

Ski Helmet Safety and Why Helmets Should be Mandatory for Skiers and Snowboarders

Samantha Stone, Computer Science
Washington University in St. Louis
December 10, 2013

Abstract

52% of ski and snowboard injuries include an injury to the brain (McBeth 562). A 2006 study found a 60% reduction in brain injury risk when the subject wears a helmet. While to some wearing a helmet is an obvious safety measure, one study found that only 67% of skiers and snowboarders in the United States wear helmets. Currently, only one state, New Jersey, has a law requiring helmet use while skiing or snowboarding. This is a report analyzes information on ski and snowboard helmets, how they work, their effectiveness, and why their use should become mandatory.

Samantha Stone

December 10, 2013

Washington University Computer Science and Engineering
6515 Wydown Blvd.
St. Louis, MO 63105

Dr. Lynnea Brumbaugh
Washington University in St. Louis
Engineering Communications Center
6515 Wydown Blvd.
St. Louis, MO 63105

Dear Dr. Brumbaugh,

I am submitting the attached report entitled *Ski Helmet Safety and Why Helmets Should be Mandatory for Skiers and Snowboarders*.

This report analyzes information on ski and snowboard helmet use and effectiveness, and current laws making helmets mandatory. 52% of ski and snowboard injuries include an injury to the brain. A 2006 study found a 60% reduction in brain injury risk when the subject wears a helmet. While to some wearing a helmet is an obvious safety measure, one study found that 33% of skiers and snowboarders in the United States do not wear helmets. Currently, only one state, New Jersey, has a law requiring helmet use while skiing or snowboarding. This report comes to the conclusion that helmets should be made mandatory in order to promote the safety of skiers and snowboarders in the United States.

I would like to acknowledge the Washington University in St. Louis library for providing access to the documents necessary to write this report. I would also like to thank Lauren Todd, the library assistant for engineering, for helping me navigate the library databases.

I hope this report expresses the need for a mandatory helmet law, and promotes safety and helmet use for skiers and snowboarders. If you have any further questions, feel free to contact me by email at s.stone@wustl.edu.

Sincerely,

Samantha Stone, B.S.C.S Candidate
Washington University Computer Science and Engineering

TABLE OF CONTENTS

Abstract.....	i
Letter of Transmittal.....	ii
1.0 Introduction.....	1
2.0 Technical Background.....	2
2.1 Head Injuries and Snowsports.....	2
2.1.1 Brain Injury.....	2
2.1.2 Brainstem Injury.....	3
2.1.3 Skull Fracture.....	3
2.2 Helmet Use and Effectiveness in Skiing and Snowboarding.....	3
2.2.1 The Physics of Helmets.....	3
2.2.2 Helmet Use Statistics.....	4
2.2.3 Head Injury and Helmet Effectiveness Statistics.....	5
2.2.4 Analysis of Statistics.....	7
2.2.5 Instructions for Proper Helmet Use.....	8
3.0 Existing Legislation.....	8
3.1 United States.....	8
3.1.1 US States With Ski and Snowboard Helmet Legislation.....	9
3.1.2 Ski Helmet Laws vs. Motorcycle and Bicycle Helmet Laws.....	9
3.2 A Study of Austria's Ski and Snowboard Helmet Law.....	9
4.0 Conclusion.....	10
Works Cited.....	12

TABLE OF FIGURES

Figure 1. Brain Injury.....	2
Figure 2. The Physics of Helmets.....	4
Figure 3. Helmet Use Statistics.....	4
Figure 4. Head Injury and Helmet Effectiveness Statistics.....	6
Figure 5. Analysis of Statistics.....	7
Figure 6. Instructions for Proper Helmet Use.....	8
Figure 7. A Study of Austria's Ski and Snowboard Helmet Law.....	10

1.0 INTRODUCTION

The most common injury of skiers and snowboarders is a brain injury (McBeth 562). 83% of those who injure their head while skiing or snowboarding are not wearing a helmet (Sulheim 922). A 2006 study concluded a 60% reduction in the risk of brain injury when the skier or snowboarder wore a helmet (Sulheim 923). According to these figures, if helmet use becomes mandatory, the number of skiers and snowboarders who sustain head injuries might greatly decrease.

Those who incur head injuries from skiing or snowboarding often sue the ski resort for tens of thousands of dollars, or even more. One lawsuit that set precedent was Sunday vs. Stratton Corporation. James Sunday, a novice skier in 1974, caught his ski on a bush buried under the snow on a beginner trail. He fell headfirst and was left quadriplegic. A jury awarded him \$1.5 million, and said that Stratton had failed to keep the beginner trail free of hazards. The ruling was held up on appeal (Insurance Journal). This lawsuit set the precedent that ski and snowboard resorts are liable for such injuries. Mandatory use of helmets could reduce the necessity for such lawsuits, and therefore save ski resorts time and money.

Many ski resorts throughout the United States have promoted ski helmet safety by making helmets mandatory for their employees and children in their instructor-led lessons. They have also made renting helmets more available and affordable. However, making helmets mandatory for all skiers and snowboarders at the resort could result in a loss of revenue, as those people who do not want to wear a helmet on the slopes might leave for a competing resort. A mandatory helmet law would remove the problem of resort competition, and instead place the burden of enforcement on the government.

This is an analysis of the literature on the use and effectiveness of helmets for skiers and snowboarders. The intended audience is skiers and snowboarders, as well as

lawmakers and managers of ski resorts. This report will first discuss head injuries and how they might occur from skiing or snowboarding. Next, this report will consider helmet use and its effectiveness in protecting from head injuries while skiing or snowboarding. This report will then discuss current law, and will finally come to the conclusion based on this information that making helmets mandatory for skiers and snowboarders in the United States is necessary.

2.0 TECHNICAL BACKGROUND

2.1 Head Injuries and Snowsports

Head injuries are the leading cause of death while skiing or snowboarding (Sulheim 919). They are the most common skiing injury, and can result in damage to the brain, brainstem, and skull. This section will discuss these three types of injuries, how they might result from skiing, and how common they are among head injuries of skiers and snowboarders.

2.1.1 Brain Injury. At any given time, the normal human brain is suspended in liquids inside of the skull. On impact, the brain bumps into the interior of the skull, as seen in Figure 1, and bounces back and forth inside of the skull, causing a concussion or possibly a more serious brain injury (Smayda 1). This can happen when a skier or snowboarder collides with another person, a tree, a manmade object, or even from a simple fall to the ground. 52% of all skiing- or snowboarding-related injuries include an injury to the brain (McBeth 562),

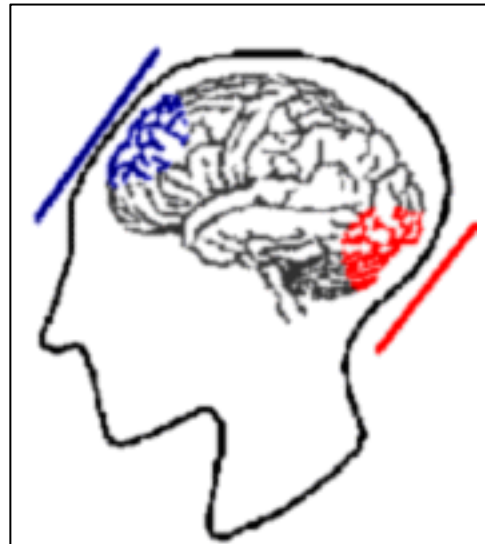


Figure 1. When the head is hit, the brain, which is normally suspended in liquids inside of the skull, collides with either side of the interior of the skull, as indicated by the highlighted sections of this figure.

which makes brain injuries the most common injury among skiers and snowboarders. Over half of these brain injuries are concussions, but more serious brain injuries, such as hematomas and cerebral contusions, can also occur. In extreme cases, brain damage can result in death.

2.1.2 Brainstem Injury. In addition to brain injury, collisions of any kind can also cause whiplash, which may lead to an injury to a person's brainstem. The brainstem, among other things, regulates a person's breathing and heart rate, and connects the brain to the spinal cord. Damage to the brainstem can create problems for a person's balance and motor control, and in extreme cases can cause paralysis. About 11.5% of head injuries from skiing or snowboarding are related to the brainstem (Levy 698).

2.1.3 Skull Fracture. A skull fracture is when one or more of the eight bones that make up the cranial skull are broken. A skull fracture can occur when a skier or snowboarder hits their head on any other object, whether that object is another person or an inanimate object. About 15% of all head injuries from skiing or snowboarding include a skull fracture (Levy 697).

2.2 Helmet Use and Effectiveness in Skiing and Snowboarding

A 60% reduction in brain injury risk is associated with wearing a helmet (Sulheim 923). Wearing a helmet prevents injury by lowering the force of a collision on the wearer's head. This section will discuss the physics of helmets, as well as statistics on helmet use and their effectiveness in preventing head injuries, and finally how to properly wear a helmet.

2.2.1 The Physics of Helmets. Helmets protect the head in a few ways. Ski and snowboard helmets include a hard plastic exoskeleton, as well as a foam liner, usually made out of expanded polystyrene (Stewart 1). The plastic exoskeleton prevents sharp objects from penetrating the foam liner. The foam liner is most

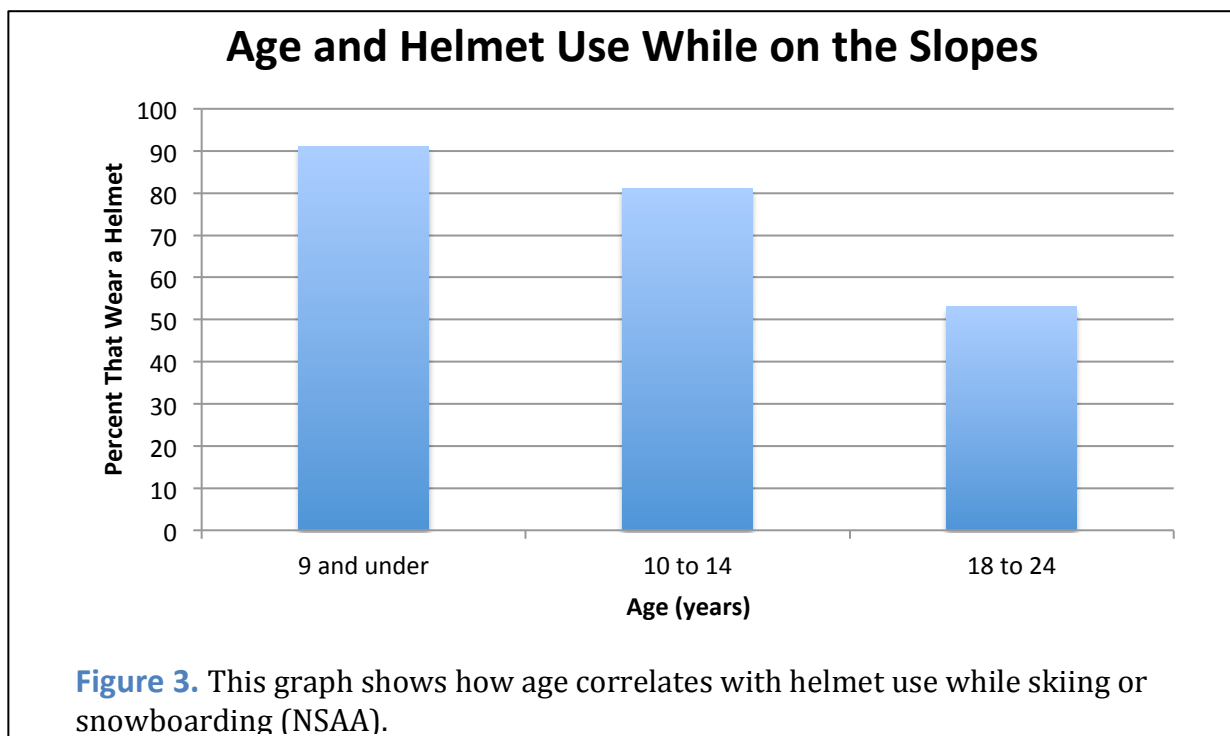
important in inhibiting head injuries, and does so by lowering the force of a collision on the helmet wearer's head.

As the equation in Figure 2 demonstrates, force and change in time have an inverse relationship; as the change in time grows, the force lessens. This is how the foam lining decreases the force on the head of the person wearing a helmet. The foam slows the head down, which increases the length of time it takes for the head to meet the collision. This increase in the change in time decreases the force on the head.

$$F = m \cdot a = m \cdot \Delta v / \Delta t$$

Figure 2. The equation for force. Force is equal to mass multiplied by acceleration. It is also equal to mass multiplied by the change in velocity divided by the change in time.

2.2.2 Helmet Use Statistics. Though helmet use in the United States has increased over time, it is still not universal. According to the National Ski Areas Association, 67% of skiers and snowboarders wear a helmet, which leaves 33% that do not wear a helmet while on the slopes. However, this number varies greatly by age. Figure 3, seen below, demonstrates the steady decline in helmet use as children reach adulthood. Only 53% of skiers and snowboarders aged 18 to 24 years old wear a helmet, representing the lowest percentage of helmet users among any age group.



This lack of helmet use leads to the question of why some skiers and snowboarders do not wear a helmet. According to the National Ski Patrol, skiers and snowboarders choose not to wear helmets for various reasons. These reasons include the beliefs that wearing a helmet will obstruct peripheral vision and that wearing a helmet encourages the wearer to ski more recklessly. Both of these beliefs have been disproved (Bianchi 37). Other reasons the National Ski Patrol names for skiers and snowboarders choosing not to wear helmets are fashion and price.

Skiing ability does appear to correlate with helmet use. A 2006 study found that those who identify themselves as “expert” or “beginner” skiers are up to 30% more likely to wear a helmet than those who describe themselves as “good” or “intermediate” (Sulheim 923). This study also found that those who have had skiing instruction are 30% more likely to wear a helmet.

2.2.3 Head Injury and Helmet Effectiveness Statistics. Skiers and snowboarders often doubt the effectiveness of helmets, and therefore choose not to wear them. A statistic that is often cited is one that says that helmets do not prevent injury when the skier or snowboarder is going over 12 to 14 miles per hour. However, one study showed that while helmets may not provide complete protection for those going over 12 to 14 mph, they can lessen the severity of injuries sustained at high speeds, and often are a lifesaving mechanism (Levy 238). Additionally, 36.6% of head and neck injuries occur from a simple fall on the ground (Levy 697), and only 32% of those who obtained head and neck injuries reported going at a high speed when the injury occurred (Hagel 282).

Age also seems to have an effect on brain injuries. Those 9 years old or under are account for only 3.1% of brain injuries, while those between the ages of 16 and 25 account for 46.9 (Levy 697). For a more in-depth look at age as a factor in brain injuries while skiing or snowboarding, refer to Figure 4 on the following page.

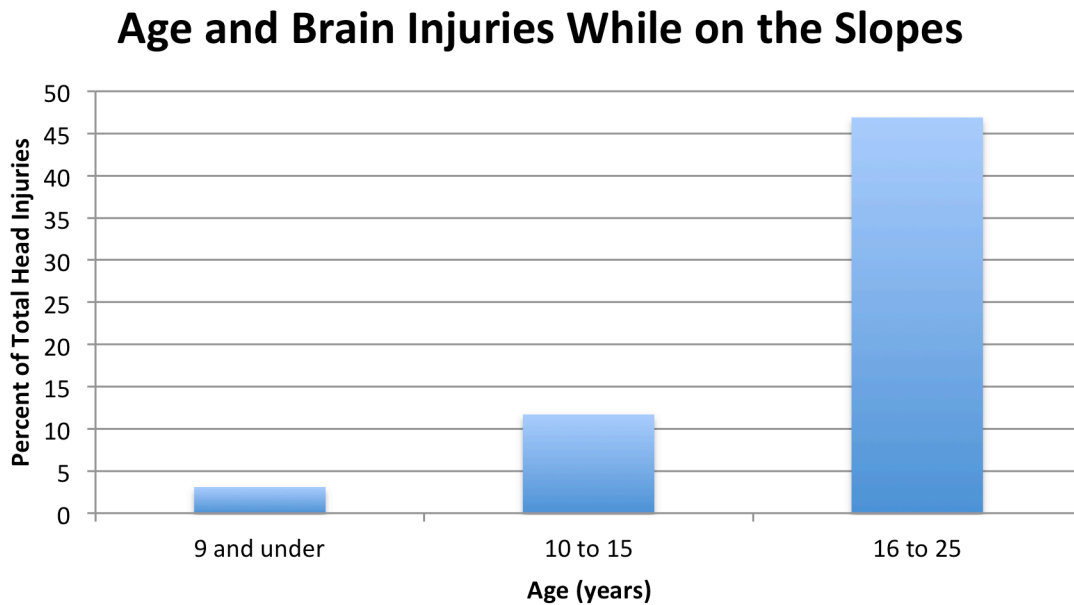


Figure 4. This graph shows how age correlates with brain injuries while skiing or snowboarding (Levy 697).

The study that found that helmet use is more common among those who consider themselves “expert” or “beginner” skiers over those who consider themselves “intermediate” or “good” skiers also found an interesting parallel in head injury patterns. The study found that “good” and “intermediate” skiers account for about 55% of head injuries (Sulheim 923). That study also found that those who have had some skiing instruction account for less than 30% of head injuries.

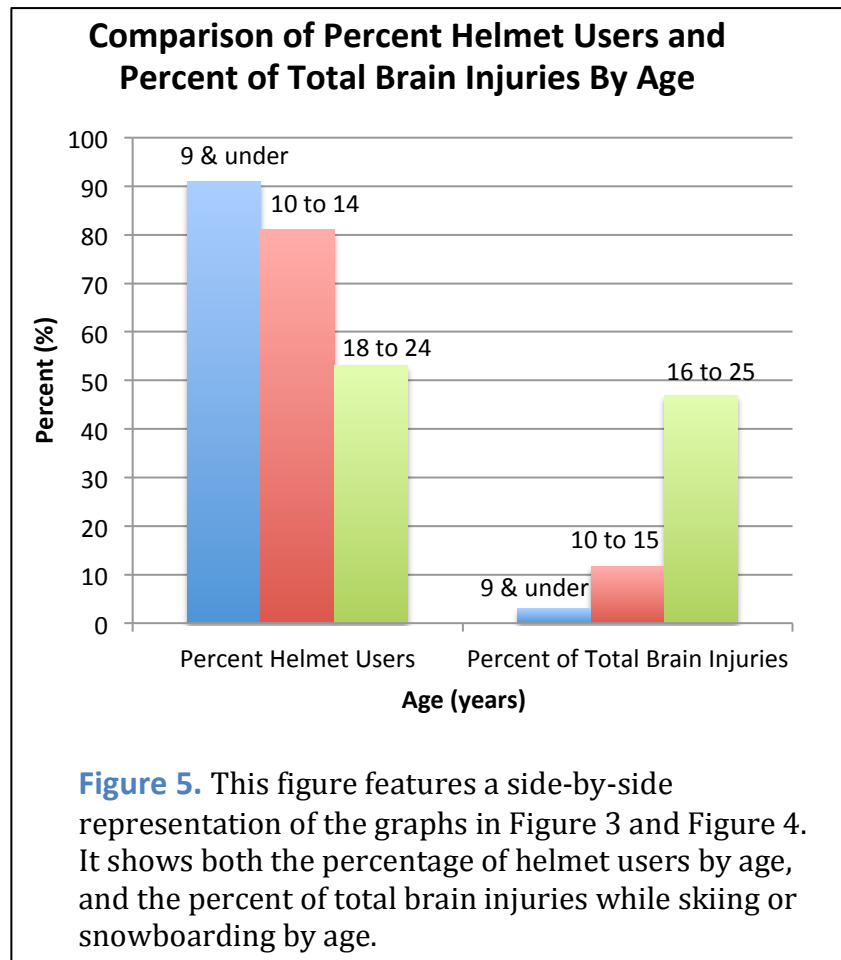
A 2006 study found that head injury is much more common in skiers and snowboarders who do not wear helmets. Those who do not wear helmets account for 83% of both standard and severe head injuries (Sulheim 922). The study concluded that there is a 60% reduction in brain injury risk for a skier or snowboarder who wears a helmet.

2.2.4. Analysis of Statistics. From the statistics in sections 2.2.3 and 2.2.4, we can realize that helmet use and brain injury correlate to one another. Figure 5 places the graphs of Figure 3 and Figure 4 next to one another for comparison. These graphs depict the inverse relationship between wearing a helmet and percent of total brain injuries from skiing and snowboarding. Skiers and snowboarders between the age of 18 and 24 are

least likely to wear a helmet, while skiers and snowboarders between the ages of 16 and 25 account for the highest percentage of brain injuries. Inversely, those 9 and under are most likely to wear a helmet and account for the smallest percentage of brain injuries.

Additionally, studies show that the same

inverse relationship between helmet use and brain injury applies when comparing helmet use and head injuries among different skiing abilities. Those who consider themselves “expert” or “beginner” skiers are more likely to wear a helmet and less likely to get a head injury than those who consider themselves “intermediate” or “good” skiers.



2.2.4 Instructions for Proper Helmet Use. Helmets are not effective unless they are fitted properly. They must be the proper size and be correctly placed on the head. To tell whether a helmet is the proper size, place it on your head and have someone else shake it. If the helmet pops off at all, it is too small. If the helmet moves around without your head moving with it, it is too big. If the helmet and your head move together, then it is the proper size. To correctly place the helmet on your head, refer to Figure 6, which explains and depicts the proper fitting for a bike helmet. The same principle can be applied to ski and snowboard helmets.

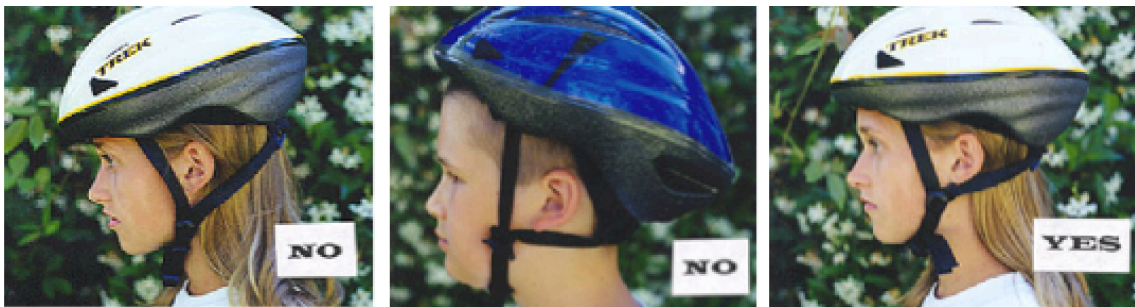


Figure 6. This figure depicts how to properly wear a bike helmet. The picture on the left shows a girl wearing her helmet too far forward on her head. This leaves the back of her head vulnerable to an injury. The middle picture depicts a boy wearing his helmet too far back on his head. This leaves the front of the head vulnerable to injury. The girl on the right is wearing her helmet properly. It sits on top of her head, and the chinstrap is tightened so that it will keep the helmet from falling off during a fall or collision.

3.0 EXISTING LEGISLATION

3.1 United States

According to the National Ski Areas Association, 42 states have at least one ski resort, however only one state has a law making helmet use mandatory. This section will discuss the existing legislation requiring helmet use while skiing or snowboarding in the United States. It will also compare these laws with motorcycle and bicycle helmet laws.

3.1.1 US States With Ski and Snowboard Helmet Legislation. In 2011, California passed a bill that would make helmets mandatory for skiers and snowboarders under the age of eighteen. However, the Governor of California at the time vetoed the bill. He explained his thinking: “Not every human problem deserves a law” (Buchanan 1). He also stated that parents should be in charge of making their children wear helmets.

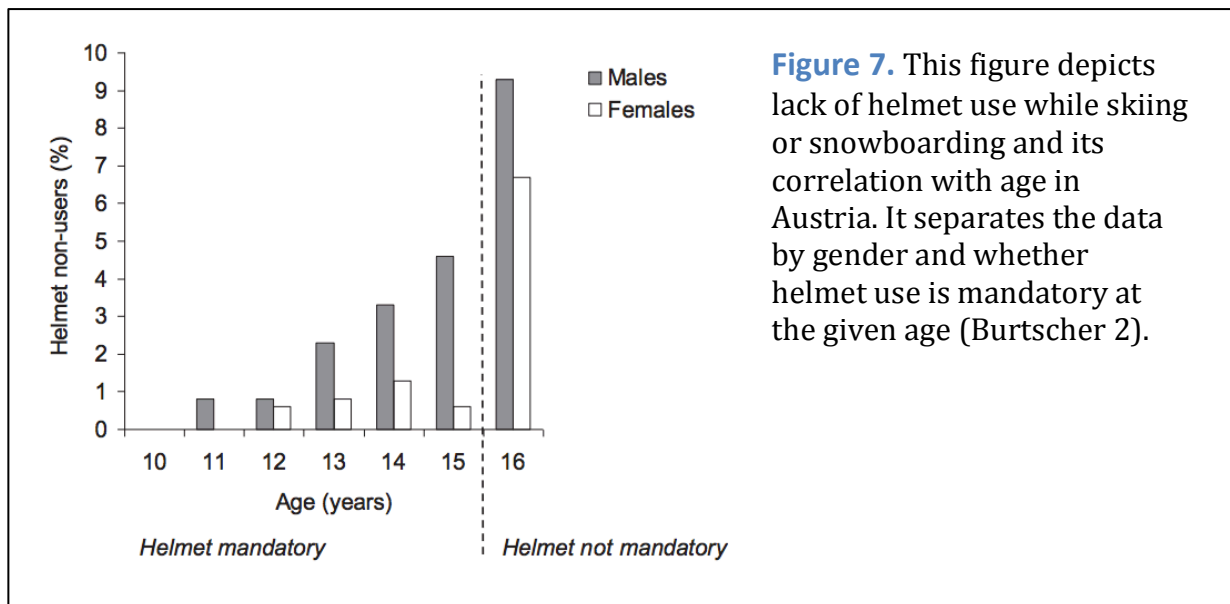
Also in 2011, New Jersey passed a bill that made helmet use while skiing or snowboarding mandatory for those under the age of 18, and the Governor of New Jersey signed the bill into law. Violators are fined \$25 for their first offense, and \$100 per offense thereafter. The hope is that this law will increase helmet use for young skiers and snowboarders. New Jersey is currently the only state with such a law, though New York has similar legislation pending.

3.1.2 Ski Helmet Laws vs. Motorcycle and Bicycle Helmet Laws. Ski helmet laws are far less frequent than motorcycle or bicycle helmet laws. 47 states have laws making wearing a helmet while riding a motorcycle mandatory. Some of these states restrict the law to those under the age of 18, while others extend the law to include adults. 37 states have bicycle helmet laws, and again some of those states restrict the law to children. However, only one state has a ski and snowboard helmet law.

3.2 A Study of Austria’s Ski and Snowboard Helmet Law

In Austria, those fifteen and under are required to wear a helmet while skiing and snowboarding. A 2013 study surveyed Austrian skiers and snowboarders between the ages of 10 and 16 about their helmet use. From age 10 to 15, during which time helmet use is mandatory for snowsports in Austria, 99% of the surveyed children reported that they use a helmet while skiing or snowboarding (Burtscher 1). However, of the 16-year-old children who were surveyed, only 91% reported using a helmet while on the slopes. These children are no longer forced to wear a helmet,

which resulted in a decrease in helmet use. An in-depth breakdown of the results of this survey appears in Figure 7 below.



4.0 CONCLUSION

Wearing a helmet while skiing or snowboarding will reduce injury during a fall or collision. Doing so is associated with a 60% reduction in brain injury risk. However, only 67% of Americans wear a helmet while skiing or snowboarding. Skiers and snowboarders find many excuses for not wearing a helmet, and yet every study on the subject concludes that it is much safer to wear a helmet while on the slopes than not to do so.

Currently only one state, New Jersey, requires the use of a helmet while skiing or snowboarding, though the law only applies to those under the age of 18. California is the only other state to have passed a similar bill, though it was vetoed on the grounds that parents should enforce helmet use for their children rather than the state. It is interesting to note that the laws in place and under consideration in the United States make helmets mandatory for those under the age of 18, when adults

are actually much less likely to wear a helmet even in places where such a law does not exist.

Based on all of the information presented in this report, a mandatory helmet law is worthy of consideration. A study done in Austria concludes that those who are not required to wear a helmet while skiing or snowboarding will do so less frequently than those who are required. This leads to the conclusion that a mandatory helmet law would indeed increase the use of helmets in the United States. Because helmet use is associated with a large decrease in head injury, such a law would promote the safety and well being of skiers and snowboarders across the United States and reduce the number of head injuries.

Works Cited

- Bianchi, Giannina, Othmar Brügger, Steffen Niemann, Mario Cavegn, R. J. Johnson, J. Shealy, V. Senner, and S. W. Dean. "Helmet Use and Self-Reported Risk Taking in Skiing and Snowboarding." *Journal of ASTM International* 8.1 (2011): 32-43. Print.
- Buchanan, Wyatt, and Marisa Lagos. "Gov. Brown Vetoes Ski Helmet, Phone Fine Bills." n.d.: n. pag. *SFGate*. 8 Sept. 2011. Web. 1 Dec. 2013.
- Burtscher, Martin, Gerhard Ruedl, and Werner Nachbauer. "Effects of Helmet Laws and Education Campaigns on Helmet Use in Young Skiers." *The Journal of the Canadian Paediatric Society* 18.9 (2013): 471-72. Print.
- Hagel, Brent E., I. B. Pless, Claude Goulet, Robert W. Platt, and Ivonne Robitaille. "Effectiveness of Helmets in Skiers and Snowboarders: Case-control and Case Crossover Study." *British Medical Journal* 330.7486 (2005): 281-83. Print.
- Levy, A. Stewart, Allison P. Hawkes, Lee M. Hemminger, and Sue Knight. "An Analysis of Head Injuries among Skiers and Snowboarders." *The Journal of Trauma: Injury, Infection, and Critical Care* 53.4 (2002): 695-704. Print.
- Levy, A. Stewart., and Richard H. Smith. "Neurologic Injuries in Skiers and Snowboarders." *Seminars in Neurology* 20.2 (2000): 233-45. Print.
- McBeth, Paul B., Chad G. Ball, Robert H. Mulloy, and Andrew W. Kirkpatrick. "Alpine Ski and Snowboarding Traumatic Injuries: Incidence, Injury Patterns, and Risk Factors for 10 Years." *The American Journal of Surgery* 197.5 (2009): 560-64. Print.
- "Resort Firm Faces Second Lawsuit Over Ski Accidents." *Insurance Journal* 13 Mar. 2012.

Smayda, Richard. "What happens to the brain during a concussion?" *Scientific American*. N.p., 26 Apr. 1999. Web. 2 Dec. 2013.

"Study Shows 67 Percent Now Wear Helmets on the Slopes." Ed. Troy Hawks. National Ski Areas Association, 15 June 2012. Web. 1 Dec. 2013.
Risk Factors for 10 Years." *The American Journal of Surgery* 197.5 (2009): 562.

Sulheim, Steinar, Ingar Holme, Arne Ekeland, and Roald Bahr. "Helmet Use and Risk of Head Injuries in Alpine Skiers and Snowboarders." *JAMA: The Journal of the American Medical Association* 295.8 (2006): 919-24.

Stewart, D., L. R. Young, R. Goel, G. Christou, M. D. Gilchrist, R. J. Johnson, J. Shealy, V. Senner, and S. W. Dean. "Evaluating the Performance of Helmet Linings Incorporating Fluid Channels." *Journal of ASTM International* 7.10 (2010): 1-7. Print.