



Skiing Helmets

An Evaluation of the Potential to Reduce Head Injury



January 1999

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EXECUTIVE SUMMARY

As part of an overall strategy to reduce head injuries, the U.S. Consumer Product Safety Commission (CPSC) staff conducted an evaluation of head injuries associated with snow skiing and snowboarding. The purpose of this activity was to assess the potential for helmets to reduce the risk of head injury.

From 1993 to 1997, the estimated number of hospital emergency room-treated injuries associated with skiing declined from 114,400 to 84,200. Head injuries associated with skiing were essentially unchanged. However, the estimated 12,700 head injuries in 1997 represent a larger proportion of total injuries than did the estimated 13,600 head injuries in 1993. During the same time period, snowboarding injuries nearly tripled from 12,600 to 37,600. The estimated number of head injuries associated with snowboarding increased from 1,000 in 1993 to 5,200 in 1997. Overall, head injuries represent about 14 percent of all skiing and snowboarding injuries. Among children under 15 years of age, head injuries are about 22 percent of the total estimated injuries (or an estimated 4,950 head injuries annually).

From February 1 through March 31, 1998, CPSC conducted a special investigation study of skiing- and snowboarding-related head and neck injuries. A key aspect of this study was to obtain information regarding the point of impact on the head to determine whether a helmet would have covered the area of injury and, therefore, might have prevented or reduced the severity of the injury. The study indicated that 44 percent of head injuries -- or an estimated 7,700 injuries annually -- could be addressed by helmet use. The study also showed that for children under 15 years of age, 53 percent of head injuries (approximately 2,600 of the 4,950 head injuries annually) are addressable by use of a helmet. In addition, based upon a review of skiing- and snowboarding-related death certificates, 11 deaths per year solely attributed to head injuries might be prevented by the use of helmets.

Studies have shown that safety helmets for motorcycling and bicycling provide effective protection against head and brain injuries, including severe brain injuries. It is also reasonable to suggest from the bicycling and motorcycling experience that a skiing helmet that meets a suitable standard could provide effective protection against head and brain injuries in many types of skiing-related incidents involving head impact. A study of ski injuries in Sweden during the 1985 - 1986 ski season reported that head injury among skiers wearing helmets was 50 percent lower than for skiers who did not wear helmets. Based upon this information, as well as the assessment presented in this report, staff conclude that the use of skiing helmets will reduce the risk of head injury associated with skiing and snowboarding.

INTRODUCTION

As part of an overall strategy to reduce head injuries, the U.S. Consumer Product Safety Commission (CPSC) staff began an evaluation of head injuries associated with snow skiing and snowboarding. The purpose of this activity was to assess the potential for helmets to reduce the risk of head injury. A key element of the evaluation was a special investigation study of head and neck injuries associated with skiing and snowboarding conducted during the 1998 winter season. Over the course of this evaluation, staff also analyzed incident data, reviewed the technical literature on skiing and on the effectiveness of helmets, assessed the voluntary standards for skiing helmets, and reviewed market information and laws and organizational policies with respect to skiing helmets. The results of the staff's assessments are presented in this report.

INJURY DATA AND HAZARD PATTERNS [1]

Injuries Associated with Skiing and Snowboarding

Data from CPSC's National Electronic Injury Surveillance System (NEISS) show that in 1997 there were an estimated 84,200 hospital emergency room-treated injuries associated with skiing. This represents a decline from 1993 when there were an estimated 114,400 injuries^{1,2}. During this same time period, snowboarding injuries nearly tripled from 12,600 in 1993 to 37,600 in 1997. In each case, the trends over time were found to be statistically significant (see Figure 1).

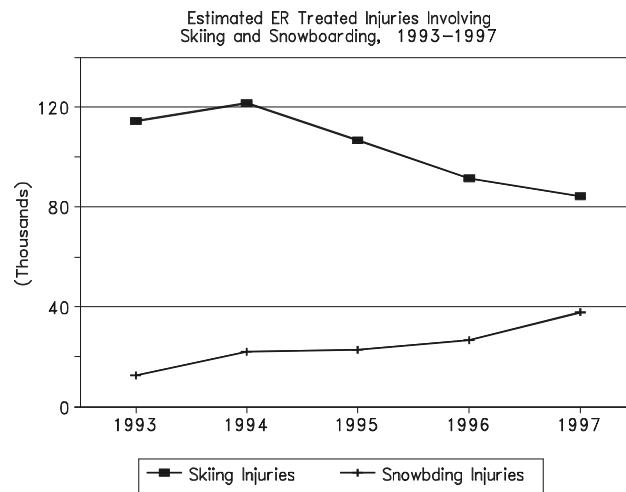


Figure 1. Estimated Emergency Room-Treated Injuries Involving Skiing and Snowboarding, 1993 - 1997

¹A reduction in knee, lower leg and ankle injuries accounted for approximately half of that decline.

²According to a National Sporting Goods Association survey of households, participation in alpine and cross country skiing has declined slightly since 1993 but not to the same degree as the decline in overall skiing injuries.

In 1997, for skiing and snowboarding combined, 18 percent of the injured were under 15 years of age; 30 percent were 15 - 24 years of age; 47 percent were between 25 and 64 years of age; and five percent were 65 years old or older. Males were the victims in 63 percent of the cases.

Most of the emergency room-treated injuries were not severe or life threatening, with 95 percent of injured persons being treated and released. In 1997, lower leg injuries, including the knee, accounted for 32 percent of the injuries associated with skiing and snowboarding.

Head Injuries Associated with Skiing and Snowboarding

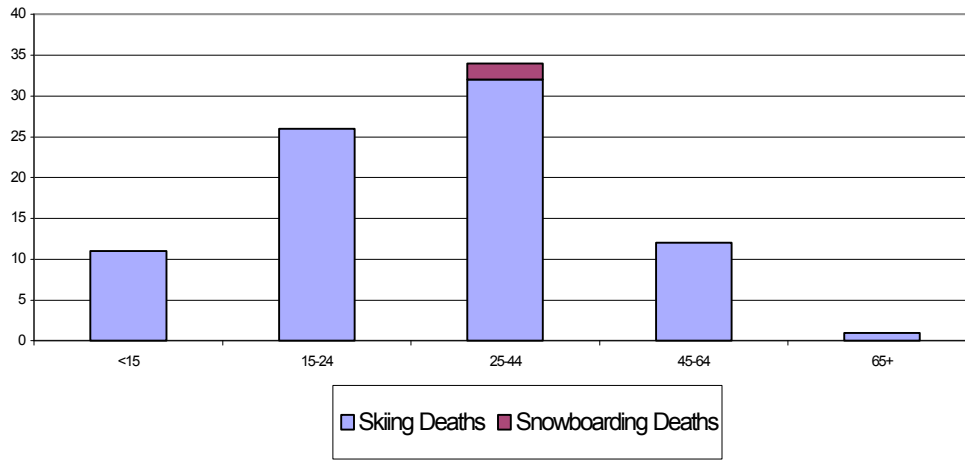
From 1993 to 1997, head injuries associated with skiing did not decrease as did the total number of injuries. The estimate was 13,600 in 1993 and 12,700 in 1997 and is essentially unchanged. However, the estimated 12,700 head injuries in 1997 represent a larger proportion (approximately 15 percent) of the total than did the estimated 13,600 head injuries in 1993 (about 12 percent). The estimated number of head injuries associated with snowboarding increased from 1,000 in 1993 to 5,200 in 1997. Overall, head injuries represent about 14 percent of all skiing and snowboarding injuries. Among children under 15 years of age, head injuries are about 22 percent of the total estimated injuries.

Deaths Associated with Skiing and Snowboarding

CPSC's Death Certificate Data Base contains information on 188 skiing- and snowboarding-related deaths for the period 1990 through 1997; this is about 24 deaths per year.³ The data were examined to identify the frequency of head injury in these fatalities. This review revealed that 108 of the reports -- greater than half -- identified head injuries as part of the cause of death. Eighty-four of these deaths were attributed solely to head injury. An age distribution of skiing- and snowboarding-related head injury deaths is shown below (see Figure 2).

³National Ski Areas Association reported an average of 36 deaths per season over approximately the same time period. The difference in data may be attributable to the fact that CPSC does not purchase reports for fall deaths from all 50 states. In addition, CPSC's Death Certificate Data Base is incomplete for 1996-1997.

Figure 2. Skiing & Snowboarding Head Injury Deaths, by Age, Death Certificates 1990-1997



Of the 108 death reports which identified head injuries as part of the cause of death, collisions were indicated in 95 of these: 86 were collisions with a stationary object (usually a tree, but lift poles were also identified in some of the reports), and nine were collisions with another person. There were four fall deaths and nine deaths in which no pattern was stated. CPSC does not purchase fall-related death certificates from most states, so the number of fall deaths might be an undercount.

Among the 80 cases which did not specify head injury, 23 reported multiple injuries without specifying a body part. Some of these may have included head injuries. The remainder of the non-head injury deaths were mostly blunt force injuries to the chest and body from striking trees or other objects. There were a small number of suffocations in deep snow and a very few collisions between skiers.

CPSC SPECIAL INVESTIGATION STUDY

From February 1 through March 31, 1998, CPSC conducted a special investigation study [1] of skiing- and snowboarding-related head and neck injuries treated in NEISS hospitals. A key aspect of this study was to obtain information regarding the point of impact on the head to determine whether a helmet would have covered the area of injury and, therefore, might have addressed⁴ the injury.

⁴For both injuries and deaths, CPSC staff recognizes that there are several additional factors, such as speed, which body part hits first, object struck, and ground condition, which can affect the outcome of a head impact. In most fatal cases, we do not have this information. Given the available data, staff believes that point of impact serves as a reasonable measure to approximate the potential benefit of a helmet.

For each of the head injuries reported, victims or parents of victims were contacted and asked to complete a questionnaire which would provide information regarding the part of the head that was injured as well as details of the incident leading to injury. Information requested in the questionnaire included lighting and weather conditions, slope conditions, number of hours skiing or snowboarding before the injury occurred, ability level of the victim and the difficulty level of the slope on which the injury occurred, the cause of the injury and the circumstances leading to the incident, types of equipment used, and whether the victim was wearing a helmet at the time of injury. There were 124 in-scope reports of head injury during the study period; questionnaires were completed on 74 of these cases.

In addition, reporting hospitals were requested to provide detail about the point of impact on the victim's head. This information, combined with that from the questionnaires, allowed staff to evaluate this critical variable using the entire study data base of 124 cases, even when questionnaires were not completed.

Study Information

Falls were the leading cause of head and neck injuries in the study data base; 69 percent of injuries were caused when the victims either hit the surface (48 percent) or fell and hit their ski equipment (21 percent). About two-thirds of the falls to the surface resulted in injuries to parts of the head which were identified as addressable by use of a helmet. Other injury patterns included the victim striking an object (14 percent) or colliding with another person (six percent).

Most head injuries during the study period were not severe or life threatening; 94 percent of victims were treated at an emergency room and released. Six percent were admitted to the hospital for treatment.

Completed investigations also revealed the following:

- ♦ Six victims were wearing helmets; all of these were under the age of 18. Based upon information provided, none of the six injuries appears to have been caused by the helmet. In five of the cases, the injuries appear to have been mitigated by use of a helmet. In some cases, injuries were to areas of the head that were covered by the helmet, and injuries were described as minor. In other cases, injuries were to other parts of the body, such as a sore neck with injuries to shoulders or hips.
- ♦ In general, the ability level of the skier matched the difficulty level of the slope. Intermediate level skiers were injured most often; the majority of those injuries occurred on intermediate-level slopes. There were very few beginners injured on expert slopes, and there were no experts injured on beginner slopes.

- ♦ Almost one-fourth of all the injuries occurred when the skier or snowboarder went over a mogul, over a jump, or hit a bump.
- ♦ The majority of injuries occurred during daylight hours, under sunny conditions, and during the first four hours of skiing or snowboarding.

Injuries Addressable by Use of a Helmet

Injuries which were considered to be addressable by a helmet were those to the top of the head, back of the head, forehead, and side of the head above the ear. Based upon these criteria, 44 percent of the head injuries in the study period were determined to be addressable by use of a helmet; 42 percent would not have been addressable; six percent of the victims were wearing helmets at the time of injury; and for eight percent of the injuries, no determination could be made.

To further evaluate the findings from the study data, staff applied these proportions to the national estimates for skiing and snowboarding head injuries for 1997 to estimate the number of head injuries which might be addressed by helmet use over the period of a full year. Using the national estimate of 17,500 skiing and snowboarding head injuries, staff estimates 7,700 injuries could be addressed annually by use of helmets. Approximately 53 percent of the injuries to children under 15 years of age (approximately 2,600 head and neck injuries) were identified as addressable by a helmet. For other age groups, approximately 40 percent of injuries may be addressed.

Staff also analyzed death certificate data. The number of potentially-addressable deaths were defined as those in which the cause of death was listed solely as head injury. Based upon the review of death certificate data, which showed that 84 deaths (from 1990 through 1997) were caused by head injury only, staff estimates that up to 11 deaths per year might be addressed by use of a helmet. While some of these deaths may not have been prevented through helmet use, this is still a conservative approach to identifying the number of potentially addressable deaths because of the known undercounting of fall-related deaths.

REVIEW OF TECHNICAL LITERATURE

A review of technical literature on head injuries associated with skiing and snowboarding was conducted. Most studies were retrospective studies of injury data from hospital records; therefore, little information on helmet use was available. The major findings of the literature review are described below:

- ♦ A nationwide study of ski injuries in Sweden during the 1985 - 1986 season reported that head injury among helmet wearers was 50 percent lower than for non-helmet users (nine percent of injured skiers wearing helmets sustained head injury compared to 18.6 percent among injured skiers who did not wear helmets) [2]. The study also showed that helmet use in Sweden is more prevalent among skiers under 18 years of age.
- ♦ In a 1993 Norwegian study on skiing injuries among children [3], the author reported that head injury was more prevalent among children 10 - 14 years old (18 percent) compared to children under 10 years old (five percent). The author attributed this difference to common use of protective helmets by the youngest children. The author also noted that the injury risk for beginning skiers was nine times greater than the risk for intermediate skiers.
- ♦ Several authors advocated the use of helmets [2, 3, 4, 5, 6, 7, 8, 9]. Recommendations were often based on bicycle helmet studies which show that helmets protect the head during impact. Also, some authors suggested that helmet use might decrease the severity of head injury even if it does not reduce the total number of injuries.

SKIING HELMET STANDARDS: PROVISIONS, EFFECTIVENESS

Until very recently, there were no U.S. voluntary standards for skiing helmets. The Snell Memorial Foundation issued two new protective headgear standards in 1998. These are S-98 *Protective Headgear for Skiing and Other Winter Activities*, and RS-98 *Protective Headgear for Recreational Skiing and Snowboarding*.

ASTM (Committee F08 on Recreational Headgear) is also developing a standard for *Protective Headgear Used in Recreational Skiing*. A new ASTM skiing helmet standard was balloted by the F08 Main Committee in October 1998. Several subcommittee members submitted negative votes on the new standard. In December 1998, a new ASTM skiing helmet task group was formed to address outstanding technical issues and to develop a revised standard for subcommittee ballot prior to the next meetings in May 1999.

The established European standard for skiing helmets is EN 1077, *Specification for Helmets for Alpine Skiers*.

Protective headgear for most recreational and motorsport activities is tested for impact management by securing a helmet onto a metal test headform. The helmet/headform assembly is dropped from a given height (generally between one and two meters) to achieve a specified impact velocity (4.4 to 6.2 meters/second, or 10 to 14 mph) onto

solid steel anvils. For most standards, the pass/fail criterion is set as a maximum allowable deceleration level upon impact. Deceleration is the rate at which the headform slows from its peak velocity to zero velocity. The maximum deceleration is measured in multiples of gravity (g) and is called "peak-g."

Safety helmet standards provide a combination of test parameters and criteria that result in effective protection against head and brain injury, even though impact test speeds may seem comparatively low with respect to possible impact speeds in a collision. Several epidemiological studies have shown the effectiveness of safety helmets in protecting against brain and head injuries. The Federal Motor Vehicle Safety Standard for Motorcycle Helmets (FMVSS 218) specifies flat anvil helmet impacts at 13.4 mph and hemispherical anvil impacts at 11.7 mph. In a 1996 study that examined the benefits of motorcycle helmet use, the National Highway Traffic Safety Administration (NHTSA) found that motorcycle helmets were 67 percent effective against brain injury and 35 percent effective against fatal injury [10].

Another example is the demonstrated effectiveness of bicycle helmets. Impact velocities specified in various bicycle helmet standards range from 10 mph to about 14 mph. A 1989 study [11] found that bicyclists with helmets meeting established standards had an 85 percent reduction in risk of head injury, and an 88 percent reduction in their risk of brain injury. These results were found when patients who sought emergency room care for bicycle-related head injuries were compared to bicyclists in the community who had crashes, regardless of injury or medical care.

A later study by the same authors [12] indicated that bicycle helmets reduce the risk of any head injury by 69 percent, brain injury by 65 percent, and severe brain injury by 74 percent. This study compared bicyclists treated in emergency departments for head injuries with bicyclists treated in emergency departments for non-head injuries. The authors stated that the overall protection is likely in excess of 80 percent, if compared to a population-based control group.

The EN 1077, Snell, and proposed ASTM skiing helmet standards contain many similar provisions, including: impact management, retention system strength, and resistance to roll-off. Although all three standards differ in their test parameters and methodologies, a ski helmet that meets any one of the three standards will provide adequate protection to reduce the risk of head injury.

MARKET INFORMATION

Ski and Snowboard Participation

The National Ski Areas Association (NSAA) is a trade association for the ski resort industry, and its members represent 350 of the 510 ski areas in the U.S. The industry is comprised of large and small resorts; however, 80 percent of skier visits are to the top 50 member ski areas [13]. Based on NSAA reports on the total number of ski area visits per season, an average of 53.4 million visits⁵ per year were made to U.S. ski resorts over a four-year period between 1993 and 1997.

According to a National Sporting Goods Association (NSGA) survey of households, between 1993 and 1997 an average of nearly ten million people participated in alpine skiing more than once a year. Snowboarding, which has been reported since 1988, increased in participation from 1.8 million participants in 1993 to 2.5 million participants in 1997.

NSGA also estimates the participation of youths between the ages of seven and 17 in both skiing and snowboarding. Between 1993 and 1997, snowboarding participation increased 43 percent in this age group, from .98 million to 1.4 million. The largest increase was in the seven to 11 year age group, which increased from .28 million to .43 million, a 54 percent increase. NSAA expects parity between the number of skiers and the number of snowboarders in five to six years [13].

Skiing Helmets, Sales and Usage

Skiing and snowboarding helmet designs vary. Some include openings for ears to allow for ease of hearing, adjustable venting systems, liners for fit and warmth, allowance for wide peripheral vision, and coverage of the back of the head. Most have indentations in them to allow for the use of goggles, and many allow for the addition of face protection equipment.

Most skiing helmets are imported from Europe. Recently available marketing literature indicates additional domestic manufacturers may enter the market by the next ski season [14]. According to SnowSports Industries America, a trade association of snow sports product manufacturers, helmet sales have increased 25 percent annually over the past five years, making helmet sales the fastest growing product category in the snow sports industry. During the 1995-1996 season, approximately 66,000 helmets were sold. For the 1996-1997 winter season, about 81,000 helmets were sold.

⁵One visit is one person visiting a ski area for all or any part of a day or night: full day, half day, night, complimentary, adult, child, season or any other ticket type.

Helmet use is not widespread with the general skiing public, although it is rising, particularly among snowboarders performing extreme tricks, students of ski and snowboard schools, and young children [15, 16, 17, 18]. SnowSports Industries America estimates that approximately five percent of alpine skiers and snowboarders wear helmets. However, given that the reported annual sales of helmets per year have not exceeded 100,000, a more reasonable estimate may be between two and three percent.

Helmet prices for adults range from about \$75 to \$300; helmets for children range from \$70 to \$150. Visits to local area ski shops and sporting goods stores indicated that most helmets were priced between \$80 and \$130. Helmets also may be rented at some ski equipment rental stores for as low as \$4 (children) to \$5 (adults) [19]. Approximately ten percent of NSAA member ski resorts offer helmet rentals [20].

Most skiing helmets include instructions to have the helmet inspected if it suffers a serious impact to determine whether it is suitable for additional protective use. Most companies offer a discount on the replacement for a crashed helmet [21].

SKIING HELMETS: STATE LAWS, FEDERAL AND ORGANIZATIONAL POLICIES

State Laws [22]

A number of states have ski safety acts, many of which pertain to the "inherent dangers" of skiing. Inherent dangers can include weather, snow, rocks, collisions with natural and manmade objects, skiers and the failure of skiers to ski within their own ability.

No states have laws requiring the use of skiing helmets for any age group.

USDA Forest Service [23, 24]

There are 135 ski areas permitted to operate in National Forests; this includes most of the major resorts. Fifty-five percent of recreational skiing occurs at these facilities.

The USDA Forest Service (USFS) administers the National Forests and has some responsibility for the health and safety of snow sport participants at these facilities. Through their permit system, ski areas must have operating plans in place which cover a variety of safety issues, including avalanche plans and adequate ski patrol. USFS's Snow Rangers administer the permits and monitor compliance.

USFS does not require recreational skiers who participate in snow sports in National Forests to wear helmets. However, there are circumstances for which their employees may be required to wear a skiing helmet. Duties which might have a requirement for

helmet use include skiing in heavily timbered or avalanche areas (e.g., while "reconning" new areas for future resort slopes) and avalanche control activities.

Some Snow Rangers already wear skiing helmets voluntarily. For employees with winter sports duties who wish to wear skiing helmets for on-the-job skiing, even when not required, the USFS does authorize the purchase of skiing helmets just as they do other protective safety gear such as goggles, ski bindings, wrist guards, etc. Helmet use among Rangers, who may be seen as role models, may also encourage children to wear helmets, which are beneficial under some circumstances.

Other Organizations

The U.S. Ski Association (USSA) is the national governing body for skiing and snowboarding. For most competitions and official training sponsored by the USSA, including national and Olympic teams, junior development programs, and disabled skier programs, helmets are required.

The National Ski Areas Association (NSAA) promotes education as the primary means to achieve safety. NSAA views a helmet as important safety equipment but considers it secondary to education [13]. Ski resorts do not require helmets for general public use, but their use is encouraged at some resorts. In an Internet advertisement of a large ski resort in Finland, free lift tickets and equipment rentals are being offered for children wearing helmets [25]. At some resorts, particularly larger ones, helmets may be required for students of ski classes. One of the largest ski resorts in Canada, Lake Louise Ski Resort, provides helmets to all of its instructors who teach children [26]. The National Ski Patrol, which certifies patrols at established ski areas, has taken the position that wearing a skiing helmet is a matter of personal choice [27].

The following organizations were contacted to determine their positions on helmet use for skiing and/or snowboarding:

- ♦ The American Medical Association supports the voluntary use of helmets and protective headgear for children and adolescents during recreational skiing and snowboarding [28].
- ♦ The Brain Injury Association (BIA) endorses and supports the use of helmets while skiing and performing other winter sporting activities. BIA believes that children in particular need to wear helmets to protect themselves [29].
- ♦ The American Academy of Pediatrics had not yet taken a position [30].
- ♦ National Safe Kids Campaign supports the voluntary use of helmets, particularly for children and adolescents [31].

SUMMARY/CONCLUSION

From 1993 to 1997, the estimated number of hospital emergency room-treated injuries associated with skiing declined from 114,400 to 84,200. Head injuries associated with skiing were essentially unchanged. However, the estimated 12,700 head injuries in 1997 represent a larger proportion of the total than did the estimated 13,600 head injuries in 1993. During the same time period, snowboarding injuries nearly tripled from 12,600 to 37,600. The estimated number of head injuries associated with snowboarding increased from 1,000 in 1993 to 5,200 in 1997. Overall, head injuries represent about 14 percent of all skiing and snowboarding injuries. Among children under 15 years of age, head injuries are about 22 percent of the total estimated injuries (or an estimated 4,950 head injuries annually).

A CPSC special investigation study of skiing and snowboarding head injuries indicated that 44 percent -- or an estimated 7,700 injuries -- could be addressed by helmet use. The study also showed that for children under 15 years of age, 53 percent of head injuries (approximately 2,600 of the total 4,950 head injuries) are addressable by use of a helmet. In addition, based upon a review of skiing- and snowboarding-related death certificates, 11 deaths per year solely attributed to head injuries might be addressed by the use of helmets.

Studies have shown that safety helmets for motorcycling and bicycling provide effective protection against head and brain injuries, including severe brain injuries. It is also reasonable to suggest from the bicycling and motorcycling experience that a skiing helmet that meets a suitable standard could provide effective protection against head and brain injuries in many types of skiing-related incidents involving head impact. A nationwide study of ski injuries in Sweden during the 1985 - 1986 ski season reported that head injury among skiers wearing helmets was 50 percent lower than for skiers who did not wear helmets. Based upon this information, as well as the assessment presented in this report, staff conclude that the use of skiing helmets will reduce the risk of head injury associated with skiing and snowboarding.

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