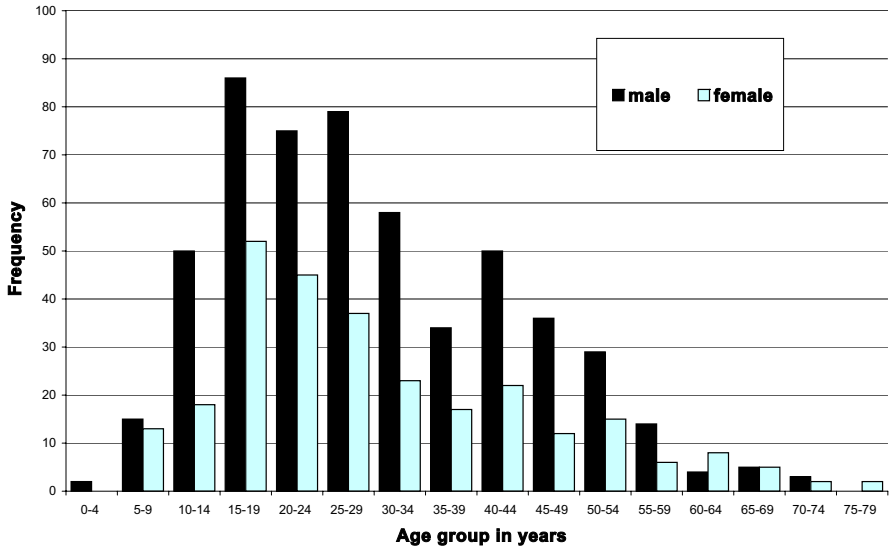
Fractures were the most common injury accounting for 53% of admissions, followed by dislocation/sprain/strains (22%). Fractures were most frequently to the tibia/fibula (27% of fractures) and forearm/wrist (23%). Intracranial injuries accounted for 8% of admissions. The lower extremity was the most frequently injured body site (41%), followed by the upper extremity (30%).

Pattern of hospital-treated snow sports injury, Victoria January 2004 to December 2006 **Table 2**

	Pattern of snow sports injury	
Characteristics	Admissions (VAED) **N = 817**	Presentations (VEMD) **N = 587**
Gender	• male (66%) • female (34%)	• male (67%) • female (32%) • missing gender (1%)
Age group in years	• 0-14 (12%) • 15-29 (46%) • 30-44 (25%) • 45-59 (14%) • 60+ (3%)	• 0-14 (10%) • 15-29 (61%) • 30-44 (23%) • 45-59 (5%) • 60+ (1%)
Activity	• Snow skiing {**62%** mostly alpine/downhill (39%)} • Snowboarding (32%) • Tobogganing (5%) • Snowmobiling (<1%) • Other/unspecified (<1%)	• Snowboarding (58%) • Snow skiing (37%) • Tobogganing (5%)
Cause	♦ Fall (72%) ♦ Hit/struck/crush object (8%) ♦ Collision with person (3%) ♦ Transport (1%) ♦ Other/unspecified (16%)	• Falls (79%) • Struck by/collision with object (7%) • Struck by/collision with person (2%) • Transport (2%) • Other/unspecified (10%)
Body site injured	• Lower extremity {**41%,** mostly knee/ lower leg (88%)} • Upper extremity {**30%:** mostly forearm/wrist (42%) shoulder/ upper arm (39%) • Head, face and neck {16%, mostly head (78%)} • Trunk (12%) • Other/unspecified (1%)	• Upper extremity {**46%,** mostly forearm/wrist (48%), shoulder (22%) and hand/fingers (18%)} • Lower extremity {**30%,** mostly knee (49%) and ankle (31%)} • Trunk (14%) • Head, face and neck (4%) • Other/unspecified (6%)
Nature of injury	– Fractures {**53%**, mostly tibia/fibula (27%), forearm (21%)} – Dislocation/sprain/strain (22%) – Intracranial injury (8%) – Muscle/tendon injury (3%) – Injury to internal organ (2%) – Open wound (2%) – Other/unspecified (10%)	♦ Sprain/strain {**36%** mostly knee (26%), wrist (17%) and ankle (16%)} ♦ Fracture {**32%,** mostly wrist (26%), hand/fingers (14%), forearm (11%) and thorax (10%)} ♦ Muscle/tendon injury (9%) ♦ Superficial (6%) ♦ Open wound (3%) ♦ Dislocation (2%) ♦ Intracranial injury (2%) ♦ Other/unspecified (10%)

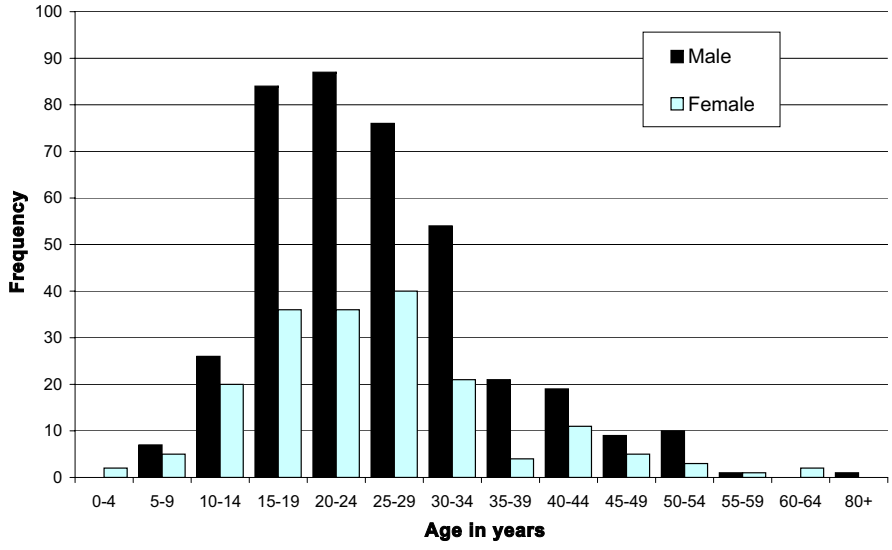
Source: Hospital admissions: Victorian Admitted Episodes Dataset (VAED)
Hospital emergency department presentations (non-admissions): Victorian Emergency Minimum Dataset (VEMD)

Frequency of snow sport hospital admissions by age and gender: Victoria, January 2004 to December 2006 (n=817) **Figure 1**



Source: Victorian Admitted Dataset (VAED), January 2004 to December 2006

Frequency of snow sport and recreation injury ED presentations (non-admissions): Victoria, January 2004 to December 2006 (n= 587) **Figure 2**



Source: Victorian Emergency Minimum Dataset (VEMD) January 2004 to December 2006

Length of hospital stay

Fifty-nine percent of cases stayed in hospital less than 2 days, 36% stayed 2-7 days and 4% stayed 8-30 days. Three cases had longer stays: 61 days for a pelvic injury, 64 days for an intracranial injury and 105 days for an injury to the cervical spine.

Comparison of length of hospital stay of snow sports cases compared with other sports injuries

Hospital stays for snow sports injuries tend to be longer than stays for other sports injuries. Forty percent of snow sport admissions stayed in hospital 2 or more days compared with 28% of all admitted sports injury cases. The average length of stay for a snow sport injury was 2.5 days (SD 5.2, range 1-105), compared with 1.7 days for all sports injuries (SD 5.0, range 0-296).

Emergency Department presentations, non-admissions (n = 587)

The VEMD grossly underestimates the true size of the problem of snow sports injuries requiring ED treatment for two reasons. First, private hospitals and eleven public hospitals that together contributed 51% (n=414) of the snow sport injury cases recorded on the VAED do not participate in the VEMD collection. Second, cases were identified through word searching the case narratives, as there are no sports activity codes on the dataset. The quality of narratives varies between hospitals. These shortcomings of the VEMD give rise to the possibility of bias and caution should be taken when interpreting these results.

Frequency

Over the 3-year period (2004-2006), 587 snow sports ED presentations (non-admissions) were recorded by the 37 VEMD participating hospitals: 251 in 2004; 204 in 2005; and 132 cases in 2006.

More than half of the ED presentations (58%) were for injuries that occurred in snow-boarding and a further 37% in snow skiing.

Table 2 summarises the overall patterns of injury among ED presentations.

Gender and age

Figure 2 shows the age and gender breakdown for snow sports ED presentations (non-admissions) based on frequency data. Males were over-represented in all 5-year age groups between the ages of 5 and 54 years. At ages 0-4 and 60-64 there were no recorded injuries to males and at 80+ there were no female cases.

Causes of injury

Falls (79%) and collisions (9%) were the major causes of injury.

Specific injury types

The most common specific injuries were knee sprains and strains (9% of all snow sport and recreation injury ED presentations), forearm/wrist fracture (12%), forearm/wrist sprains/strains (7%) and ankle sprains/strains (6%).

The highest ranked snow sport and recreation activities for injury

The next section provides an analysis of the data on the 3 leading snow sports for injury. The analysis includes VAED admissions and VEMD presentations (non-admissions) data. Ranking is based on frequency data. Table 4 shows the highest ranked snow sports for injury.

Hospital admissions for snow sport and recreation injuries by activity and length of hospital stay: Victoria, January 2004 to December 2006 **Table 3**

	Length of stay (days)								Total	
	<2 days		2-7 days		8-30 days		31+ days			
	N	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Snow skiing	287	*57*	191	*38*	24	*5*	2	*<1*	504	*100*
Snowboarding	175	*66*	81	*31*	7	*3*	1	*<1*	264	*100*
Tobogganing	20	*47*	20	*47*	3	*6*	0	*0*	43	*100*
Snowmobiling	0	*0*	3	*100*	0	*0*	0	*0*	3	*100*
Other	1	*33*	2	*67*	0	*0*	0	*0*	3	*100*
Total	**483**	*59*	**297**	*36*	**34**	*4*	**3**	*<1*	**817**	*100*

Source: Victorian Admitted Dataset (VAED) January 2004 to December 2006

Snow sport and recreation activities most associated with injury **Table 4**

	Deaths N	Hospital Admissions N	ED presentations N
• Skiing	2	504	218
• Snowboarding	-	264	340
• Tobogganing	-	43	29

Source: Deaths: National Coroners Information System (NCIS), Hospital admissions: Victorian Admitted Dataset (VAED) and Hospital emergency department presentations (non-admissions): Victorian Emergency Minimum Dataset (VEMD), January 2004 to December 2006

Skiing injury

Over the 3-year study period, there were 2 skiing-related deaths and 722 hospital-treated skiing injuries (504 admissions and 218 ED presentations). Males accounted for 62% of admissions and 58% of presentations. As shown in Figure 3 both admissions and presentations peaked among persons aged 15-19 years (19% of admissions and 15% of ED presentations).

Deaths (n = 2)

As previously described there were two downhill skiing related deaths over the 3-year study period. The first was a male experienced skier aged in this 30s who crashed into a tree at speed whilst skiing and sustained fatal head injuries. The deceased was not wearing a helmet. The second case is still under coronial investigation. Newspaper reports indicate he also died from head injuries caused by a collision with a tree.

Hospital admissions (n = 504, annual average frequency = 168)

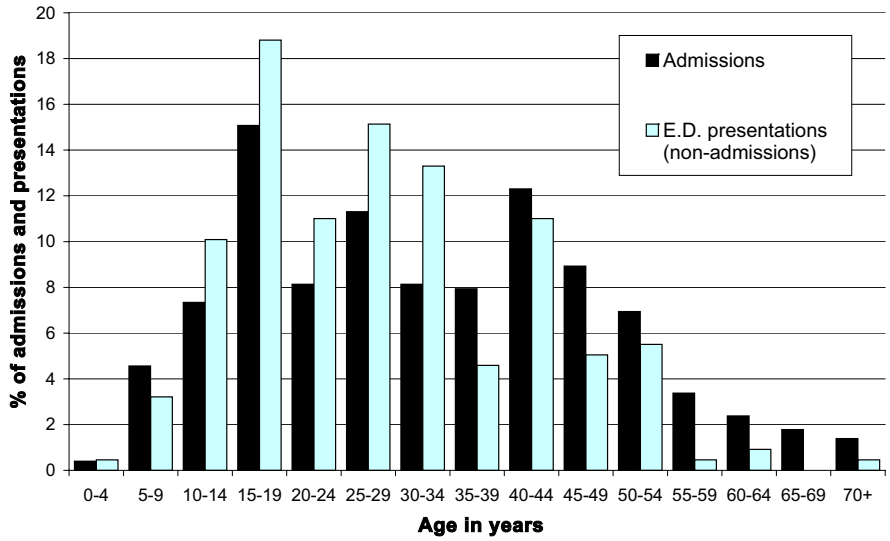
Skiing accounted for 62% of hospital admissions for injuries related to snow sports. There were 504 skiing-related admissions, 220 were recorded in 2004, 175 in 2005 and 109 in 2006. The decrease in cases is related to the snow cover in each season which affects participation. Of cases that specified the type of skiing involved (n=221), 89% occurred in alpine/downhill skiing, 7% in ski jumping and 4% in cross country skiing.

The lower extremity was the most frequently injured body site (53%), followed by the upper extremity (22%) and head/face (15%). Fractures accounted for 46% of admissions and dislocations/sprains/strains a further 31%. The most common specific injuries were knee dislocations (25%), tibial fractures (20%) and intracranial injury (8%).

Fifty-seven percent of skiing injury cases were admitted to hospital for less than 2 days, 38% stayed 2-7 days and 5% stayed 8-30 days. Two injured skiers had hospital stays in excess of 31 days; one suffered spinal cord and cervical spine injuries and the other a major head injury.

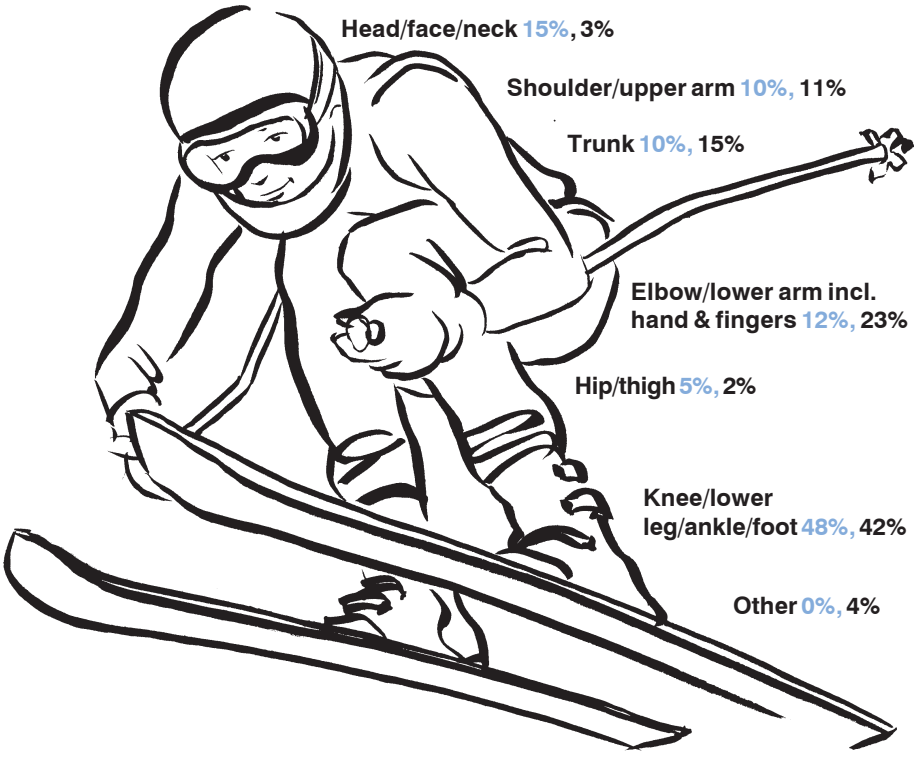
Most snow skiing admissions (67%) were caused by falls. The VAED coding provides no further detail on the circumstances of the injury. Analysis of case narrative data for

Skiing injury (admissions and ED presentations – non admissions) by age group: Victoria, January 2004 to December 2006 (*n*=722) **Figure 3**



Source: Victorian Admitted Dataset (VAED) and Victorian Emergency Minimum Dataset (VEMD) January 2004 to December 2006

Skiing injury by body site – admissions and ED presentations (non-admissions) **Figure 4**



Source: Admissions - VAED January 2004 to December 2006
Presentations - VEMD January 2004 to December 2006

admissions recorded on the VEMD (n=53), provided sparse detail. Only six cases provided information on the circumstances of the injury. In 3 cases the skiers were injured when they hit trees and in the other cases the skier was injured when he/she collided with another skier.

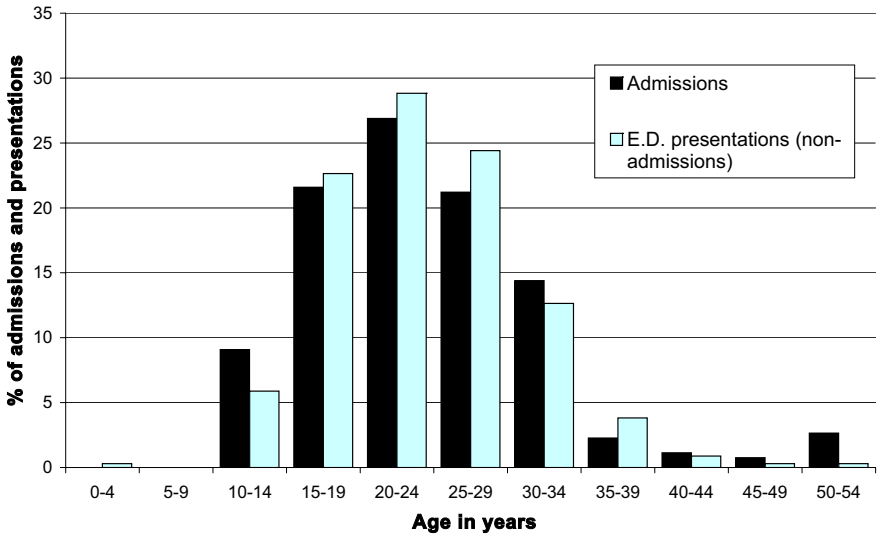
Hospital ED presentations (non-admissions) (n = 218, annual average frequency = 73)

Skiing accounted for 37% of all ED presentations for snow sports injuries. There were 218 skiing injury ED presentations recorded in the VEMD over the 3-year study period, 101 cases in 2004, 67 in 2005 and 50 in 2006. Very few (3%) of VEMD skiing injury narratives include information on the type of skiing.

As for admissions, the lower extremity was the most frequently injured body region (44%), particularly the knee (27% of all snow skiing presentations) and ankle (9%). Other commonly injured body sites were the hand/fingers (11%), shoulder (9%), forearm/wrist (8%) and thorax (7%). Sprains and strains were the most frequently occurring type of injury accounting for 41% of presentations. Fractures (28%) and injuries to the muscles and tendons (9%) were also common. The most frequently occurring specific injuries were knee sprains/strains (18% of snow skiing presentations), hand/finger fractures (7%) and forearm/wrist and ankle sprains/strains (each 5%).

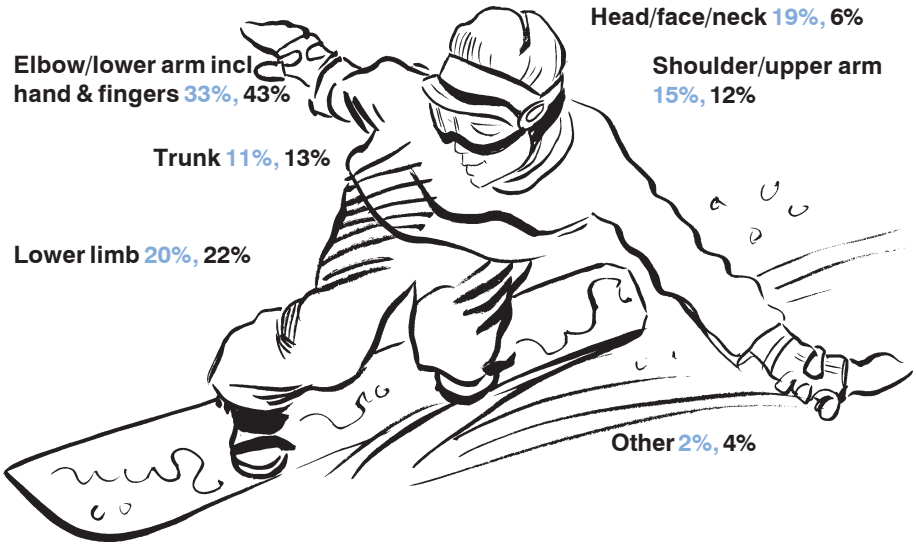
Most injuries (83%) were caused by falls. Other mechanisms included twisting injuries (7%), colliding with a stationary object (6%, including trees, ski poles and in one case a fence) and colliding with another skier (2%).

Snowboarding injury (admissions and ED presentations-non admissions) by age group: Victoria, January 2004 to December 2006 (*n*=604) **Figure 5**



Source: Victorian Admitted Dataset (VAED) and Victorian Emergency Minimum Dataset (VEMD) January 2004 to December 2006

Snowboarding injury by body site and severity **Figure 6**



Source: Admissions - VAED January 2004 to December 2006
Presentations - VEMD January 2004 to December 2006

Snowboarding injury

Over the 3-year study period, there were 604 hospital-treated snowboarding injuries (264 admissions and 340 ED presentations). Males accounted for 77% of admissions and 74% of presentations. The gender difference was most marked in this sport; with males more highly represented in snowboarding injury cases than in skiing and tobogganing cases. Approximately three-quarters of hospital treated snowboarding injury was to persons aged 15-29 years (70% of admissions and 76% of presentations).

Hospital admissions (n = 264, annual average frequency = 88)

Snowboarding accounted for 32% of all admissions for snow sports injuries. One hundred and seventeen admissions were recorded in 2004, 81 in 2005 and 66 in 2006.

Nearly half the injuries (48%) were to the upper extremity, with the elbow and forearm accounting for half of the upper extremity injury admissions. Other commonly affected injury sites were the lower extremity (20%) and head/face (19%). Fractures accounted for 63% of admissions, intracranial injury 10% and dislocations, sprain and strains a further 9%. The most common specific injuries were distal forearm/wrist fractures (22%), lower leg fracture (11%), intracranial injury (9%), humerus fracture (8%), radial shaft or head fracture (6%), knee sprain/ strain or dislocation (4%) and clavicle fracture (3%).

Two-thirds (66%) of snowboarding injury cases stayed in hospital for less than 2 days, 31% stayed 2-7 days, 3% stayed 8-30 days and one injured person was hospitalised for 61 days for injuries of the pelvic organs.

Eighty-four percent of snowboarding injury admissions were caused by falls. The VAED coding provides no further detail on the circumstances of the injury. Analysis of case narrative data for admissions recorded on the VEMD (n = 75) provided limited additional information. Only four narratives provided more detail on collision events: two snowboarders collided with skiers, one with a stationary bus and another with a pole. There were two reports of snowboarders being injured when struck by a snowboard and two further reports of snowboarders being injured when they were attempting a jump. Eleven cases narratives provided more

detail on the fall event. In five cases it was reported that the snowboarder struck his head when he fell and six specifically noted that the snowboarder fell onto his/her outstretched hand/s.

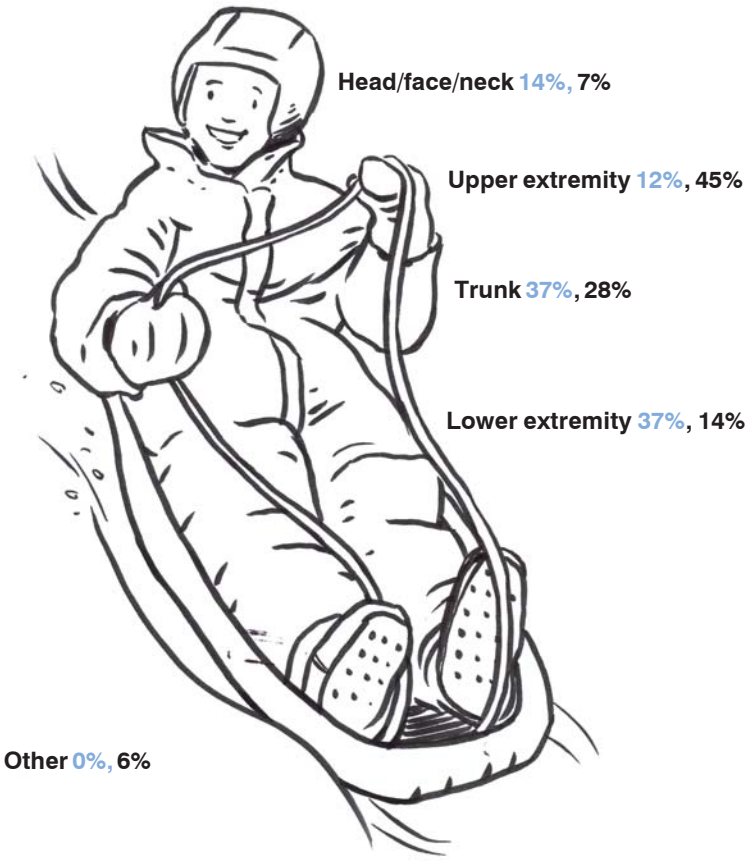
Hospital ED presentations (non-admissions) (n = 340, annual average frequency = 113)

Snowboarding accounted for 340 (58%) of all ED presentations (non-admissions) for injuries in snow sports. One hundred and thirty-eight snowboarding-related ED presentations were recorded in 2004, 128 in 2005 and 74 in 2006.

As for admissions, the upper extremity was the most frequently injured body site (55%), mostly the wrist (24% of all ED presentations – non-admissions) and shoulder. Other commonly injured sites were the ankle (10%), thorax (8%) and knee (7%). Sprains/strains and fractures were the most frequently occurring types of injury accounting for 35% and 33% of injuries respectively. Injuries to the muscles and tendons (9%) and superficial injury (7%) were also common. The most frequently occurring specific injuries were wrist/forearm fracture (17% of snowboarding ED presentations), wrist sprain/strain (8%) and shoulder sprains/strain (7%).

The major cause of snowboarding injury ED presentations (non-admissions) was falls (85%). Narrative data were limited in the amount of extra detail reported, however falls onto outstretched hands or falls while attempting jumps and tricks were noted. Being struck by or colliding with an object (the board, a tree) accounted for 7% of ED presentations for snowboarding injury.

Tobogganing injury by body site and severity **Figure 7**



Source: Admissions - VAED January 2004 to December 2006
ED presentations - VEMD January 2004 to December 2006

Tobogganing injury

Over the 3-year study period, there were 72 hospital-treated tobogganing injury cases (43 admissions and 29 presentations).

Hospital admissions (n = 43, annual average 14)

Males and females were almost evenly represented in admissions (21 males, 22 females). Admissions were spread across all 5-year age groups from 5-9 years to 65-69 years, with peaks in ages 10-14 (14% of cases), 20-24 (14% of cases) and 40-44 years (16% of cases).

The leading cause of injury was falls (55% of injury cases) followed by collisions (16%). Fracture was the most common injury type (65%). The body sites most frequently injured were the trunk or lower extremity (each 37%), head/face (14%) and the upper extremity (12%). Length of stay in hospital was longer than for other snow sport cases with most patients (54%) staying longer than 2 days. The average length of stay was 2.8 days (SD 2.36, range = 1 to 9 days).

Hospital ED presentations (n = 29, annual average 10)

Most ED presentations with tobogganing injuries were male (59%). As for admissions, ED injury cases were spread across the 5-year age groups with peaks in 40-44 year age group (21%), and children aged 5-9 (17%) and 10-14 (17%).

The most common cause of injury was falls (69%, n=20). One other case occurred when a toboggan hit the injured person and the cause was unspecified for the remaining case. Fractures (38%), sprains/strains and superficial injuries (each 14%) were the most frequently occurring injuries. The upper extremity was the most commonly affected body site (45%), followed by the trunk (28%) and lower extremity (14%).

Discussion

Snow sports, particularly snowboarding, are increasingly popular recreational activities. The latest Exercise, Recreation and Sport Survey (ERASS) conducted in 2005 estimated that 81,700 Victorians aged 15 years and over participated in snow and ice sports activities over the previous 12 months, representing a 15% increase in participation

since 2003 (ASC, 2005). Participation in the two major sports (skiing and snowboarding) is not reported separately. Approximately 60% of participants are males (ASC, 2005).

Accurate snow sports injury rate data takes account of exposure (time at risk), using data on days of active skiing/snowboarding to form the denominator. There have been no recent estimates of Victorian injury rates for either skiing or snowboarding. In an unpublished report to government on snow safety prepared by MUARC in 1998, the mean injury rate per 1,000 skier days for all Victorian resorts was estimated at 4.4 per 1,000 skier days, based on Ski Patrol Injury Reports and visitor day data from all seven Victorian ski resorts over the period 1994-97 (Cassell et al., 1998). Bladin et al (1993) reported a similar injury rate for snowboarding (4.2 per 1,000 snowboarding visits) from a prospective study of injuries treated at the ski resort medical centres at Mt Hotham, Falls Creek and Mt Buller over the 4-year period 1989 to 1992.

The present study covered fatalities and serious (hospital-treated) injury. As shown, injury-related deaths are rare in snow sports in Victoria. Both of the fatal incidents recorded over the 3-year study period occurred in 2005 and involved male downhill skiers (one a child and the other an adult aged in his 30s) losing control and running into trees lining the ski slope. Both deaths were reportedly caused by head injuries, although the Coroner's Findings are not yet available for the child case. Other studies consistently show that traumatic brain injury is the leading cause of child and adult fatalities in skiing (Morrow et al., 1988; Tough & Butt 1993; Sacco et al., 1998; Xiang & Stallones, 2003; Xiang et al., 2004; Meyers et al., 2007). As reported here, previous research also indicates that the leading mechanism of fatal skiing injuries is collision, most commonly with trees (Morrow et al., 1988; Furrer et al., 1995; Sacco et al., 1998; Xiang & Stallones, 2003).

No snowboarding-related deaths were recorded over the 3-year study period. An overseas study involving larger populations of skiers and snowboarders reported that the risk of death in downhill (alpine) skiing is much higher than in snowboarding (Sacco et al., 1998). Study authors warn that this difference may disappear with the increase in popularity of slalom and acrobatic snowboarding (Sacco et al., 1998).

Over the three-year study period, there were 1,404 hospital-treated snow sports injury cases, 817 admissions and 587 emergency department (ED) presentations (non-admissions). ED presentations are under-estimated because small rural hospitals located close to the snowfields (Alpine Health – Bright and Mt Beauty and Mansfield District Hospital) and private hospitals do not contribute data to the VEMD. Also, the major ski resorts operate medical clinics that treat less severe injuries and their role overlaps with the usual function of the hospital ED in the treatment of sports injuries. For example, more than 1,400 injured snow sports participants were treated at the Falls Creek Medical Centre in the 2004 and 2005 snows seasons, most commonly for ligament sprains.

The frequency of hospital-treated snow sport injury cases almost halved between 2004 and 2006. This trend is most likely related to decreased participation as the snow season in 2004 was among the best on record followed by poor seasons, in terms of snow cover, in 2005 and 2006. (All but one of the Victorian ski resorts closed before the official season closing date in 2006 due to lack of snow cover.)

Pattern of injury

Participation data collected by the ERASS (ASC, 2005) indicate that males comprise 60% of adult participants in snow/ice sports, which largely accounts for the over-representation of males (66%) in snow sports admissions and presentations. The 15-24 year old age group accounted for 61% of snow sports admissions and 46% of ED presentations and, again, this may be due to higher participation in this age group. However, a Canadian study of ski injuries among skiers and snowboarders that used data from 3 surveys to estimate the number of participants and annual number of outings by age, sex and activity found that, for all body regions, injury rates increased steadily as age decreased (Hagel et al., 2004). An earlier study conducted at one Canadian resort also found higher injury rates of both minor injury (defined as requiring only first aid) and more serious injury (defined as referred to a medical centre) among males compared with females and children and teenagers aged 7-17 years compared with adults aged 18 years and older (Cadman & Macnab, 1996).

Falls caused three-quarters of hospital-treated injuries in our study, followed by collision with objects, mostly trees (7-8%) and collision with skiers, snowboarders and bystanders (2-3%). As previously reported from several studies (Bladin et al., 1993, Bladin & McCory, 1995; Hagel, 2007–review), a different pattern of injury was evident among skiers and snowboarders, with knee and lower leg injuries commonest in skiers and wrist and forearm injuries commonest in snow-boarders. In general, our study showed that injuries to skiers appeared to be more severe than injuries to snowboarders, with skiers accounting for 62% of hospital admissions for snow sports injuries, yet 37% of hospital ED presentations (non-admissions). There is conflicting evidence from previous research with some studies agreeing with our finding (Shorter et al., 1996 & 1999), others finding that snowboarders sustain more serious injuries than skiers, particularly head and spinal injuries (Hackam et al., 1999; Levy et al., 2002; Sulheim et al., 2006; Donald et al., 2005) and another reporting no difference (Skokan et al., 2003).

Risk factors for injury

Hagel (2005) recently conducted a critical review of the research literature on child skiing and snowboarding injury. He found that most published studies were descriptive case series without exposure estimation. Studies of this type can only identify potential risk factors, as they do not include a comparison group of non-injured participants. Hagel concluded that the evidence from the 13 studies included in his review — case series with exposure estimation, prospective cohort and case control studies— provided some support for the following intrinsic (personal) and extrinsic risk factors:

- Intrinsic (personal) risk factors: lower ability/less experience (especially beginner skiers and snowboarders); younger age (skiers and snowboarders), but some studies show that adolescents are at higher risk of injury than children; past injury (perhaps due to incomplete rehabilitation); and being female.
- Extrinsic risk factors: incorrect binding adjustment (skiers); participation in snowboarding for injury severity (compared with skiing), using rented equipment (skiers); failure to wear a helmet (skiers and snowboarders); failure to wear wrist guards (snowboarders); and certain slope characteristics (skiers: groomed runs compared with powder and easier compared with difficult; snowboarders: half-pipe compared with marked runs and

on hard, icy or slushy terrain compared with prepared slopes).

There were conflicting findings in the literature on the protective effect of lessons including falls training. Hagel commented that the evidence in support of risk factors was tentative rather than conclusive as the reviewed studies were of variable quality. Evidence from our analysis of hospital-treated snow sports injury does not support the proposition that snowboarders are more at risk of serious injury than skiers, although we did not have access to reliable participation data.

In 1996, MUARC researchers undertook comprehensive literatures reviews of injury countermeasures and their effectiveness for snowboarding (Kelsall & Finch, 1996a), alpine (Kelsall & Finch, 1996b) and cross-country (Kelsall & Finch 1996c) skiing. The reports are still available through the MUARC website (www.monash.edu.au/muarc) and provide some interesting background information but the literature reviews have not been updated. There has been no recent published critical review of the risk factors for adult snow sports injury. However, several recently published analytical studies have identified a few risk factors.

Two case control studies involving snow sports participants of all ages conducted in Scotland provide evidence that snowboarding and alpine skiing carry higher risks of injury than telemark skiing and skiboarding and that first day participants in all these snow sports are at greater risk of injury than their more experienced counterparts, especially if aged less than 17 years and older than 28 years, if snowboarding, if having taken instruction (perhaps due to overconfidence) or if using rental or borrowed gear (Langran & Saelvaraj, 2002; Langran & Sivasubramanian, 2004). Other studies support the proposition that 'beginners' (defined differently) are a high-risk group for injury in both skiing and snowboarding (Ronning et al., 2001; Langran & Selvaraj, 2002; Bladin et al., 1993; Goulet et al., 1999; Ungerholm & Gustavsson, 1985).

A number of equipment-related factors have been implicated in injury. Incorrectly adjusted bindings have been correlated with increased lower leg injury rates in skiing (Ungerhome & Gustavsson, 1985; Deibert et al., 1998). Non-use of helmets was found to be associated with a significantly increased risk of head injury in both skiing and snowboarding in Norwegian and Canadian case control studies by Sulheim et al. (2006), Hagel et al. (2005) and Macnab et al (2002). The non-wearing of wristguards was found to be a significant risk factor for wrist injury among snowboarders in six studies (a mixture of RCT, cohort and case control designs) included in a recent systematic review of the literature by Russell and colleagues (2007). The studies on the effectiveness of protective equipment are discussed in more detail below.

Bergstrom and Ekeland (2004) investigated the blackspots for frequent and severe injury on two alpine ski areas over several seasons in Norway and found that the architecture of the slopes (such as converging slopes, compressions when hit by skiers at great speed and congestion especially when beginners and more experienced skiers intermix on narrow slopes) was a risk factor for injury in one area and that injuries increased as grooming hours reduced over the study period in the other area.

Preventing skiing and snowboarding injury

Reducing lower limb injuries in skiing

Our hospital-based study revealed that 53% of admissions and 44% of ED presentations (non-admissions) for skiing injury in 2004-6 were for injuries to the lower limb. Admitted cases were mostly knee dislocations and tibial fractures, while ED presentations were most commonly knee sprains. Ligament injuries are underestimated in hospital injury surveillance datasets as a substantial proportion of sports participants with knee and ankle sprains present to sports medical clinics and general practitioners. Although there is some variation, most studies report that the lower limb is the most frequently injured body site among skiers (Hagel, 2005, review).

Several study authors comment that improvements in the design and technology of the ski-boot-binding systems since the 1970s have achieved the objective of reducing the incidence of below-the-knee lower leg fractures and ankle sprains in alpine skiing, but that modern ski equipment has not protected the knee from serious injury (Koele et al., 2002; Natri et al., 1999; St Onge et al., 2004). Long-term studies of the trend in skiing injuries at resorts in the US indicate that lower leg injuries reduced by as much as 80% through the 1980s, whereas severe knee sprains, usually involving the anterior cruciate ligament (ACL), increased significantly over the decade (Johnson et al., 1993; Shealy 1993). Failure of ski bindings to release due to incorrect bindings adjustment and lack of maintenance is an established risk factor for lower leg injuries (Deibert et al., 1998).

Langran reports that the increasing incidence of ACL and other knee ligament injuries in skiing has generated debate about the level of protection afforded by current binding settings used throughout the world, as defined by the International Standards Organisation (ISO) and other national standards setting agencies (www.ski-injury.com). The ISO settings, set out in tabular form, are based on the skiers weight and height with some adjustment for skill level, age (over 50 years) and length of ski boot sole. No consideration is given to sex and age (except for over 50s) despite evidence that females and children are at higher risk of knee ligament injury (Cadman & Macnab, 1996; Laporte et al., 1999). Some French researchers from Medicins des Montagne (MdeM, an association of French ski resort doctors) argued that the ISO settings were set too high and that the non-release of bindings was contributing to an excess of knee injuries in these and lower-weight males (Laporte et al., 1999).

In 2000, the French Association for Standardisation (AFNOR) unilaterally introduced a revised standard for ski binding settings, based on gender, boot size, skier weight and skier ability (self-assessed). In general, the new standard lowered settings by 15% for males weighing less than 55kg, all females and all beginners. The French government funded a large-scale publicity campaign to inform skiers of the changes. Marc Binet from MdeM reported at meetings of the International Society for Skiing Safety (ISSS) in 2003 and 2005 that, among skiers treated by the French MdeM group, ACL injury rates have since reduced by 26% (and other knee sprain rates by 38%) with no increase in injuries due to inadvertent bindings release (Langran, 2007a&b).

Other investigators suggest that current release binding settings are optimal and question whether the reported improvement in the ACL injury rates is due to the lower bindings settings or the more widespread use of the shorter carving skis (Langran, 2007a). Research on a new binding system that provides a release mechanism that minimises the risk of ACL injury, most commonly occurring in a backwards fall, is well advanced and the new binding is expected to come onto

the market in 2008 (Howell, 2007). The effectiveness of this type of binding release system, that has two pivot points on the boot rather than one, and therefore senses twist loads applied to the ski both at the front and the back, is supported by a laboratory simulation study (St-Onge et al., 2004).

Results of two intervention studies to reduce knee injury are reported in the literature. A Danish case control study conducted by Jorgensen et al. (1998) found that showing a video on skiing safety, including instructions on how to check and adjust bindings, on buses going into a ski resort changed safety-related behaviours and reduced all-injury risk and knee injury risk in inexperienced skiers.

Results showed that the bindings test was performed by significantly more skiers in the intervention group compared with skiers in the control group who were not shown the video during their inward bus trip (86% vs. 59%, p<0.05). Twenty-two per cent of skiers in the intervention group adjusted their bindings compared with 14% in the control group. In the intervention group, 16% of all skiers were injured vs. 23% in the control group. Knee injuries made up 33% of all reported injuries and for inexperienced skiers knee injury risk was significantly lower if the bindings had been tested (p<0.05). Results are promising but findings need to be confirmed in a larger study in which there is independent assessment of injuries rather than reliance on self-reported injury data gathered by questionnaire.

Ettlinger et al. (1995) conducted awareness raising sessions for skilled skiers (ski instructors and patrollers) in ski resorts in Vermont in the United States alerting them to the high risk of ACL injuries from a particular type of uncontrolled fall, using a training video that showed actual injury events. Participants were trained to recognise the potential high-risk fall situation and to quickly correct one or more of the six elements of the fall that were believed to contribute to the risk of ACL injury. The taught response included landing on both feet after a jump whenever possible and keeping knees flexed and skis together on landing or falling.

Pre- and post- intervention data on ACL injuries in 4,000 on-slope ski staff from the 20 ski areas that fully participated in the training program were compared to data from 22 ski areas where staff were not exposed. In the intervention group, serious knee sprains declined by 62% in trained patrollers and instructors compared to two previous seasons, but no decline in ACL injuries was observed in the unexposed group (P=0.005). The intervention and comparison groups were not carefully defined in the report and no data were collected from participants on their level of adoption of the recommended landing techniques. The effectiveness of this intervention requires confirmation in further well-conducted studies.

Reducing wrist/forearm injury in snowboarding

Our study indicates that the predominant injury among hospital-treated snowboarders is forearm/wrist fracture. Forty-three percent of all snowboard injury admissions were upper limb fractures, mostly to the distal forearm and wrist (22% of all snowboarding injury cases), humerus (8%) or ulnar/radial shaft or head (6%). Seventeen percent of ED presentations were forearm/wrist fractures and a further 8% were forearm/wrist sprains and strains. Other Australian and international studies report high levels of wrist/forearm injuries among snowboarders (Bladin & McCrory, 1995; Chow et al., 1996; Machold et al., 2000; Idzikowski et al., 2000)

Chow et al (1996) describe the typical mechanism of wrist fracture among snowboarders. Because the snowboarder's feet are fixed to the snowboard, the lower limbs absorb only a small amount of energy on impact. Usually the snowboarder uses outstretched arms to break the fall and they absorb the full force of the impact, making them vulnerable to injury (Chow et al 1996). Because of the high incidence of wrist injury among snowboarders, particularly fracture to the growth plate in children that may lead to deformity of the wrist, it is recommended that snowboarders should wear gloves with built-in wrist guards and that children should not snowboard until they are aged seven.

Russell et al. (2007) recently conducted a systematic review of the effect of wrist guards on wrist and arm injuries among snowboarders. Six studies met the study eligibility criteria and were included in the review (Machold et al., 2002; Ronning et al., 2001; Machold et al., 2000; O'Neill, 2003; Hagel et al., 2005 and Idzikowski et al., 2000). There were two randomised control trials (conducted in Norway and Austria), two prospective cohort studies (conducted in Austria and the U.S) and two case-control studies (conducted in Canada and the U.S.). The results were pooled and analysis consistently showed that wrist guards significantly reduced the risk of wrist injury, although reviewers assessed the quality of all included studies as low due to design and reporting deficiencies.

Among participants in the four RCTs and prospective cohort studies there were 14 wrist injuries in 4407 snowboarders who wore wrist guards compared with 110 injuries in the 6277 snowboarders who did not. Analysis showed there was a significant decrease in the risk of wrist injuries (RR: 0.23; 95% CI: 0.13, 0.41), wrist fractures (RR: 0.29; 95% CI; 0.10.0.87) and wrist sprain (RR: 0.17; 95% CI: 0.07, 0.41) among snowboarders who wore wrist guards. Within the two case control studies, 55 of the 426 snowboarders who wore wrist guards sustained an injury whereas 2048 of the 7095 snowboarders who did not wear a wrist guard had a wrist injury. Analysis showed that the odds of a wrist injury were significantly less in snowboarders who wore wrist guards (odds ratio: 0.46; 95% CI: 0.35, 0.62) than their counterparts who did not.

The challenge remains to convince snowboarders to wear wrist guards. Wear rates in the four reviewed case control and cohort studies ranged from 24% to 39%. Overseas research shows that the major barriers to wear are similar to the barriers to helmet wearing and wearing of wrist guards in skating sports: the perception among non-wearers that they are uncomfortable, ineffective, fear of injury from the wrist guard itself, 'don't see the need', cost, 'uncool' appearance and unavailability (Fuchs et al., 2005; Langran, 2007c).

The International Society of Skiing Safety (ISSS) has formed an expert group to push for the development of a specific safety standard for snowboarding wrist guards. There are currently at least two wrist protection devices on the market —*Flexmeter* and *Biomex* protection (integrated into *Level* gloves)— that meet the specifications for wrist protectors for snowboarding devised by expert groups of scientists including physicians, engineers and trauma specialists (Brugger, 2004; Machold et al., 2001; Langran 2007c). The promotion of snowboarding-specific wrist guards is recommended because they provide optimal protection (Machold et al., 2002; Langran 2007c), even though wrist guards designed for in-line skating/wrist injury rehabilitation have been shown to reduce wrist injuries in snowboarders (Ronning et al., 2001; O'Neill, 2003).

Reducing head injury in skiing and snowboarding

Head injury is a leading cause of snow sports fatalities and serious injury (Sulheim et al., 2006; Levy et al., 2002; Sacco et al., 1998). Overall, head injury accounted for the two fatalities and 13% of hospitalised snow sports injury cases in our study (16% of snowboarding hospitalisations and 11% of skiing hospitalisations). Previous all-ages studies variously report that head injury cases account for between 3% and 23% of hospital-treated snowboarding and skiing injury cases (Siu et al., 2004; Ueland & Kopjar, 1998; Sacco et al., 1998; Nakaguchi et al., 1999; Xiang et al., 2005; Langran, 2007b). Some studies found that snowboarders are more at risk of head injury than skiers (Fukuda et al., 2001; Hagel et al., 2004; Nakaguchi et al., 1999).

Common scenarios for head injuries in snow sports include: skiers losing control and crashing into trees, lift towers and other obstacles; collisions with/being hit by the lift T-bar, other skiers and snowboarders; novice snowboarders losing control and falling backwards hitting the occiput region of the head; and more advanced snowboarders who crash land during the performance of a jump or trick (Levy et al., 2002; Fukudo et al., 2001; Nakaguchi et al., 1999; Sacco et al., 1998).

Although ski helmets cannot always mitigate the head impact forces involved in average to high speed collisions with solid objects, *for example* trees, fences and lift towers, three case control studies provide encouraging evidence that helmets are effective in the prevention of less severe head injuries (Sulheim et al., 2006; Hagel et al., 2005a; Macnab et al., 2002).

Sulheim et al (2006) reported a 60% reduction (OR 0.40; 95%CI 0.30-0.55) in the odds of head injury in helmet wearers compared with uninjured controls based on a study that included 3277 injured skiers and boarders and 2922 non-injured controls drawn from 8 Norwegian ski resorts. Hagel and colleagues' study of 1082 cases of head or neck injury and 3295 controls (who had injuries other than head or neck injuries) found a 29% reduction in odds of any head injury (OR 0.71, 95% CI 0.55 to 0.92) in cases compared with controls and a reduction of 56% for serious head injury i.e., injuries requiring evacuation by ambulance (OR 0.44, 95% CI 0.24 to 0.81) (Hagel et al., 2005a). Macnab et al. (2002) reported a 43% reduction in the odds of head, face and neck injury in young skiers and snowboarders aged less than 13 years who wore helmet compared with those that did not.

Opponents of helmet wearing argue that they increase the risk of neck injury (particularly among children), reduce the wearer's field of vision and hearing and increase the speed or risk taking the behaviour of the wearer due to a false sense of security. Study results are conflicting on whether helmet wearing increases the risk of neck injury, but the weight of evidence tends towards no increased risk or a protective effect. Macnab et al. (2002) reported no associated increase in the risk of a cervical spine injury with helmet use in children and Sulheim et al. (2006) reported a trend toward a lower risk of neck injury among helmet wearers. The study by Hagel et al. (2005a) was unable to rule out the possibility of increased risk. All studies lacked sufficient power to provide conclusive evidence on this issue.

To investigate whether helmet wearing encouraged risk-taking behaviour, Hagel et al. (2005b) studied the effect of helmet use on severity and crash circumstances in non-head and non-neck injured skiers and snowboarders. Using a matched case control study design, the authors found no evidence that helmet use influenced injury severity or was related to high–energy crash circumstances (crashes that resulted in non-helmet equipment damage or that occurred at high speed or on more difficult runs than usual, and jumping-related crashes) and concluded that helmet use in skiing and snowboarding is not associated with increased risk taking (Hagel et al 2005b).

A recent Victorian study of helmet wearing by snowboarders who presented in the 2004 and 2005 snow seasons to the Mt Buller Medical clinic found that 17.6% had been wearing helmets and none had sustained a head injury whereas none of the nine snowboarders treated for head injuries had been wearing helmets (Slaney et al., 2007). The authors reported that a recent informal survey of helmet wearing by skiers and snowboarders at Mt Buller by ski lift personnel estimated that the rate of helmet use was 20% among adults and 68% among children. They recommended that helmets should be made compulsory for children who are more susceptible to head injury (Slaney et al., 2007). Reports from overseas indicate that helmet wearing rates among skiers and snowboarders are generally fairly low (12-13% in the US and Scotland), but have increased in places where they are actively promoted (31% for alpine skiers and 28% for snowboarders in Norway and 58% among snow sports participants in Tarnaby, Sweden) (Langran 2007b). There are no helmet use data for Victoria. Identified barriers to wear include non-recognition of the need for head protection, appearance, discomfort and cost (Brugger, 2004; Langran 2007)

Othmar Brugger from the Swiss Council for Accident Prevention (bfu) undertook a Delphi survey of 30 German, French, Austrian and Swiss experts to assist the design of an improved helmet that was more protective and met some of the barriers to wear articulated by snow sports participants (Brugger, 2004). The consensus recommendations were that helmets should be worn by skiers and snowboarders of all ages and abilities and that helmets should have the following attributes: lightweight; primarily protect the skullcap and back of the head; not affect sight or hearing; not assist hyperextension of the cervical spine; and satisfy specific sporting fashion demands.

Brugger commented that helmets complying with the European Standard (EN 1077; 1996) meet the first three criteria, that research findings tend to indicate that current ski-helmet design satisfy the fourth criteria, and that it is in the interests of ski helmet manufacturers to design and market helmets that are attractive and acceptable to the target group (Brugger, 2004). Stewart Levy, a neurosurgeon with Intermountain Neurosurgery and Neurosciences in Denver, Colorado and his colleagues undertook a social marketing and helmet loaner program in Denver from 1998. The evaluation (based on independent observation and self-report) showed that their program was effective in increasing helmet use among skiers and snowboarders from 7.7% and 24.2%, respectively, in 1998-9 to 20.3% and 44.2% in 2001-2 (Levy et al., 2007).

Helmet acceptance was significantly higher among patrons of participating rental outlets that did not charge for helmet hire than among patrons of rental outlets that charged for helmet hire (1998-99: 13.8% vs.1.4%, $p<0.01$; 2000-01: 33.5 vs. 3.9, $p<0.01$; and 2001-02: 30.3% vs. 4.5%, $p<0.1$). Role models (ski patrollers and ski instructors) were provided with helmets and educated about their effectiveness in preventing traumatic brain injury. The marketing program included media interviews and presentations by neurosurgeons/physicians, and educational stickers and posters distributed by volunteers.

Other preventive measures for skiing and snowboarding

Other preventive measures recommended by researchers/experts that require further evaluation include: pre-season conditioning program; improved ski boot and ski pole design; improved binding design to reduce ACL injury in skiing; wearing of appropriate clothing/protective equipment including eyewear and sun protection; adequate nutrition and limited/no alcohol intake; skier safety education and skills training; speed and collision control on slopes; separation of skiers and snowboarders and beginners/ novices from other slope users; careful progression from easier to harder runs based on skills development; identification and mitigation of environmental hazards by resort/ park operators; regular grooming of slopes; and active and well-trained ski patrollers who have a high level of training/certification in first aid.

Preventing injury in tobogganing

No interventions to reduce tobogganing injury have been evaluated. Recommended measures to prevent/reduce injuries in the research literature are: improved steering and braking devices on toboggans, creation/selection of safe sites/trails free of trees, rocks, potholes and other hazards with a level run-off at the end, inspection of trails for safety, skills and safety instruction for beginners, safety awareness education, helmet wearing especially for children, and close adult supervision of children (although studies have show that injuries to children occur even when under parental supervision).

Study limitations

Case capture

Case capture by hospitals is particularly deficient for snow sports injury. The VAED covers hospital admissions to all public and private hospitals in Victoria but in 57% of unintentional injury cases recorded over the study period the activity undertaken when injured is not specified. The VEMD captures cases presenting to the 37 public hospitals that offer a 24-hour emergency service. Half of the admitted cases recorded on the VAED (n=414) were from hospitals that do not contribute to the VEMD collection, hence ED presentations are probably grossly underestimated in this report. Also, we rely on information in case narratives to identify snow sports injury and some of our larger hospitals record poor quality narratives. Our report does not cover snow sport injury cases treated in resort medical clinics (that run into the thousands each season), sports medicine clinics (that treat a high proportion on knee ligament injuries) and general practitioners.

Recommendations

Injury surveillance and research

- VISU to seek support of the Department of Human Services for a targeted approach to improve case narrative data contributed by large hospitals participating in the Victorian Emergency Minimum Dataset (VEMD).
- VISU to liaise with Sports and Recreation Victoria (SRV) to separate snow and ice sports in future ERASS sports participation surveys conducted under the auspice of the Australian Sports Commission. This would require additional funding to increase the Victorian sample size to a level that yields reliable data for selected minor sports.
- Snow resorts to collect reliable exposure data (participation and/or time-at-risk) for specific snow and ice sport and recreational activities to allow the estimation of injury risk per participant/time unit in these recreational activities and comparison of injury risk between snow and other sport and recreation activities.
- Snow resorts should publish detailed annual injury reports covering cases treated at resort medical centres and use reports for injury prevention.

Injury prevention

- Parents should enrol beginner skiers and snowboarders in lessons and closely supervise their skiing/snowboarding sessions and progression to more demanding runs/tricks.
- Skiers and snowboarders should undertake pre-season conditioning.
- All skiers and snowboarders should wear Standards-approved helmets to prevent or ameliorate head injuries. The injury prevention benefits of helmet wearing should be marketed to skiers and snowboarders.
- Compulsory helmet wearing should be considered for children
- Helmet hire should be offered free with every ski and snowboard rental. Ski patrollers and ski instructors should always wear recommended protective gear.
- All snowboarders should wear wrist guards designed specifically for snowboarding. A harmonised Standard should be developed for wrist guards used in snowboarding.
- Ski bindings should be tested by a professional at the beginning of each season and checked and adjusted by the skier each day. Equipment rental staff should be trained and performance tested on a regular basis to ensure that they are setting bindings correctly, especially for child skiers. Skiers should be trained to self-test and adjust bindings.
- Design standards should be developed for snowboard jumps.
- Resort managers should map blackspots for frequent and severe injuries and design out/ eliminate hazards or take measures to ameliorate their impact.
- Runs should be regularly groomed.

Brochures available from www.smartplay.com.au

Injury in ice sports

Hospitalised ice sport-related injuries were identified on the Victorian Admitted Episodes Dataset (VAED) using the activity codes U51.20 Ice hockey, U55.0 Bobsledding, U55.1 Ice skating and ice dancing, U55.5 Speed skating and U55.7 Curling. Emergency department (ED) presentations were selected from the Victorian Emergency Minimum Dataset (VEMD) if the 250-character text narrative 'Description of Injury Event' variable included the text terms: ice skating, luge, speed skating, bobsled, curling, ice hockey and spelling variations/abbreviations.

There were 275 hospital-treated injuries related to ice sports in the 3-year period January 2004 to December 2006 (86 admission and 189 ED presentations). Most injuries (n=238, 87%) occurred in ice skating, the most popular of these sports.

Ice skating injuries (n=238)

There were 238 hospital-treated ice skating injuries (79 admissions and 159 ED presentations) over the 3-year study period.

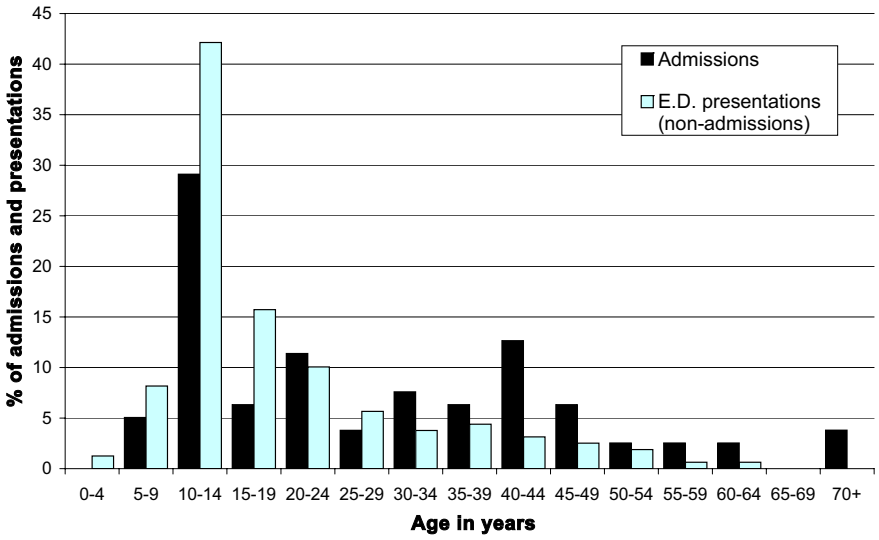
Females accounted for 51% of admissions and 48% of presentations. Children aged 10-14 years were over-represented, accounting 29% of admissions and 42% of presentations, but participation may be high in this age group (Figure 1).

Hospital admissions (n = 79, annual average frequency 26)

The frequency of admitted cases increased by a small amount each year, with 21 admissions recorded in 2004, 24 in 2005 and 34 in 2006. Most injuries were caused by falls (89%). The knee/lower leg was the most frequently injured body site (41%), followed by the forearm/wrist (29%) and the head/face (11%). By far the most frequently occurring injury was fracture [82%, mostly knee/lower leg (48%) and wrist/forearm (34%)], followed by intracranial injury (5%) and dislocation/sprain/strain (4%).

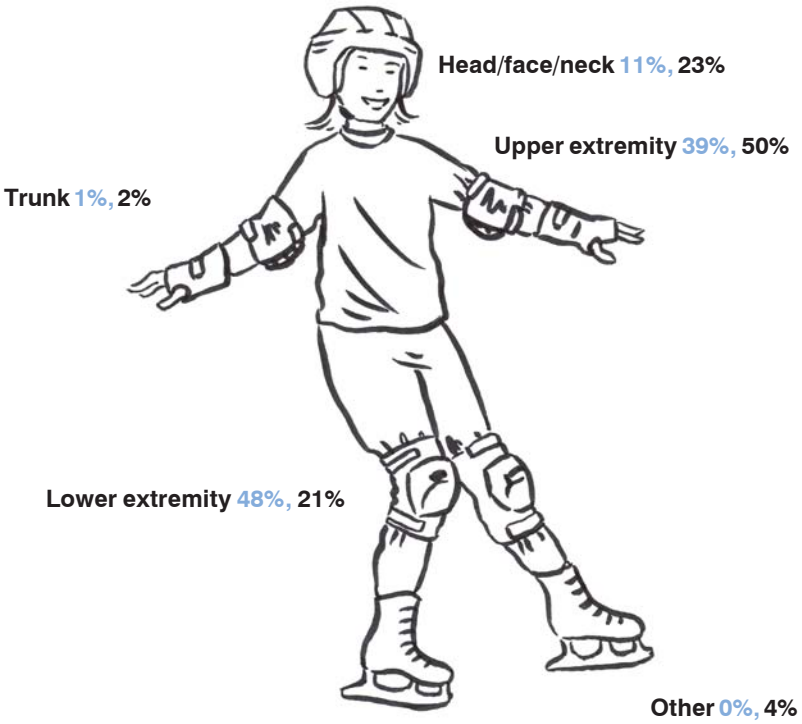
Fifty-seven percent of ice skating injury admissions had hospital stays less than 2 days, 42% stayed 2-7 days, and the remaining case stayed 11 days (for treatment of a fracture to the subcapital section of the femur).

Ice skating injury hospital admissions and ED presentations by age group, Victoria, January 2004 to December 2006 (n=238) **Figure 1**



Source: Victorian Admitted Dataset (VAED) & Victorian Emergency Minimum Dataset (VEMD), January 2004 to December 2006.

Ice skating injury by body site and severity **Figure 2**



Source: Victorian Admitted Dataset (VAED) and Victorian Emergency Minimum Dataset (VEMD) January 2004 to December 2006.

Hospital ED presentations (non admissions) (n = 159, annual average frequency 53)

As for admissions, the frequency of ED presentations increased each year, 39 injuries were recorded in 2004, 58 in 2005 and 62 in 2006.

Half of the ice skating ED presentations were to the upper extremity, mostly the forearm/wrist (30% of all ice skating injury ED presentations) and elbow (8%). Other common body sites injured were the head and face (14%) and the ankle (11%). Fractures (31%), sprains and strains (28%) and open wounds (16%) were the most common injury types. The predominant specific injuries were forearm/wrist fracture (18% of total ice skating injury presentations), open wounds to the head and face (10%) and forearm/wrist sprain/strain (10%).

As for admissions, the major cause of injury was falls (90% of cases). A further 6% of injuries were caused by lacerations from skate blades and 2% were caused by collisions with other ice-skaters.

Ice hockey injuries (n=33)

Ice hockey accounted for 33 hospital-treated injuries (3 admissions and 30 ED presentations). Males were much more likely to be injured than females (88% vs. 12%) but this associated with their higher participation in the sport. Injuries peaked in the 15-19 year age group (40%) but the age of cases ranged from 14 to 52 years. The most common causes of ice hockey injuries were collisions with another player/checking (36%, n=12), falls (33%, n=11) and being struck by or colliding with an object e.g. puck, stick or rink wall (30%, n=10).

Fracture was the most frequent injury type (30%), followed by sprain/strain (24%) and open wound (21%). The head/face/neck (27%) and shoulder (27%) were most commonly injured, followed by the ankle (12%), knee (12%) and hand (9%). Approximately 10% of ice hockey injury cases were admitted to hospital (2 ankle fracture cases and one case of a fractured jaw).

Sledding injuries (n=4)

There were only 4 hospital admissions and no reported ED presentations for sledding-related injury over the 3-year study period. This is probably due to the comparative popularity of tobogganing in the snowfields and lack of opportunity in populated areas because of the confined region that receive snowfalls in Victoria. Two injured persons were male and two female, all were aged between 14 and 30 years. Two were hit/struck/crush injuries, one was an overexertion injury and the other was coded as a transport injury. Three of the admitted cases stayed overnight in hospital (one case involved an ankle fracture, one a tibia/fibula fracture, and the other a neck sprain), while the other case stayed 14 days for treatment of an open wound to the lower leg that became infected.

Discussion

There are limited opportunities in Victoria to ice skate in public rinks or to participate in ice sports so the frequency of related hospital-treated injuries is small compared with the more popular roller sports. This situation may change when the new National Ice Sports Centre is opened in the Docklands precinct of Melbourne, scheduled for late 2008. It is timely, therefore, to consider the safety of ice sports and the prevention measure that should be implemented to minimise injury.

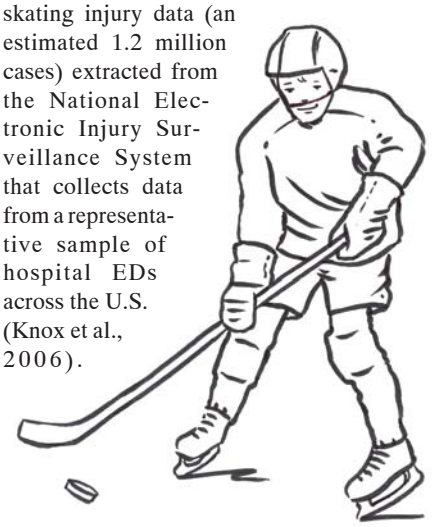
Preventing ice skating injuries

A number of studies have shown that the opening of a permanent or temporary ice rink results in an epidemic of injuries presenting to the nearby hospital emergency department (Clarke et al., 2006; Dillon et al., 2006; Oakland, 1990; Williamson & Lowdon, 1986). Clarke et al. (2006) reported that the opening of a temporary rink over the Christmas period near Cork, Ireland, had a significant impact on the Cork University Hospital emergency department service with 125 skating-related attendances over the 6-week period in which the rink was in place. In a related study, Dillon et al (2006) noted an increase in orthopaedic admissions to the same hospital associated with the opening of the temporary rink. Admissions (mostly for severe leg fracture) increased by 8%. The average length of hospital stay of ice-skaters was 2.6 days and the average time missed from work by injured working adults was 6.1 weeks. Lack of experience appeared to be a major contributory factor to injury, as 15 of the 18 injured ice skaters had not skated previously.

Williamson & Lowdon (1986) reported that the opening of a new rink in the catchment area of a hospital in England produced a large increase in the workload of the Accident Service. A total of 203 patients with ice skating injuries presented to the hospital over a 2-month period with 103 noteworthy injuries including 61 fractures, 2 dislocations and 2 severed tendons. The same research group investigated ice skating injury presentations to an Oxford hospital situated near a well-established rink and reported that demand on hospital services decreased markedly over time. Similarly, Oakland (1990) found that the opening of an ice rink in Hampshire, England resulted in 469 attendances at the local hospital ED in the first 12 months but that the injury rate (ED presentations per 1,000 visits to the rink) declined over time. These studies provide further support to the proposition that inexperience is a risk factor for ice skating injury.

The pattern of injury in ice skating reported in these hospital-based studies is similar to that found in our study with fall-related lower extremity fractures prominent in hospital admissions and fall-related upper extremity (forearm/wrist) fractures/sprains more prominent in non-admitted cases.

Knox and colleagues investigated the differences in the risk associated with head injury for child ice skaters, roller skaters and in-line skaters by analysing 10 years of skating injury data (an estimated 1.2 million cases) extracted from the National Electronic Injury Surveillance System that collects data from a representative sample of hospital EDs across the U.S. (Knox et al., 2006).



The most common mechanism of injury in ice skating (and the other types of skating) was a fall.

The proportion of head injuries among ice skaters (13.3%) was around three times that for roller skaters (4.4%) and in-line skaters (5.0%) and the proportion of concussions (4.3%) was 5-7 times greater than found among roller- and in-line skaters. Our study

found similarly high proportions of head injury cases (11 % of admissions and 15% of ED presentations) and intracranial (concussion) cases (5.1%) among ice skaters treated in Victorian hospitals compared with other skating sports (in-line and roller skating). Head injuries comprised 5% of hospital admissions and 3% of ED presentations for inline/rollerskating injury over the three-year study period and intracranial injury a further 3% of hospital admissions and 1% of ED presentations.

An explanation of the high head and brain injury rate in child ice skaters is provided by a recent video study of skating-related falls (Knox & Comstock, 2006). The study found that child ice skaters and roller/inline skaters fall similarly (usually forwards) and that both types of skaters try to break their fall by extending out their arms or hands. However, because ice is a low friction surface, attempts by ice-skaters to break their fall are often unsuccessful, and the head/face impacts with the ice. The authors give qualified support for helmet wearing by ice skaters but question the protective effect of currently available hybrid (multisport) and specialist ice-skating helmets because they do not protect the face. The research team has designed and patented a new type of protective device, a combination wrist guard-glove with slip resistant palm material that allows the ice skater to successfully break a fall. They hope that the device will have the dual benefits of preventing wrist and head/face injuries but the relative injury rates will need to be monitored carefully in controlled and field evaluations.

Study authors support a number of safety recommendations for child skating activities that arise from their research findings including:

- mandatory helmet, wrist guard, knee and elbow pad wearing and use of well fitting skate-boots to protect the ankle;
- padding of boards around ice skating rinks;
- graduated instruction and skills-testing programs that require children to demonstrate a certain level of skill before being allowed to skate with more advanced skaters;
- separation of beginner/novice and experienced skaters in time or space;
- postponement of a child's ice-skating debut to at least age 5 years; and
- provision of close adult supervision of child ice skaters aged 6-10 years.

(McGeehan et al., 2004; Knox et al., 2006; Williamson & Lowdon, 1986; Bernard et al., 1988; Oakland 1990).

Preventing ice hockey injuries

Ice hockey is a minor sport in Victoria with 554 registered player members in 2006 (357 senior male players, 182 junior male players and 15 female players) belonging to 7 clubs (IHA, Annual Report 2006). There is currently no women's league in Victoria.

Over the 3-year study period there were 3 hospital admissions (all adult players) and 30 ED presentations equally distributed between adult (senior) and child (junior) players] for ice hockey injuries. Spinks' & McClure's recent review identified that, at the junior sports level, ice hockey has the highest injury rate per hours of exposure and the highest rate of injury per player season of the13 junior organised sports (mostly team ball sports) that have been the subject of sports research that aims to quantify the risk of injury per exposure time (Spinks & McClure, 2007).

Our small case series found that the head/face/neck and the shoulder were the most frequently injured body sites and that the most common causes of injury were checking (collisions with other players), falls and being struck by the puck, stick or rink wall. A review of the literature on ice hockey injuries in children also found that the primary mechanism of injury was body checking (collisions), followed by stick and puck contact (Benson & Meeuwisse, 2005).

Biasca et al. (2002) conducted an historical review of the effectiveness of measures to reduce head and neck injuries in ice hockey and found that compulsory helmet and face guard use regulations (introduced in 1975 and strengthened in 1978) had reduced head/face/eye injury. The authors noted a tendency in modern ice hockey for a more aggressive high-speed playing style that has increased the energy of collisions causing an increase in the incidence and severity of craniofacial injuries. The authors found that illegal play, often not penalised by the referee, is a major cause of head and facial injuries in helmeted and face-protected players. The risk of injury is exacerbated if the helmet-visor/facemask is not securely fastened by the chinstrap, as the stick or puck can slide directly under the visor/facemask. The authors called for the compulsory wearing of mouthguards to reduce dental trauma in the sport.

Recommendations for injury prevention [supported by the American Osteopathic Academy of Sports Medicine (2002), the Canadian Academy of Sports Medicine (1988), the Committee on Sports Medicine of the American Academy of Pediatrics (2000) and other experts} include:

- education of hockey personnel on the potential catastrophic injuries that can occur due to rule violations i.e., checking from behind, high sticking and blows to the head;
- stricter rules and their enforcement including automatic game suspension for serious rule violations and for fighting;
- skills training in checking and limiting checking in hockey players 15 years and under;
- head injury education programs for players and coaches;
- mandatory full face shield protection for players, referees and linesmen;
- wearing of mouthguards;
- use of properly fitted and Standards certified equipment and protective equipment;
- continued research into safer boards and the use of larger ice surfaces;
- research to establish injury risk factors at the different levels of play; and
- research to establish optimal training and conditioning regimes.

(Benson & Meeuwisse, 2005; Biasca et al., 2002; Daly et l., 1990)

Preventing sledding injuries

The suggested preventive measures for sledding are the same as those for tobogganing (see page 12) with the additional recommendation that sledders should never sled in a head-first position.







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Box 1. Methods of extracting snow and ice sport and recreational injury from hospital injury datasets Data were extracted from the Victorian Admitted Episodes Dataset (VAED) and the Victorian Emergency Minimum Dataset (VEMD) using different methods due to database-specific coding issues.The VAED records hospital admissions for all Victorian hospitals, both public and private. VAED data are coded using the World Health Organization International Classification of Diseases (ICD) coding system. Data for the period January 2004 to December 2006 are coded to ICD version 10-AM. Snow and ice sport injuries were identified using the following ICD10 Activity codes: U51.20 Ice hockey, U55.0 Bobsledding, U55.1 Ice skating and ice dancing, U55.20 Alpine and downhill skiing, U55.21 Nordic and cross country skiing, U52.22 Freestyle skiing, U52.23 Snow ski jumping, U52.28 Other specified skiing, U52.29 Skiing, unspecified, U55.3 Snowmobiling, U55.4 Snowboarding, U55.5 Speed skating, U55.6 Tobogganing, U55.7 Curling, U55.8 Other specified ice or snow sport, U55.9 Unspecified ice or snow sport and U67.0 Biathlon (winter) OR the following External Cause Codes: W02.3 Fall involving snow ski, W02.4 Fall involving snow board, W02.5 Fall involving ice skate.The VEMD records public hospital presentations to 37 Emergency Departments, representing all Victorian public hospitals that operate 24-hour emergency departments. Narrative data were utilised to identify specific snow and ice sport and recreation injury cases, as there are no specific codes to identify cases. Keywords used in the search included: aerial, alpine, bobsled, cross country, curling, freestyle, ice hockey, ice skating, luge, moguls, Nordic, ski jumping, slalom, snowboarding, snow skiing, speed skating, tobogganing (and spelling variations of these). There were several cases of non-specific skiing injury that occurred outside the official snow skiing season (June to September) and these were removed as there was insufficient information to determine if they were snow- or water- skiing cases. Supplementary analyses of narrative data from VEMD-recorded hospital admissions for snow and ice sport and recreation were performed to provide additional information on the circumstances of injury of hospitalised cases as the VAED records no narrative data. There was sparse additional information on the circumstances and contributory factors in narratives.

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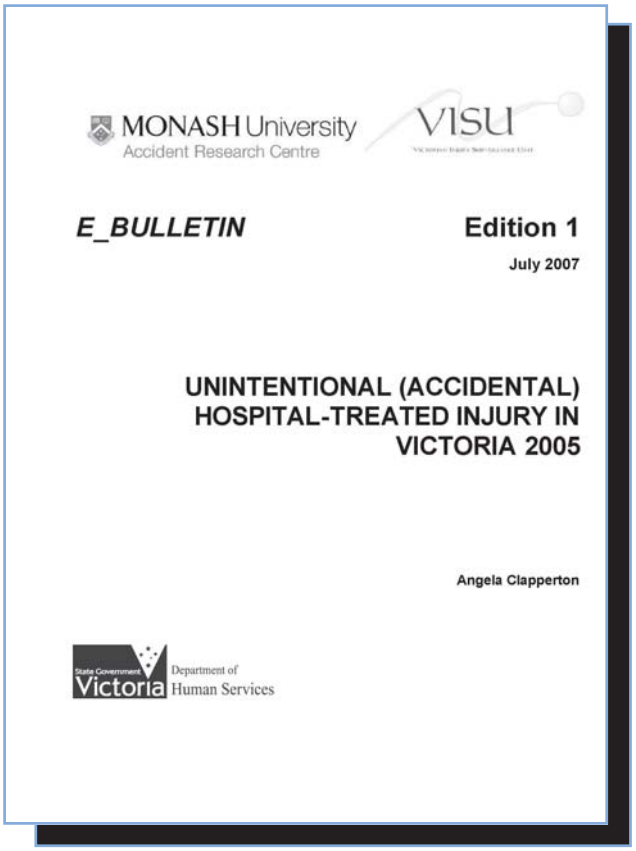
9th World Conference on Injury Prevention and Control

15-18 March, 2008 - Mexico

This Conference will give special attention to the processes of globalization and their implications for injuries and violence. The WHO is urging governments to address the two main themes of Violence and Traffic Accidents. The conference will also emphasize the global patterns in Technological and Epidemiological Transitions, proposing international collaboration as a fundamental strategy for the design and promotion of policies for injury prevention and safety promotion.

www.safety2008mx.info/ing/



Unintentional (accidental) hospital-treated injury in Victoria 2005

This is the first of a series of regular E-bulletins that will provide an overview of the injury profile for Victoria utilising injury surveillance datasets. This edition provides an overview of unintentional ('accidental') hospital-treated injury in 2005.

Available free to download at www.monash.edu.au/muarc/VISU/

The next E-bulletin will provide an overview of fatal injury in Victoria, 2005. It will be posted in early November.

VISU Information request service

VISU serviced 250 information requests in 2006/07 utilising the three injury surveillance databases available to MUARC: the Australian Bureau of Statistics - Death Unit Record File (ABS-DURF); Victorian Admitted Episodes Dataset (VAED) and the Victorian Emergency Minimum Dataset (VEMD).

The most frequently requested topics were: elderly fall injury, playground and play equipment injury, DIY home maintenance injury, home injury, dog bite, sports injury poisoning, nursery furniture and equipment injury, off-road vehicle injury (ATVs and motorcycles) and local community injury profiles (by Local Government Area).

• Who can access VISU injury data?

The VISU data and information request service is open to government and non-government organisations, the higher education and schools sector, industry and business and community members. We are not able to provide a direct service to primary and secondary school students.

• Any charges?

A standard format response is free-of-charge. Additional analysis may be purchased for a cost-recovery fee of $100 per hour (GST exclusive).

• How do I make a request

Data and information requests can be made by telephone (9905 1805) or email: visu.enquire@muarc.monash.edu.au

Young People, Crime and Community Safety: engagement and early intervention

25 - 26 February 2008
RACV Club, Melbourne, Victoria

CONFERENCE AIM

Young people are disproportionately involved in risk-taking, antisocial behaviours and other activities which compromise their safety and the safety of others. They are also highly at risk of experiencing reduced opportunities in life through the influence of such factors as low educational attainment, early school leaving, involvement with the law, low socioeconomic status, ethnicity and disability.

This two-day conference, being conducted jointly by the AIC and the VSCN, will explore approaches to integrating evidenced-based prevention and early intervention strategies to engage young people as active participants in community safety.

Conference Themes

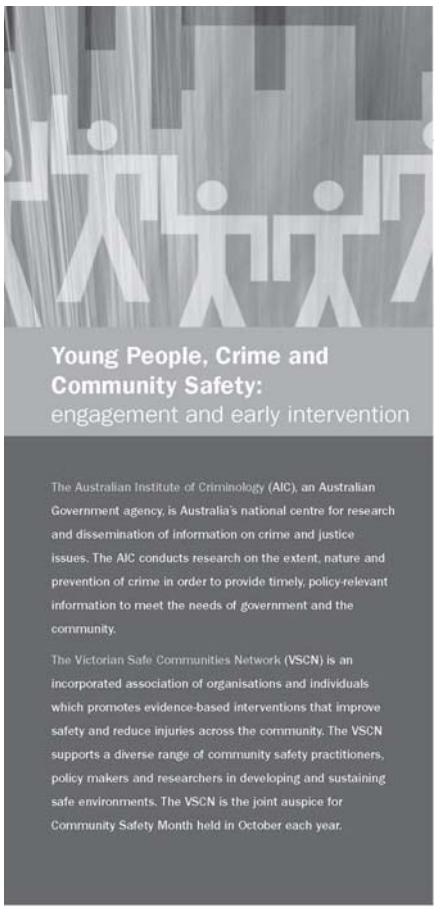
- Crime and violence
- Integrating health and community safety
- Alcohol and other drugs
- Emergency management
- Programs for young people

WHO SHOULD ATTEND

Young people, those with a direct responsibility for the health, safety and wellbeing of young people, and those with research, policy and program management responsibilities, including:

- Federal, state and local government officers
- Police and emergency services officers
- Justice professionals and criminologists
- Youth organisations and workers
- Education professionals
- Health authorities and professionals
- Academics
- Community-based agencies
- Emergency services
- National and state NGOs

www.vscn.org.au



VSCN Victorian Safe Communities Network Inc

Playspace Resource Kit

Nearly 10% of all child injury hospitalisations are playground related. This equates to over 6,000 children being admitted to hospital each year from playground injury, with countless more children injured who do not require hospital admission. What's more, these numbers appear to be rising.

The objective of the Playspace Resource Kit is to improve the standards of Australian playgrounds, by providing organisations with information on how to create safe play areas for children. Kidsafe believes that by doing this, there will be a reduction in the number of children sustaining injuries in playgrounds.

Aimed primarily at organisations such as playgroups, day care and childcare centers, the resource kit contains 19 information sheets. These sheets cover areas such as the Australian Standards, recommended equipment and under-surfacing materials, equipment items and maintenance requirements.

The Playspace Resource Kit is designed as a user-friendly, practical tool where information and recommendations can be easily understood and followed.

Playspace Resource Kit $29.95
www.kidsafevic.com.au/
Email: info@kidsafevic.com.au

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General Acknowledgements

Participating hospitals

From October 1995
Austin & Repatriation Medical Centre
Ballarat Base Hospital
The Bendigo Hospital Campus
Box Hill Hospital
Echuca Base Hospital
The Geelong Hospital
Goulburn Valley Base Hospital
Maroondah Hospital
Mildura Base Hospital
The Northern Hospital
Royal Children's Hospital
St Vincents Public Hospital
Wangaratta Base Hospital
Warrnambool & District Base Hospital
Western Hospital - Footscray
Western Hospital - Sunshine
Williamstown Hospital
Wimmera Base Hospital
From November 1995
Dandenong Hospital

From December 1995
Royal Victorian Eye & Ear Hospital
Frankston Hospital

From January 1996
Latrobe Regional Hospital

From July 1996
Alfred Hospital
Monash Medical Centre

From September 1996
Angliss Hospital

From January 1997
Royal Melbourne Hospital

From January 1999
Werribee Mercy Hospital

From December 2000
Rosebud Hospital

From January 2004
Bairnsdale Hospital
Central Gippsland Health Service (Sale)
Hamilton Base Hospital
Royal Women's Hospital
Sandringham & District Hospital
Swan Hill Hospital
West Gippsland Hospital (Warragul)
Wodonga Regional Health Group

From April 2005
Casey Hospital

National Injury Surveillance Unit

The advice and technical back-up provided by NISU is of fundamental importance to VISU.

How to access VISU data:

VISU collects and analyses information on injury problems to underpin the development of prevention strategies and their implementation. VISU analyses are publicly available for teaching, research and prevention purposes. Requests for information should be directed to the VISU Co-ordinator or the Director by contacting them at the VISU office.

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Monash University WEB SITE Accident Research Centre

All issues of *Hazard* and other information and publications of the Monash University Accident Research Centre can be found on our internet home page:
http://www.monash.edu.au/muarc/visu

Coronial Services

Access to coronial data and links with the development of the Coronial Services statistical database are valued by VISU.

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Victoria The Place To Be

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